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Indo-Pacific-European Hub
for Digital Partnerships

ヨーロッパとインド太平洋のための
デジタルパートナーシップ強化

디지털 파트너십 강화
유럽 및 인도 태평양의 경우

D4.1:

Report on synergies and commonalities in policies, strategies and programs between the EU and Indo-Pacific countries

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Abstract	This report examines the synergies and commonalities in policies, strategies, and programs between the European Union (EU) and Indo-Pacific countries, focusing on digital and trade partnerships as well as research and development (R&D) initiatives in Information and Communication Technologies (ICT).
Keywords	ICT, R&D iniciatives and programes; partner countries; digital partnerships

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EXECUTIVE SUMMARY

This report examines the synergies and commonalities in policies, strategies, and programs between the European Union (EU) and Indo-Pacific countries, focusing on digital and trade partnerships as well as research and development (R&D) initiatives in Information and Communication Technologies (ICT). The main goal is to identify strategic areas for collaboration, highlight shared challenges, and propose recommendations to maximize the impact of these partnerships on sustainable economic development and global digital transformation.

The EU has established digital partnerships with Japan, South Korea, and Singapore, as well as a Trade and Technology Council with India, aiming to promote digital transformation, strengthen cybersecurity, and develop emerging technologies such as 5G/6G networks, artificial intelligence (AI), and quantum computing. Each partner country brings unique initiatives to the table. Japan's strategy focuses on "Society 5.0," integrating the physical and digital realms to address social challenges through advanced technologies. South Korea prioritizes areas such as AI semiconductors, the metaverse, cybersecurity, and quantum technology. Singapore emphasizes smart cities, data governance, and sustainability, while India is advancing industrial digitalization and strengthening its ICT infrastructure through initiatives like the "National Quantum Mission."

Collaboration between the EU and these Asian nations is supported by robust mechanisms, including regulatory and standards alignment, joint funding for research projects, stakeholder engagement through public-private partnerships, and the development of advanced technological infrastructure. These mechanisms foster joint initiatives in priority areas such as AI, quantum computing, and sustainable digital solutions.

The report outlines key recommendations to enhance these partnerships, including strengthening semiconductor and critical resource supply chains, promoting ethical digital governance, fostering interoperability of international standards, investing in digital skills development, and establishing centres of excellence in emerging technologies. These actions aim to align strategic priorities between the regions and promote technological inclusion.

In conclusion, the digital partnerships between the EU and Indo-Pacific countries hold significant potential to transform economies and societies by addressing global challenges and fostering innovation. This report provides a detailed roadmap for future collaborations, reaffirming the shared commitment to sustainable development, inclusive economic growth, and the responsible advancement of technology.

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ABBREVIATIONS

AGNIi	Accelerating Growth of New India's Innovations
AI	Artificial Intelligence
ANRF	Anusandhan National Research Foundation
C-DOT	Centre for Development of Telematics
CoEs	Centres of Excellence
CSAR	Collaboration in Science and Research
DoT	Department of Telecommunications
DST	Department of Science and Technology
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GII	Global Innovation Index
HEIs	Higher Educational Institutions
ICT	Information and Communication Technology
IoT	Internet of Things
IP	Internet Protocol
I-STEM	Indian Science, Technology, and Engineering Facilities Map
M2M	Machine to Machine
MeitY	Ministry of Electronics and Information Technology
MGB	Mission Governing Board
MSIT	Ministry of Science and ICT
MSMEs	Micro, Small, and Medium Enterprises
MTRC	Mission Technology Research Council
NDTSP	National Deep Tech Startup Policy
NFV	Network Function Virtualization
NGN	Next Generation Networks
NIC	National Informatics Centre
NIELIT	National Institute of Electronics and Information Technology
NIPA	National IT Industry Promotion Agency
NPR	National Population Register
NQM	National Quantum Mission
NRI	Network Readiness Index
NTIS	National Science and Technology Knowledge Information Service
PM-STIAC	Prime Minister's Science, Technology, and Innovation Advisory Council
PRIME	Project Review and Information Management Electronics System
PSA	Principal Scientific Adviser
RAN	Radio Access Networks
SDN	Software Defined Networks
SDR	Software Defined Radio
SW	Software
TWG	Thematic Working Groups
VLC	Visible Light Communication

1   DIGITAL PARTNERSHIP BETWEEN EU AND ASIAN COUNTRIES

Digital technologies play a crucial role in the advancement of societies towards sustainability, openness, fairness, and prosperity. Significant developments in communication networks, electronic systems, artificial intelligence, big data, high-performance computing, automation, and decision support are occurring rapidly. Although these technologies hold valuable benefits, the adoption and implementation present various challenges such as gaining acceptance and trust, ensuring data and internet security, addressing barriers to access, governance issues, and managing power consumption. Post covid-19 pandemic, there is a pressing need to ramp up international cooperation to accelerate technological advancements. This cooperation should focus on facilitating the socially and environmentally beneficial uptake of technology in markets and enhancing Europe's competitive position.

Digital partnerships have emerged as critical channels for fostering innovation, economic growth, and cross-border collaboration. Among the most dynamic collaborations is the strategic alliance between the European Union (EU) and some key Asian nations including India, Japan, Singapore, and South Korea. These partnerships harness the combined strengths and expertise of both regions to drive digital transformation, enhance technological capabilities, and tackle common challenges in the digital sphere.

The EU has initiated Digital Partnerships (DPs) with Japan (2022), South Korea (2022), and Singapore (2023). Additionally, the EU and India have fortified their strategic collaboration by establishing a Trade and Technology Council (TTC) in 2022. These partnerships are aimed at deepening digital cooperation and regulatory alignment, fostering increased bilateral trade and investment, and ensuring mutual benefits for societies and businesses in both regions within the rapidly expanding global digital economy.

The EU's engagement with India, Japan, Singapore, and South Korea in digital cooperation is driven by shared interests and objectives. Each partnership presents a unique opportunity to capitalize on the synergies between Europe's advanced digital infrastructure and Asia's vibrant technology ecosystems. By deepening collaboration in technological and policy areas from data free flow with trust, cybersecurity, 5G/6G technology, data governance, quantum computers, and artificial intelligence to digital dialogue, policies and education, these partnerships aim to unlock new avenues for economic development, foster inclusive growth, and ensure the ethical and responsible use of digital technologies.

This document will lay the groundwork for exploring the multifaceted dimensions of the digital partnerships between the EU and its Asian counterparts. From joint research and innovation

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initiatives to policy dialogues and capacity-building opportunities, these partnerships exemplify the potential of international collaboration to shape the future of the digital economy and society. As we delve into each partnership, we will uncover the key areas of ICT R&D activities, strategic priorities guiding collaboration, industrial involvement, national funding mechanism, identified present collaboration, and potential synergies and communalities of ICT R&D initiatives in the EU and Asian counterparts. Deliverables should not refer to project-internal matters such as WPs.

2 STATUS AND PROGRESS OF DIGITAL PARTNERSHIPS / TRADE AND TECHNOLOGY COUNCIL

The European Union (EU) has strategically positioned itself as a global leader in fostering international collaboration through its Digital Partnerships (DPs) and the establishment of the Trade and Technology Council (TTC). These partnerships align with the EU's Digital Compass strategy's pillars[1] - skills, infrastructure, business transformation, and public service digitization – strengthening the EU's capacity to promote human-centric digital transformation globally. These initiatives aim to deepen digital cooperation, strengthen regulatory alignment, research and development in ICT sectors, businesses and development, and expand trade and investment with key partners in Asia, including Japan, Republic of Korea, Singapore, and India. As digital technologies increasingly drive economic growth and societal transformation, these partnerships represent a significant step toward addressing shared global challenges and promoting innovation.

The Digital Partnerships with Japan, South Korea, and Singapore, launched between 2022 and 2023, and the TTC with India, established in 2022, reflect a shared commitment to shaping the future of the digital economy summarized in Table 1 and the detail about the roadmaps will be delivered in detail in chapters 3,4,5 and 6 under subchapters Present Collaboration with the EU. By leveraging complementary strengths, these collaborations aim to enhance technological capabilities in areas such as artificial intelligence, quantum computing, 5G/6G networks, cybersecurity, and data governance. They also focus on aligning policy frameworks to create a cohesive digital ecosystem that benefits both regions. The partnerships underscore the EU's and Asian Pacific countries' dedication to promoting sustainable, inclusive, and secure digital transformation on a global scale.

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[1] 2030 Digital Compass: the European way for the Digital Decade - Article 6: International Partnerships for the Digital Decade. Available in: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021DC0118

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Table 1: Roadmap of DPs and TTC between EU and Asia Pacific Countries.

Year	Agreement
Japan	
2011	Bilateral cooperation on Science and Technology (S&T)[2]
2015	New Strategic Partnership in Research and Innovation[3]
2018	Economic Partnership Agreement (EPA) [4] and the Strategic Partnership Agreement (SPA)[5].
2023	Digital Partnership between EU-Japan[6]
2024	The second meeting of the EU-Japan Digital Partnership Council[7]
Republic of Korea	
2006	Science and Technology (S&T) Agreement.
2010	Framework Agreement[8]
2011	Free Trade Agreement (FTA)[9]
2020	Digital cooperation[10]
2023	Digital Partnership[11]

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[2] Roadmap for EU-Japan S&T Cooperation. Available in: https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/europe-world/international-cooperation/bilateral-cooperation-science-and-technology-agreements-non-eu-countries/japan_en#agreements-and-arrangements

[3] New strategic partnership in Research and Innovation between the European Commission and the Government of Japan endorsed by 23rd Japan-EU Summit. Available in: https://www.mofa.go.jp/dns/isc/page18e_000124.html

[4] EU-Japan Economic Partnership Agreement. Available in: https://trade.ec.europa.eu/access-to-markets/en/content/eu-japan-economic-partnership-agreement

[5] EU-Japan Strategic Partnership Agreement (SPA). Available in: https://www.eeas.europa.eu/node/57491_en

[6] Japan-EU Digital Partnership Council Held. Available in: https://www.meti.go.jp/english/press/2023/0703_002.html

[7] EU and Japan advance joint work on digital identity, semiconductors, artificial intelligence. Available in: https://digital-strategy.ec.europa.eu/en/news/eu-and-japan-advance-joint-work-digital-identity-semiconductors-artificial-intelligence

[8] Korea - EU Political Relations. Available in: https://overseas.mofa.go.kr/be-en/wpge/m_7448/contents.do#:~:text=Oct.,Jun.

[9] South Korea, EU trade relations with South Korea. Facts, figures and latest developments. Available at: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/south-korea_en

[10] Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0118&from=en

[11] Korea – EU Digital Partnership. Available in: https://k-erc.eu/digital-partnership/

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2024	Second Digital Partnership meeting[12]
Singapore	
2014	EU-Singapore Investment Protection Agreement (EUSIPA)[13]
2018	EU – Singapore Partnership and Cooperation Agreement (EUSPCA)[14]
2019	European Union-Singapore Free Trade Agreement (EUSFTA)[15]
2022	EU-Singapore Digital Partnership Agreement (EUSDPA)[16]
2024	EU-Singapore Digital Trade Agreement (EUSDTA)[17]
India	
2004	Strategic Partnership[18]
2022	EU-India Trade and Technology Council (TTC)[19]
2023	1st Meeting EU-India TTC Memorandum of Understanding (MoU) on semiconductors cooperation
2024	The seventh to ninth round of EU-India Free Trade Agreement (FTA)

The partnerships underscore a shared commitment to shaping a secure, inclusive, and sustainable digital economy on a global scale. The next chapters will provide detailed roadmaps for each partnership, providing s brief status of the ICT research activity, research and innovation priorities, identified national funding mechanism, overview of recent collaboration activities, and highlight on potential synergies and communalities, emphasizing their strategic importance in addressing global challenges and driving technological and economic transformation.

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[12] Joint Statement of the second meeting of the European Union – Republic of Korea Digital Partnership Council. Available in: https://digital-strategy.ec.europa.eu/en/library/joint-statement-second-meeting-european-union-republic-korea-digital-partnership-council

[13] EU-SINGAPORE INVESTMENT PROTECTION AGREEMENT (IPA). Available in: https://www.europarl.europa.eu/legislative-train/package-other-fta/file-eu-singapore-ipa

[14] Partnership and Cooperation Agreement between the European Union and its Member States, of the one part, and the Republic of Singapore, of the other part. Available in: https://www.consilium.europa.eu/en/documents-publications/treaties-agreements/agreement/?id=2014027&DocLanguage=en

[15] EUSFTA. The European Union-Singapore Free Trade Agreement (EUSFTA). Available in: https://www.mti.gov.sg/Trade/Free-Trade-Agreements/EUSFTA

[16] EU-Singapore Digital Partnership. Available in: https://digital-strategy.ec.europa.eu/en/library/eu-singapore-digital-partnership

[17] EU and Singapore conclude negotiations for landmark Digital Trade Agreement. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_3982

[18] EU's Strategy on India: Time to Revitalise the Natural Partnership. Available in: https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=4814&lid=2837#:~:text=The%20EU%2DIndia%20Strategic%20Partnership%20was%20signed%20in%202004.,%2C%20economic%2C%20and%20development%20cooperation

[19] EU-India: new Trade and Technology Council to lead on digital transformation, green technologies and trade. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_596

3 OVERVIEW OF ICT RESEARCH AND DEVELOPMENT (R&D) INITIATIVES IN JAPAN

3.1 INTRODUCTION OF ICT R&D PROGRAM

Japan is a leader in using ICT (Information and Communications Technology) to address social challenges and drive innovation. Their approach to R&D (Research and Development) emphasizes collaboration throughout the entire process, from idea to implementation. This collaboration includes universities, businesses, and international partners.

Japan's ICT R&D scene is a powerhouse of innovation, fuelled by both government and private investment. Total expenditure on R&D during fiscal year (FY) 2022 reached a record high of 20.70 trillion yen, reflecting a 4.9% increase from the previous year [1]. This significant investment highlights Japan's commitment to technological advancement. Programs like the Ministry of Internal Affairs and Communications' SCOPE initiative actively support cutting-edge projects. The focus of research goes beyond just technological advancement, addressing societal issues like disaster preparedness and sustainable practices [2].

One key focus of Japan R&D is Society 5.0, which aims to create a human-centered society that merges the physical and digital worlds. This includes using advanced technologies like AI and quantum computing to improve areas like sustainability and quality of life [3].

Challenges include fostering collaboration gap between different research areas and institutions, as well as attracting and retaining top talent [4]. A deeper view is presented as follows:

1. **Collaboration Gap:** The persistent collaboration gap between academic research and industry application in Japan's ICT R&D landscape poses a significant challenge. This gap prevents the innovative ideas generated in universities and research institutions from being translated into commercially viable products and services [5].

2. **Sociocultural Resistance:** One of the significant challenges to Japan's digital transformation is the long-standing cultural resistance among the Japanese public. This resistance is deeply rooted in societal concerns over privacy and the potential misuse of personal information. Many people fear that linking personal information to digital systems, such as the My Number Card, could grant the government access to their health information and financial assets. These concerns contribute to a general reluctance to adopt digital technologies and services, impeding the country's progress toward a fully digital society [6].

3. **Policy Intervention:** Policy interventions in the digital ICT sector in Japan have been significant, reflecting the government's proactive stance towards fostering innovation, enhancing infrastructure, and promoting digital transformation across various industries. For example, the newly formed Digital Garden City Nation initiatives not only offer opportunities such as grants to the local governments, but also brings problems to be solved such as population decrease, aging demographics, and the decline of industries that are more pronounced in rural regions compared to urban areas [4].

4. **Talent Pool:** Japan's shrinking population particularly among older generations may lack of familiarity and comfort with using new technologies, creating a barrier to adoption especially for older generations. In Japan, digital skills are notably deficient among older adults, with 41% of individuals aged 55-65 lacking basic ICT skills, compared to an OECD average of 34%. Moreover, among those without an upper-secondary education degree, 54.5% lack basic digital skills, compared to an OECD average of 42% [7]. Based on this issue, Japanese government introduces new policy that opens opportunities to invite foreign labour as skilled workers representing 40% of 2.05 million foreign workers in 2023 [8]. The new policy measures in Japan include issuing special work visas for foreign ICT workers, encouraging universities to create ICT-specific departments and incorporate ICT skills in entrance exams, and implementing mandatory programming classes in elementary and high schools. Concerns remain that these initiatives may not effectively address the skills gap unless accompanied by increased financial incentives for ICT graduates to pursue careers in government roles [4].

However, challenges remain. Encouraging collaboration across sectors and fostering international partnerships are crucial for continued progress. Retaining skilled professionals in the highly competitive ICT field is another hurdle. Despite these challenges, Japan remains well-positioned to be a global leader in ICT, with exciting opportunities in areas like AI, robotics, and advanced materials.

3.2 RESEARCH AND INNOVATION PRIORITIES

Japan urges to lead the realization of a "New Form of Capitalism" focused on sustainability and enhancing people's well-being. Central to this vision is the establishment of a nation driven by

science and technology, marking the first pillar of Japan's growth strategy presented by the cabinet office[20]

Investing in human resources, especially in science and technology, is a central part of the government's strategy, seen as crucial for future innovation. This strategy aligns with the broader goal of Society 5.0, a human- centred society that balances economic growth with the resolution of social issues. The Sixth STI Basic Plan emphasizes a "virtuous cycle of social transformation through Convergence Knowledge (So-Go-Chi) and investment in knowledge and people," highlighting the interconnectedness of science, technology, and innovation with economic and societal development [9].

Each year Japan frameworks an Integrated Strategy to enhance predictability by outlining priority measures for the year, fostering a virtuous cycle of growth and distribution through science, technology, and innovation. To realize these goals, it is essential to leverage Japan's strengths in cutting-edge science and technology and develop strategic processes for Society 5.0, addressing global challenges and promoting sustainable growth. Collaboration between the government and the private sector is crucial to implementing this vision and achieving the outlined goals, ensuring the benefits of R&D reach society and local communities. Below are major initiatives and each priority areas discussed by the Council for Science, Technology and Innovation (CSTI) in 2023:

1. Transformation into a Sustainable and Resilient Society: The goal is to redesign society to solve global challenges, ensure safety and security, and promote well-being for all inhabitants. This involves leveraging cyberspace and physical space to create a dynamic cycle where data and AI are accessible and secure for everyone. Key initiatives include achieving net-zero greenhouse gas emissions and building resilience against natural disasters and pandemics [10].

2. Promotion of Innovation and Startups: Establishing new industrial infrastructure to support the emergence of startups and fostering value creation through collaboration among diverse entities. This includes the deployment of Smart Cities in Japan and globally, which will be pioneers in implementing Society 5.0 principles [10].

3. Enhancing R&D Capacity: To win in international competition, CSTI aims to enhance research and development capacities by recruiting new project managers and launching research projects aligned with Moonshot goals. This program sets ambitious goals to tackle critical social challenges such as super-aging society and global warming by promoting aggressive R&D. The

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[20] Integrated Innovation Strategy 2022. Available at: https://nsearch.cao.go.jp/cao/search.x?q=strategy+2022&submit=Search&mode_ja_cao=ja_cao&page=1&ie=UTF-8&tmpl=en

goals include achieving breakthroughs in areas like ultra-early disease prediction, AI robots, sustainable resource circulation, and quantum computing by 2050 [10].

4. Promotion of Public/Private R&D Investment: Through programs like PRISM[21] and BRIDGE[22], the CSTI aims to direct government policies towards areas that can effectively induce private investment and maximize the impact of government spending. Focus areas include AI technologies, innovative technologies (construction/infrastructure maintenance and disaster prevention/mitigation), biotechnologies, and quantum technologies [10].

This analysis has identified several critical areas for investment and development as follows: Artificial Intelligence and Robotics, Cybersecurity, Digital Transformation, Data Science and Analytics, and Quantum Technologies.

Recently, on the 3rd of June 2024, the CSTI held a conference on Science Technology and Innovation where the Japanese Innovation Strategy for 2024 was outlined.

The direction of the strategy is the automation and labour-saving through AI and robotics. These are seen as a critical priority due to the worsening labour shortage, and preparation for and response to frequent disasters are also urgent issues. The focus includes sectors like healthcare, autonomous driving, and finance, where the societal impact is of particular significance. The strategy emphasizes a thorough study of legal regulations to counter the risks associated with AI, such as the spread of misinformation, discrimination, bias and criminal activities, ensuring that its application in society is safe and expedited. An example of Japan's heavy emphasis on advanced robotics development is the Robot Revolution & Industrial IoT Initiative, a national strategy aimed at transforming manufacturing and industry through robotics, AI, and the industrial IoT. Launched in 2015, it focuses on increasing productivity, addressing labour shortages, and maintaining Japan's global competitiveness. Key areas include smart factories, AI-driven automation, and data-driven supply chains. The initiative promotes open collaboration between industries, academia, and government (including already ongoing joint actions with Germany as part of the Industrie 4.0 platform[23]) to develop interoperable standards and enhance cybersecurity. It also encourages SMEs to adopt advanced manufacturing technologies. By integrating robotics with IIoT, Japan aims to lead in next-generation manufacturing, optimize energy use, and boost industrial efficiency. Also related to automation and advanced robotics are initiatives such as Mitsubishi Electric's e-F@ctory, a smart

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[21] "PRISM" program. Available at: https://www8.cao.go.jp/cstp/panhu/prism2021_e/p1-2.pdf

[22] "Bridging Research and Development with Society 5.0 (BRIDGE)". Available at: https://www8.cao.go.jp/cstp/bridge/index.html

[23] Robot Revolution & Industrial IoT Initiative. Available at: https://www.plattform-i40.de/IP/Redaktion/EN/Standardartikel/international-cooperation-japan-2018.html

manufacturing initiative that integrates IoT, AI, and automation to enhance productivity, reduce costs, and improve efficiency in industrial operations through real-time data analysis and connected systems.

Besides AI initiatives, emphasis is also being placed on support for research and talent development in nuclear fusion, quantum technology, and biology. A collaborative approach is being championed to foster innovation using AI in quantum technology and robotics. Furthermore, the "International Centres of Excellence Initiative" financed by a fund worth approximately 10 trillion yen aims to secure world-class research outcomes and bolster Japan's research capabilities.[24]

Japan's concern with free data flow and data spaces implementation is also worth noting. Japan's Data Free Flow with Trust (DFFT) initiative, introduced by former Prime Minister Shinzo Abe at the 2019 World Economic Forum, aims to promote cross-border data flows while ensuring trust in privacy, security, and intellectual property rights. DFFT seeks to balance the benefits of data-driven economic growth with the protection of individual rights and national security. The concept was first endorsed in the G20 Osaka Leaders' Declaration in 2019 and has since been a focal point in international discussions on digital governance. In 2023, during Japan's G7 presidency, efforts were made to operationalize DFFT by establishing the Institutional Arrangement for Partnership (IAP), focusing on developing compatible policies and practices to facilitate trusted data flows[25].

Regarding advanced computing capabilities, Japan has aimed to become a model leading country. Examples in development include the Fugaku supercomputer, developed by RIKEN and Fujitsu. Fugaky is one of the world's fastest supercomputers, operational since 2021. It excels in AI, big data, and industrial simulations, aiding manufacturing, disaster prevention, and drug discovery, supporting Japan's digital transformation and scientific research initiatives[26].

The role that science, technology, and innovation play in these areas is becoming increasingly important, and the necessity to accelerate the social implementation of technology was identified. The three strengthening measures in pursuing this strategy in the digital field are:

1. **Integrated strategy for key technologies**:

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[24] Japan Sets Forth Innovative Strategy for National Science and Technology Advancement in 2024. Available in: https://elblog.pl/2024/06/04/japan-sets-forth-innovative-strategy-for-national-science-and-technology-advancement-in-2024/

[25] Operationalizing Data Free Flow with Trust (DFFT). Available in: https://www.csis.org/analysis/operationalizing-data-free-flow-trust-dfft

[26] These are the world's most powerful supercomputers. Available in: https://www.weforum.org/stories/2021/01/supercomputer-world-technology-computer-japan-fugaku/

a. Development of core technologies, R&D through technological integration with other strategic fields (industry-academia-government collaboration, promotion of R&D using AI, robotics, IoT, etc.)

b. Establishment of domestic industrial infrastructure, promotion of innovation through startups, etc. (early creation of use cases, strengthening base/hub functions, etc.)

c. Cultivation and securing of human resources from industry, academia, and government (cultivation and securing of human resources for industrialization, market development, and R&D, etc.)

2. **Strengthening cooperation from a global perspective**:

a. Leading and participating in international rule-making regarding important technologies, etc. (promoting development and use, ensuring safety, ensuring presence, etc.)

b. Strengthening cooperation between science, technology and innovation policy and economic security policy (strategic research and development including international cooperation and collaboration, preventing technology outflow, etc.)

c. Actively utilizing resources from a global perspective, strategic collaboration (forming a base for international brain circulation, participating in top international scientific circles, etc.)

3. **Strengthening competitiveness in the field of AI while ensuring safety and security**:

a. Accelerating innovation in and through AI (strengthening R&D capabilities, promoting the use of AI, upgrading infrastructure, etc.)

b. Ensuring safety and security of AI (governance, safety considerations, measures against false and misinformation, intellectual property, etc.)

c. Promoting international collaboration and cooperation (international collaboration based on the results of the Hiroshima AI Process, etc.)

In addition, Japan will continue to steadily promote policies on the three existing pillars of the Integrated Innovation Strategy 2024[27], including the "Strategic promotion of cutting-edge science and technology" by promoting key fields, namely, research and development of AI, fusion energy, quantum, bio, materials, etc. and the promotion of semiconductor production base securing and research and development as digital social infrastructure, information and communications infrastructure development, Beyond 5G (6G).

3.3 IDENTIFICATION OF NATIONAL FUNDING MECHANISM

Funding for "The World's most Advanced ICT"

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[27] siryo1-1.pdf (cao.go.jp); Agenda of the 73rd Council on Science, Technology and Innovation - Council for Science, Technology and Innovation - Cabinet Office (cao.go.jp)

The National Institute of Information and Communications Technology (NICT) in Japan is the only public research institute specializing in ICT, playing an important role in promoting research and development and working on social implementation.

The "Five Priority Areas" of NICT for Research are the five areas of advanced electromagnetic wave technology, innovative networks, cybersecurity, universal communication, and frontier science. From a medium- to long-term perspective, each field is working on cutting-edge, basic, and foundational themes. In addition, NICT promotes cross-sectional and strategic R&D in the four strategic areas ("Beyond 5G, AI, Quantum Information and Communications, and Cybersecurity") that should be strategically pursued [11].

Figure 1: Priority research areas of NICT [11].

Analysing the Competitive Research Funding System budget for 2024 (see Annex I), can be concluded that only the Innovative Information and Communications Technology Beyond 5G (6G) fund is available with an initial budget of around 16.000-million-yen. (During 2023 it was given a 15.000-million-yen budget and later it was supplemented with 19.000-million-yen).

At the moment, the following open calls for proposals for the commissioned research projects in R&D Contract Research Initiatives are available in Table 2, under a specific research field:

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Table 2: Open calls for proposals funded by National Institute of Information and Communications Technology.

National Institute of Information and Communications Technology			
Call topic	**Link**	**Research Field**	**Amount**
Research and development of ultra-high-speed parallel laser light source technology for short-distance ultra-high-speed optical fiber links (#239)	Summary (e-rad.go.jp)	Ultra-high-speed laser light source that achieves both ultra-high-speed operation of 200 ~ 400 Gbps per channel, which is more than 2~4 times that of existing technologies, and low-power operation that can be applied to future hyperscale data centers, AI computing, 6G access networks, and other large-capacity short-range optical networks	The maximum amount is 100 million yen (tax included) for each fiscal year.*
Research and development of decentralized in-network storage and applications for highly reliable data distribution (#238)	Summary (e-rad.go.jp)	Decentralized in-network storage framework using blockchain and NICT secure off-chain storage, and to demonstrate its effectiveness through application demonstration	The maximum amount of R&D budget is 25 million yen (including tax) in 2024 and 50 million yen (including tax) in 2025 per project.*
Research and development of high-performance and highly reliable in-vehicle optical network infrastructure technologies for fully autonomous driving (#237)	Summary (e-rad.go.jp)	High-performance and highly reliable in-vehicle optical network" that supports fully autonomous driving by creating a new innovative in-vehicle optical network and solving various problems	The maximum amount is 120 million yen (tax included) in 2024, 100 million yen (tax included) in 2025, and 90 million yen (tax included) in 2026.*
Empirical research and development to solve social and regional issues by promoting digitalization such as data utilization (3rd session) (#236)	Summary (e-rad.go.jp)	Proposer selects a problem from a wide range of current social and regional issues, conducts research and development aimed at solving it by promoting digitalization using ICT and data, and demonstrates the results in areas facing issues	The total amount of 12 million yen (tax included) in 2024 and 20 million yen in 2025 will be capped per project.*

*Proposals to be adopted may be decided after adjusting the budget amount of the proposal [12]

Funding for the Promotion of Science, Technology and Innovation creation

Japanese government research and development investment is intended to be a catalyst to induce research and development in the private sector, encouraging the efforts of related parties, and engaging in research and development, etc. as a whole country with an appropriate division of roles between the public and private sectors. As so, it was decided to strengthen the strategic promotion function of the Council for Science, Technology and Innovation (hereinafter referred to as "CSTI") in order to create innovation that goes beyond the framework of each ministry and agency while overlooking the efforts of each ministry and agency.

As part of this, two programs were created for CSTI to allocate budgets to initiatives related to key technologies, businesses, systems, social acceptance, human resources, etc. that are necessary

for the social implementation of R&D results, and initiatives to promote the expansion of private R&D investment through these initiatives, regardless of the framework of the ministry or agency:

(1) **Strategic Innovation Promotion Program (SIP)**: A program that promotes R&D in a seamless manner, from basic research to social implementation, and engages in cross-disciplinary R&D through cooperation between ministries and agencies in industry-academia-government collaboration.

(2) **Bridging Program between R&D and Society 5.0 (BRIDGE)**: A program that aims to expand R&D investment and improve the efficiency of fiscal expenditure by guiding the R&D measures of each ministry and agency to "R&D target areas" that are expected to have a high effect of inducing private R&D investment

Strategic Innovation Promotion Program (SIP):

The SIP has been promoting themes that address the most important social problems facing Japan, as well as contribute to the resurgence of Japanese economy. Under the strong leadership of Program Directors (PD) for each subject, it promotes interdisciplinary research and development covering from fundamental study to industrial application with industry-academia-government cooperation.

The 12 projects identified as key to the rebirth of Japan and its position as a world leader are: Big-data and AI-enabled Cyberspace Technologies; Intelligent Knowledge Processing Infrastructure Integrating Cyber and Physical Domains; Cyber Physical Security for IoT Society; Automated Driving for Universal Services; "Materials Integration" for Revolutionary Design System of Structural Materials; Photonics and Quantum Technology for Society 5.0; Technologies for smart bio-industry and agriculture; Energy system for an IoE society; Enhancement of National Resilience against Natural Disasters; Innovative AI Hospital System; Smart Logistics Services; Development of Innovative Technologies for Exploration of Deep-sea Resources.

For this program a budget of 28.000-million-yen was set in 2023 for programs in a competitive research funding system.

The BRIDGE Program between R&D and Society 5.0

BRIDGE program is designed to address the implementation and acceleration of government policies in areas where public and private R&D investment is expected to expand and ultimately,

bridge to the Society 5.0 that Japan aims for. For this program a budget of 10.000-million-yen was set in 2023 for programs in a competitive research funding system.

The List of Bridge Measures adopted in 2023 and 2024 in the digital field by Ministry is represented in the Table 3 [13]:

Table 3: List of Bridge Measures adopted in 2023 and 2024 in the digital field [13].

Ministry	Topic	Duration
National Police Agency	Development of AI training tools for listening from children	2023-2024
Ministry of Internal Affairs and Communications	Social Implementation of Cyberspace Sensitivity Evaluation Technology Utilizing Brain Information	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Commercialization of control devices for large-scale quantum computers	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Development of Quantum Hybrid Optimization Algorithm Platform	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Ultra-Minimally Invasive Quantum Life Technology by Quantum Light Sensing	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Quantum Product Commercialization Promotion Platform Construction Project	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Acceleration of social implementation of three-dimensional non-destructive testing systems using neutron beams for preventive maintenance of social infrastructure	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Innovation in biological imaging based on multi-element utilization	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	Construction and demonstration of "Japan's version of the Disaster Charter" that brings together satellite observation resources	2023-2025
Ministry of Education, Culture, Sports, Science and Technology	2nd Material Startup Incubation Promotion Project	2024-2026
Ministry of Education, Culture, Sports, Science and Technology	Building a Commercial Optical Quantum Computer	2024-2026
Ministry of Education, Culture, Sports, Science and Technology	Creation of new use cases by μ-modularization of quantum spin sensors	2024-2025
Ministry of Health, Labour and Welfare	Digital Healthcare Databank Concept Contributing to the Development of Healthcare Digital Twins	2023-2025
Ministry of Health, Labour and Welfare	Establishment of a Precision Nutrition Practice Platform and Social Implementation	2023-2025

Ministry	Topic	Duration
Ministry of Health, Labour and Welfare	Construction and social implementation of a digital medical databank that contributes to the development of the medical digital twin	2024-2026
Ministry of Health, Labour and Welfare	Establishment of next-generation rapid laboratory diagnostics for infectious disease crisis management and social implementation of a system for collecting, analyzing, and sharing laboratory data	2024-2026
Ministry of Agriculture, Forestry and Fisheries	Development of data-driven soil management technology that achieves both productivity and reduction of environmental impact	2023-2025
Ministry of Agriculture	Development of smart facility horticulture technology that enables the deployment of highly productive environmental control technology from Japan	2023-2025
Ministry of Agriculture	Development of automated technology and digital platform for data conversion and integration for business process transformation related to agricultural infrastructure	2023-2025
Ministry of Agriculture	Establishment of a support platform for food tech companies to expand the use of domestically produced soybeans	2023-2025
Ministry of Agriculture	AI Agriculture Social Implementation Project	2023-2025
Ministry of Agriculture	Standardization of commodity codes and sophistication of distribution of agricultural and fishery products and food products through source marking technology	2023-2025
Ministry of Agriculture	Development and dissemination of AI identification technology for national land history using time-series and three-dimensional models for rapid disaster recovery, etc.	2024-2026
Ministry of Agriculture	Building the foundation for pesticide creation AI	2024-2026
Ministry of the Environment	Advancement of pollen observation methods using AI and remote sensing technologies to address the pollen allergy problem	2024
Ministry of Economy, Trade and Industry	Development of dynamic maps for public areas	2023-2025
Ministry of Economy, Trade and Industry	Practical global research in the field of AI × robotics and services	2023-2025
Ministry of Economy, Trade and Industry	Social implementation of next-generation smart logistics platform realized by optimal medical device selection by AI	2023-2025
Ministry of Land, Infrastructure, Transport and Tourism	Promotion of DX in the infrastructure field	2023-2025
Ministry of Land, Infrastructure, Transport and Tourism	Enabling the Urban Digital Twin	2023-2025
Ministry of Land, Infrastructure, Transport and Tourism	Social Implementation of Remote Sensing Technology Using Satellites in the Housing and Social Capital Fields	2023-224

Ministry	Topic	Duration
Ministry of Land, Infrastructure, Transport and Tourism	Collaboration with startups for localized and sudden storm weather countermeasures: Real-time disaster prevention field construction using AI	2023-2025
Ministry of Land, Infrastructure, Transport and Tourism	Improving the accuracy of flood forecasting using innovative integrated weather data	2023-2025
National Police Agency	R&D on anti-counterfeiting ability evaluation and verification technology of products using access control functions using biometric authentication	2023-2024
Ministry of Education, Culture, Sports, Science and Technology	Research and development of cumulonimbus cloud hazard prediction information and development of social implementation model	2023-2024

Other commissioned research projects in R&D

A list of the open calls for proposals for the commissioned research projects in R&D Contract Research Initiatives is presented in Table 4, considering the digital areas, in which the projects will be newly implemented from the year 2024.

Table 4: List of the open calls for proposals for the commissioned research projects in R&D Contract Research Initiatives.

New Energy and Industrial Technology Development Organization	
Call topic	**Link**
Deep Tech Startup Support Fund	概要 (e-rad.go.jp)
Public offering for the "Post-5G Information and Communications System Infrastructure Strengthening Research and Development Project/Development of Advanced Semiconductor Manufacturing Technology"	Summary (e-rad.go.jp)
Call for proposals for "Technology development for constructing a surface-based renewable energy heat utilization system" (FY2024)	Summary (e-rad.go.jp)
Green Innovation Fund Project / Development of next-generation solar cells / Next-generation solar cell demonstration project	Summary (e-rad.go.jp)
Japan Science and Technology Agency	
Development and demonstration of disaster observation and prediction technology using high-altitude drones [Economic Security Key Technology Development Program]	Summary (e-rad.go.jp)
Establishment of technology to verify unauthorized functions related to supply chain security (firmware/software): Evaluation method for the intentionality of unauthorized functions [Second call for applications for the Economic Security Critical Technology Development Program]	Summary (e-rad.go.jp)

New Energy and Industrial Technology Development Organization	
Call topic	**Link**
Next Generation AI Human Resource Development Program (Support for Young Researchers)	Summary (e-rad.go.jp)
Rapid and highly accurate multi-gas sensing system technology that enables detection and identification of various substances	Summary (e-rad.go.jp)
Research on human work transfer leading to effective transfer of know-how Digital infrastructure technology	Summary (e-rad.go.jp)
Development of elemental technology related to processing technology (FS)	Summary (e-rad.go.jp)
(1) Research and development center for core technologies for economic security [Program for fostering key technologies for economic security]	Summary (e-rad.go.jp)
CONCERT-Japan "Digital Transformation and Robotics for Sustainable Agriculture"	Summary (e-rad.go.jp)
National Agriculture and Food Research Organization	
FY2024 Initial Budget: Development, improvement and practical application of next-generation smart agricultural technology	Summary (e-rad.go.jp)
Japan Agency for Medical Research and Development	
Fourth application for the Innovative Medical Technology Research and Development Promotion Program (Industry-Academia-Government Collaboration Type) [Academia Type]	Summary (e-rad.go.jp)

JST Funding programs

The Strategic Basic Research led by the Japan Science and Technology Agency (JST), are top-down initiatives designed to tackle national challenges by fostering innovative and transformative technologies. These programs establish temporary virtual research institutes comprising researchers from diverse organizations, including universities, enterprises, public institutions, and international collaboration. The key programs are represented in Table 5.

Table 5: JST funding programs

Programs	Research Areas and Prioritised Themes	Link
JST-Mirai Program	Advanced Intelligent Information Society, Super Smart Society, and Sustainable Society, using a "Small-start Type" approach for feasibility studies evolving into full-scale research, guided by R&D supervisors. The "Large-scale Type" focuses on concentrated investments in high-priority "Technology Themes" defined by MEXT, forming foundations for future technologies.	Link
Strategic Basic Research Programs (SBRP)	1. CREST: green technology, life sciences, nanotechnology, materials science, and information technology. 2. PRESTO: green innovation, life sciences, nanotechnology, and information technology, with a particular emphasis on interdisciplinary	Link 1 Link 2 Link 3 Link 4

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Programs	Research Areas and Prioritised Themes	Link
	and forward-looking projects. The program includes areas like material conversion, cellular control, quantum frontiers, and trustworthy AI, promoting high-impact research through targeted funding and leadership by expert supervisors. 3. ERATO: life sciences, nanotechnology, materials science, and information technology to address societal and technological challenges. By funding interdisciplinary and innovative projects like sensory transduction in plants, RNA modification, quantum entanglement, and AI-driven chemical reaction design. 4. ACT-X: AI-driven innovation, life sciences, materials, and environmental biotechnology. By fostering advancements in areas such as next-generation AI, trans-scale material innovation, and cyberinfrastructure. 5. ALCA-NEXT: Energy Conversion and Energy Storage Area, Resource Circulation Area, Green Biotechnology Area, Semiconductor Area, Green Computing and DX Area, and Full-scale R&D. 6. CRONOS: Information and Communication Infrastructure (sensing, networks, quantum communication, and security) and Information Processing Infrastructure (information services, encryption, and quantum circuits)	Link 5 Link 6
RISTEX(Research Institute of Science and Technology for Society)	Ethical, Legal, and Social Issues (ELSI) associated with advancing science and technology	Link
SOLVE for SDGs:Solution-Driven Co-creative R&D Program for SDGs	Preventing social isolation and loneliness through innovative, multidisciplinary research in areas such as community building, healthcare, youth engagement, workplace inclusion, and elderly support	Link
Moonshot Research and Development	Overcoming human limitations (body, brain, space, and time), ultra-early disease prediction and intervention, AI robots that adapt and evolve, sustainable resource circulation, a fault-tolerant quantum computer, and sustainable care systems. Other targets include ensuring global food security, mitigating extreme weather threats, fostering mental well-being, and advancing fusion energy for a resource-constrained world, all contributing to a sustainable and dynamic future	Link
BOOST (Broadening Opportunities for Outstanding young researchers and doctoral students in STrategic areas)	AI and interdisciplinary fields	Link
Green Technologies of Excellence（GteX）	Storage battery area, hydrogen area, and biomanufacturing area	Link
Industry-Academia Collaboration and Technology Transfer		
COI-NEXT (Program on open innovation platform for industry-academia co-creation)	Quantum technology, environment, energy, and biotechnology	Link
OPERA(Program on Open Innovation Platform with Enterprises, Research Institute and Academia)	Advancing quantum applications for longevity societies, creating genome-editing technologies, developing urban disaster-resilient systems, integrating physiological data for wearable devices, and designing zero-level prevention strategies for well-being	Link
A-STEP (Adaptable and Seamless Technology Transfer Program through Target-Driven R&D)	ICT, advanced manufacturing, functional materials, and agri-bio technologies	Link

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Programs	Research Areas and Prioritised Themes	Link
NexTEP (Newly extended TEchnology transfer Program)	The research areas are varied from semiconductor practice, biomedical innovation, medicine and more. There were some examples of company-university collaboration funded by NexTEP to accelerate commercialization by supporting company's large-scale practical development and obtain the sustainable business growth, yet many are not executed due to the developmental risk. NexTEP aims.	Example 1 Example 2 Example 3
START (Program for Creating STart ups from Advanced Research and Technology)	Life sciences, environmental and energy, information and communications, nanotechnology and materials, agriculture, forestry and fisheries and others.	Link
SUCCESS (SUpport program of Capital Contribution to Early-Stage companies)	The SUCCESS program supports early-stage startups leveraging JST's R&D outcomes by providing capital, technical assistance, and access to intellectual properties and facilities. It aims to stimulate private-sector investment and promote practical applications of JST's innovations, with a maximum investment of 500 million yen per company and a cap of half the total voting rights.	Link
Intellectual Property Utilization Support Program	The Intellectual Property Utilization Support Program by JST enhances innovation by supporting universities in managing, transferring, and commercializing research outputs. Key services include licensing university research, collecting promising patents for technology transfer, assisting with international patent acquisitions, and offering expert consultations to strengthen intellectual property management and foster industry-academia collaboration.	Link
Bilateral Collaborations		
ASPIRE (Adopting Sustainable Partnerships for Innovative Research Ecosystem)	AI & Information, Biotechnology, Energy, Materials, Quantum, Semiconductors, and Telecommunications. Partners: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, EU, Finland, France, Germany, Italy, Netherlands, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland, UK, US	Link
SATREPS (Science and Technology Research Partnership for Sustainable Development)	environment, energy, bioresources, disaster prevention, and infectious disease control. Partners: Ukraine, Croatia, Serbia, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyz, Îndia, Indonesia, Cambodia, Srilanka, Thailand, Nepal, Bangladesh, the Philippines, Bhutan, Vietnam, Malaysia, Myanmar, Mongolia, Laos, Algeria, Egypt, Ethiopia, Cameroon, Gabon, Ghana, Kenya, Zambia, Djibouti, Sudan, Tanzania, Tunisia, Namibia, Burkinafaso, Botswana, Madagascar, Malawi, South Africa, Mozambique, Morocco, Tuvalu, Tonga, Vanuatu, Palau, Fiji, Argentina, El Salvador, Colombia, Chile, Panama, Brazil, Peru, Bolivia, Mexico, and Türkiye	Link
SICORP (Strategic International Collaborative Research Program) formerly SICP (Strategic International Research Cooperative Program)	1. SICORP (SICP): Marine science, biotechnology, ICT, energy, and disaster risk management. Partners: Australia, Brazil, Canada, China, Croatia, Denmark, Finland, France, Germany, India, Israel, Korea, Mexico, New Zealand, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, the United Kingdom, the United States of America, and the EU 2. AJ-CORE: Environmental science for Japan, South Africa, and at least one African country. 3. E-ASIA: materials (nanotechnology), agriculture (food), alternative energy, disaster risk reduction and management, advanced interdisciplinary research towards innovation, environment, countermeasures for COVID 19 in medical and non-medical research. 4. EIG CONCERT-Japan: Solutions for carbon-neutral cities, design of materials with atomic precision, sustainable hydrogen technology, ICT,	Link1 Link 2 Link 3 Link 4 Link 5 Link 6 Link 7 Link 8 Link 9

Programs	Research Areas and Prioritised Themes	Link
	smart water management, functional porous materials, efficient energy storage and distribution, food crops and biomass production technologies, photonic manufacturing. 5. Belmont Forum: Systems of Sustainable Consumption and Production, Towards Sustainability of Soils & Groundwater for Society, Disaster Risk, Reduction and Resilience, Transdisciplinary Research for Ocean Sustainability, Science-driven e-Infrastructures Innovation, Resilience in Rapidly Changing Arctic Systems, Transformations to Sustainability, Sustainable Urbanisation Global Initiative: Food-Water-Energy Nexus, Climate Predictability and Inter-Regional Linkages, Arctic Observing and Research for Sustainability, Food Security and Land Use Change, Scenarios of Biodiversity and Ecosystem Services, Towards a Sustainable Earth. 6. V4 (Czech, Hungary, Poland and Slovakia): Advanced materials. 7. Japan-China-Korea: Global issues and issues of concern in Northeast Asia that are critical to the region 8. J-RAPID: Disaster support. Partners: US, UK, France, Indonesia, Thailand, the Philippines, Nepal, New Zealand 9. CHIRP: Environment/Energy, bioresources, disaster prevention, and ICT. Partners: ASEAN, India and China	
SAKURA SCIENCE Exchange Program	Exchange program	Link
NEXUS (Networked Exchange, United Strength for Stronger Partnerships between Japan and ASEAN)	Exchange program between Japan and ASEAN countries	Link

The programs balance advancing foundational scientific knowledge and fostering innovations that lead to economic, social, and cultural value. JST funding program integrates outreach, human resource development, and global engagement to maintain research excellence and ensure societal and practical applications of their outcomes reaching out diverse stakeholders either in bilateral and multilateral collaboration.

Quantitative analysis of competitive research funding programs for 2024

By analysing the information collected about the competitive research funding programs in ICT domains, and as is shown in the Figure 2, can be perceived that the Agency with the higher number of programs is Honshu, with competitive programs related to Disaster Prevention Measures and the New Energy and Industrial Technology Development Organization (NEDO) with the largest programs in terms of funding for energy-saving technologies and Cyber-Physical Development of Quantum-Classical Hybrid Technology.
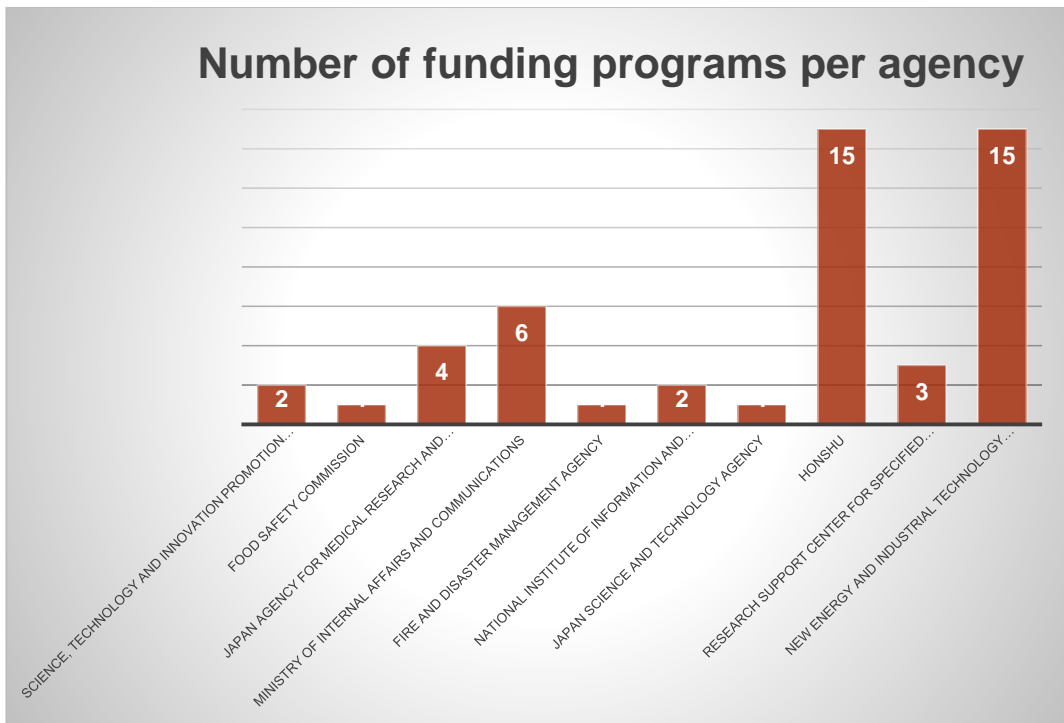
Figure 2: Number of funding programs per agency.

If we consider the INPACE clusters thematic grand-domains and analyse its emphasis in each one of the funding agencies, shows, as it can be seen below, that Cluster shown in Figure 3 has the major representation in terms of competitive research directions and measures.
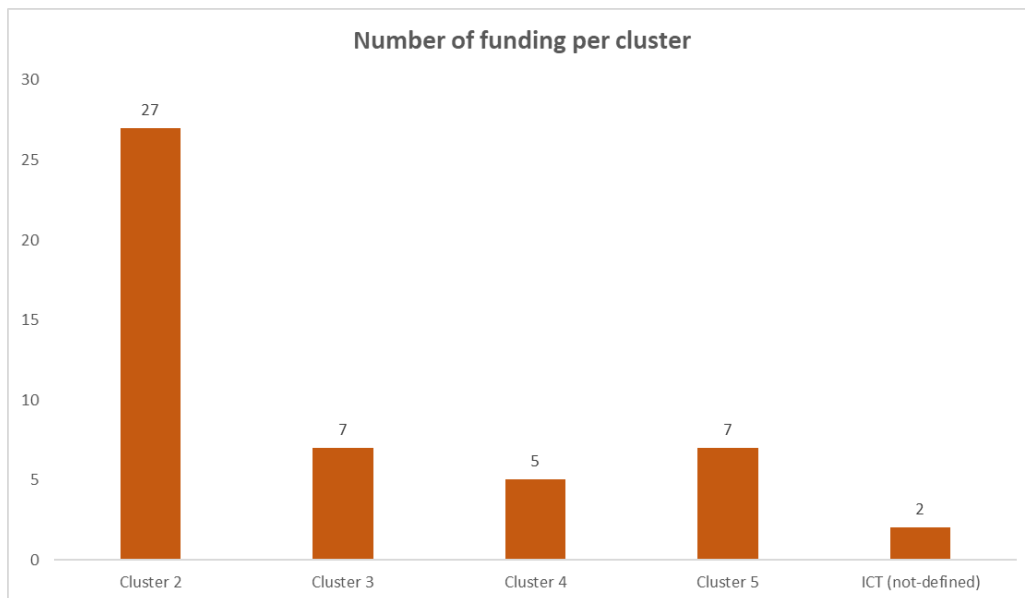
Figure 3: Number of funding per cluster

In terms of amounts of investment, based on the information collected (and resumed in the Annex II) the competitive research funding programs for 2024 has a total of around 183.000 million-yen,

that are allocated through the different funding agencies. Making a distribution in terms of amounts per INPACE Thematic Working Groups, is shown clearly that in competitive funds a big amount of the government is allocated to the TWG 2.8 "Digitalization of industry, infrastructures and services" (meaning that belongs to cluster 2; TWG 8 – see Annex I), representing around 30% of the total budget, followed by IoT (TWG 17) and Smart Cities and communities (TWG 5).

3.4 PRESENT COLLABORATION WITH THE EU

Roadmap EU-Japan Collaboration

The roadmap of EU-Japan cooperation highlights the steady development of their relations over the past two decades, driven by shared interests in scientific and technological advancements. This partnership emphasizes mutual benefits through collaborative research and innovation activities, focusing on areas like space technology, security research, disaster resilience, and advanced industrial technologies. Various framework agreements and formal collaborations, such as those involving the Japan Science and Technology Agency (JST) and the Ministry of Education, Culture, Sports, and Science and Technology (MEXT), facilitate these cooperative efforts. Additionally, both parties are committed to improving framework conditions to enhance researcher mobility and cooperation, as well as extending their partnership to cover consultations on major science, technology, and innovation policy issues.

EU is an important strategic partner for Japan, and their bilateral research and innovation relations have consistently advanced over the past twenty years [14]. The foundation for this collaboration was laid in 2011 with a cooperation agreement on science and technology focused on promoting research excellence, fostering economic growth, and enhancing industrial competitiveness. This was further expanded in 2015 with a Joint Vision Statement that prioritized joint research in ICT, aeronautics, critical raw materials, health, energy, and environmental sciences. The partnership also supports measures like jointly funded projects, enhanced researcher mobility, and consultations on science and innovation policies, including Open Science, to promote public engagement and raise the visibility of their cooperative efforts.

The partnership is reinforced by two key agreements: the 2018 Economic Partnership Agreement (EPA) and Strategic Partnership Agreement (SPA). The EPA removes trade barriers, liberalizes markets, and fosters economic growth, symbolizing a commitment to free trade and open markets. Meanwhile, the SPA establishes a comprehensive framework for collaboration on global challenges such as climate change, security, and sustainable development. Built on shared values like democracy and the rule of law, the SPA enhances political and sectoral cooperation, providing a clear structure for joint initiatives and dialogue, enabling the EU and Japan to leverage their

combined strengths to address critical global issues effectively [15]. The SPA was recently (December 2024) strengthened via a meeting held in Brussels, with a special focus on the EU-Japan Digital Partnership, Green Alliance, Partnership on Sustainable Connectivity and Quality Infrastructure[28].

In 2023, Digital Partnership between EU-Japan has officially been established representing a collaborative effort to advance digital innovation and cooperation across various sectors. It aims to leverage shared strengths in technology and policy to promote economic growth, enhance digital infrastructure, and address global challenges in some focus areas as follows: Semiconductors, secure and resilient submarine connectivity, generative AI, digital transformation of SMEs, and interoperability of trust services for digital trade and data flow [16].

Finally, the second meeting of the European Union-Japan Digital Partnership Council, held in April 2024, solidified the growing collaboration between these two regions. A key highlight was the launch of a joint call for proposals to initiate collaborative research on 6G, the next generation of mobile network technology. This signifies a shared commitment to shaping the future of mobile communications. The meeting also emphasized the importance of open, secure, and resilient networks, including those built on cloud services. Additionally, both sides acknowledged the value of existing initiatives like the EU AI Office and Japan's AI Safety Institute (AISI), expressing a desire for future collaboration, potentially through a formal agreement[29]. While details of discussions on other focus areas like semiconductors, SME digital transformation, and cybersecurity are not publicly available, this second meeting suggests continued progress and a commitment to leveraging existing strengths and exploring future-oriented research in the EU-Japan digital collaboration [17].

In addition, in July 2024, the EU and Japan have reached an agreement to simplify digital trade, reduce costs, and enhance efficiency by enabling smoother cross-border data flows. This deal, set to be included in the EU-Japan Economic Partnership Agreement (EPA), aligns with the EU's digital agenda and Indo-Pacific Strategy, promoting a unified approach to digital trade and opposing digital protectionism. Benefits include eliminating costly data localization requirements, fostering competitiveness, and providing a predictable legal framework for businesses across sectors like financial services, e-commerce, and transport. Both parties reaffirmed their commitment to shaping global data flow rules based on shared values [18]. The agreement is part of broader efforts,

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[28] Japan and the EU hold the 5th meeting of the Joint Committee of the Japan-EU Strategic Partnership Agreement (SPA). Available in: https://www.mofa.go.jp/erp/ep/pagewe_000001_00132.html

[29] Report on The Public-Private Stakeholders Workshop ahead of - The 2nd EU-Japan Digital Partnership Council Meeting. Available at: https://eprd.pl/wp-content/uploads/2024/04/REPORT-DP-EU-Japan-FINAL.pdf

including updates to the EPA's automotive regulations [30] and support for EU-Japan industrial cooperation through initiatives like the High-Level Economic Dialogue, Business Round Table, and the EU-Japan Centre for Industrial Cooperation.

The strategic partnership between EU-Japan has widened into another sector. In November 2024, EU and Japan concluded the EU-Japan Security and Defence Partnership. This partnership emphasizes the interconnectedness of Europe and the Indo-Pacific, highlighting shared values and interests in promoting a free, open, and rules-based international order. It identifies areas of cooperation including maritime security, cyber resilience, counter-terrorism, space security, and hybrid threat management. The partnership builds on strategic documents from both parties, aiming to enhance their mutual security frameworks through structured dialogues, capacity-building initiatives, and multilateral cooperation. Key priorities include aligning on defence initiatives, disarmament, and the Women, Peace, and Security agenda, with regular reviews to ensure sustained progress and adaptability to evolving security challenges [19].

Collaborative Mechanism

The collaborative framework between the EU and Japan serves as a cornerstone of their strategic partnership in research and innovation. This section explores the structured mechanisms and processes that facilitate seamless joint efforts. Through European funding programs such as FP7, H2020, and Horizon Europe, Japanese entities have actively participated in numerous funded projects, strengthening bilateral cooperation.

Under FP7, Japan contributed to 103 successful collaborative projects out of 2,163 proposals, with 57 participating entities and an EU contribution of €529 million. In H2020, 176 collaborative projects were approved from 3,355 proposals, involving 87 Japanese partners and an EU contribution of €535.5 million. Horizon Europe further advanced these efforts with 98 collaborative projects out of 2,040 proposals, featuring 46 Japanese participants and an EU contribution of €281.3 million[31]. These collaborations have evolved in scope and outreach, expanding into diverse fields and reflecting the growing strength of mutual partnerships and agreements between the EU and Japan.

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[30] The Eu-Japan Automotive Industry in the Face of Environmental and Technological Disruption. Available at: https://cdnw8.eu-japan.eu/sites/default/files/publications/docs/2024-03-policy-eujapan-automotive-environmental.pdf

[31] Collaboration with other countries EU-Japan taken on 29 November 2024. Available in: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/1213b8cd-3ebe-4730-b0f5-fa4e326df2e2/sheet/e1b57f9a-669b-4962-bdb9-0151c523120f/state/analysis

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The 2023 EU-Japan Digital Partnership Council meeting reinforced the collaborative mechanism between the two parties, emphasizing digital innovation and tackling global challenges. This mechanism is the improvement of the first meeting and specified some specific fields including: Memorandum of Cooperation on Digital Identities and Trust Service [32], Expert Team on Semiconductors, Administrative Arrangement on Public Support Transparency[33], Cooperation on Data Governance, and Collaboration on Submarine Cables.

In conclusion based on the EU – Japan present collaboration, it can be categorised into 9 key main mechanisms, explained below:

1. **Joint Initiatives and funding programs**: the EU and Japan collaborate on digital transformation through joint projects in AI, IoT, and robotics while funding joint research under ERC, MSCA, FP7, H2020, and Horizon Europe and equivalent Japanese programs for emerging technologies like with the financial support from the Japan Science and Technology Agency (JST) for examples, Next Generation Communication Networks, IoT/Cloud/Big Data platforms in social application contexts, and Experimental testbeds on Information-Centric Networking[34]. In addition, with another funding scheme JST-EU co-funding scheme, the focus was in Advanced Materials for Power Electronics based on wide bandgap semiconductor devices technology and Innovative and sustainable materials solutions for the substitution of critical raw materials in the electronic power system and some others joint calls involving Japan in the Horizon 2020[35].

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[32] EU-Japan Memorandum of Cooperation on Digital Identities and Trust services to implement Data Free Flow with Trust. Available in: https://digital-strategy.ec.europa.eu/en/library/eu-japan-memorandum-cooperation-digital-identities-and-trust-services-implement-data-free-flow

[33] Joint Statement of the second meeting of the European Union - Japan Digital Partnership Council. Available in: https://www.meti.go.jp/press/2024/05/20240501002/20240501002-en.pdf

[34] Horizon 2020 Work Programme 2016-2017. Available at: https://ec.europa.eu/futurium/en/system/files/ged/h2020-wp1617-leit-ict_en_1.pdf

[35] EU-Japan Cooperation Horizon 2020. Available at: https://agaur.gencat.cat/web/.content/Documents/Internacionalitzacio/documents_articles/Horizon-2020-and-cooperation-with-Japan_Aida-Diaz.pdf

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2. **High-level Dialogue in Policy and Regulatory Alignment**: Efforts focus on harmonizing data governance frameworks, enhancing cross-border data flows[36], cybersecurity[37,38] and aligning ethical AI deployment and trustworthy systems[39] with shared regulatory standards. Additionally, digital trade agreements[40] integrate principles that ensure seamless and secure cross-border digital transactions, aligning with both regions' economic priorities.

3. **Industry and Stakeholder Engagement**: Public-private partnerships and innovation between EU and Japan take up in the various forms such as joint ventures[41] (EU-Japan Centre for Industrial Cooperation by DG GROW and METI)[42], consortia, merger & acquisition or contractor/supplier agreements, and hosting events organised and supported by network with EU Business hub for Japan and ROK, Japan External Trade Organization (JETRO), Enterprise Europe Network (EEN), EU-Japan Business Round Table (BRT), Japan Business Council in Europe (JBCE) and Europe Business Council (EBC) as the examples[43]. These hubs leverage collaboration among companies, academia, and governments highlight emerging technologies. Table represents example of the industrial involvement in paving the future digital partnership in both sides.

Table 6: List of sample industrial and stakeholder involvement in joint activities/events.

Events (Link)	Areas of Interest	Short Description
Open Application		
Defence Business Mission in Japan Link	• Aerospace technologies • Cyber-security and IT and AI technologies • Counter terrorism solutions • Crisis management solutions • Hybrid threat countermeasures	The Centre's Defence Business Mission will accommodate 12 EU defence-related SMEs the opportunity to exhibit at DSEI Japan 2025, a premier defence exhibition in Tokyo from May 21-23, showcasing cutting-edge solutions to key Indo-Pacific decision-makers. Participants will engage in a pre-event

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[36] EU-Japan deal on data flows enters into force. Available in: https://policy.trade.ec.europa.eu/news/eu-japan-deal-data-flows-enters-force-2024-07-01_en

[37] Security and Defence Partnership between the European Union and Japan. Available in: https://www.eeas.europa.eu/sites/default/files/documents/2024/EU-Japan%20Security%20and%20Defence%20Partnership.pdf

[38] ENISA Consolidated Annual Activity Report 2023. Available in: https://www.enisa.europa.eu/publications/corporate-documents/enisa-consolidated-annual-activity-report-2023

[39] Report from the expert group on How Ai Principles should be implemented. Available in: https://www.meti.go.jp/shingikai/mono_info_service/ai_shakai_jisso/pdf/20210709_8.pdf

[40] EU-Japan deal on data flows enters into force: A New Era of Digital Economic Cooperation. Available in: https://www.rplt.it/eu-japan-deal-on-data-flows-enters-into-force-a-new-era-of-digital-economic-cooperation/

[41] Europe Japan Joint Venture: more choice, more value. Available in: https://business.lufthansagroup.com/at/en/about-us/joint-ventures/japan-joint-venture

[42] EU-Japan Center for Industrial Cooperation. Available in: https://www.eu-japan.eu/

[43] EU-Japan cluster collaboration – Japan. Available in: https://www.clustercollaboration.eu/content/japan

	• Drone or AUV technologies • Laser-, acoustic or satellite communication technologies • Maritime defence technologies • Guide Missile technologies • Radar technologies • Other defence-related services and equipment	pitching/networking day with Japanese officials and EU defence attaches, supported by interpreters and translated materials. The program also includes a preparatory webinar on Japanese market insights and etiquette. Eligible SMEs must specialize in defence technologies, be EU-based or part of the Single Market Program, and commit to the entire event schedule.Program, and commit to the entire event schedule.
Green Business Mission in Japan Link	• Smart technologies: hydrogen, batteries, photovoltaics, smart-grid, wind power, and biomass • Carbon-zero solutions	The EU-Japan Centre invites SMEs and Clusters specializing in green technology to participate in the Decarbonization Expo 2025, a premier event during Green Transformation Week in Tokyo from February 19-21, 2025. This mission provides a unique opportunity to engage with nearly 70,000 visitors and 1,500 exhibitors, focusing on renewable energy, carbon-neutral solutions, and green innovation. Participants will gain networking opportunities, market insights, and access to Japanese business partners through a shared booth supported by interpreters and promotional materials.
First EU-India Joint Researchers Workshop – October 9th Link	Semiconductor ecosystem, its supply chain and innovation	This initiative aims to enhance bilateral cooperation in trade, technology, and innovation. On November 23, 2023, the EU and India finalized a Memorandum of Understanding on deepening collaboration in the semiconductor ecosystem. The workshop focused on topics like "More than Moore" functionalities, heterogeneous integration, sustainable manufacturing, and IC & system design, featuring policy and industry sessions with key representatives from the European Commission and India's Semiconductor Mission.
EU and India to convene high-level regional experts to discuss how to combat exploitation of online spaces by extremist actors Link	• Terrorist Content Online (TCO) Regulation • Digital Services Act	The EU, in collaboration with India's Ministry of External Affairs and the Global Counter-Terrorism Council, is hosting a regional conference on August 21-22, 2024, to address the challenges of online radicalization. The event gathers experts from India, Bangladesh, Maldives, Sri Lanka, and several European nations. It aims to enhance counter-terrorism cooperation in the Indo-Pacific region and explore strategies to combat online extremism. The conference will highlight the EU's efforts, such as its Terrorist Content Online (TCO) Regulation and Digital Services Act, and focus on strengthening partnerships between the EU, India, and neighboring countries in combating digital extremism.
NTT DOCOMO and Space Compass partners with Airbus on HAPS, committing to a USD$100 million investment in AALTO Link	• The solar-powered Zephyr High Altitude Platform Station (HAPS) • Advanced earth observation for disaster response and rural coverage	This strategic partnership aims to commercialize HAPS for connectivity and earth observation services in Japan and across Asia, with a global rollout planned for 2026. Zephyr offers transformative capabilities, including 5G connectivity and advanced earth observation for disaster response and rural coverage. The investment strengthens AALTO's industrial roadmap and deepens collaboration with Airbus, NTT DOCOMO, and Space Compass, supporting Japan's evolving telecommunications infrastructure.
Fujitsu and METRON collaborate to drive ESG success: slashing energy costs, boosting	• Carbon neutrality in the manufacturing industry • Energy management service "Energy Consumption Optimization"	Fujitsu Limited and METRON SAS have partnered to launch "Energy Consumption Optimization," a service leveraging Fujitsu's quantum-inspired Digital Annealer technology and METRON's energy management expertise to enhance productivity and reduce environmental impact in manufacturing. Targeting Japan

productivity with new manufacturing industry solutions **Link**		and Germany from April 2024, the service visualizes energy consumption and optimizes operations to support carbon neutrality goals. This initiative builds on their collaboration since March 2023 and will be showcased at Hannover Messe 2024, promoting innovation in industrial decarbonization and contributing to a more sustainable future.

4. **Infrastructure and Technology Development:** The partnership supports the joint development of transport connectivity, enhancement of safety and security of transport, advanced networks like 6G and satellite internet, addressing cybersecurity challenges through shared frameworks to protect critical infrastructure. It also emphasizes green ICT initiatives to reduce the environmental impact of technologies, including data centres and AI models. Examples: EU-Japan Bilateral Aviation Safety Agreement (June 2020) and Paris Air Show in Tokyo (June 2021) aeronautic event, including discussion of collaboration in the aeronautics supply-chain and decarbonising air transport [20].

5. **Sustainable Transport Connectivity**: Both EU and Japan aim to achieve sustainable transport connectivity, align regulatory frameworks for synergy, interconnect transport corridors, and enhance the safety and security of transport systems [20].

6. **Skills Development and Knowledge Sharing:** EU-Japan focus on strengthening academic exchanges through programs like Erasmus+, MSCA, fostering cultural collaboration via joint events such as workshops, trainings, and investment promotion, and promoting policy dialogue on education, culture and sport [20].

7. **Coordination Mechanisms**: High-level dialogues ensure regular alignment of priorities, while specialized working groups focus on areas like AI, cybersecurity, and quantum technologies. Annual summits strengthen collaboration, review progress, and maintain alignment with global digital strategies. In early 2024, an BRT and EU-Japan Business-to-Government discussion was held during the annual EU – Japan Industrial Policy Dialogue (IPD) represented by the government (DG GROW and METI) and Industries (co-Chair companies NEC and Merck). This meeting highlighted collaboration in areas such as supply chain resilience, advanced materials, digital transformation, and regulatory alignment. The IPD emphasized public-private partnerships to enhance supply chain security, foster advanced technologies for carbon neutrality, and ensure a clear regulatory environment promoting competition and sustainability. The Digital Partnership Council focused on policy coordination in digitalization, economic security, and environmental sustainability, advocating free trade, harmonized standards, and technological innovation. Key areas of collaboration include semiconductor value chains, digital skills development, AI, 6G, and post-quantum

cryptography. Stakeholders also emphasized the importance of engaging SMEs, investing in digital literacy, and leveraging joint efforts to advance EU-Japan strategic priorities [21].

8. **Regional Focus**: Collaborative digital projects in the Indo-Pacific align Japan's investments in Southeast Asia with Europe's Indo-Pacific strategies to promote connectivity and development and West-Africa [22].

9. **Economic and Strategic Development**: Strengthen by SPA and EPA, and the Digital and Security Partnerships, provide a robust structure for advancing trade, research, and global governance. Collaborative priorities include emerging technologies like 6G, AI safety, and semiconductor development [16] and automotive, alongside strategic goals such as cross-border data flow, maritime security, cyber resilience, counter-terrorism, space security, and hybrid threat management [19]. With regular reviews, formal dialogues, and joint initiatives, this partnership underscores a commitment to innovation, resilience, and a rules-based international order, leveraging collective strengths to address global challenges effectively and sustainably.

They have also worked together on creating and contributing to international standards for interoperability and fostering open, global digital ecosystems. The examples of joint calls under H2020 (EU partners) and funding schemes from the national fundings (Japanese partners)[44].

In the form of joint initiatives between EU and Japan is driven by Joint Research Centre (JRC), EuroHPC, MSCA & JST and/or JSPS in strategic locations and wide areas within the EU and Japan to foster long-term collaboration. The Joint Research Centre (JRC) and its Japanese partners committed to ongoing collaboration on foresight, clean energy technologies, disaster risk management, marine and earth science, and nuclear safeguards and security through some activities including joint research projects, Joint workshops/conferences, researcher exchange and mobility, and formal statements outlining specific areas of focus and project details etc. These activities are presented below:

- EU-Japan Digital Partnership: The EuroHPC JU[45]: Collaboration focuses on the HPC, AI and DA application communities, represented by the CoEs, academic and industrial organizations addressing the strategic research areas that are material, biomedical and climate. Collaborative Activities include: 1) Share information and deepen respective understandings in raw materials supply chain risk management, innovation, and recycling

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[44] CALL: EU-JAPAN JOINT CALL. Available in: https://www.h2020.md/en/call-eu-japan-joint-call

[45] The European High Performance Computing Joint Undertaking (EuroHPC JU). Available in: https://eurohpc-ju.europa.eu/about/discover-eurohpc-ju_en

and circularity frameworks and exchanging information on projects and relevant support instruments and 2) Joint training

- The JRC and NISTEP (National Institute of Science and Technology Policy): collaboration that focuses on foresight activities, which involve exploring future trends and emerging issues[46]. Collaboration activities include a workshop and joint publication.

- JRC and AIST (the National Institute of Advanced Industrial Science and Technology): Collaboration in research and development of energy conversion and storage, as well as in establishing a common evaluation platform for solar cells. Collaboration activities include: 1) Benchmarks for solar cells, and performance evaluations of new solar cells, and 2) Joint publication[47].

- JRC – DPRI (the Disaster Prevention Research Institute) of Kyoto University: Collaboration on disaster risk management, particularly earthquake preparedness. Collaboration activities include: Joint research programs and Exchange/visits[48].

- JRC – Japan Atomic Energy Agency (JAEA): Collaboration for research and development in nuclear energy, including nuclear safety, nuclear waste management, and nuclear fusion. Collaboration Activities include: 1) Joint support research and development projects in nuclear energy technologies, aiming to improve safety, efficiency, and sustainability, 2) Safeguards activities (Workshop/Webinar) to ensure that nuclear materials are not diverted for military purposes, and 3) an agreement for the joint implementation of the Broader Approach Activities in the field of fusion energy research[49].

- MSCA – JSPS & JST: Collaborative areas include: Bilateral programs, Core-to-core program, ASPIRE (Adopting Sustainable Partnerships for Innovative Research Ecosystem (ASPIRE) program, with collaborative activities such as researcher exchange, Joint Research Projects/Seminars, and Joint call, joint research, mobility[50].

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[46] JRC to collaborate on foresight with Japan's National Institute of Science and Technology Policy. Available at: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/jrc-collaborate-foresight-japans-national-institute-science-and-technology-policy-2023-07-13_en

[47] JRC to collaborate on foresight with Japan's National Institute of Science and Technology Policy. Available in: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/jrc-collaborate-foresight-japans-national-institute-science-and-technology-policy-2023-07-13_en

[48] Courtesy Visit to DPRI by Director-General Stephen Quest European Commission Joint Research Centre. Available in: https://www.dpri.kyoto-u.ac.jp/news_en/17690/

[49] EU and Japan, good collaboration practices in nuclear security. Available in: https://www.eias.org/wp-content/uploads/2016/03/PPT_Presentation_Naoi_Abousahl_23.09.2016.pdf

[50] Co-funding available to Japanese researchers for staff exchanges under MSCA. Available in: https://marie-sklodowska-curie-actions.ec.europa.eu/news/co-funding-available-to-japanese-researchers-for-staff-exchanges-under-msca

In addition, collaboration between the European Union (EU) and Japan in the field of digital research and development (R&D) is robust and multifaceted, encompassing various technological domains and initiatives including co-funded research grants for collaborative projects on some strategic areas (e.g., AI, quantum technologies, etc) including present EU-Japan collaboration in the Connected Cooperative & Automated Mobility (CCAM) Partnership where Japan is mentioned and classified as the priority country to collaborate with. There are some recent calls indirectly mentioned Japan as one of the countries to be considered as an eligible partner. Several recent collaboration joint grants shown in Annex II. Some examples of bilateral collaboration between some EU member states and Japan shown can be found in the Annex II.

3.5 POTENTIAL SYNERGIES AND COMMONALITIES BETWEEN JAPANESE NATIONAL PROGRAMS AND EUROPEAN PROGRAMS

The European Union (EU) and Japan stand as global powerhouses in scientific research and technological innovation. By fostering synergies and communalities between their respective national programs and reflecting to the successful previous projects in FP7 and H2020, they unlock a wealth of potential benefits. This section explores these exciting possibilities, examining how aligning specific programs can lead to groundbreaking advancements and a more prosperous future for both regions.

From the latest 2nd EU-JAPAN DIGITAL PARTNERSHIP COUNCIL MEETING, we can conclude that there are some recommendations that might be potentially implemented to nurture EU-Japan digital partnership. Recommendations include promoting Japan's association with the Horizon Europe Program to facilitate joint research initiatives and increasing cooperation on data spaces and 6G development. Harmonizing standards, particularly in cybersecurity and IoT, and fostering a robust AI governance framework are also emphasized. Additionally, there is a call to strengthen the semiconductor supply chain, invest in digital skills development, and establish digital maturity centres within universities to drive competitiveness and innovation. Continuous dialogue and strategic cooperation on digital policies and international standards are crucial to the partnership's success Complementing strengths: The EU excels in areas like basic research and infrastructure development, while Japan is known for its prowess in translating research into cutting-edge technologies. Collaboration allows each region to leverage the other's strengths, accelerating innovation.

Key areas synergies and communalities:

- **Addressing global challenges in digitalization with shared priorities**: Both Japan and Europe emphasize sustainability, digital transformation, and global governance, with programs like Japan's Society 5.0 and the EU's Global Gateway and Horizon Europe targeting advancements in AI, cybersecurity, green and sustainable energy, and infrastructure. Similar to existing

programs, establishing co-funded grants specifically for joint EU-Japan research projects in the priority areas [20][23].

- **Digital Governance and Standards**: Collaborative efforts focus on promoting international digital standards, including data privacy, cybersecurity, and AI governance, leveraging frameworks such as the EU-Japan Connectivity Partnership and bilateral dialogues [20][24].

- **Supply Chain Resilience**: Both regions aim to enhance semiconductor and rare earth supply chains, coordinating investments to foster innovation while reducing dependency on external actors like China[51].

- **Capacity Building and Regulation**: Joint initiatives in developing technical assistance, digital inclusion, and human-centered regulatory frameworks ensure sustainable and impactful digital transformation globally [23].

- **Private Investment Mobilization**: Programs prioritize leveraging private funds for infrastructure projects, enabling stronger digital and physical connectivity through business missions in specific fields such as biotech, defence, digital, green, innovative, smart factory and robotics, and space missions in low- and middle-income countries[52].

- **Trade Facilitation**: The EU and Japan have significant potential synergies and complementarities in trade activities, built on their robust collaborative framework under the Economic Partnership Agreement (EPA) and Strategic Partnership Agreement (SPA) that have been updated and improved regularly reaching out potential areas for collaboration such as automotive and security and defence [18][19]. These agreements facilitate the removal of trade barriers, promote cross-border data flows, and create a predictable legal framework for sectors like financial services, e-commerce, and transport. Joint initiatives focus on emerging technologies such as AI, 6G, and semiconductors, as well as green technologies like renewable energy and sustainable materials, aligning with both regions' economic and environmental priorities. Moreover, industry and stakeholder engagement through events like the EU-Japan Business Round Table and specialized missions in green and defence sectors further drive

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[51]Japan and the European Union agree closer cooperation to develop advanced materials as they look to de-risk from Chinese supply chains. Available in: https://pamirllc.com/blog/japan-eu-cooperation-develop-advanced-materials-de-risk-from-chinese-supply-chains

[52] EU-Japan Centre for Industrial Cooperation, Business Missions in Japan. Available in: https://www.eu-japan.eu/business-missions-japan

industrial collaboration, enhance market access, and promote innovation, making their partnership a model for global economic cooperation.

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4   OVERVIEW OF ICT RESEARCH AND DEVELOPMENT (R&D) INITIATIVES IN REPUBLIC OF KOREA

4.1   INTRODUCTION OF ICT R&D PROGRAM

Republic of Korea's ICT industry has been a global leader, excelling in electronics, telecommunications, semiconductors, and digital content. Companies such as Samsung, LG, SK Hynix, and Naver have played crucial roles in shaping the global tech landscape. The industry benefits from high levels of innovation, substantial R&D investments, advanced infrastructure, and a skilled workforce.

Republic of Korea's ICT sector is highly competitive and innovative, with several key strengths. The country is a leading global exporter of ICT products, contributing $233 billion in exports in 2022, including semiconductors, displays, and mobile phones. Republic of Korea is renowned for its high level of innovation, ranking sixth in the Global Innovation Index 2022, and invests heavily in R&D, particularly in areas like AI, 5G, and quantum computing. It also boasts one of the world's most advanced ICT infrastructures, with nearly universal broadband internet penetration and leading mobile and fixed broadband speeds. Additionally, Republic of Korea has a highly educated workforce, with a strong emphasis on science and engineering, making it a top contender in AI talent globally. Korea's investment in AI and big data and its application in real-life automation solutions has been noteworthy. An example is Korea's K-AI Pilot initiative, led by Korea Aerospace Industries (KAI), which aims to integrate artificial intelligence into light combat aircraft. By 2026, the project seeks to achieve autonomous flight capabilities, progressing to semi-autonomous flight[53]. Korea's Data Dam project, launched in 2020, is a national AI and big data initiative aimed at collecting, processing, and sharing high-quality data, to further develop smart industries and aid digital transformation across sectors[54]. As part of Korea's national 5G strategy, ETRI (Electronics and Telecommunications Research Institute) collaborated with government bodies, telecom companies, and private enterprises to advance 5G technologies, including smart factories, digital healthcare, and drone applications. Through initiatives like the DNA + drone technology project, ETRI helped integrate AI, data, and 5G for real-world applications in law enforcement, environmental monitoring,

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[53] South Korea's KAI to Test Artificial Intelligence (AI) Pilot in FA-50 Light Combat Aircraft. Available in: https://defencesecurityasia.com/en/south-koreas-kai-to-test-artificial-intelligence-ai-pilot-in-fa-50-light-combat-aircraft

[54] Data dam project begins, being key to Digital New Deal. Available in: https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=453&searchOpt=&searchTxt=

and agriculture. Its contributions, alongside Korea's proactive policy framework, helped the country become a global leader in 5G deployment, providing valuable insights for other nations aiming to scale their own 5G networks [55]. Korea's high-performance computing investment is mainly highlighted by the development of the NURION supercomputer, located at the Korea Institute of Science and Technology Information (KISTI)[56], while cloud computing and integration is developed under fierce competition in the private sector, such as the Naver Cloud Platform solutions which support and enhance infrastructure scalability [57]. Korea's digital transformation strategy is strengthened by the Smart Factory Initiative, an initiative to modernize manufacturing by integrating AI, IoT, big data, and automation. Launched in 2014, it aims to enhance productivity, reduce costs, and improve global competitiveness, especially for SMEs, by establishing smart factories, focusing on real-time data analytics, robotics, and digital twins. By 2030, South Korea plans to have 30,000 smart factories that support customized, flexible manufacturing systems to adapt to market demands and strengthen South Korea's position in advanced manufacturing[58]. However, despite Republic of Korea's ICT industry strengths, the country faces significant challenges mainly related to the increasing competition from China and other emerging economies. Its heavy reliance on hardware, such as semiconductors and mobile phones, makes it vulnerable to market fluctuations and technological obsolescence. Additionally, Republic of Korea lags in software and digital content, sectors with higher growth potential. Slowing domestic demand and a saturated market for products like smartphones further constrain growth. Complex regulatory frameworks and policy uncertainties also hinder innovation and the adoption of new technologies [25].

The budget for R&D across all ministries was 26.5 trillion won in 2024 and the budget approved for Ministry of Science and ICT (MSIT) was 18.6 trillion won. MSIT planned to focus its 2024 budget on five major areas [26]:

(1) Securing core technologies of strategical value - to maintain a super-gap technological advantage in key fields, and to secure next generation and original technologies in the fields of 12 Critical and Emerging Technologies;

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(2) Supporting international cooperation and overseas expansion - to open up the window of opportunity for world-class research, nurturing global digital talents, and facilitating the overseas market breakthrough by domestic digital businesses;

(3) Cultivating science, technology, and digital talents - to support the growth of emerging researchers, and to produce core research personnel in Critical and Emerging Technologies and digital talents ready for practice;

(4) Promoting digital diffusion - to integrate hyperscale AI into specialized fields such as law, healthcare, and public sectors, allowing for all citizens to enjoy benefits garnered by AI in their daily lives;

(5) Enhancing capabilities of research institutes and regional innovation – to support the commercialization of research outcomes and creation of new businesses, to enhance the innovation functionality of research institutes and local organizations.

The total government R&D budget increased in 621.7 billion won compared to the initial government proposal. This additional funding was allocated to address concerns regarding uncertainty in employment circulating within the research community, particularly for students and employees in small and medium-sized enterprises, and also for next generation and original technology research as well as for state-of-the-art research equipment. For instance, this additional budget included 6 billion won for the next-generation network (6G) industrial and technological development project [26].

4.2 RESEARCH AND INNOVATION PRIORITIES

In June 2022, the Korean government announced the Digital Innovation and Diffusion Strategy, which outlines plans to invest significantly in six major innovative technology areas. These areas include AI, AI semiconductors, 5G-6G, quantum technology, metaverse, and cybersecurity, with the goal of exploring and expanding both domestic and global markets (Digital Innovation and Diffusion Strategy [27].
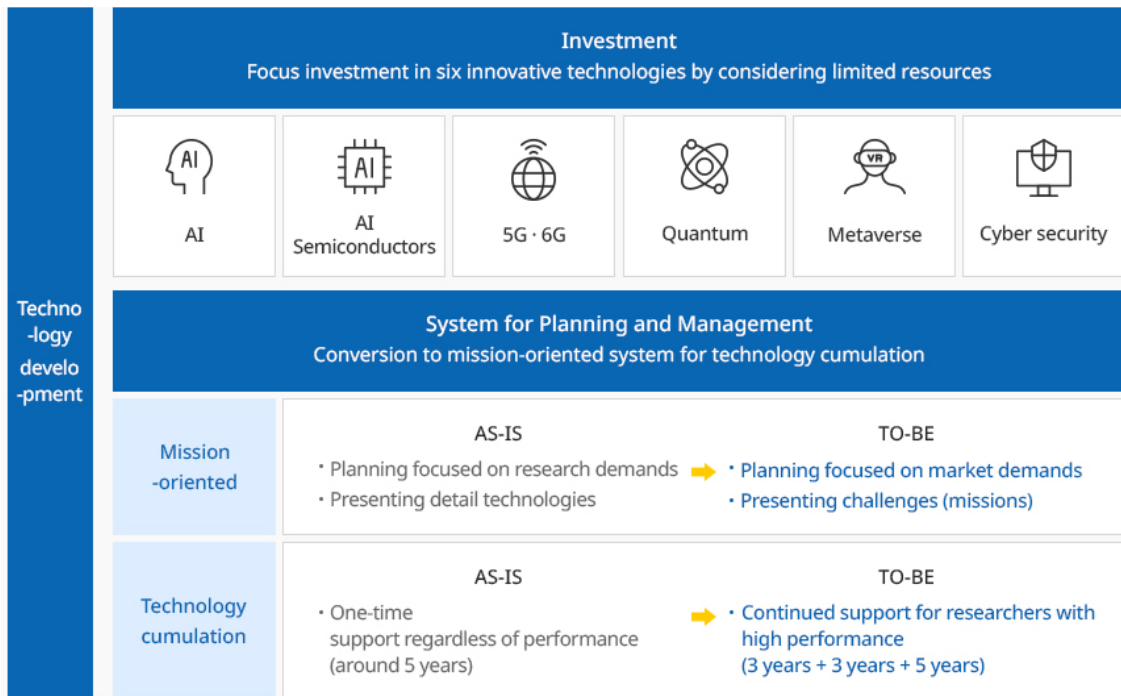
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Figure 4: Illustration of the Republic of Korea technology development strategy (Adapted from Invest Korea Website [28].

Table 7: Rationale and development goals for the innovative priority areas (Digital Innovation and Diffusion Strategy [29]).

Strategic Area	Rationale	Development goals
AI	Strategic technology that is a key foundation to drive digital transformation across industries and has high security utility value and will determine the outcome of the technology supremacy competition.	Strengthen AI SW technology to become an AI superpower
AI semiconductors	It is in its early stages globally but has huge market potential	Secure world-class source technologies (NPU, PIM) and rapidly spread them in the domestic industrial ecosystem to become the world´s top AI semiconductor powerhouse
5G-6G	Essential infrastructure to cope with rapidly increasing data usage and a key foundation for the development of new convergence industries such as autonomous smart factories	Dramatically improve latency, seamless 6G source technology enabling real-time remote services and ultra-realistic VR-AR
Quantum	High valued as a military security strategic asset such as encrypted communication, stealth radar, submarine navigation	Localize quantum computing technology, dramatically increase the transmission distance of quantum cryptographic communication, and secure core application technologies for quantum sensors
Metaverse	Expected to be the next platform after smartphones, transforming the digital technology paradigm and acting as a catalyst to drive digital industrial structure transformation	Platform to spread the use of the metaverse strengthening devices, production technology for the creator ecosystem and blockchain technology for the virtual convergence economy
Cyber Security	Virtual convergence economy Cybersecurity needs to be strengthened as a digital infrastructure such as digital twins are expanding and attack methods are diversifying	Securing intelligent security core technologies and data security sources technologies for cyber warfare and future technologies (6G quantum)

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4.3 IDENTIFICATION OF NATIONAL FUNDING MECHANISM

Ministry of Science and ICT

In a press release published on February 13, 2024, the Ministry of Science and ICT (Minister Lee Jong Ho, MSIT) announced its major policy implementation plan for 2024. The goal was to "become a global science and technology powerhouse and a digital model nation." The plan included four major strategies and twelve key tasks to enable Korea to achieve another round of growth surge as a global science and technology powerhouse and digital model country in 2024 [30].

1. Creating a world-leading R&D hub

MSIT intended to enhance international R&D collaboration by expanding joint research with advanced countries and attracting overseas talent. This includes partnering with world-class research institutes and allowing direct participation of overseas organizations in government-funded projects. The Ministry increased funding and support for young researchers, providing scholarships across all levels of science and engineering education, and improved financial incentives for innovation. This included raising funds for outstanding researchers and enhancing rewards for technological inventions. Finally, MSIT reformed the R&D system to encourage bold and innovative research, even if it carries a high risk of failure. The Ministry planned to enact and revise laws to support challenging R&D, consolidate fragmented projects for better effectiveness, and remove fiscal year constraints to allow more flexibility in project start times.

2. Driving innovation through challenging R&D

The government has accelerated the development of three transformative technologies: quantum, AI, and advanced biotechnology. In the quantum field, the creation of an open quantum fab was planned as well as a cloud service to support the development of quantum algorithms for a domestically developed 20-qubit quantum computer. The plan also includes a demonstration of long-distance transmission of quantum Internet technology (100m to 100km) and the advancement of world-leading quantum gravity sensors, all set to be launched in the second half of 2024. In the field of AI, the Ministry of Science and Information & Communication Technology (MSIT) planned to promote next-generation technology development to overcome the limitations of generative AI, such as false answers and bias. The establishment of an "AI research hubs" in Korea and the United States to conduct advanced research with leading overseas researchers, was also planned for the second half of 2024.

The Ministry is fostering three leading global technologies in next-generation semiconductors and next-generation networks. To secure 'super gap' next-generation semiconductor technologies, the

plan focuses on AI semiconductors, compound semiconductors, and advanced packaging. For next-generation network projects, it includes 6G commercialization and standardization, demonstration of domestic open LAN (open wireless access network) equipment in 2024, and a preliminary feasibility study of low-orbit satellite communication. For a low-power network, the Ministry intended to develop AI algorithms to save power for base stations and apply domestic AI semiconductors on a full scale.

3. Leading the AI and digital transformation

The Ministry of Science and ICT (MSIT) aims to identify new businesses and services that can drive economic growth and job creation through AI and digital innovation. The goal was to enhance people's lives by integrating AI into all aspects of daily life. MSIT planned to encourage widespread AI implementation in key areas such as education, healthcare, and law, and provide comprehensive support for rapid AI innovation in data, regulatory practices, human resource development, and financial and taxation realms. Additionally, the government will enact the Artificial Intelligence Act and establish the AI Safety Research Institute to build a foundation for reliable AI development and operation. A private autonomous AI reliability inspection and certification system will also be introduced.

Specialized support will be provided for promising domestic AI and digital businesses to explore overseas markets, including opportunities in digital twins, metaverses, SW, and OTT. Efforts will be made to expand digital territory by establishing a digital export pioneering team and the Middle East IT Support Center in Dubai, as well as by expanding cooperation channels.

4. Inclusive AI and digital technologies for all

MSIT is committed to creating an inclusive AI and digital society, ensuring that people from anywhere in the country can benefit from AI and digital technologies. The goal is for the AI and digital industry to contribute to people's livelihood and safety. To achieve this, MSIT plans to increase the number of pilot digital innovation districts that include core AI infrastructure in provincial areas. Additionally, there are plans to promote regional AI convergence projects in Chungcheong, Gangwon, Honam, and Yeongnam to boost local industries. This initiative also involves expanding regional digital innovation projects and smart villages in order to address local issues using AI and digital technologies. Moreover, through the establishment of 13 SW Future Learning Centers and the SW Shared Growth Project, MSIT will support students in underprivileged areas.

Furthermore, the government aims to improve the oligopolistic structure of the telecommunications market and enhance competition by providing support for the utilization of telecommunications facilities and the distribution of devices. This support is intended to ensure a smooth transition for

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new telecommunications service providers that have obtained frequencies through auctions. Lastly, the government is committed to enhancing the national safety and cyber threat response capabilities by building a more robust digital safety system [30].

The Korean government has undertaken several reforms to enhance the R&D system with the goal of transitioning to a leading R&D infrastructure. The "Investment Direction for 2025" aims to build upon these efforts and expedite the transition to a world-leading R&D system on a full scale. The plan involves significant changes to the R&D investment system to ensure that Korea remains at the forefront of technological innovation. To maximize the effectiveness of government investment, MSIT plans to overhaul the current R&D investment and execution system. This includes enhancing cooperation across different ministries, ensuring that budgets are allocated efficiently, and making the investment process more flexible to adapt to rapidly changing technological landscapes. The government also aims to increase transparency by making R&D funding details and research outcomes publicly accessible, reducing administrative burdens on researchers. The investment strategy emphasizes high-risk, high-reward R&D projects that could lead to significant technological advancements. The government plans to support these projects by providing special exemptions and continued funding for those that show tangible results. Finally, the strategy includes a strong focus on achieving technological sovereignty. The government plans to significantly increase funding for key technologies such as AI, biotechnology, and quantum technology, aiming to elevate Korea to the status of a G3 country by 2030. Investments will also be directed towards next-generation semiconductor technologies, securing critical supply chains, and exploring emerging areas like space and cybersecurity [31].

President Yoon has consistently highlighted the importance and vision of establishing a "new digital order" to the global community, beginning with the New York Initiative in September 2022. He has been at the forefront of international discussions on AI and digital norms. To further this vision, the government introduced the "Digital Bill of Rights" in September of the previous year (2023), which serves as the foundational guide for this new digital order. Building on the "Digital Bill of Rights," the Ministry of Science and ICT (MSIT) conducted an "Assessment on Response to Deepening Digitalization" in collaboration with 26 ministries and agencies, including the Ministry of Economy and Finance and the Ministry of Education. This assessment took place from October 30 to December 29, 2023, and included a public perception survey conducted with 2,000 individuals aged 15 and older from November 16 to December 13, 2023. The goal was to evaluate the government's overall response to the digital era. Through a series of three inter-ministerial meetings (held on October 30, 2023; January 30, 2024; and April 3, 2024), a total of 52 critical issues were identified, including AI safety and the need for AI copyright law reform. The Action Plan developed in response outlines 20 policy tasks designed to address these 52 issues, all rooted in the philosophy and five

principles of the "Digital Bill of Rights." Of these, eight key tasks have been prioritized due to their high public interest, significant impact, and urgency. These tasks will be closely monitored to ensure the achievement of concrete results. The eight key tasks, identified through expert consultation and collaboration among various ministries, include [32]:

1. Ensuring the safety, reliability, and ethical use of AI technology.
2. Combating fake news generated by deepfake technology.
3. Reforming copyright laws related to AI development and usage.
4. Addressing digital disasters and cyber threats/crimes.
5. Improving digital accessibility and providing alternative access methods.
6. Establishing stable telemedicine services.
7. Protecting the right to disconnect.
8. Guaranteeing the right to be forgotten.

National IT Industry Promotion Agency (NIPA)

The National IT Industry Promotion Agency (NIPA) is dedicated to enhancing the competitiveness of the ICT industry and contributing to economic growth through efficient support and by laying the groundwork for the promotion of industrial technology. NIPA's focus areas include [33]:

o Policy research and development support for the ICT industry

o Facilitating the establishment of the ICT industry and developing its human resources

o Stimulating the distribution market for ICT industry development and providing marketing support

o Promoting businesses related to the convergence and utilization of ICT technology

o Facilitating international exchange, cooperation, and overseas expansion related to the ICT industry.

NIPA is a key governmental organization in Republic of Korea dedicated to advancing the country's information technology (IT) sector and plays a pivotal role in driving innovation, fostering industry growth, and supporting IT-related businesses. By promoting the IT industry, supporting startups, and facilitating global market entry, NIPA helps to position Republic of Korea as a powerhouse in the global IT landscape. Through its various programs and initiatives, NIPA has significantly contributed to the growth of Republic of Korea's IT industry. It has supported the development of numerous successful IT companies, facilitated the global expansion of Korean technologies, and helped maintain the country's leadership in key technology sectors.

Table 8 presents NIPA strategic areas and their respective main focuses and objectives. For each of those strategic areas, there are/were different programs/initiatives available. Table 9 includes some details for some of these programs.

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Table 8: Strategic areas in NIPA.

Strategic area	Main focus	Objective	Recent programs/initiatives
Spread of artificial intelligence across countries and industries	AI Clould AI semiconductor AIoT Blockchain	Create an ecosystem to accelerate the growth of AI specialized companies and related businesses, and promote strategic projects and infrastructure advancement for intelligence in all industries.	• AI semiconductor technology talent supply platform • AI legal Assistance Services Spread • Expanding AI media and culture enjoyment • Support for large-scale AI-based academic activities (…) see more here
Leading regional industrial innovation and fostering new SW industries	SW Digital health Metaverse	Develop new services that integrate emerging SW technologies, such as AI, IoT, and blockchain, with other industries to enhance the competitiveness of existing and regional specialized industries.	• Innovation Hub Artificial Intelligence Data Fusion Project • Leading AI-based healthcare services (…) see more here
Securing global competitiveness in the ICT industry	Global Regulatory Sandbox	Supporting the expansion of overseas ICT companies, fostering industrial manpower, and creating an ICT ecosystem. This includes improving software quality, creating a fair environment, and enhancing regulations for new software industries.	• Improving the SW industry market environment • Building a Metaverse Digital Media Innovation Hub • 2024 Global Future Unicorn Development (ICT GROWTH) Project (…) see more here

Table 9: Examples of projects/calls recently announced in NIPA.

Title	Purpose	Target	Amount
Support for large-scale AI-based academic activities (Link)	Promoting AI everyday life and strengthening national AI competitiveness by supporting the development of work assistance services for experts in academic and research fields	A consortium between AI companies capable of developing AI-based academic activity support services and demand institutions seeking to introduce and utilize the services.	Total KRW 12 billion (2024-2027, 4 years) - KRW 3 billion in 2024
Digital Innovation Company Global Growth Voucher Support (Link)	Enhance the global competitiveness of digital innovation products and services by linking (matching) the technology development and service verification of digital innovation companies with ICT specialized companies	Digital innovation SMEs and startups with overseas expansion plans	300 million won
Industry-tailored Innovation Voucher Support Project (Link)	To promote actual digital transformation by providing customized company- wide training and consulting to small and medium-sized enterprises that have a need for digital transformation	Domestic small and medium-sized enterprises with digital transformation needs	2.45 billion won

Title	Purpose	Target	Amount
Innovation hub artificial intelligence data fusion project (Link)	Establishing a regional AI convergence system, including regional digital innovation and improvement of corporate technological capabilities through AI technology cooperation and convergence projects between companies and universities	Consortium comprised of local leading and participating project implementation organizations from Busan and Daegu	14 million won
SW Safety Innovation Service Demonstration Support Project (Link)	Enhancement of SW stability in areas closely related to safety in people's daily lives through support for verification of SW safety innovation services in the SW convergence new industry sector	SW companies developing and supplying SW safety products and services + SW safety consulting companies	Up to 400 million won in total, 2 or less projects (up to 200 million won per project)
Global ICT Future Unicorns in 2024 (ICT GROWTH) (Link)	Discover promising ICT companies with high global growth potential and foster them into future unicorn companies through comprehensive support such as overseas expansion and financial support (investment and financing) linkage.	Small and medium-sized enterprises in the ICT or ICT-based convergence / composite fields with global capabilities	

Quantitative analysis of competitive research funding programs for 2024

Upon reviewing the data gathered on research funding programs in Republic of Korea, it is evident that the Ministry of Science and ICT has the highest number of projects, aligning with expectations (Figure 5: Figure 5). This indicates a strong focus on research and innovation within the ministry. According to the projects listed on the NTIS portal, the majority of R&D projects are from the Ministry of Science and ICT, Ministry of Oceans and Fisheries, Ministry of Environment, Ministry of Public Administration and Security, and Ministry of Health and Welfare.

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and programs between the EU and Indo-Pacific countries
PU - Public
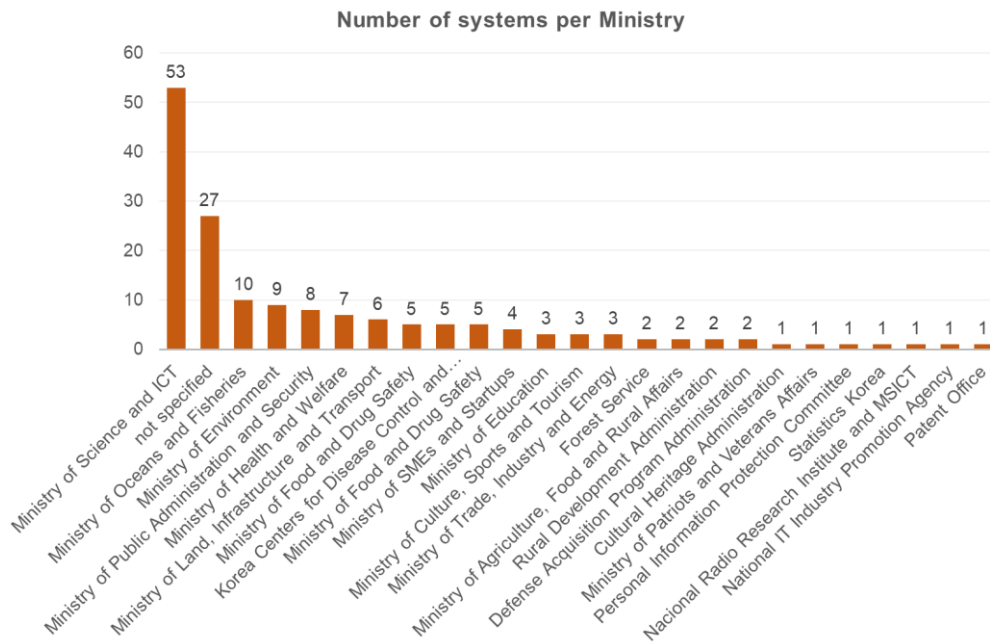
Figure 5: Distribution of research projects related to ICT in Republic of Korea [34]

Upon examining the thematic grand-domains of the INPACE clusters and analyzing their emphasis within each of the funding agencies, it is noticed that cluster 2 holds a predominant representation in terms of research directions and measures (Figure 6). Most of the proposed measures are dedicated to the digitalization of industry, infrastructures, and services (TW2.8). Development and use of artificial intelligence is also significantly considered an important priority in research activities (TW3.9) (see Figure 7).

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Number of funding per cluster
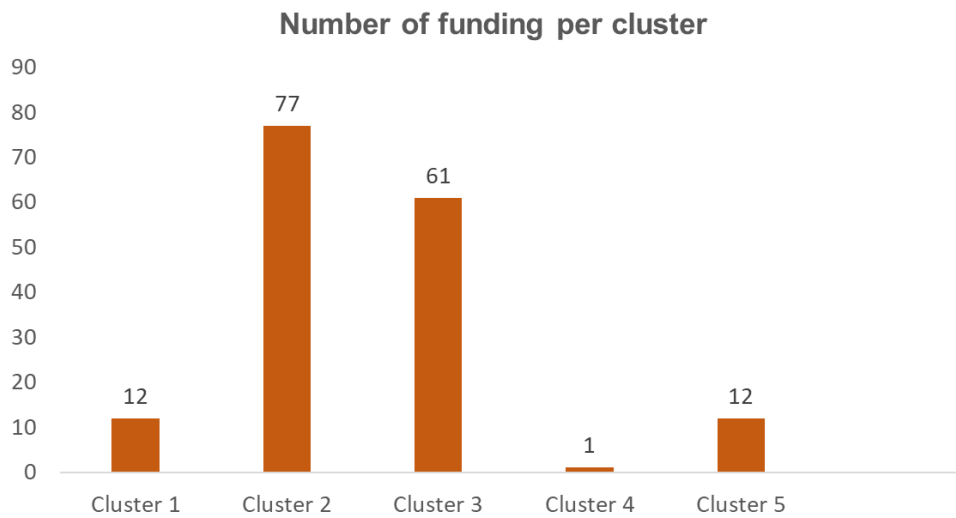
Figure 6: Number of funding projects per cluster.

Number of funding per thematic Working Group
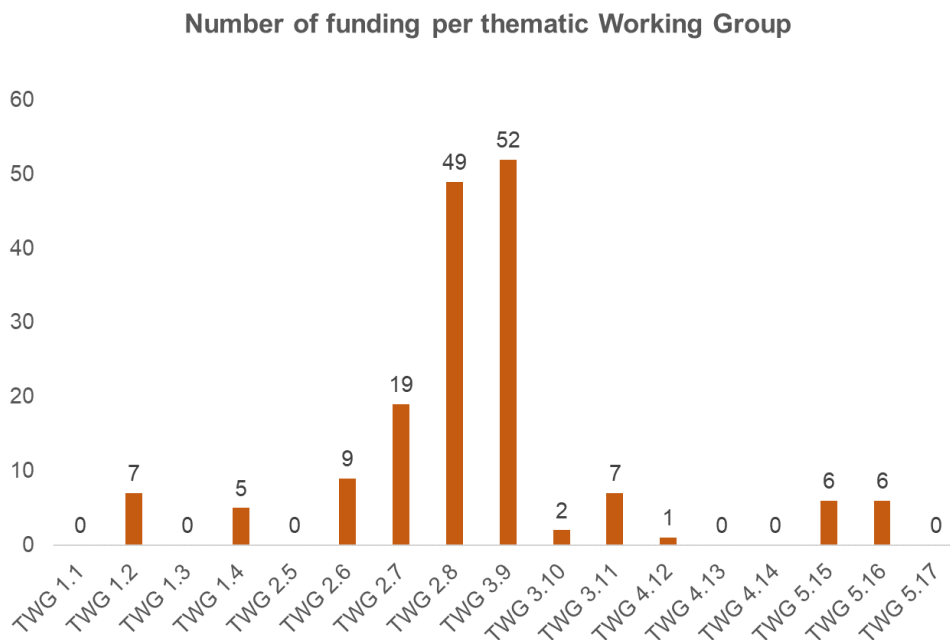
Figure 7: Distribution of project per INPACE Thematic Working Groups.

Figure 8 shows a distribution of the research projects in terms of amounts per INPACE Thematic Working Groups. It is observed clearly that a big amount of the budget is allocated to the TWG 3.9 "Trusted AI" (meaning that belongs to cluster 3; TWG 9), representing 30% of the total budget, followed by "Digitalization of industry, infrastructures and services" (TWG 8), "Data technologies (TWG 10) and High performing computing (TWG11), with 19%, 14% and 13% budget allocation. There are two more Thematic Working Groups with a significant amount of budget allocated, "5G and beyond" (TWG 15 and "Regulation, legislation, policy" (TW1.2), both with 111% of the budget allocated.

Distribution of the research programs for 2024 (in won)
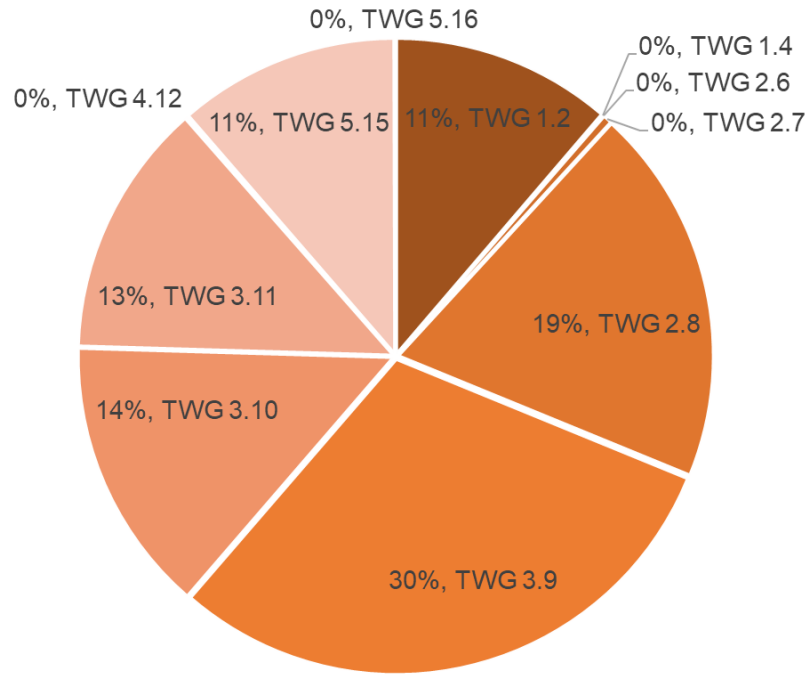
Figure 8: Budget distribution of the research programs in 2024.

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4.4 PRESENT COLLABORATION WITH THE EU

Roadmap EU- Republic of Korea Collaboration

The EU and Republic of Korea (ROK) have developed a strong relationship through a series of key agreements that span various areas of cooperation. These agreements have laid the foundation for a multifaceted partnership, starting with the Science and Technology (S&T) Agreement in 2006, which initiated collaboration in research and development. This agreement facilitated joint projects, information sharing, and capacity building in scientific and technological fields, paving the way for innovation and knowledge transfer between the two regions [35].

In 2010, the relationship was elevated to a strategic partnership with the Framework Agreement, which expanded cooperation to include political, economic, and security issues. This comprehensive framework addressed global challenges such as climate change, energy security, and human rights[59], solidifying the political dimension of the EU-ROK relationship.

The Free Trade Agreement (FTA) in 2011 further strengthened the partnership by eliminating tariffs and trade barriers, thus boosting trade and investment between the two regions. This agreement has been instrumental in enhancing economic growth, creating new business opportunities, and deepening economic ties[60].

These three agreements are highly complementary, forming a solid foundation for the EU-ROK partnership. The S&T Agreement initiated cooperation in innovation, the Framework Agreement provided a broader strategic framework, and the FTA established the economic basis for the partnership. Together, they have resulted in increased trade and investment, technological advancement, and strengthened political ties, enabling joint efforts to address global challenges, especially in the digitalization.

The ROK-EU Summit conclusions of 2020 outlined a shared vision for digital cooperation between Republic of Korea (ROK) and the European Union (EU). Both sides emphasized the importance of a coordinated approach to harness digital technologies while managing associated risks, with a commitment to human-centric digitalization as stated in the Commission's 2030 Digital Compass in 2021[61]. The Fourth Industrial Revolution was identified as a key area for collaboration, alongside

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[59] "Korea – EU Political Relations, Oct 2010, Korea and the EU agreed to elevate their relationship into a Strategic Partnership". Available at: https://overseas.mofa.go.kr/be-en/wpge/m_7448/contents.do#:~:text=Oct.,Jun.

[60] "South Korea, EU trade relations with South Korea. Facts, figures and latest developments". Available at: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/south-korea_en

[61] "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee Of The Regions". Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0118&from=en

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plans to formalize a comprehensive Digital Partnership. This partnership is expected to focus on critical areas like semiconductors, AI, next-generation networks (5G and beyond), cybersecurity, and the digital economy. Additionally, there will be efforts to develop digital skills through education and training.

In 2022, the Ministerial Forum for Cooperation in the Indo-Pacific highlighted the need for enhanced partnerships and collaboration among Indo-Pacific nations and with external partners. The forum discussed the vital role of the digital economy, infrastructure, and education in transforming economies and societies. They emphasized the need for an open, safe, secure, and human-centric internet, with a particular focus on network security issues, including 5G, and reaffirmed the importance of adopting the highest security standards. The forum also stressed the importance of high-level personal data protection, as highlighted in a Declaration between the EU and nine Indo-Pacific countries (Australia, Comores, India, Japan, Mauritius, New Zealand, the Republic of Korea; Singapore, Sri Lanka), to bolster trust in the digital economy and ensure secure data flows.

Then, in June 2022, the 18th EU-ROK Joint Committee represented a significant advancement in the bilateral relationship between the European Union and Republic of Korea. The discussions led to important outcomes, particularly in the areas of economic security and digital collaboration. Both parties acknowledged the critical importance of resilient supply chains and agreed to enhance cooperation to strengthen them. The meeting also laid the groundwork for a future ROK-EU Digital Partnership, exploring potential areas of collaboration within the digital areas[62].

With this foundation, the ROK-EU Digital Partnership aims to become a global model for digital cooperation, driving innovation, creating jobs, and improving citizens' lives in both regions. Building on this strong foundation, the EU and Republic of Korea are now expanding their cooperation into new areas, such as the digital economy, green technology, and security. The EU-ROK Digital Partnership, for example, leverages this established groundwork to tackle the challenges and opportunities of the digital age, further deepening the collaboration.

The roadmap for the ROK-EU Digital Partnership focuses on achieving tangible outcomes in 11 priority areas of digital cooperation. These areas include collaborative research, semiconductors, high-performance computing and quantum technologies, cybersecurity, beyond 5G/6G, skills and digital inclusion, artificial intelligence, digital platform cooperation, data laws, digital identity, and digital trade. Additionally, the partnership will explore ways to support SMEs' digital transformation

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[62] "The European Union and the Republic of Korea advance their strategic partnership at the annual Joint Committee meeting". Available at: https://www.eeas.europa.eu/eeas/european-union-and-republic-korea-advance-their-strategic-partnership-annual-joint-committee-meeting_en

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and share best practices for achieving sustainability and a circular economy. The priority areas will be regularly reviewed and updated through the Korea-EU Digital Partnership Council [36].

In 2024, the second meeting of Korea-EU digital partnership are advancing collaboration in key technology areas, including semiconductors, 5G/6G, and quantum technologies through joint research projects in semiconductors and 6G expected to begin by late 2024, alongside the launch of a Semiconductors Researchers Forum and a Quantum expert group to foster cooperation. Research priorities fall into generative AI, cybersecurity, ICT standardization, SME digitalization, Artic undersea cables, secure and resilient data flows [37][38].

Collaborative Mechanism

The ROK-EU Digital Partnership employs a variety of collaborative mechanisms, each tailored to different aspects of their cooperation. Under European funding schemes including FP7, H2020, and Horizon Europe, Korean entities have developed cooperation in some funded projects. Under FP7, South Korea participated into 54 successful signed collaborative projects out of 1069 with 30 participants and 283.8 M € of EU contribution. Under H2020, there were 84 approved collaborative projects out of 2729 with 75 participated partners. EU contributed about 685,8 M €. In addition, under Horizon Europe, there have been 52 collaborative projects out of 1188 with 46 number of participants and EU contribution of 444.8 M €[63].

These mechanisms can be broadly classified into several categories based on their focus and objectives.

1. **Research and Innovation (R&I) Collaboration** is a key component, where both sides engage in joint research activities. This includes leveraging programs like, MSCA, EUREKA, Horizon Europe and Korea's national R&D projects to explore cutting-edge technologies such as AI, cybersecurity, semiconductors, and quantum technologies. For example, in the area of semiconductors, both parties are establishing forums for researchers and engaging in joint research on advanced semiconductor technologies. Similarly, in High-Performance Computing (HPC) and Quantum Technologies, the collaboration extends to promoting joint research, facilitating access to HPC and quantum infrastructures, and developing applications in these fields shown in Annex II.

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[63] Collaboration with other countries EU-Republic of South Korea taken on 29 November 2024. Available in: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/1213b8cd-3ebe-4730-b0f5-fa4e326df2e2/sheet/e1b57f9a-669b-4962-bdb9-0151c523120f/state/analysis

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2. **Standardization and Policy Alignment**, which focuses on harmonizing standards and aligning policies between the two regions. In the semiconductor sector, this involves cooperation on international standardization, particularly in trusted chips and chip security. The Beyond 5G/6G collaboration is another example, where both sides are working together on the development and standardization of 6G technologies, including aspects like interoperability and spectrum needs. In the realm of Artificial Intelligence, the partnership aims to align AI governance, laws, and standards in international bodies [36]. Additionally, the EU and Republic of Korea have achieved notable alignment in policy standardization across economic, digital, and environmental domains. They collaborate closely on enhancing economic security by mitigating dependencies on China and advancing technology sectors such as semiconductors and electric vehicle batteries. In the digital area, they focus on "human-centric digitalization," reflecting common principles of consumer protection and ethical technology use. In addition, both are united in their efforts to combat climate change, coordinating aid and policies, particularly in the Pacific Islands, to address environmental challenges effectively [39].

3. **Information Sharing and Capacity Building** is another crucial mechanism, where both sides share valuable information and build capacities in key areas. In offshore wind, circular (bio) economy, and quantum computing, researchers, funding agencies, and private sector representatives from ROK and Norway gathered for an event focused on enhancing research and higher education collaboration, and getting insights into existing projects and future funding opportunities from Norwegian and Korean research agencies [64] .The partnership also encourages the exchange of information and best practices in online and digital platform policies. Furthermore, in the area of digital skills and inclusion, the partnership promotes sharing training programs and facilitating exchanges to build digital capacities across both regions [37].

4. **Infrastructure and Technology Development**. Collaboration in AI, the focus is on foundational models and generative AI, aimed at advancing human-centered and reliable AI. The goal is to enhance collaboration to fully leverage AI's benefits and promote cooperative efforts within international standards organizations related to AI [37]. There is also a collaborative effort on digital identity and trust services, where both sides work together to develop and ensure the interoperability of digital identity solutions [36].

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[64] "The Norwegian embassy in Korea hosted its first research networking event in Seoul". Available at: https://k-erc.eu/2023/11/ri-cooperation-category/16727/

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5. **Industry and Trade Collaboration** is another significant aspect, particularly in promoting the digital transformation of SMEs and supporting sustainable digital practices. In the semiconductor industry, there is a concerted effort to enhance transparency and resilience in the supply chain, with cooperation on export controls[65] being a critical area of focus [36].

6. **Joint Forums and Working Groups** play an essential role in facilitating ongoing dialogue and collaboration. For example, in HPC and Quantum Technologies, a working group has been established for quantum technology experts to drive practical cooperation. Similarly, in the semiconductor sector, a forum for researchers is being created to discuss the latest technologies and trends [37].

Overall, the ROK-EU Digital Partnership employs a multi-faceted approach to collaboration, encompassing research, policy alignment, infrastructure development, industry cooperation, and public-private partnerships, all aimed at achieving significant joint outcomes in priority areas.

4.5 POTENTIAL SYNERGIES AND COMMONALITIES BETWEEN REPUBLIC OF KOREA NATIONAL PROGRAMS AND EUROPEAN PROGRAMS

In the digital partnership between Republic of Korea and the European Union, the synergies and communalities, particularly in the context of the digital partnership, reflect a strong alignment in both regions' strategic priorities and goals in research and innovation. Both regions recognize the critical importance of the digital transformation in driving future growth, enhancing competitiveness, and ensuring sustainable development. This shared understanding forms the foundation of their digital collaboration in some specific key areas:

1. Collaborative innovation and research in emerging technologies such as AI, cybersecurity, semiconductors, HPC, quantum technology, 5G and 6G, digital standardisation, and other emerging areas of technology: Both Korea and the EU have national programs that prioritize investment in these cutting-edge technologies, recognizing their potential to revolutionize industries and improve societal outcomes. Initiated in May 2023, the EU and ROK formally organised a negotiation to associate Republic of Korea (ROK) with Horizon Europe. The negotiations were successfully concluded that researchers and organizations will gain privileged access to participate in Horizon Europe's Pillar II from 2025 onwards. In addition, EU-ROK started

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[65] "Keynote speech by Executive Vice-President Dombrovskis at Korea University". Available at: https://ec.europa.eu/commission/presscorner/detail/en/speech_23_5461

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the cooperation in the Smart Networks and Service Joint Undertaking (SNS JU) and the Institute of Information and Communications Technology Planning and Evaluation (IITP).

2. Depth cooperation in the emerging technologies (semiconductor, HPC and Quantum Technology, cybersecurity and trust, beyond 5G/6G, and online and digital platform) sectors: The semiconductor and HPC industries are the cornerstone of the global economy, and the relationship between the European Union (EU) and the Republic of Korea (ROK) has emerged as a critical axis in this sector. Korea is a global powerhouse in semiconductor production, particularly in memory chips [36]. This has made it a crucial supplier for European tech companies. Conversely, the EU boasts a strong position in semiconductor equipment and materials, making it a valuable partner for Korean chipmakers. This complementary nature of their strengths has fostered a robust trade relationship and recalled the commitments in the competition chapter of the Free Trade Agreement signed in 2011. This cooperation not only focus on the semiconductor supply chain but also the establishment of cooperative activities such as EU-ROK forum for semiconductor researchers, the exchange of information, talent exchange, infrastructure & research collaboration and an exploration for international standardisation of trusted chips and chip security [40].

3. The EU's Digital Strategy[66] and Korea's Digital Strategy[67] are prime examples of how both regions are aligned in their approach to digital innovation. These initiatives focus on creating a robust digital infrastructure, supporting startups and tech companies, and ensuring that technological advancements are inclusive and benefit all sectors of society.

4. The importance of data related laws and systems protection, privacy, and cybersecurity: Both Korea and the EU have established comprehensive regulatory frameworks to ensure data free flow with trust while preserving the regulatory autonomy in each country, reflecting a shared commitment to safeguarding the personal data, and to develop initiative in the implementation of data policies and digital identity solutions. This alignment in regulatory standards facilitates smoother cooperation and exchange of information between the two regions, fostering trust and ensuring that digital innovations are implemented responsibly.

5. The collaborative efforts in the development of global standards for digital technologies: Both Korea and the EU are active participants in international forums such as OECD and ITU where

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[66] "A Europe fit for the digital age". Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en

[67] "Korea to come up with the Roadmap of Digital ROK, realizing the New York Initiative". Available at: https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&bbsSeqNo=42&nttSeqNo=742

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they advocate for the establishment of global norms and standards that reflect their shared values, such as openness, transparency, and inclusivity.

6. Another area of commonality is the focus on the development of digital infrastructure, digital capacity building, and digital inclusion. Both regions are committed to ensuring that the benefits of digital transformation are accessible to all citizens, regardless of geographic location or socioeconomic status. This is evident in the ROK national program reflected in the KOICA mid-term Strategy for Education 2021-2025[68], which include initiatives to expand digital infrastructure in rural areas, provide digital skills training, and support digital literacy among vulnerable populations. The collaboration between Korea and the EU in this area highlights their shared belief that digital progress should be inclusive and equitable.

In conclusion, the digital partnership between Korea and the EU is characterized by strong synergies and shared goals. Their collaboration is underpinned by a mutual commitment to advancing digital innovation, ensuring data protection and cybersecurity, developing global standards, and promoting digital inclusion.

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[68] "KOICA's Sectoral Mid-Term Strategy 2021-2025". Available at: https://koica.go.kr/bbs/koica_kr/2058/332080/download.do.

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5 OVERVIEW OF ICT RESEARCH AND DEVELOPMENT (R&D) INITIATIVES IN SINGAPORE

5.1 INTRODUCTION OF ICT R&D PROGRAM

The Information and Communications Technology (ICT) Research and Development (R&D) program of Singapore is a significant part of the country's broader strategy to drive innovation, digital transformation, and economic growth.

An overview of the key aspects of the ICT R&D program in Singapore is presented below:

Strategic Focus Areas

The ICT R&D program of Singapore is focused on the Digital Economy and Smart Nation. This is a program that supports the development of technologies that align with Singapore's vision of becoming a Smart Nation. This includes AI, cybersecurity, IoT (Internet of Things), and data analytics. The ICT R&D is also focused on developing solutions for urban challenges, including smart city infrastructure, sustainable development, and efficient urban planning [41]. Additionally, virtual Singapore is a dynamic 3D digital model and collaborative data platform that serves as a digital twin of the city-state. Launched in 2014 as part of Singapore's Smart Nation initiative, it integrates real-time data to support urban planning, disaster management, and environmental monitoring. The platform enables stakeholders to simulate and analyze various scenarios, facilitating informed decision-making for sustainable development. By providing a comprehensive virtual environment, Virtual Singapore enhances the city's ability to plan and manage its infrastructure and resources effectively[69]. Singapore's commitment to smart city development and digital transformation is further highlighted in the Punggol Digital District initiative, a 50-hectare smart business park integrating digital industries and research facilities. Its focus areas are cybersecurity, AI, and fintech. The district features sustainable, green buildings and is expected to be fully operational by 2026[70].

Government Support and Funding

Singapore's government allocates significant funding to ICT R&D through its Research, Innovation, and Enterprise (RIE) Plans. These plans outline the strategic direction for research and development across various sectors, with ICT being a major focus.

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[69] Virtual Singapore - Building a 3D-Empowered Smart Nation. Available in: https://geospatialworld.net/prime/case-study/national-mapping/virtual-singapore-building-a-3d-empowered-smart-nation/

[70] Punggol Digital District – Singapore's blueprint for future smart districts. Available in: https://www.straitstimes.com/multimedia/graphics/2025/02/punggol-digital-district/index.html

Additionally, agencies like the National Research Foundation (NRF) and the Infocomm Media Development Authority (IMDA) play key roles in driving ICT R&D by providing grants, infrastructure, and support to research institutions, universities, and private companies.

The National Research Foundation (NRF), under the Prime Minister's Office, oversees Singapore's Research, Innovation, and Enterprise (RIE) ecosystem, offering grants such as the NRF Fellowship, Competitive Research Program, and Central Gap Fund. Singapore has increased its focus on technology for government systems and fostering deep tech startups, reflected in a surge of investments from S$324 million in 2020 to S$861 million in 2021. Key initiatives include the Singapore-MIT Alliance for Research and Technology (SMART) Innovation Centre under the RIE 2025 plan, with grants like Innovation Grant 2.0 and I2START. ICT R&D efforts, led by agencies like IMDA and A*STAR, focus on AI, blockchain, and quantum technologies, alongside supporting the nationwide 5G rollout with advancements in applications like drone detection and satellite communications [42].

The government also encourages the establishment of innovation labs and testbeds where new technologies can be developed, tested, and scaled. Examples include Smart Nation initiatives and autonomous vehicle testbeds[71].

The program also focuses on building a strong talent pipeline in ICT through education and training initiatives. Scholarships, fellowships, and collaborations with top global universities are part of this effort to attract and nurture talent in fields like AI, cybersecurity, and data science [43].

5.2 RESEARCH AND INNOVATION PRIORITIES

The Singapore's Research, Innovation, and Enterprise (RIE) Plan is the cornerstone in Singapore's development into a knowledge-based, innovation-driven economy and society.

RIE Plans are the strategic frameworks that guide the country's investment in research and development (R&D) to drive innovation and economic growth. These plans are revised periodically, and they include significant allocations for Information and Communications Technology (ICT) as part of Singapore's broader goals of becoming a global innovation hub and a Smart Nation.

RIE 2025 Plan (2021-2025)

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[71] NTU, LTA and JTC Unveil Singapore's First Autonomous Vehicle Test Centre. Available in: https://www.smartnation.gov.sg/media-hub/press-releases/ntu-lta-and-jtc-unveil-singapores-first-autonomous-vehicle-test-centre/

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In RIE 2025 Plan, the Singapore government will sustain investments in research, innovation and enterprise at about 1% of Singapore's GDP over 2021-2025 ($25 billion) — the largest sum so far dedicated to R&D in Singapore's history. This reflects the Singapore government's sustained, long-term commitment to R&D through economic cycle [44].

RIE 2025 is organized along four strategic domains, supported by three cross-cutting horizontals represented in Figure 9, to support businesses in adopting science and technology, and expanding into adjacent areas with "high growth potential". The image below represents the research and innovation priorities defined in this plan[72].

Manufacturing, Trade and Connectivity

- Leveraging R&D to reinforce Singapore's position as a global business and innovation hub for advanced manufacturing and connectivity

Human Health and Potential (HHP)

- Better transform and protect health, advance human potential and create economic value for Singapore

Urban Solutions and Sustainability (USS)

- Renew and build a liveable, resilient, sustainable and economically vibrant city for tommorrow

Smart Nation and Digital Economy (SNDE)

- Develop technology leadership to drive our Smart Nation ambition, and achoe Singapore's position as a trusted digital innovation hub

Academic Research
- Build a robust base of research capabilities and peaks of international excellence

Manpower
- Nuture a strong research and innovation talent pipeline

Innovation and Enterprise
- Accelerate enterprise innovation

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[72] RIE Ecosystem – The RIE2025 Plan. Available in: https://www.nrf.gov.sg/rie-ecosystem/ecosystem/

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Figure 9: Representation of four strategic domains supported by three cross-cutting horizontals in adopting science and technology [44].

Smart Nation and Digital Economy (SNDE)

The Smart Nation and Digital Economy (SNDE) domain focuses on advancing strategic and emerging technologies to achieve Singapore's Smart Nation goals and capitalize on digital economy growth. Key efforts include accelerating the development and adoption of AI, cybersecurity, trust technologies, communication and connectivity, and quantum computing. Investments will also target 5G and future communication technologies while driving the nationwide adoption of AI model-building.

- **AI**

SNDE will continue to build on Singapore's AI R&D strengths and invest in new areas, including explainable AI, small data techniques and federated learning; strengthening the speed to market through technology translation labs and creating foundational building blocks for AI capabilities; as well as orchestrating the research and innovation ecosystem to address national needs and industry demand in sectors such as trade and connectivity, built environment, and professional services.

- **Cybersecurity**

RIE 2025 efforts will focus on further strengthening the cybersecurity ecosystem, and raising capabilities across national research institutes, industry and government.

- **Trust technologies**

Going into RIE2025, SNDE will focus on developing new technology solutions that will underpin the security of digital transactions and entrench Singapore as a trusted digital node. These include fair and explainable privacy preserving technologies to obtain data insights in a secure and transparent manner, and platforms to facilitate interoperability between the various blockchain technology solutions available on the market.

- **Quantum**

Singapore will continue to build on its quantum capabilities and keep abreast of international developments. This includes new areas of focus, such as quantum communications and quantum key distribution, quantum sensing and imaging, as well as quantum algorithms

- **Communications and connectivity**

5G (and beyond) communications is globally touted as the next big leap in wireless communications. RIE efforts will continue to grow Singapore's communications and connectivity capabilities, such as in telecoms security, management and optimisation. The investment will be focused in communications research, innovation and translation, and develop new consumer and business applications to encourage widespread adoption of future communication technologies, and support Singapore's Smart Nation ambitions.

The RIE Plans represent Singapore's strategic approach to integrating ICT into its long-term vision for innovation and economic development, and Singapore's commitment to leveraging ICT as a key driver of societal transformation. These plans emphasize the importance of developing a skilled workforce in ICT through education, training, and international collaboration. Partnerships with global technology companies, research institutions, and other countries are also an important part of the RIE plans [44].

5.3 IDENTIFICATION OF NATIONAL FUNDING MECHANISM

In the Smart Nation and Digital Economy domain, there are several Funding Initiatives (FIs) (grant schemes) managed by Implementing Agencies across Singapore[73].

Infocomm Media Development Authority (IMDA)

The main governmental agency responsible for Singapore's Information and Communications Technology (ICT) development and regulation is the Infocomm Media Development Authority (IMDA). IMDA operates under the Ministry of Digital Development and Information, formerly known as Ministry of Communications and Information (MCI). IMDA plays a central role in the country's digital transformation and Smart Nation initiatives[74].

The main Funding initiatives operating under IMDA responsibility are:

- **AI Singapore (AISG):** A Singapore's national program in AI that seeks to catalyse, synergise and boost Singapore's AI capabilities. Since its launch in 2017, it has contributed towards driving Singapore's scientific excellence in AI research, growing local AI talent, and supporting the translation of AI technology through some calls for AI research proposal. The recent one is the sixth call for AI research proposal in 2024. The AI Research Grant Call 2024 by AISG seeks proposals that advance fundamental AI research aligned with the vision of

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[73] Ecosystem Wide Funding Initiatives (Fis). Available in: https://www.nrf.gov.sg/rie-ecosystem/ecosystem-wide-fis/mtc-fis/

[74] Research and Statistic by IMDA. Available in: https://www.imda.gov.sg/about-imda/research-and-statistics

"Discriminating Information." This vision focuses on enhancing AI capabilities to distinguish information from misinformation, assess the impact of false information, and develop methods for prevention and mitigation. Key research areas include information authentication, interpretation and generation, and user profiling. Proposals must align with this vision and meets the classification of AI core technical areas including cognitive modelling and systems, game theory and economic paradigms, heuristic search and optimization, knowledge representation and reasoning, machine learning, multiagent systems, natural language processing (NLP), planning and scheduling, reasoning under uncertainty, robotics, search and constraint satisfaction, and vision. The winner will be supported for up to three years with funding of up to S$1 million[75].

- **Future Communications R&D Program:** IMDA and the National Research Foundation (NRF) have invested close to S$70 million to set up Singapore's first national Future Communications Research and Development Program (FCP) [76]. This program aims to jumpstart cutting-edge communications and connectivity research in Singapore, which help to grow relevant local capabilities, with potential to translate into innovative products, services and even companies.

  The program also actively seeks partnerships with R&D counterparts, both domestically and internationally, with the intention of exploring opportunities in joint research, and/or educational projects as well as joint workshops to exchange and strengthen knowledge in the area of future communications and its applications.

  The FCP will support AI and Cybersecurity research for the next-generation communications infrastructure, support innovative testbeds and provide scholarships for those who wish to pursue research work in the area of future communications. FCP will also look to build and strengthen international partnerships and collaborations across borders.

- **Digital Trust Centre**: The Digital Trust Centre (DTC) was first launched at the AsiaTechX (ATx) Singapore on 1 June 2022, with the aim to lead Singapore's research and development efforts for trust technologies and to support talent development in this space. Funded by IMDA and the NRF under the RIE 2025, the national centre is hosted at the Nanyang Technological University, focusing on key areas of Trust Technologies, such as Privacy Enhancing Technologies (PETs) for data sharing and solutions to evaluate the

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[75] AI Research Grant Calls. Available in: https://aisingapore.org/research/grant-call/

[76] Future Communications Research and Development Programme (FCP. Available in: https://www.imda.gov.sg/how-we-can-help/future-communications-research-and-development-programme

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trustworthiness of AI systems. The recent grant call was open from 17 June 2024 to 16 August 2024. Its goal is to foster innovation, digital transformation, and real-world application of trust solutions. Each project can receive up to S$1 million for a 12-month duration. Proposals will be evaluated on alignment with DTC's objectives, real-life use cases where trust technology is critical, and the potential sector-wide impact of the solution. The proposed opportunities and focus areas shall include, but are not limited to, the following:

A. Trusted Analysis and Compute: Privacy-preserving AI; Privacy-preserving tech (Full Homomorphic Encryption (FHE); Searchable Symmetric Encryption (SSE) with analytics; Data Synthesis (DS); Secure Multi-Party Computation (SMPC); Federated Learning (FL); Differential Privacy (DP))

B. Decentralisation and Web 3.0: Blockchain analytics (in particular, against financial crimes); Trusted decentralised digital identity; Decentralised computing and storage systems

C. Trusted Accreditation: Trustworthy AI; Responsible AI – Traditional AI risks of users and organisations; Safe AI - Frontier AI risks of societal harms and public safety[77]

- **The TechSkills Accelerator (TeSA)**: an initiative led by IMDA in collaboration with industry and government agencies to develop a skilled ICT workforce. It offers structured training through programs like the Company-Led Training (CLT) for fresh graduates and mid-career professionals, the TeSA for ITE and Polytechnics (TIP) Alliance for students, and the Skills Framework for ICT to guide career development. By equipping individuals with in-demand tech skills such as AI, cybersecurity, and data analytics, TeSA ensures Singapore remains competitive in the digital economy[78].

Besides these four main funding initiatives, inside IMDA there are several programs and grants available, aiming to support different ICT activities. Some examples[79] can be found in the Table 10 below:

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[77] Digital Trust Centre (DTC Singapore) Innovation Grant Call. Available in: https://www.imda.gov.sg/proposal-submission/dtc-sg-innovation-grant-call#:~:text=The%20DTC%20Singapore%20Innovation%20Grant,co%2Ddevelop%20Trust%20Tech%20solutions.

[78] TechSkills Accelerator (TeSA). Available in: https://www.imda.gov.sg/how-we-can-help/techskills-accelerator-tesa

[79] Documentation of Press Releases, Factsheets, and Speeches by IMDA. Available in: https://www.imda.gov.sg/resources/press-releases-factsheets-and-speeches?page=1&support=all&type=all&year=all

Table 10: Samples of Grant Calls by IMDA.

Programs & Grants	Description	Amount	More details
10gbpsnationwide broadband network (10g nbn) Grant	The application is opened to all NBN Operating Companies who are interested to provide residential 10 Gigabit-Passive Optical Network (10G-PON) services.	S$100 million	Singapore is investing ahead in 10G Nationwide Broadband Network (NBN) | IMDA
5G Grant	5GInnovation Program will be supporting and encouraging enterprises and industries to adopt and implement new 5G applications in live operating environment. The 5G Innovation Program will also be supporting solution providers and technology developers commercialising 5G solutions, by making the benefits of 5G more accessible to companies, focusing on: i) Domain areas (ie. Robotics & IoT, AI & Data, AR/VR); ii) Commercialization and deployment of 5G solutions	n.d.	5G Grant | 5G Innovation Program | IMDA
5G Innovation	IMDA is exploring six strategic clusters to focus on where 5G bears the most potential: (i) Maritime Operations; (ii) Urban Mobility; (iii) Smart Estates, (iv) Industry 4.0, (v) Consumer applications and (vi) Government applications.	n.d.	5G Innovation | IMDA
5G Open Testbed	As part of the efforts to democratize 5G innovation for all businesses, 5G commercial service is now available at these testbeds: 1) Maritime Drone Estate (MDE); 2) Science Park 2; 3) 5G Living Lab @ PIXEL	S$30M	5G Open Testbed | IMDA

Ministry of Digital Development and Information (MDDI)

The Ministry of Digital Development and Information (MDDI), renamed from Ministry of Communications and Information – Technology Office (MCI-TO) plays a pivotal role in driving Singapore's digital mandate in four key domains: (1) Digital Economy; (2) Digital Government; (3) Digital Security; (4) Digital Society. MDDI oversees the development of the infocomm technology, cybersecurity, and media sectors; the Government's digitalization initiatives; and the national library, national archives, and public libraries. The Ministry is also responsible for effective public communications, and the Government's information and public communication policies.

The main Funding initiative operating under MDDI responsibility is:

Combatting the Weaponisation of the Internet (CWI): The CWI Research Program seeks to build technological capabilities and competencies amongst Singapore's Institutes of Higher Learning (IHLs) and Research Institutes (RIs) to combat online harms. This is to counter the rapidly evolving

and increasing online harms in the Internet ranging from mis- and dis-information, hate speech to scams [45].

National Quantum Office/A*STAR

The National Quantum Office (NQO) serves as the control tower to coordinate quantum RIE activities in Singapore. Among others, this office has the responsibility to drive the implementation of Singapore's RIE Strategy for Quantum with the guidance of the National Quantum Steering Committee and coordinate major public investments in quantum technologies, such as the Centre for Quantum Technologies, the Quantum Engineering Program, and other ecosystem-wide quantum initiatives.

The vision of the National Quantum Strategy is to strengthen Singapore's position as a leading hub in the development and deployment of quantum technologies. The National Quantum Strategy is hosted in the Agency for Science Technology and Research (A*STAR) and will be resourced with close to $300 million from Singapore's Research, Innovation and Enterprise 2025 (RIE 2025) plan under the National Research Foundation (NRF) Smart Nation and Digital Economy (SNDE) domain over the next 5 years.

The main Funding initiatives operating under NQO responsibility are:

Quantum Engineering Program: Singapore's Quantum Engineering Program (QEP) aims to realise the benefits of quantum technologies for society. Launched in 2018, it supports translational research focused on industry challenges and initiatives to nurture a quantum ecosystem. Coordinated nationally across various research organisations, the QEP is hosted by the National University of Singapore (NUS), and supported by the National Research Foundation and the Agency for Science, Technology and Research (A*STAR).

Below there are some of the R&D projects funded so far under the second phase of the Quantum Engineering Program (QEP2.0). Proposals were selected after international peer review and evaluation of submissions to a series of open calls in 2021. The projects range from two to three years long. Currently, there are no calls available. Some progressing projects are represented in Table 11 [45][46].

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Table 11: Progressing projects funded by Quantum Engineering Program.

Projects in progress	Description
Evaluation of all-transparent optical routers for a quantum network embedded in a classical optical fiber network **Projects - QEP Singapore (qepsg.org)**	The core part of this project is to develop optical multiplexers that can bypass classical Internet routing hardware, and provide a reconfigurable optical routing on a spectral window that is not used for classical traffic. The main challenge was to identify and characterize the switching technology suitable for quantum traffic
Heterogenous quantum interfaces over metropolitan distances **Projects - QEP Singapore (qepsg.org)**	This project aims to demonstrate entanglement or quantum information exchange across different physical systems by making use of optical qubits that ideally are compatible with telecom fibers.
Architecture and Protocols for the Quantum Internet **Projects - QEP Singapore (qepsg.org)**	The objective of this project is to develop network layer solutions for the quantum Internet. While the quantum Internet focuses on the transfer of qubits and quantum entanglement, one of its key requirements is that it will co-exist and share the same physical resources (e.g. optical fibers) as the traditional Internet. This project specifically considers the problems associated with the co-existence of quantum Internet with next-generation data networks that are going to be based on softwarization and virtualization of network functions.
Evaluation of all-transparent optical routers for a quantum network embedded in a classical optical fiber network	This project aims to establish the hardware necessary to implement a dial-up transparent optical network for quantum communication riding on the existing fiber network in Singapore.
Heterogenous quantum interfaces over metropolitan distances	This project aims to demonstrate entanglement or quantum information exchange across different physical systems by making use of optical qubits that ideally are compatible with telecom fibers.
Optical fiber characterization and noise mitigation for quantum clock comparison and application	The key objectives of this project are therefore to establish an optical network with local research ecosystem to carry out dedicated experiment: 1. To understand and characterize high-quality delivery of optical atomic clock signals through optical fibers, with the proposal of noise mitigation solutions. 2. To build a rack-mounted laser system for Lu+ clock and provide clock signals for characterizing the optical fiber link to be established.
A scalable, programmable atom-array platform for quantum simulation of dynamical and material physics	We aim to realize a scalable and programmable quantum simulator using reconfigurable arrays of ultracold atoms that are individually trapped in optical tweezers. This will be achieved on two fronts: first, we will develop new atom-sorting algorithms that allow us to demonstrate large-scale defect-free atom arrays; second, we will use Floquet techniques to increase the programmability of interactions between atoms in the tweezer array
Atomic Engineering of Donor-based Spin Qubits in Silicon	We aim to advance spin-based qubits as a basic quantum computing resource through materials engineering in semiconductors. One leading platform is based on precision placed donors in silicon which is a mature technological material with many well-established processes for wafer level fabrication
Building non-cryogenic centimeter scale magnetometers with 10 fT/Hz1/2 sensitivity in Singapore for Earth science and defense applications	In this project, we are developing alkali atomic scalar magnetometers as the next-generation of ultra-sensitive magnetometers that are capable of reaching fT/sqrt(Hz) sensitivities without needing the cryogenic cooling that current state-of-the-art Superconducting Quantum Interference Devices (SQUIDs) require. This translates to significant cost-savings and flexibility in operation, which can not only enhance many of the applications listed above, but also unlock heretofore unexplored applications.
Single Photon Detectors for Quantum Sensing and Communications	This project aims to develop integrated APDs for visible light, which will enable quantum information and sensing applications based on quantum emitters operating at visible wavelengths, such as trapped ions, colour centers in diamond, quantum

Projects in progress	Description
	dots, 2D materials, etc. Such devices will also greatly benefit application areas such as visible-light communications and low-light imaging.

Centre for Quantum Technologies: The Centre for Quantum Technologies (CQT) is Singapore's flagship research and development centre for quantum science and technology. CQT drives cutting-edge research in the areas of quantum computing, communication and sensing. It also supports Singapore's various national quantum platforms and plays a pivotal role in building Singapore's quantum ecosystem[80].

Cyber Security Agency (CSA)

The Cyber Security Agency of Singapore (CSA) was formed in 2015 and is the national body that protects Singapore's cyberspace. CSA's core mission is to keep Singapore's cyberspace safe and secure, to underpin our National Security, power a Digital Economy, and protect Singapore's Digital Way of Life.

The main Funding Initiative operating under NQO responsibility is:

National Cybersecurity R&D Program (NCRP): The National Cybersecurity R&D Program seeks to develop R&D expertise and capabilities in cybersecurity for Singapore. It aims to improve the trustworthiness of cyber infrastructures with an emphasis on security, reliability, resiliency and usability. The Program Office will receive funding of S$62 million under the RIE2025 NCRP Funding Initiative[81]. It started its operations in August 2023.

Smart Nation and Digital Government Office (SNDGO)

Led by the Ministry of Digital Development and Information (MDDI), the Smart Nation initiative is a way forward, seamlessly integrating technology to transform how its people and businesses live, work and play. Singapore has set its sights on becoming a world-class, tech-driven city-state.

The main Funding Initiative under this Office is:

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[80] Industry Projects and Partnerships. Available in: https://www.quantumlah.org/page/key/industry-projects

[81] CSA Establishes CyberSG R&D Programme Office with Four Year Funding of S$62 Million to Drive Research and Development to Build Up Cybersecurity Capabilities in Singapore. Available in: https://www.csa.gov.sg/News-Events/Press-Releases/2023/csa-establishes-cybersg-r-d-programme-office-with-four-year-funding-of-62-million-to-drive-research-and-development-to-build-up-cybersecurity-capabilities-in-singapore

Translational R&D for Digital Government: The Translational Research and Development for Application to Smart Nation (TRANS) Grant funds translational R&D and technology or process innovations in areas that are aligned to the emerging and focused tech areas. This initiative taps on research institutes' capabilities to solve public sector challenges, demonstrates feasibility of new ideas and encourages agencies to experiment and deploy innovative solutions one of the grantees is from Smart Nation Translational lab (SNTL) under Nanyang Technological University[82]. The Smart Nation Translational Lab (SNTL) focuses on research in Big Data Analytics, Internet of Things (IoT), Urban Sound Analytics, Intelligent Edge Computing, and Edge-Cloud Architecture. SNTL projects are being field-deployed across residential and business areas to test edge analytic devices developed by its IoT core team. Key initiatives include distributed sensing for edge analytics, advancements in Home Fire Alarm Devices (HFAD) using sensor analytics, and system setups for kerbside parking proof-of-concept (POC)[83].

Agency for Science, Technology and Research (A*STAR)

The Agency for Science, Technology and Research (A*STAR) is Singapore's leading government agency in fostering world-class scientific research and talent for its economy. It plays a pivotal role in advancing the Research, Innovation, and Enterprise (RIE) 2025 plan across strategic domains. The agency fosters world-class scientific research and talent development to support Singapore's knowledge-based economy. A*STAR oversees key research institutes like the Institute for Infocomm Research (I^2R), Institute of High-Performance Computing (IHPC), and Institute of Materials Research and Engineering (IMRE), along with horizontal technology programs such as AI, Analytics, and Informatics (AI). Recent highlights include collaborations on 5G infrastructure with arQana Technologies and innovations in materials R&D through the Accelerated Materials Development for Manufacturing (AMDM) program, which leverages AI, high-performance computing, and automation.

The RIE2025 plan was announced in December 2020, where a huge budget of S$25 billion was allocated for the next 5 years. This signified Singapore's strong focus and emphasis on R&D for the nation, especially when the budget of RIE2025 for R&D is the highest so far in Singapore's history. The RIE2025 comprises of 4 main domains: manufacturing, trade and connectivity (MTC); human health and potential (HHP); urban solutions and sustainability (USS); and, Smart Nation and digital economy (SNDE).[84] It also compasses various ICT projects from commissioned to competitive with

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[82] Grants – External Funding. Available in: https://www.ntu.edu.sg/sntl/research-capabilities/grants

[83] Smart Nation Translational Lab (SNTL). Available in: https://www.ntu.edu.sg/sntl

[84] The Roadmap to RIE 2025. Available in: https://research.a-star.edu.sg/articles/features/the-roadmap-to-rie2025/

the ultimate objective of establishing the country's ambition as a Smart Nation. A*STAR manages and hosts several research institutes that focuses on ICT innovations. For example, the Institute for Infocomm Research (I²R) under A*STAR specialises in digital world innovations for a thriving and resilient Singapore harnessing AI, Connectivity and Cybersecurity[85].

Apart from managing and hosting research institutes, A*STAR also participates in many collaborations. For instance, A*STAR is partnering with the Infocomm Media Development Authority (IMDA) and AI Singapore (AISG) on the National Multimodal LLM Program (NMLP) launched in December 2023. The S$70 million project is funded by the National Research Foundation, Singapore (NRF) to venture into the R&D of a multi-modal large language model (LLM).[86]

In addition, A*STAR offers various enterprise and innovation schemes to boost the adoption of ICT technologies in industries. SIMTech, a research institute of A*STAR, supports the Growing Enterprises through Technology Upgrade (GET-Up) initiative to ensure local technology-intensive businesses can keep up with international competition through the Technology for Enterprise Capability Upgrading (T-Up) program. As such, this could give local firms a competitive advantage in the international technological market.

Furthermore, the upgrading of Singapore's nationwide broadband network is deployed at A*STAR's Advanced Remanufacturing and Technology Centre (ARTC). This 5G upgrading initiative is in response to rising demands for new technologies within households and to accelerate Singapore's Industry 4.0 transformation. This initiative is also in collaboration with Singtel and JTC.[87]

As such, it is evident that A*STAR is a key player in the ICT R&D field contributing significantly to Singapore's position as a leading global technology hub.

AI Singapore (AISG)

AI Singapore (AISG), a national program launched by the National Research Foundation in 2017, aims to advance Singapore's AI capabilities through cutting-edge research, talent development, and industry collaboration. AISG addresses critical global and national issues via Grand Challenges, leveraging AI technologies to solve complex problems in targeted sectors. Four major challenges have been launched to date:

o   AI for Materials Discovery Grand Challenge: Focuses on using AI to discover advanced

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[85] Research Capabilities Institute for Infocomm Research. Available in: https://www.a-star.edu.sg/i2r/research-capabilities

[86] Artificial Intelligence in Singapore. Available in: https://www.imda.gov.sg/about-imda/emerging-technologies-and-research/artificial-intelligence

[87] 5G Innovation. Available in: https://www.imda.gov.sg/how-we-can-help/5g-innovation

materials that are 50% lighter while retaining or enhancing their functional properties. Selected teams receive up to S$4 million for the first stage and up to S$5 million for the second stage.

o   Robust AI Grand Challenge: Aims to develop resilient AI models for Computer Vision (CV) systems in autonomous vehicles, targeting recovery of 80% accuracy after adversarial attacks. The challenge supports research on object detection, stereo depth estimation, and semantic segmentation.

o   AI in Education Grand Challenge: Seeks AI-driven solutions to improve Mother Tongue Language learning for primary school students, enhancing oral proficiency by 20% over two years. Teams receive up to S$3.5 million in funding for the initial phase.

o   AI in Health Grand Challenge: Focuses on AI applications in primary care to reduce disease progression in diabetes, hypertension, and high cholesterol patients by 20% within five years [47].

100 Experiments (100E)

100 Experiments (100E) is AI Singapore's flagship program to solve industries' artificial intelligence (AI) problem statements and help them build their own AI teams. An organisation can propose 100E problem statements where no commercial off-the-shelf (COTS) AI solution exists, but they can potentially be solved by AI Singapore's engineering team within a 9-month collaboration period. AI Singapore will provide co-funding of up to S$180 thousand per 100E project for the engineering team from AI Singapore to work on the organisation's problem statement. The team will fully undertake the project for 7 months to develop and deploy an AI minimum viable model. The AI Singapore team is staffed by full-time AI, data and platform engineers as well as apprentices from the AI Apprenticeship Program (AIAP). The organisation is then required to match the funding in-kind (AI/engineering/IT/domain manpower) and in cash [48].

AI Apprenticeship Program (AIAP)

The AI Apprenticeship Program (AIAP) was created to meet AI Singapore's requirements for AI professionals. It grew out of a need for a core group of Singaporean AI talents working in AI Singapore, solving both Singapore's and Singapore companies' problem statements with AI. The present program is developed as an improvement to answer the insufficient talents in AI. It focuses on self-directed, passionate Singaporeans with some of the required AI technical knowledge and skills but may not have the opportunity to undertake real-world AI projects. It offers a 3-month intensive deep-skilling training and then a 6-month real-world AI project. AIAP is recognised as the leading AI deep-skilling program in Singapore and the world [49].

Centre for Advanced Robotics Technology Innovation (CARTIN) by Nanyang Technological University Singapore

The Centre for Advanced Robotics Technology Innovation (CARTIN) focuses on developing innovative, accessible, and user-friendly robotics solutions to enhance key sectors in Singapore: logistics, manufacturing, and eldercare. Its two research areas, Sentient Autonomy and Collaborative Autonomy, address critical technology gaps.

For logistics, CARTIN aims to create robust navigation systems for autonomous vehicles, moving beyond traditional infrastructure-based systems. In manufacturing, it seeks to enhance collaborative robots (cobots) by enabling safe and efficient teamwork between robots and humans, improving productivity in tasks like assembly. In eldercare, robotic companions are being designed to support the physical, emotional, and social needs of the elderly, promoting independent living and reducing caregiver strain [50].

SkillsFuture Singapore by Ministry of Education

SkillsFuture is a national movement in Singapore aimed at providing citizens with opportunities to develop their fullest potential throughout life, regardless of their starting points. It emphasizes lifelong learning and skills mastery, encouraging individuals to continually strive towards greater excellence through knowledge, application, and experience.

The movement is driven and coordinated by SkillsFuture Singapore (SSG)[88], a statutory board under the Ministry of Education. SSG promotes a culture of lifelong learning and strengthens the ecosystem of quality education and training in Singapore. Its mission is to enable individuals to learn for life, pursue skills mastery, and develop fulfilling careers, contributing to a future-ready Singapore.

SkillsFuture offers various initiatives to support individuals at different stages of their careers:

- SkillsFuture Credit: Provides Singaporeans aged 25 and above with credits to offset course fees for approved skills-related courses. A base credit of S$500 is provided, which does not expire. Additional top-ups have been introduced for mid-career individuals to encourage reskilling and upskilling.

- SkillsFuture Series: A curated list of short, industry-relevant training programs focusing on emerging and in-demand skills across various economic growth sectors, such as Digital, Care,

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[88] SKILLSFUTURE. Available in: https://www.skillsfuture.gov.sg/

Green, and Industry 4.0. These programs are available at basic, intermediate, and advanced levels to cater to adult learners with different proficiencies.

- Skills Frameworks: Developed in collaboration with employers, industry associations, education institutions, unions, and the government, these frameworks provide key sector information, including details on occupations, job roles, and the required existing and emerging skills. They serve as a guide for individuals to make informed decisions about career development and skills upgrading.

Through these initiatives, SkillsFuture aims to help individuals make well-informed choices in education, training, and careers; develop an integrated, high-quality system of education and training that responds to constantly evolving needs; promote employer recognition and career development based on skills and mastery; and foster a culture that supports and celebrates lifelong learning.

Quantitative analysis

Considering the information that is publicly available and the main funding initiatives in R&D identified in the previous subchapters under the Smart Nation and Digital Economy Domain, we can identify the following amounts (Singapore million dollars) attributed for each research field under the 2025 RIE plan:

- AI Singapore (AISG): 250 AI Singapore (AISG): $250 million

- Future Communications R&D Program: $70 millions

- Digital Trust Centre: $50 millions

- Combatting the Weaponisation of the Internet: amount not available.

- National Quantum Office (NQO) /National Quantum Strategy: $300 millions of investment through National Quantum Office (NQO).

- National Cybersecurity R&D Program: $62 millions

- Translational R&D for Digital Government: amount not available.

Based on this information, and considering INPACE TWG's classification represented by Figure 10, by analysing the graphic below, we can conclude that a big amount of the government budget under the RIE 2025 is allocated to the "High performance computing" and/or "Ground-breaking technologies" immediately followed by the "5G and beyond". The other groups have more or less an

equal distribution, but is relevant to see that they are also well represented in this domain of Smart Nation and Digital Economy and its relevancy for the Singapore R&D strategy [44].
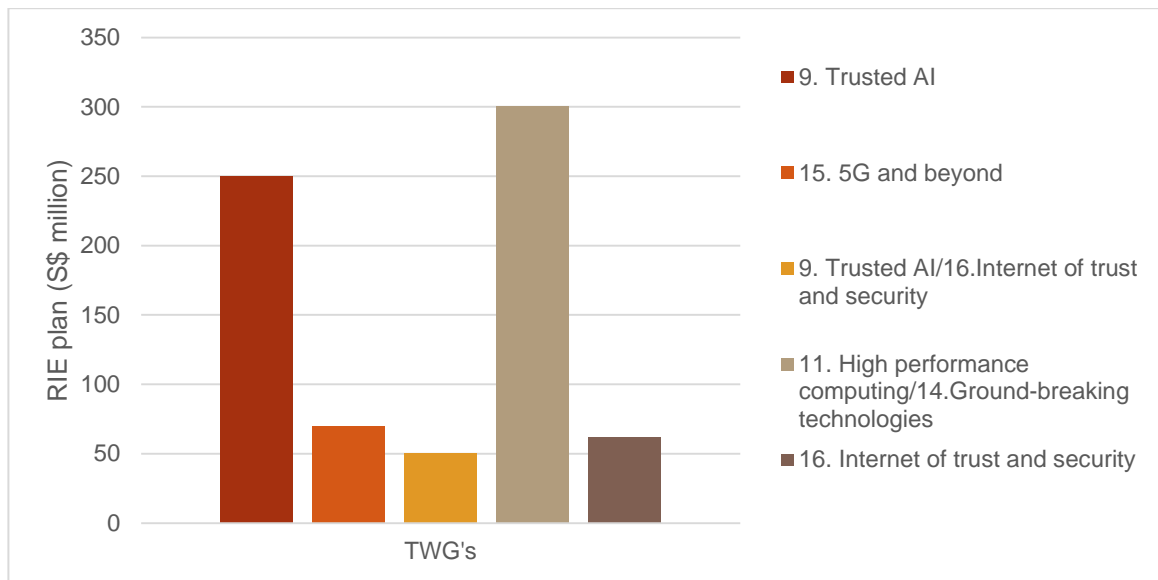

Figure 10: Investment in ICT sectors based on RIE2025 plan [44]

5.4 PRESENT COLLABORATION WITH THE EU

Roadmap EU-Singapore Collaboration

The European Union-Singapore Free Trade Agreement (EUSFTA) is the first FTA between the EU and an ASEAN country, marking a significant milestone in EU-ASEAN relations. Negotiations began in 2009 and concluded in 2012 for goods and services, while investment protection was finalized in 2014, leading to the separate EU-Singapore Investment Protection Agreement (EUSIPA). The EUSFTA was signed in 2018 and entered into force in November 2019 [89]. The agreement strengthens the trade and investment relationship between the EU and Singapore, with bilateral trade in goods. It provides Singapore businesses with improved market access, reduces barriers, and enhances opportunities in government procurement and intellectual property protection.

Negotiations for the EUSFTA concluding for goods and services in 2012 and for investment protection in 2014, leading to the separate EU-Singapore Investment Protection Agreement (EUSIPA). The EUSIPA replaces 12 existing bilateral investment agreements and introduces a new

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[89] EUSFTA. The European Union-Singapore Free Trade Agreement (EUSFTA). Available in: https://www.mti.gov.sg/Trade/Free-Trade-Agreements/EUSFTA

Investment Court System (ICS) for high investment protection and regulatory rights. It received consent from the European Parliament in February 2019 and was endorsed by the Council in November 2019[90]. In addition, EU – Singapore Partnership and Cooperation Agreement (EUSPCA) in 2018, will enhance political dialogue and cooperation between the EU and Singapore across various sectors, while the EUSIPA will further strengthen the already robust investment ties between the two parties[91].

The EU-Singapore Digital Partnership (EUSDP) strengthens the strategic cooperation between the EU and Singapore, building on existing frameworks like the EU-Singapore Free Trade Agreement (EUSFTA), Investment Protection Agreement (EUSIPA), and Partnership and Cooperation Agreement (ESPCA). Announced in December 2022, this partnership focuses on advancing collaboration in digital technology, aligning with the 2030 Digital Compass and the EU's Indo-Pacific Strategy. The agreement emphasizes cooperation in areas like digital trade, digital connectivity (digital infrastructure, data centres, and submarine telecommunications cables), 5G and beyond 5G technologies, data free flow with trust, cybersecurity, global semiconductors supply chain, AI, online platforms, trust services (digital identity and its exchange information), digitalization in the financial sector, data innovation, SMEs' digital transformation, digital education and trainings, and fostering shared goals of a fair and competitive digital economy [51].

The Digital Trade Principles, a key outcome of this partnership, promote free digital trade while protecting privacy. The partnership also facilitates joint projects, such as paperless trading and electronic payments, and strengthens international collaboration on digital standards. The Digital Partnership Council, co-chaired by EU and Singaporean officials, oversees the implementation of key priorities, including AI governance, e-identification, and SME digital transformation, marking a pivotal step in enhancing digital ties between the EU and Singapore[92].

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[90] EU-SINGAPORE INVESTMENT PROTECTION AGREEMENT (IPA). Available in: https://www.europarl.europa.eu/legislative-train/package-other-fta/file-eu-singapore-ipa

[91] Key Achievement in 2021. Available in: https://euinasean.eu/cooperation/bilateral-cooperation/singapore/

[92] EU and Singapore launch Digital Partnership. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_467

Eventually, in July 2023, EU and Singapore launched negotiations on a Digital Trade Agreement (DTA)[93]. The EU-Singapore Digital Trade Agreement (EUSDTA)[94] marks a significant milestone in strengthening digital connectivity between Singapore and the European Union, further enhancing an already robust trade relationship. This agreement provides legal certainty for companies and consumers, establishes clear rules for digital trade, and promotes secure data flows while protecting personal information. By prohibiting data localisation requirements and preventing unjustified barriers to digital trade, the EUSDTA enables seamless, cost-effective transactions and supports secure digital systems. It also prioritizes consumer protection and opens new opportunities for small and medium-sized enterprises (SMEs) to participate in the digital economy [52]. Negotiations on the EUSDTA were formally concluded on July 2024, and as of 2025, both the EU and Singapore are working on finalising the signing of the agreement.[95]

In conclusion, the EU-Singapore Digital Trade Agreement (EUSDTA), built on the foundation set by the EUSFTA, EUSIPA, EUSPCA and other trade pacts, represents a pivotal step in the evolving digital partnership between the EU and Singapore, enhancing their longstanding trade relationship. By establishing clear, legally binding rules for digital trade, the EUSDTA will foster greater transparency, security, and efficiency in cross-border digital transactions. This agreement not only addresses current challenges in the digital economy, such as data protection and the prevention of unjustified trade barriers, but also opens new opportunities for businesses, particularly SMEs. As the first digital trade deal between the EU and an ASEAN country, the EUSDTA sets a precedent for future region-to-region digital connectivity and positions both parties at the forefront of global digital transformation [52].

Collaborative Mechanism

The EU-Singapore Digital Partnership establishes several collaborative mechanisms to strengthen cooperation across various digital sectors. The EU and Singapore have engaged in various projects under FP7, Horizon 2020 and Horizon Europe based on EU dashboard. Under FP7, there were 25 successful signed collaborative projects out of 447 with 10 participations and 129.1 M € of EU contribution. Under H2020, there were 27 signed grants with 7 participated partners. EU contributed

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[93] Joint Statement on the launch of negotiations for an EU-Singapore digital trade agreement. Available in: https://policy.trade.ec.europa.eu/news/joint-statement-launch-negotiations-eu-singapore-digital-trade-agreement-2023-07-20_en

[94] EU and Singapore conclude negotiations for landmark Digital Trade Agreement. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_3982

[95] EU-Singapore Free Trade Agreement, Investment Protection Agreement and Digital Trade Agreement. Available in: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/singapore/eu-singapore-agreements_en

about 52.78 M €. In addition, under Horizon Europe, there have been 24 collaborative projects with 10 number of participants and EU contribution of 275.1 M €[96]. These previous mechanisms have aimed to facilitate joint actions, foster interoperability, and ensure progress on shared digital goals. Key collaborative mechanisms include:

1 Digital Partnership Council: This annual ministerial-level meeting, co-chaired by representatives from both the EU and Singapore, provides strategic guidance and reviews progress on the partnership's initiatives. It sets the priorities for implementation and ensures that the collaboration remains aligned with mutual objectives. The secretariat for the EU-Singapore Digital Partnership council will be jointly managed by Singapore's Ministry of Trade and Industry, Ministry of Communication and Information, and the European Commission's Directorate-General for Communications Networks, Content and Technology. This informal arrangement ensures coordination of activities on both sides, involving all relevant services and agencies [51][54].

2 A Joint Work Plan & Deliverables: The EU and Singapore will develop joint work plans to guide their cooperation in areas like digital trade, cybersecurity, and infrastructure. These plans build on existing frameworks, such as the EUSFTA 2nd Committees meeting, and ensure coordination without adding bureaucratic burdens [51][54].

3 Stakeholder Engagement: Regular engagement with stakeholders, including businesses, industry experts, and civil society, will be integrated into the partnership. This ensures broad input and collaboration on priority digital issues like AI, data governance, and digital identity. For example, joint digital partnership dialogues with stakeholders. [48][51] For example, matchmaking event, in 2023, EU-Singapore Cluster Matchmaking Event was held from October 30 to November 1 in Singapore, brought together 34 EU delegates from 27 clusters and 5 SMEs across 18 countries to explore business opportunities in sectors like agri-food, healthcare, digital tech, and green tech. Organized by the European Commission and Enterprise Singapore, the event featured B2B matchmaking sessions, site visits, and presentations, fostering collaboration and innovation between EU and Singaporean businesses. Building on the EU-Singapore Free Trade Agreement (EUSFTA) and Digital Partnership, the event facilitated 205 successful business meetings, with participants

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[96] Collaboration with other countries EU-Singapore taken on 29 November 2024. Available in: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/1213b8cd-3ebe-4730-b0f5-fa4e326df2e2/sheet/e1b57f9a-669b-4962-bdb9-0151c523120f/state/analysis

highlighting the potential for strategic partnerships and market expansion in the region's dynamic economy[97].

In addition, in 2024, The EU-Singapore Matchmaking Event, organized by the European Commission in collaboration with Enterprise Singapore and the Singapore Business Federation, will take place on 22-24 October 2024 during the Singapore International Energy Week. The event brought together cluster organizations and SMEs from the EU, non-EU countries in the Single Market Program, and Singapore to promote Cluster-to-Cluster (C2C), Cluster-to-Business (C2B), and Business-to-Business (B2B) collaborations. Key activities include a seminar on EU-Singapore cooperation, site visits, pitching sessions, and matchmaking meetings aimed at fostering partnerships in clean energy, green tech, eMobility, and sustainability. Participants will also attend the Singapore International Energy Week Expo and engage in knowledge exchange to boost cooperation in research, development, and innovation[98].

1 Expert Dialogues and Exchanges: The partnership promotes exchanges of best practices and technical expertise in the field of digital education and training, including digital skills for the workforce, ICT specialists and women. The workshops help align standards and regulatory approaches to facilitate smooth cooperation. [48][51] The list of the example of joint expert dialogues and exchanges are presented in Annex II.

2 Pilot Projects: The partnership encourages joint pilot projects, particularly in areas like digital identity interoperability, cross-border data flows, and cybersecurity and other areas. For example, EUREKA and MSCA in the Horizon 2020 scheme. In addition, in 2024, EU and Singapore ave initiated exploratory discussions regarding Singapore's potential association with Horizon Europe, the EU's research and innovation program[99]. List of sample pilot projects can be seen in Annex II.

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[97] EU-Singapore Matchmaking Event 2023. Available in: https://www.clustercollaboration.eu/content/eu-singapore-matchmaking-event-2023

[99] EU and Singapore open exploratory talks on association to Horizon Europe. Available in: https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/eu-and-singapore-open-exploratory-talks-association-horizon-europe-2024-04-23_en

5.5 POTENTIAL SYNERGIES AND COMMONALITIES BETWEEN SINGAPORE NATIONAL PROGRAMS AND EUROPEAN PROGRAMS

The EU-Singapore Digital Partnership (EUSGDP) and the EU-Singapore Digital Trade Agreement (EUSDTA) create strong synergies with both Singapore's national programs and European initiatives. In 2022, a high-level panel on EU-Singapore Research and Innovation Cooperation: Present and Future Prospects was held at Nanyang Technological University (NTU), Singapore. The panel emphasized the strong EU-Singapore partnership in trade and innovation, highlighting shared goals in modernizing societies sustainably through international collaboration. It provided an overview of 49 potential European partnerships in Horizon Europe Pillar II, Pillar III and cross pillars II & III. For example, in Pillar II - Cluster 1: Innovative Health Initiative, Global Health Partnership, Rare diseases etc; in Cluster 4: High Performance Computing, AI-Data-Robotics, Photonics etc; in Cluster 5: Clean Hydrogen, Clean Energy Transition, etc; in Cluster 6: Climate Neutral, Sustainable & Productive Blue Economy, Safe & Sustainable Food System and others [55].

In detail, there are significance synergies between EU and Singapore, particularly in digital innovation (digital identity and trust technologies), trade facilitation, and sustainability. The detailed information will be explained below:

1. Digital Innovation: The EUSGDP focuses on cooperation in areas such as AI, cybersecurity, and data governance, which aligns with Singapore's Smart Nation and Digital Economy (SNDE) initiatives[100]. Singapore's Singpass digital identity system has become a global leader, with 97% of the population using it to access government and private services securely. Singpass, part of Singapore's National Digital Identity (NDI) initiative, simplifies daily transactions like paying taxes and renewing passports, while offering strong security through two-factor authentication. The system, praised for its convenience and innovation, has inspired other countries to seek collaboration[101] [56].

   These programs mirror the EU's goals under Digital Europe and the 2030 Digital Compass to enhance digital infrastructure, promote secure data flows, and develop trust services like digital signatures. The Digital Europe Program (DIGITAL) is an EU initiative aimed at advancing digital technology for businesses, citizens, and public administrations. With a budget of over €7.9 billion, it supports key areas like supercomputing, artificial intelligence, cybersecurity, and

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[100] Smart Nation and Digital Economy. Available in: https://www.nrf.gov.sg/rie-ecosystem/ecosystem-wide-fis/snde-fis/

[101] Digital Identity Spotlight: Singapore. Available in: https://www.1kosmos.com/identity-management/digital-identity-spotlight-singapore/

advanced digital skills[102]. DIGITAL is aligned with the EU's 2030 Digital Compass goals, focusing on digital transformation across sectors, including semiconductors, through the Chips Act. It complements other EU programs like Horizon Europe and Connecting Europe Facility. The program promotes a Digital Single Market, funds multi-country projects, and upholds digital rights and principles that prioritize security, fairness, and sustainability in the digital age[103].

2. Policy standardisation: Singapore's AI development in policy standards plays a crucial role in establishing a trusted and responsible AI ecosystem. The country has pioneered initiatives like the Model AI Governance Framework[104], which adopts a principles-based, collaborative, and practical approach to AI regulation. This framework balances innovation with risk management, ensuring AI solutions are transparent, accountable, and aligned with ethical standards. Singapore's governance strategy is deeply integrated with its Smart Nation vision, fostering collaboration between government, industry, and academia to drive AI advancements while addressing societal challenges. By contributing to global AI governance discussions and aligning regulations with international standards, Singapore positions itself as a leader in AI policy, ensuring that technological growth benefits both businesses and the wider society responsibly.

3. Trade Facilitation: The EUSDTA supports digital trade by eliminating barriers such as data localization, enhancing e-commerce, and creating frameworks for cross-border transactions. It enables secure data flows, seamless transactions, and protects personal data and intellectual property. The agreement prohibits data localisation, shields consumers from unfair practices, and promotes cooperation, offering more opportunities for SMEs to engage in the digital economy. [51] This complements Singapore's Trade Trust initiative to revolutionize global trade by digitizing cross-border trade documents, such as bills of lading, which are traditionally paper-based. This digital solution enhances efficiency, reduces costs, and lowers fraud risks using blockchain technology to verify document authenticity and ownership[105] and facilitates smoother interactions between businesses in both regions, leveraging Singapore's strategic position in

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[102] The Digital Europe Programme. Available in: https://digital-strategy.ec.europa.eu/en/activities/digital-programme

[103] Europe's Digital Decade: digital targets for 2030. Available in: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en#the-path-to-the-digital-decade

[104] How to address the AI Governance discussion? What can we learn fr learn from Singapor om Singapore's AI str s AI strategy?. Available in: https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=1000&context=caidg

[105] IMDA's Trade Trust transforms cross-border trade through digitalisation. Available in: https://www.imda.gov.sg/resources/blog/blog-articles/2024/01/tradetrust-transforms-cross-border-trade

Southeast Asia and the EU's focus on expanding digital markets through secure and seamless trade.

These efforts align with the EU's broader digital trade strategy, which focuses on promoting e-commerce, electronic contracts, and data protection[106]. By enabling seamless transactions and digital connectivity, the EUSDTA and TradeTrust complement each other, leveraging Singapore's strategic position and the EU's digital market expansion goals. This synergy fosters a secure, efficient environment for businesses, especially SMEs, in both regions, while also facilitating cooperation in areas like e-signatures and data governance [57].

4. Sustainability: Both the EU and Singapore emphasize green digital technologies. Singapore's RIE2025 under Urban Solutions and Sustainability (USS) Funding Initiatives (FIs) aligns with the EU's Green Deal and sustainability targets under the EUSGDP, especially in terms of using digital innovation to drive the green transition. This includes efforts to enhance smart city solutions, energy-efficient infrastructures, and circular economy principles. Under RIE2025, Urban Solutions and Sustainability (USS) In clean energy, Singapore's Research Centres for Clean Energy (ReCCE) and Low-Carbon Energy Research (LCER) initiatives focus on decarbonization and hydrogen technologies [58], aligning with the EU Green Deal's commitment to clean energy transitions and low-carbon alternatives [59]. Both regions are actively pursuing research and innovation on alternative energy sources.

In urban sustainability, Singapore's Green Buildings Innovation Cluster (GBIC) and Cities of Tomorrow programs focus on developing energy-efficient building technologies and creating sustainable, resilient cities. [55] These align with the EU's focus on sustainable urban development and smart cities as part of its Green Deal goals. Singapore's Built Environment Technology Alliance (BETA) mirrors EU efforts to a renovation wave initiative. This initiative targets to improve energy efficiency, reduce energy poverty, and support the construction sector. It targets public and private buildings, with a focus on social housing, schools, and hospitals. The EU will enforce energy performance regulations, explore emissions trading for buildings, and promote innovative financing and digitalization in the construction industry [59].

For climate resilience, Singapore's initiatives like the Climate Impact Science Research Program (CISR) and Marine Climate Change Science (MCCS) focus on climate adaptation strategies, including sea-level rise and marine protection [58]. These complement the EU's Green Deal Missions "Adaptation to climate change and societal transformation" drives climate change

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[106] Digital trade. Available in: https://policy.trade.ec.europa.eu/help-exporters-and-importers/accessing-markets/goods-and-services/digital-trade_en

adaptation involving regions, citizens, and stakeholders. Partnerships with industry and Member States will support innovation in areas like batteries, clean hydrogen, and low-carbon steel. The European Institute of Innovation and Technology will promote collaboration on climate change adaptation [59].

Additionally, Singapore also just released Singapore Green Plan 2030 and funding initiatives[107] in 2021, aiming at developing urban sustainability in Singapore's Cities of Tomorrow (CoT)[108] R&D program and waste-to-energy technologies, with Singapore's Closing the Resource Loop and Waste-to-Energy (WTE) initiatives[109].and the EU's climate pact will build on existing citizens' dialogues and assemblies across the EU, as well as social dialogue committees, to engage regional and local communities, including energy communities. The European Urban Initiative will assist cities in developing sustainable urban strategies, while the EU Covenant of Mayors will remain central in supporting cities and regions committed to ambitious climate and energy policies [59]. Both regions also emphasize the importance of urban sustainable development, novel and promising technologies, improving process efficiency; and/or reducing the energy consumption in urban areas.

In conclusion, the EU-Singapore Digital Partnership (EUSGDP) and Digital Trade Agreement (EUSDTA) create synergies in digital innovation, trade facilitation, and sustainability. Both regions align in areas like AI, cybersecurity, and secure data flows, with Singapore's Singpass and the EU's Digital Europe Program leading digital transformation. The EUSDTA complements Singapore's TradeTrust by digitizing cross-border trade, enhancing efficiency, and reducing fraud. On sustainability, Singapore's Green Plan 2030 and RIE2025 initiatives align with the EU's Green Deal, focusing on clean energy, urban sustainability, and climate resilience. These partnerships drive collaboration in digital and green technologies, boosting innovation in both regions.

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[107] Funding for Communities, Schools, Businesses. Available in: https://www.greenplan.gov.sg/funding/

[108] Cities of Tomorrow (CoT) R&D Programme. Available in: https://www1.bca.gov.sg/buildsg/buildsg-transformation-fund/cities-of-tomorrow-cot-r-d-programme

[109] Waste-to-Energy (WTE) Test-bedding and Demonstration Funding Initiative. Available in: https://www.nea.gov.sg/programmes-grants/grants-and-awards/research-innovation-and-enterprise-funding-initiatives/wte-testbed-demo-initiative

6 OVERVIEW OF ICT RESEARCH AND DEVELOPMENT (R&D) INITIATIVES IN INDIA

6.1 INTRODUCTION OF ICT R&D PROGRAM

India, the world's fifth-largest economy, is at the forefront of global challenges such as digitalization, space exploration, vaccine development, and the transition to zero emissions. Despite its significant role on the global stage, India's research and development (R&D) expenditure remains less than one percent of its GDP, considerably lower than the world average of about 2.2%. This gap highlights a key area for improvement in India's aspirations to become a global leader in innovation.

While developed countries like the United States and South Korea invest heavily in R&D, with percentages closer to 3-4% of GDP, India is striving to boost its investment. Key sectors, including space exploration with missions like Chandrayaan, green energy initiatives like hydrogen research, and advancements in healthcare and vaccines, demonstrate India's strong focus on strategic R&D areas. However, the disparity in spending underscores the need for stronger policies and increased collaboration between government, academia, and industry to unlock India's full potential. A major hurdle is that India's R&D spending is not predominantly driven by the private sector, like global R&D leaders such as the U.S. and South Korea, where the private sector plays a larger role [60].

The Gross Expenditure on Research and Development (GERD) is a crucial indicator used to measure the overall state of R&D in a country. It includes expenditure by business enterprises, higher educational institutions (HEIs), government, and not-for-profit organizations on R&D activities. In 2022, India's GERD, including its corporate sector's contribution, lagged behind many key global economies. While the corporate sector is a major contributor to GERD in countries like the United States, South Korea, and China, India's corporate contribution to GERD has remained constant for the past five years. This suggests that India has not seen the same level of private sector investment in R&D as other rapidly advancing nations, and the lack of growth in corporate R&D expenditure could be one of the reasons for the slow progression in overall national R&D investment. The low participation of corporates in Indian R&D has indeed been recognized as a major challenge in the country's innovation landscape. According to the Economic Survey of India, one of the primary reasons for India's low GERD, especially in comparison to the top 10 global economies, is the disproportionately lower contribution from the business sector (Figure 11). This comparison underscores the need for India to foster greater private sector involvement in R&D and enhance its overall investment to remain competitive on the global stage [61].
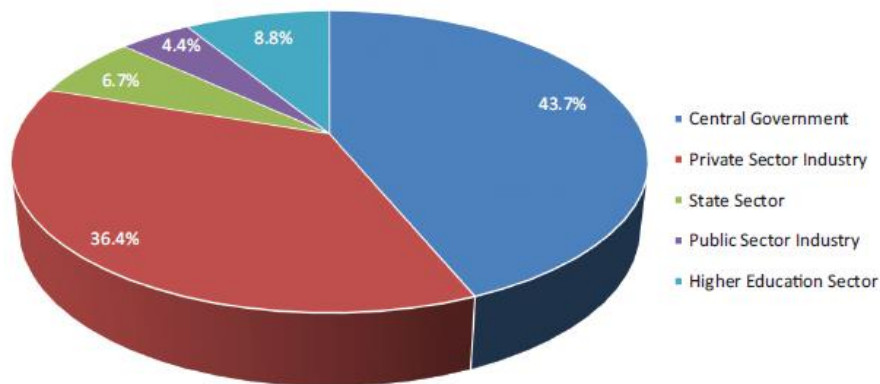
Figure 11: National R&D expenditure in 2020-21 (Adapted from R&D Statistics at a glance 2022-23 [60]).

India has shown remarkable progress in innovation rankings, rising from 81st place in 2015 to 40th in the Global Innovation Index (GII) in 2023. According to the WIPO Indicator Report 2023, India is ranked 6th in both Resident and Non-Resident Patent Filing activity worldwide. India has improved its ranking to 60th position in 2023 from 79th position in 2019, according to the Network Readiness Index (NRI) 2023 report. The NRI is a prominent global index that assesses the application and impact of information and communication technology (ICT) in 134 economies worldwide [63].

India's Information and Communication Technology (ICT) sector has grown into one of the most crucial pillars of the country's economy, driving digitalization, innovation, and global competitiveness. The ICT sector plays a vital role in India's broader efforts to strengthen its research and development (R&D) landscape, aligning with national initiatives to boost investment in emerging technologies. However, despite its potential, India's R&D investment in ICT and other key industries remains relatively low when compared to global leaders. In the ICT sector, Indian firms primarily focus on software services, with limited investment in hardware R&D, resulting in lower R&D intensity compared to international competitors. For example, India's ICT sector saw an R&D expenditure rate of around 0.87% of turnover in recent years, which is significantly lower than sectors like pharmaceuticals and defence, where the rate is higher [60].

In addition, driven by technological innovation and a strong regulatory framework, India's digital payment landscape, Unified Payments Interface (UPI) has undergone a remarkable transformation as the a real-time payment system launched by the National Payments Corporation of India (NPCI) in 2016. UPI has become a global benchmark for digital payments, processing over 15 billion transactions per month as of 2024[110]. Its open architecture, seamless interoperability, and zero

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[110] The organisation of digital payments in India-lessons from the Unified Payments Interface (UPI). Available in: https://www.bis.org/publ/bppdf/bispap152_e_rh.pdf

transaction costs have made it a dominant force in India's financial ecosystem, enabling instant peer-to-peer and merchant transactions. By integrating mobile-based payments, QR codes, and credit lines while maintaining strict data protection regulations, UPI has significantly boosted financial inclusion. Its expansion into international markets further highlights its role in shaping the future of digital payments worldwide.

6.2 RESEARCH AND INNOVATION PRIORITIES

The Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) was established in August 2018 as a high-level advisory body that provides strategic direction on science, technology, and innovation (STI) matters. Its primary role is to assess India's progress in these fields, identify challenges, and suggest interventions that align with national priorities. The council plays a vital role in developing a forward-looking roadmap for STI and advising the Prime Minister on key policies and strategies [64].

PM-STIAC's responsibilities include ensuring collaboration and coordination between different ministries, scientific departments, and agencies. It also focuses on fostering innovation ecosystems by encouraging public-private partnerships, promoting technology-driven entrepreneurship, and driving the implementation of major S&T missions. These missions aim to address critical areas aligned with national interests and long-term economic growth.

The council has approved several important missions, including:

- Deep Ocean Exploration Mission – To explore underwater resources and enhance India's capabilities in ocean sciences.

- AI Mission – Focusing on Artificial Intelligence to solve complex societal problems.

- National Quantum Mission (NQM) – For advancing quantum computing and related technologies.

- Waste to Wealth Mission – Transforming waste into valuable resources.

- National One Health Mission – Addressing health challenges at the human-animal-environment interface.

- Electric Vehicle Mission – Promoting electric mobility in India.

- AGNIi Mission – Accelerating growth of New India's innovations by supporting startups and innovators.

Other significant missions include the Natural Language Translation Mission, National Biodiversity Mission, Bio-Science for Human Health Mission, and Mission on Science & Technology for

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Sustainable Livelihood Systems. Each of these is designed to leverage science and technology to address pressing national and global challenges, driving innovation while ensuring sustainability [64].

The AI Mission focuses on sectors like healthcare, education, agriculture, smart cities, mobility, and infrastructure. It emphasizes extensive collaboration between academia and industry to build core research capabilities in AI across India. The mission also seeks to foster international partnerships to push the frontiers of AI technology, create new knowledge, and develop impactful applications. In alignment with this mission, the Government of India initiated the National Program for AI in the 2018-19 budget, which was mandated to the NITI Aayog. This program was aimed at guiding research and development in emerging AI technologies, ensuring India's leadership in AI innovation. Additionally, the launch of INDIAai, India's National AI Portal, serves as a one-stop platform for AI-related developments, resources, and information, supporting AI growth across the country [65][66][67].

The National Quantum Misson (NQM) of the PM-STIAC is designed to push India's capabilities in quantum technology, addressing some of the most significant challenges in science and technology today. This mission focuses on gaining a deep understanding and control of quantum mechanical systems, essential for breakthroughs in various areas, including national security. To keep up with global advancements, the Indian government has prioritized quantum technology. On April 19, 2023, a total outlay of Rs 6003.65 Crore for a period of eight years was approved. NQM, led by the Department of Science and Technology (DST), aims to advance India's quantum technology landscape through a "hub-spoke-spike" model. This involves creating Centres of Excellence (CoEs), consortia, and individual scientist-led projects. The mission is overseen by a Mission Governing Board (MGB) chaired by Dr. Ajai Chowdhry and supported by the Mission Technology Research Council (MTRC), chaired by the Principal Scientific Adviser (PSA) to the Government of India. NQM will establish four Thematic Hubs (T-Hubs) in key areas: Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices. A Call for Pre-Proposals for these T-Hubs was issued in January 2024 [68][69][70][71].

6.3 IDENTIFICATION OF NATIONAL FUNDING MECHANISM

Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC)

The PM – STIAC plays a crucial role in fostering India's research and innovation landscape by overseeing several ecosystem initiatives aimed at enhancing collaboration, capacity building, and innovation in the country. Key PM-STIAC ecosystem Initiatives include [64]:

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1. **Anusandhan National Research Foundation (ANRF):** This initiative focuses on improving research funding, particularly in higher education institutions (HEIs), and strengthening collaboration between academia, industry, and government to boost India's research output;

2. **National Technology Clusters:** Aimed at creating regional hubs for scientific and technological innovation, these clusters encourage cross-disciplinary collaboration and facilitate public-private partnerships. They serve as platforms to develop and test new technologies across sectors;

3. **I-STEM Portal:** The Indian Science, Technology, and Engineering Facilities Map (I-STEM) is a comprehensive national platform designed to provide access to research facilities, tools, and instruments across the country, promoting more efficient use of resources;

4. **AGNIi (Accelerating Growth of New India's Innovations) Mission:** AGNIi supports the scaling and commercialization of innovations developed by Indian startups, offering them access to industry partners and government-backed networks;

5. **Waste to Wealth Mission:** This initiative focuses on converting waste materials into valuable resources, promoting sustainability and innovation in waste management;

6. **G20 Collaboration:** India has engaged globally through initiatives like the G20 CSAR (Collaboration in Science and Research), facilitating international research collaboration to address shared challenges such as climate change, energy, and health.

The Government of India has introduced several initiatives to boost investment in research and development (R&D) and strengthen the country's research ecosystem. A key development is the Anusandhan National Research Foundation (ANRF) Act, 2023, which underscores the government's commitment to making R&D a central pillar of national progress. The Anusandhan National Research Foundation Act, 2023, outlines an estimated cost of ₹50,000 crore for the period 2023-2028 [72].

Another significant policy is the *National Deep Tech Startup Policy (NDTSP)*, which focuses on overcoming challenges faced by deep tech startups. This policy aims to complement existing *Startup India* programs by creating a supportive ecosystem that allows deep tech startups to thrive. It includes targeted interventions that address the unique challenges these startups face, such as high capital requirements, long gestation periods, and the need for cutting-edge R&D. Together, these policies are intended to strengthen India's position as a leader in science, technology, and innovation [73]

Ministry of Electronics and Information Technology (MeitY)

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The Ministry of Electronics and Information Technology (MeitY) is the central authority in India responsible for shaping and implementing policies related to Information and Communication Technology (ICT). It plays a key role in publishing reports, offering guidelines, and sharing updates on research and development initiatives in the sector. MeitY envisions the e-development of India as a driving force for the country's transformation into a developed nation and an empowered society.

The Ministry's mission is to advance e-governance initiatives that empower citizens, foster inclusive and sustainable growth in the electronics, IT, and IT-enabled services (ITeS) industries, and strengthen India's involvement in global Internet governance. MeitY's approach includes the development of human resources, the promotion of research, innovation, and R&D, improving efficiency through digital services, and ensuring a secure cyberspace. The Ministry aims to support the creation of a robust digital infrastructure for public services, stimulate growth in electronics manufacturing and the IT sector, and foster research and development in cutting-edge ICT areas. Additionally, it seeks to promote digital skills development, secure the nation's cyberspace, and ensure that the benefits of technology contribute to more inclusive growth. Moreover, MeitY actively works to increase India's presence and influence on international platforms of Internet governance [73].

The National Informatics Centre (NIC), established in 1976, operates under the Ministry of Electronics and Information Technology (MeitY) as the technology partner of the Government of India. NIC plays a crucial role in providing technology-driven solutions to both Central and State Governments, helping to design and develop IT systems that enhance governance and public services. In addition to offering ICT infrastructure to the government, NIC also explores and advises on the use of emerging technologies, ensuring that India remains at the forefront of digital transformation in governance [74].

The National Institute of Electronics and Information Technology (NIELIT), operating under the administrative control of the Ministry of Electronics & Information Technology (MeitY), Government of India, is dedicated to human resource development in the fields of Information, Electronics, and Communications Technology (IECT). NIELIT has proven its expertise by undertaking research and development projects, offering consultancy services, and executing turnkey projects in areas such as office automation, software development, and website creation. Additionally, NIELIT serves as the nodal agency for the Data Digitization of the population in 15 states and 2 Union Territories for the creation of the National Population Register (NPR) on behalf of the Registrar General of India (RGI) [75].

The Centre for Development of Advanced Computing (C-DAC) is the leading R&D organization under the Ministry of Electronics and Information Technology (MeitY), dedicated to advancing

research and innovation in information technology, electronics, and related areas. Established in response to emerging opportunities and national priorities, C-DAC has grown into a vital institution for strengthening India's technological capabilities. It plays a pivotal role in addressing global trends and market demands by developing cutting-edge technologies and solutions in areas such as high-performance computing, artificial intelligence, cybersecurity, and more. C-DAC works in close collaboration with MeitY to implement key government policies, strategic initiatives, and digital transformation programs, driving the nation's vision for technological self-reliance. As a hub of high-end research and development, C-DAC leverages its expertise, talent, and resources to innovate and deploy advanced IT products and solutions for various sectors, including healthcare, education, agriculture, and governance. By collaborating with funding agencies, industry partners, and other stakeholders, C-DAC continues to contribute to India's progress in the global technology landscape, ensuring the nation's competitiveness and leadership in the digital age [76].

MeitY research and development group includes several divisions, namely R&D in Electronics, R&D in Information technology, Schemes & Policies, R&D in Convergence, Communications & Broadband Technologies and Strategic Electronics (R& in CC&BT), Startup, innovation & IPR group, PRIME (Project Review and Information Management Electronics System), and R&D in Cyber Security [77].

- **R&D in Information Technology**

The R&D in Information Technology plays a pivotal role in the digital transformation of India, contributing significantly to both economic growth and employment. Initially driven by software development services, India's IT sector has evolved into a global hub for R&D, with multinational companies and home-grown IT giants establishing innovation centers in the country. The government's initiatives like **Digital India**, **Make in India**, and **Aatmanirbhar Bharat** emphasize the importance of IT-driven innovation for self-reliance and global leadership.

The major focus areas of R&D in Information Technology revolve around **emerging technologies** that have the potential to reshape industries and society. These include: Quantum Technology; Blockchain based solutions; Non-financial Web3 Applications; Perception and Cognitive Engineering; AR/VR/ Metaverse; Digital Twin; Multisensory Immersion; Deepfake; Application of Artificial Intelligence (AI); Artificial Wisdom; Edge computing; Industry 5.00++, Society 5.00++; Big Data Analytic; Green Computing; Digital Preservation; Free and Open Source Software [77].

- **R&D in Convergence, Communications & Broadband Technologies**

The R&D in Convergence, Communications & Broadband Technologies (CC&BT) and Strategic Electronics promotes research, development, and innovation in next-generation communication

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technologies and strategic electronics, which are fundamental technologies for economic growth, infrastructure modernization, and driving digital transformation across various sectors.

R&D in CC& BT division focus on thrust areas like Next Generation Networks (NGN) and Communication Technologies Massive MIMO, Software Defined Radio (SDR), Software Defined Networks (SDN), Network Function Virtualization (NFV), Cognitive Radio, Heterogeneous Wireless Networks, 5G and beyond, 6G, Next Generation Mobile Technologies, Broadband Wireless Technologies, Green Communications, Quantum Communication, Vehicular Communication, Cyber Physical System, Artificial Intelligence enabled Communication, Big Data Analytics and Internet of Things (IoT) for societal applications, Machine to Machine (M2M) Communication and Strategic Electronics, with applications in both Civil and Defence domains, ICT applications in strategic sector; Broadband Wireless Access Technologies; Visible Light Communication (VLC), Vehicular ad-hoc Networks (VANET); IP based products/services; Electro-magnetic wave applications; High power RF/Microwave tubes; Terahertz (THz) wireless systems; Radar Systems, etc.

The activities in the R&D projects are focused on creating intellectual properties that lead to patents, designing innovative algorithms for product development, and developing prototypes to advance technological solutions. The outcomes of these projects will significantly contribute to achieving the goals set for the 'Make in India' and 'Digital India' initiatives of the Government of India [77].

- **R&D in Cyber Security**

As cyber threats grow in scale and sophistication, India recognizes the urgent need to build a robust research base for technology and product development, including testing, evaluation, certification frameworks, and standardization. MeitY is actively collaborating with academia, R&D labs, and industry stakeholders to address the nation's security challenges across various cyber domains. The Cyber Security Thrust area of Research include following domains: Embedded Systems and IoT Security; Cyber Forensics; Mobile Device Security; Threat Intelligence and AI/ML based Threat Modelling; Network and System Security; Critical Infrastructure/Industrial Security; Detection & Mitigation of Malware; Risk Assessment & Mitigation [77].

- **Project Review and Information Management Electronics System (PRIME)**

The Project Review and Information Management Electronics System (PRIME) is a web-based system designed to manage the entire life cycle of funding for R&D projects. This includes online submission of project proposals for funds, review and recommendations, and archival. PRIME aims to make the funding process paperless and increase transparency. The system provides easy access to information and a user-friendly experience for all users. It includes built-in communication

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features and allows easy tracking of proposal status, providing researchers with timely updates and reducing unnecessary delays [77].

Ministry of Communications

The Department of Telecommunications (DoT), part of the Ministry of Communications in the Government of India, is responsible for policy formulation, licensing, and coordination of telecommunications services in India, including development and regulation of infrastructure and standards. Under DoT, the Standards-R&D-Innovation division was established in 2019 to take forward the objectives of the National Digital Communications Policy (NDCP) 2018, with strategic roles such as promoting research and development (R&D), standardization, and innovation in Digital Communications Technologies (DCTs) to position India as a leader in the global communications technology landscape. The Telecom Startups-MSMEs Mission (TSuM) is an institutional mechanism aimed at fostering R&D and supporting Startups and Micro, Small, and Medium Enterprises (MSMEs) in the telecommunications sector. The mission recognizes that Startups and MSMEs are crucial for driving indigenous technology development, particularly in the telecom industry, and plays a pivotal role in positioning India as a leader in homegrown telecommunications technologies [78].

The Telecom Design Collaboration Sprint, a novel initiative by the Department of Telecommunications (DoT), brought together a diverse group of startups, MSMEs, academia, and research institutions to collaborate on cutting-edge telecom innovations. Hosted at the **International Institute of Information Technology in** Bangalore, this sprint focused on developing a comprehensive 5G telecom stack and setting the groundwork for future advancements like 6G. Leading startups and MSMEs specializing in Radio Access Networks (RAN) and core telecom ecosystems, along with prestigious institutions such as several institutes, such as Indian Institutes of Technology of Madras and Delhi, and Centre for Development of Telematics C-DOT [79].

6.4 PRESENT COLLABORATION WITH THE EU

Roadmap EU-India Collaboration

The digital collaboration between the European Union (EU) and India has evolved significantly over the past few decades, driven by mutual interests in technology, innovation, economic growth, and addressing global digital challenges. This collaboration encompasses a wide range of initiatives, agreements, and partnerships aimed at fostering a robust digital ecosystem, enhancing digital governance, and promoting sustainable development. Below is a comprehensive overview of the EU-India digital collaboration:

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1. Following the 1994 EU-India Cooperation Agreement, both parties developed a multi-layered institutional framework, upgrading their relationship to a "Strategic Partnership" in 2004. In 2007, negotiations began for a broad-based bilateral trade and investment agreement, but after 15 rounds, the talks stalled in 2013 due to differing ambitions between the two sides [80].

2. In 2021, EU and Indian leaders agreed to resume negotiations for a "balanced, ambitious, comprehensive, and mutually beneficial" trade agreement. They also initiated separate talks on an investment protection agreement and a geographical indications (GIs) agreement. The negotiations aim to address long-standing market access issues, and both sides are now actively engaged in these discussions [81][82].

3. In 2022, the launch of the EU-India Trade and Technology Council. This strategic coordination mechanism aims to address challenges at the intersection of trade, technology, and security, deepening cooperation between the EU and India. The Council will guide political decisions, coordinate technical work, and ensure implementation, reflecting the need for strategic engagement due to rapid geopolitical changes. The EU-India Trade and Technology Council (TTC) will guide cooperation on security, green and digital technologies, and resilient supply chains. TTC will focus on the preparation of the three working groups focusing on strategic technologies like AI and semiconductors, green energy innovations, and trade and supply chain resilience. These efforts will support ongoing trade and investment talks, with potential for further digital investment discussions[111].

   In addition, the European Parliament encouraged negotiators to secure a comprehensive and mutually beneficial free trade agreement with India, prioritizing sustainable growth, reducing inequalities, and supporting digital and green transitions. Parliament urged that core International Labour Organization (ILO) principles be included, and that the agreement aligns with the European Green Deal, the "farm to fork" strategy, and COP26 goals. Additionally, it welcomed the separate negotiations for an investment protection agreement, calling for the establishment of both a multilateral investment court and a specific EU-India investment court [83][84].

4. The EU-India Trade and Technology Council (TTC) held its first meeting in May 2023, focusing on deepening strategic cooperation in trade, technology, and security. In this meeting, three working groups to address key areas: digital technologies and governance, green energy and sustainability, and trade and resilient value chains were established. Key initiatives include

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[111] EU-India: new Trade and Technology Council to lead on digital transformation, green technologies and trade. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_596

collaboration on quantum computing, AI, semiconductors, renewable hydrogen, and digital public infrastructure. Both sides aim to foster innovation, address global challenges, and align with climate and sustainable development goals, with a follow-up meeting scheduled to assess progress.

Additionally, in November 2023, the signing of a Memorandum of Understanding (MoU) on semiconductors aims to deepen cooperation on the semiconductor ecosystem under the EU-India Trade and Technology Council (TTC). The agreement focuses on strengthening resilience in semiconductor supply chains, promoting research and development, enhancing skills, and ensuring transparency in public subsidies. Both sides will share best practices, collaborate on innovation, and encourage stakeholder engagement, including industry and academic institutions [85].

5. In 2024, the seventh to ninth round of EU-India Free Trade Agreement (FTA) negotiations took place and a new working method was introduced, allowing Chief Negotiators to drive discussions on seven key chapters. While progress was made, particularly on Intellectual Property Rights, significant divergences remain on many issues. Specific topics discussed included Energy and Raw Materials, Anti-Fraud, and Trade and Sustainable Development. In addition, Digital Trade was addressed, reviewing key issues like data flows, privacy, cybersecurity, and open internet access, leading to constructive discussions [86][87][88].

In summary, the digital partnership between the European Union and India has developed into a significant strategic alliance, focused on shared objectives in technology, economic growth, and global digital governance. Beginning with the EU-India Cooperation Agreement in 1994 and culminating in the establishment of the Trade and Technology Council in 2022, both sides have consistently worked toward strengthening their digital infrastructures, promoting innovation, and enhancing supply chain resilience. Key areas of cooperation include artificial intelligence, semiconductors, and digital governance, all aimed at driving sustainable growth and addressing global challenges. As negotiations progress on critical trade and digital matters, this partnership is set to deepen, advancing mutual interests in security, prosperity, and sustainable development in a digitally interconnected world.

Collaborative Mechanism

The chapter delves into the collaborative mechanisms that underpin the EU-India digital partnership. It outlines how both parties have established structured frameworks to facilitate cooperation, ensuring a coordinated approach to addressing shared challenges faced in the digital era. These mechanisms, such as the Trade and Technology Council and dedicated working groups, serve as the foundation for advancing mutual objectives, particularly in the digital sphere. The collaborative

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framework between the European Union (EU) and India is rooted in strategic cooperation to address shared challenges in areas like trade, technology, and governance. The EU and India have engaged in various projects under FP7, Horizon 2020 and Horizon Europe based on EU dashboard. Under FP7, there were 170 successful signed collaborative projects out of 2767 with 157 participants and 510. M € of EU contribution. Under H2020, there were 85 signed grants with 141 participated partners. EU contributed about 563.6 M €. In addition, under Horizon Europe, there have been 42 collaborative projects out of 937 with 49 number of participants and EU contribution of 184.4 M €[112].

The collaborative mechanisms between the EU and India encompass a variety of frameworks designed to strengthen their strategic partnership across key areas. Here are the main types:

1. Working Groups:

Established in 2022, TTC coordinated political and technical efforts to advance cooperation in digital technologies, green energy, and trade resilience. It focuses on aligning policies and fostering innovation in 3 working Groups, they are:

- Working Group 1 on Strategic Technologies, Digital Governance and Digital Connectivity has outlined key priorities for collaboration between India and the European Union in the first meeting taking place on May 3, 2023, in a hybrid format. It was co-chaired by the Secretary of MeitY and the Director General of DG CONNECT (EC). Both sides will engage in Quantum and High-Performance Computing R&D to address global challenges like climate change and bio-informatics, while also coordinating within the Global Partnership on Artificial Intelligence (GPAI) on responsible AI [63]. They concluded a Memorandum of Understanding on the strategic semiconductor sector by November 2023 [85], work on bridging the digital skills gap, and explore mutual recognition of certifications. Cooperation will also focus on promoting interoperable IT and telecom standards, enhancing Digital Public Infrastructure (DPI) to support inclusive digital economies, and advancing secure, privacy-preserving solutions for developing countries. In line with their environmental commitments, both regions plan to invest in clean technologies and innovation to meet net-zero emissions and reverse biodiversity loss by 2030.

- Working Group 2 on Green and Clean Energy Technologies will focus on Renewable and Low Carbon Hydrogen, Electric Vehicle Batteries, and Standards. They will collaborate on wastewater treatment, waste-to-energy projects, and address marine plastic pollution. The

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partnership will also promote battery circularity, raw material recovery, and develop interoperable standards to drive innovation, sustainability, and support climate goals.

The 2nd Ministerial Meeting of the India-EU Trade & Technology Council (TTC) Working Group on Green and Clean Energy Technologies, held on 24 November 2023, focused on future collaboration in clean energy. Both sides presented roadmaps addressing technological gaps and discussed solutions in areas like waste-to-green hydrogen, battery recycling, marine plastic litter, and wastewater management. They also explored organizing a matchmaking event between Indian and European start-ups for collaboration in battery recycling and decentralized waste-to-energy projects. Discussions included formalizing cooperation through agreements on research, innovation, financing, and intellectual property rights[113].

- Working Group 3 on Trade, Investment and Resilient Value Chains will focus on deepening cooperation in four key areas: (1) establishing principles for resilient value chains and targeting specific supply chains of mutual interest, (2) resolving market access and trade barriers, (3) sharing information on foreign direct investment screening mechanisms, and (4) addressing multilateral trade issues, particularly in relation to the World Trade Organization. Both sides will also work on issues related to carbon border measures.[114]

In addition, In G20 meeting, India (represented by the Ministry of Electronics and Information Technology (MeitY)) led the Digital Economy Working Group (DEWG). The group focused on three priority areas: Digital Public Infrastructure (DPI), Security in the Digital Economy and Digital Skilling through NASSCOM's FutureSkills to foster a skilled workforce in AI, cloud computing, cybersecurity, and other emerging technologies to meet growing industry demands[115]. Four DEWG meetings were held in Lucknow, Hyderabad, Pune, and Bengaluru, culminating in the Digital Economy Ministers' Meeting (DEMM) in August 2023. Key achievements include the adoption of an Outcome Document addressing frameworks for DPI, the One Future Alliance (OFA) for financing DPI in low- and middle-income countries (LMICs), and various initiatives to enhance digital skills and cybersecurity awareness [63].

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[113] India - EU TTC Working Group 2 (WG2) on "Green & Clean Energy Technologies" in the tab Second Ministerial Meeting of India-EU TTC. Available in: https://www.psa.gov.in/india-eu-ttc

[114] India – EU Joint Statement 1st Meeting of the Trade and Technology Council. Available in: https://www.mea.gov.in/bilateral-documents.htm?dtl/36553/India__EU_Joint_Statement_1st_Meeting_of_the_Trade_and_Technology_Council

[115] FUTURE SKILLING DIGITAL ECONOMY. Available in: https://skillsip.nsdcindia.org/sites/default/files/kps-document/NASSCOM%20future-skilling-for-the-digital-economy%202020%20%281%29_0.pdf

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2.   Joint Workshop/Seminar/Conference:

The EU and India engage in co-organising events such as workshop/seminar/conference, particularly in emerging technologies like EU-India electric vehicle battery recycling technologies exchange, India - EU Connectivity Conference, EU-India Joint Researchers Workshop in Semiconductor ecosystem, its supply chain and innovation and more These collaborations are aimed at addressing global challenges, including climate change, health, and digital transformation. Table 12 is the list of examples of open call and past events:

Table 12: List of examples of open call and past events for joint workshop/seminar/conference.

Events (Link)	Areas of Interest	Short Description
Open Tender		
EU & India Electric Vehicle Battery Recycling Technologies Exchange 2024 Link	Electric Vehicle Battery Recycling Technologies	The Delegation of the European Union to India, in partnership with the Office of the Principal Scientific Adviser (O/o PSA) to the Government of India, is inviting expressions of interest from EU-based start-ups and SMEs in Electric Vehicle Battery Recycling Technologies. Selected ventures will pitch at a matchmaking event under the EU-India Trade and Technology Council (TTC), with winners receiving an exploration trip to India. This initiative aligns with a similar effort in India, where Indian start-ups will also participate. Six start-ups will be chosen to pitch, with three receiving financial support to visit battery recycling facilities and stakeholders in India
Past events		
The India-EU Trade & Technology Council (TTC) Working Group 2 (WG2) on Green & Clean Energy Technologies Link	Waste-to-green hydrogen, marine plastic litter, wastewater treatment, e-mobility, battery recycling, charging infrastructure, and standards.	The event, organized by the Office of the Principal Scientific Adviser and hosted by the Ministry of New and Renewable Energy, focused on areas such as waste-to-green hydrogen, marine plastic litter, wastewater treatment, e-mobility, battery recycling, charging infrastructure, and standards. Key outcomes included identifying collaboration opportunities on hydrogen safety, plastic waste management, battery recycling, wireless charging, and co-developing standards and practices for green energy technologies.
India - EU Connectivity Conference (June 01-02, 2023) Link	Digital, energy, and transport connectivity	The event, inaugurated by Meghalaya's Chief Minister and India's Minister of State for External Affairs, focused on enhancing interstate and cross-border connectivity. Discussions emphasized addressing project bottlenecks and promoting localized, off-grid energy solutions. A study of EU-driven projects will help identify joint implementation opportunities.
First EU-India Joint Researchers Workshop – October 9th Link	Semiconductor ecosystem, its supply chain and innovation	This initiative aims to enhance bilateral cooperation in trade, technology, and innovation. On November 23, 2023, the EU and India finalized a Memorandum of Understanding on deepening collaboration in the semiconductor ecosystem. The workshop focused on topics like "More than Moore" functionalities, heterogeneous integration, sustainable manufacturing, and IC & system design, featuring policy and industry sessions with key

		representatives from the European Commission and India's Semiconductor Mission.
EU and India to convene high-level regional experts to discuss how to combat exploitation of online spaces by extremist actors Link	Terrorist Content Online (TCO) Regulation Digital Services Act	The EU, in collaboration with India's Ministry of External Affairs and the Global Counter-Terrorism Council, is hosting a regional conference on August 21-22, 2024, to address the challenges of online radicalization. The event gathers experts from India, Bangladesh, Maldives, Sri Lanka, and several European nations. It aims to enhance counter-terrorism cooperation in the Indo-Pacific region and explore strategies to combat online extremism. The conference will highlight the EU's efforts, such as its Terrorist Content Online (TCO) Regulation and Digital Services Act, and focus on strengthening partnerships between the EU, India, and neighboring countries in combating digital extremism.

3.   Joint Research & Development (R&D) Initiatives:

The EU-India Joint Research and Development (R&D) initiatives are aimed at strengthening collaboration in key areas of mutual interest, fostering innovation, and addressing global challenges. These initiatives span various sectors such as science, technology, clean energy, digital technologies, and sustainable development. Some key examples of open and past call between EU and India for joint Research & Development (R&D) Initiatives can be found in Annex II.

4.   High-Level Dialogues:

High-Level Dialogues between the EU and India are a key component of their strategic partnership, aimed at enhancing cooperation across multiple sectors. These dialogues bring together senior officials, policymakers, and experts from both sides to discuss and coordinate efforts in areas of mutual interest. Key High-Level Dialogues shown in Table 13 include:

Table 13: List of examples of open call and past events for joint workshop/seminar/conference.

Events (Link)	Areas of Interest	Short Description
India-EU Joint Committee on S&T Cooperation Sets Strategic Agenda for 2025-27 Link	Green energy, marine plastic litter, battery recycling, hydrogen technologies, wastewater treatment, and E-mobility	The 14th EU-India Joint Steering Committee on Science and Technology Cooperation, co-chaired by the European Commission and India's Department of Science and Technology, focused on deepening their 24-year research partnership. Key outcomes included the renewal of the EU-India S&T Agreement (2025-2030) and ongoing collaboration through the EU-India Trade and Technology Council, targeting areas like green energy, hydrogen technologies, and E-mobility. Both sides emphasized emerging fields such as personalized medicine and biotechnology. The committee celebrated India's participation in Horizon projects and discussed improving cooperation frameworks, researcher mobility, and gender equality. Additionally, Indian battery-recycling startups were offered a market exploration trip to the EU under the TTC initiative, highlighting growing green tech collaboration.

EU-India advance cooperation on CBAM Link	Carbon markets, energy efficiency, and renewable energy cooperation, digital economy taxation	Director-General Gerassimos Thomas led a mission to New Delhi to engage with Indian government officials and industry leaders on tax, customs, and the EU Carbon Border Adjustment Mechanism (CBAM). The discussions focused on CBAM's environmental goals, India's decarbonization plans, and mutual efforts to improve its implementation, especially for MSMEs. Talks also covered carbon markets, energy efficiency, and renewable energy cooperation. Additionally, tax matters like the Two-Pillar Solution for digital economy taxation were discussed, along with reinforcing customs cooperation, particularly on cross-border e-commerce and designer drug precursors. Meetings with industry stakeholders provided insights into CBAM challenges and opportunities.
EU-India: Joint Press Release on Fourth Strategic Partnership review meeting in New Delhi Link	Climate, clean energy, trade, mobility, digital issues, and Free Trade Agreement	India and the EU held their fourth Strategic Partnership Review Meeting on May 8, 2023, in New Delhi, led by India's Secretary (West) Sanjay Verma and the EU's Deputy Secretary General Helena König. They reviewed progress on their "Roadmap to 2025" and discussed cooperation in areas such as human rights, connectivity, and global security, including Ukraine. Both sides emphasized the importance of multilateral collaboration, condemned terrorism, and committed to strengthening their partnership across all sectors.

5. Global Initiatives:

In 2020, during the G20, India actively participated in discussions on ICT issues, focusing on emerging technologies, security, data privacy, and digital inclusion. At the G20 Digital Ministers Meeting on July 22, 2020, India emphasized the importance of data sovereignty and advocated for the responsible use of data in the digital economy. Then, India also joined the Global Partnership with some countries including EU on Artificial Intelligence (GPAI), aligning with global efforts for responsible AI development. Additionally, India shared its AI experiences and future plans at the GPAI Council Meeting during the Montreal Summit in December 2020 [89].

6. Stakeholder Engagement:

EU-India stakeholder engagement involves collaboration across multiple sectors, bringing together governmental, industrial, and civil society representatives from both regions. Key areas of focus include trade, technology, energy, climate change, innovation, and digitalization.

In April 2023, eight European startups participated in the week-long program in Hyderabad and Bengaluru, engaging with ecosystem facilitators like VCs, partners, and corporations. Two startups, Cast AI and AgeVolt, are ready to scale, while six others are exploring market opportunities for the first time. The program included a flagship demo day, "Blue Carpet Night," to showcase innovation and foster partnerships. The initiative aims to deepen the EU-India partnership in innovation and tech[116].

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[116] EU-India Innocenter hosts 8 high-impact European tech startups at T-Hub Hyderabad. Available in: https://www.eeas.europa.eu/delegations/india/eu-india-innocenter-hosts-8-high-impact-european-tech-startups-t-hub-hyderabad_en

In addition, from 2018 to 2020, the EU and India organized three annual conferences on Advanced Biofuels under the "EU-India Clean Energy and Climate Partnership," fostering collaboration between the European Commission and India's Ministry of Petroleum and Natural Gas. These conferences led to the creation of a Stakeholder Group on Advanced Biofuels (SGAB), which held its first workshop in February 2023 in Bangalore. The group, consisting of experts from both regions, discussed priority areas for cooperation, focusing on overcoming barriers to biofuel deployment, promoting innovation, feedstock supply, and identifying shared research interests. Key participants included HPCL, BPCL, IOCL, and international energy companies like Total Energies and Shell[117].

India is also actively fostering 5G implementation and technology development by recently becoming a member of the OpenAirInterface Software Alliance (OSA), via the Indian Institute of Science[118]. The OSA is a French-based organization with the mission of developing wireless cellular Radio Access Network (RAN) and Core Network (CN) technologies, and disseminating its an open software protocols[119]. The project is part of an Indian government's initiative to create 5G test beds with research collaboration across different partners around the world.

In the investment sector, the joint EU-India Stakeholder Event on Foreign Direct Investment (FDI) Screening highlighted the shared goal of both parties to remain open to foreign investments while safeguarding national security and public order. The event, the first of its kind, aimed to provide businesses and civil society with insights into the FDI screening mechanisms in the EU and India. Key presentations covered India's FDI policy reforms and the EU's FDI Screening Regulation, emphasizing the importance of balancing security concerns with openness to investment. Participants discussed transparency, human rights considerations, and regulatory harmonization. The event underscored the need for robust frameworks to manage investment risks while promoting growth and cooperation[120].

There is an opportunity to join the EU-India Matchmaking Event, organized by the European Commission, will take place from November 19-21, 2024, in Bengaluru, India, as part of the

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[117] Kick-off meeting for EU-India stakeholder group on advanced biofuels. Available in: https://www.cecp-eu.in/events/post/kick-off-meeting-for-eu-india-stakeholder-group-on-advanced-biofuels

[118] Indian Institute of Science joins the OpenAirInterface Software Alliance as member. Available in: https://openairinterface.org/news/indian-institute-of-science-joins-the-openairinterface-software-alliance/

[119] About the OpenAirInterface Software Alliance. Available in: https://openairinterface.org/about-us/

[120] Joint EU-India Stakeholder Event – Foreign Direct Investment Screening. Available in: https://policy.trade.ec.europa.eu/events/joint-eu-india-stakeholder-event-foreign-direct-investment-screening-2024-02-08_en

Bengaluru Tech Summit 2024. This event aims to foster collaborations between cluster organizations, SMEs from the EU, non-EU countries under the COSME program, and India. It will feature Cluster to Cluster (C2C), Cluster to Business (C2B), and Business to Business (B2B) matchmaking, focusing on sectors like biotech, digital, green tech, and advanced manufacturing. Activities will include webinars, site visits, seminars, pitching, and debriefing sessions to enhance cooperation in research, innovation, and industry collaborations[121].

6.5 POTENTIAL SYNERGIES AND COMMONALITIES BETWEEN INDIA NATIONAL PROGRAMS AND EUROPEAN PROGRAMS

There are several potential synergies and communalities between India's national programs and European Union (EU) programs, particularly in the fields of digital related technology, sustainable development, and trade. Both India and the EU share common goals of fostering innovation, sustainable growth, and digital transformation, creating opportunities for collaboration. Here are some key areas of synergy:

1.   Open and Fair Trade

Since the relaunch of the Free Trade Agreement (FTA), Investment Protection Agreement (IPA), and Agreement on Geographical Indications (GIs) in 2022, the EU and India have held nine rounds of negotiations. Discussions on key areas such as Trade in Goods (TIG), Rules of Origin (RoO), Government Procurement (GP), and Sanitary and Phytosanitary Measures (SPS) have yielded varying degrees of progress. While some chapters, such as dispute settlement, services, and investment, saw advancements, other areas like market access, technical barriers to trade (TBT), and transparency remain contentious. Efforts are ongoing to bridge gaps, particularly in sustainable development, regulatory practices, and sector-specific issues. Despite challenges, negotiators continue working towards an open and fair-trade agreement [86][87][88][90][91][92][93][94][95].

2.   Foreign and Security Policy

The EU and India are strengthening their cooperation in foreign and security policy with a focus on promoting democracy, human rights, and a rules-based international order. Digital security is a key component of this partnership, with both sides aiming to combat hybrid threats, such

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[121] EU-India Matchmaking Event in Bengaluru 2024. Available in: https://www.clustercollaboration.eu/content/eu-india-matchmaking-event-bengaluru-2024#:~:text=Description,India%2019%2D21%20November%202024.

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as disinformation, through intelligence-sharing mechanisms. Additionally, their cooperation extends to protecting maritime security and promoting peace in the Indo-Pacific region, with a focus on digital and data protection regulated in the India's Digital Personal Data Protections Act (DPDPA) 2023[122]. Efforts are also made to align their positions on digital aspects of defence in multilateral fora like the UN and G20 [96].

3. Digitalization

The EU-India synergy in digitalization focuses on promoting a human-centric digital transformation through initiatives like the EU Digital Single Market and Digital India, aiming to establish global digital standards characterized by safe and ethical technology deployment. Key areas of collaboration include ICT cooperation, cybersecurity, 5G, and innovation, with regular dialogues between public and private sectors. Both partners are working towards regulatory alignment and advancing cooperation on new technologies while discussing digital economy taxation under the G20. However, India's protectionist policies, such as data localisation laws and restrictions on foreign e-commerce companies, pose challenges to free data flow and future negotiations on data protection, potentially hindering deeper cooperation [97].

4. Sustainable Modernization

The EU and India share a significant convergence in their sustainable development strategies, placing green issues at the core of their modernization efforts. While India focuses on the energy and mobility transition, the EU employs a broader approach through the European Green Deal, which includes agricultural transition and biodiversity protection. Climate and energy partnerships are pivotal in their relationship, exemplified by initiatives like the Green Strategic Partnership between Denmark and India. However, divergences arise regarding the application of the 'common but differentiated responsibility' principle in climate action and the associated burden-sharing costs for adaptation and mitigation. Both parties seek investment and technology to support their development plans. Gender equality is another shared priority, with both sides recognizing the importance of empowering women for socio-economic development and enhancing global scientific capacity. Future collaboration efforts should emphasize joint international research and best practice exchanges to accelerate women's participation and address post-pandemic challenges of increasing gender inequality [97].

5. Research & Innovation

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The EU-India Strategic Partnership Roadmap 2025 outlines cooperation in research and innovation, aiming to widen its scale and impact under the EU's Horizon Europe program. Both sides seek to strengthen partnerships in health, bioeconomy, and Earth system sciences. They also aim to increase researcher mobility and promote cooperation in social sciences and humanities. Additionally, the roadmap addresses gender equality, innovation potential, nuclear energy, artificial intelligence, and global governance [98].

In addition, both entities collaborate extensively in areas of mutual interest such as climate change, clean energy, water management, and sustainable development. The Horizon 2020 program facilitated significant cooperation, with Indian researchers benefiting from EU programs like the Marie Skłodowska-Curie Actions. The relationship is poised for growth under Horizon Europe (2021-2027), focusing on innovation ecosystems and joint research projects, particularly in green technologies, sustainable agriculture, and resource efficiency [99].

6. Information and communications technology

The EU-India partnership on Information and Communications Technology (ICT) is a strategic collaboration aimed at addressing global challenges and driving socioeconomic development through digital transformation. Since 2001, both regions have focused on creating a modern information society by aligning the EU's Digital Single Market and India's Digital India initiatives. Key areas of cooperation include ICT standardization, 5G, machine-to-machine communications, cybersecurity, and research in emerging technologies. Collaborative projects like the 'EU-India Cooperation on ICT-related Standardisation, Policy and Legislation' have advanced cooperation on 5G and intelligent transport systems. This synergy is essential for ensuring inclusive digital growth and post-pandemic resilience [100][101].

7 FOSTERING EU-INDO PACIFIC COUNTRIES DIGITAL COOPERATION: KEY RECOMMENDATIONS

7.1 EU-INDO-PACIFIC DIGITAL PARTNERSHIPS: BRIEF COUNTRY-BY-COUNTRY SUMMARY

The European Union (EU) and its Indo-Pacific partners, Japan, the Republic of Korea (ROK), Singapore, and India, share a commitment to advancing digital cooperation. By leveraging complementary strengths, these collaborations address shared global challenges and foster innovation across digital technologies.

Below is a list of shared Priorities and Areas of Collaboration, regarding each Digital Partnership established between the EU and each partner country, **highlighting strengths and weaknesses** within the different digital and technological sectors, and identifying possible collaboration pathways with the EU:

1. The **EU-Japan Digital Partnership** features advanced capabilities in **cybersecurity, IoT, and 5G/6G development**, complemented by strong research in **AI, quantum**, and others. Japanese established **digital infrastructure, semiconductor R&D**, and comprehensive **smart city** programs through Digital Garden City Nation and SCI-Japan showcase their technological prowess. While **facing challenges** in **digital skills development**, **digital maturity gaps**, and **R&D integration**, the partnership pursue **joint standardization for ethical technology** in critical areas such as cybersecurity, IoT, 5G/6G, and AI governance, creating a foundation for interoperability and ethical technology deployment, **co-funded research** through collaborative efforts in the areas 5G/6G networks, enhancing satellite communication, and supporting clean energy innovations through the Green Deal and Artificial intelligence (AI), shared platforms for responsible AI, and supply chain resilience initiatives. Additionally, both regions aim to bolster **digital skills** and **establish digital maturity centers** to enhance innovation. Japan's initiatives, such as Vision for a Digital Garden City Nation, Smart City Institute Japan (SCI-Japan), Strategic Innovation Promotion Program (SIP), Bridging Program between R&D and Society 5 align with these goals by fostering smart city development, digital infrastructure, and seamless integration of R&D into society.

2. The **EU-ROK Digital Partnership** builds on South Korea's advanced semiconductor industry through the K-Belt Plan and strong innovation ecosystem in transformative technologies which can revolutionise industries and society, such as **semiconductors, AI systems, next-generation computing technologies, 5G/6G, metaverse, and cybersecurity.** With

established frameworks like Horizon Europe, for example CEI initiatives, MSCA and EUREKA combined with the comprehensive national programs such as Korean New Deal and K-Belt Plan, they address **challenges** including **talent shortages**, **technology gaps**, and **supply chain transparency** through **joint R&D** in the key topics (AI, semiconductors, compound semiconductors, and advanced packaging), **technical standards harmonisation** by alongside cybersecurity advancements, CEI's cloud and IoT, and **talent development programs** via researcher/student exchange**.**

3. The **EU-Singapore digital partnership with the EU** leverages its advanced **cybersecurity framework**, strong **digital trade infrastructure**, comprehensive **sustainable urban development** through collaborative R&D programs like Horizon Europe, EUREKA, and Singapore initiatives (Smart Nation strategy, Singapore Cybersecurity Consortium, National Research Foundation) in the focused areas (AI, cybersecurity, trust technologies, quantum technologies, and 5G (and beyond) communication, AI-driven urban solutions, and digital economy technologies). Despite **challenges** in **digital trade agreement implementation**, **talent shortages**, and **data governance frameworks**, the partnership focuses on **joint initiatives in sustainable urban development, cybersecurity research, digital trade facilitation, trust technologies, and harmonizing standards and aligning policies**.

4. **The EU-India Trade and Technology Council** capitalises on India's **large economic growth**, digital talent pool, **strong initiatives in digital inclusion**, and **advanced technologies** in the field of agriculture, space exploration and vaccine development as well as **digital services** through the Digital India program, India's Bharat 6G Alliance, India's Agristack and Digital Green initiatives. While addressing **regulatory alignment**, infrastructure gaps, harmonisation of standardization, and digital divide issues, the partnership pursue collaboration in ocean exploration, quantum computing technologies, AI, cybersecurity, 6G, regulatory framework alignment, digital inclusion, , waste management systems, human-animal environment interface, sustainable urban solutions in terms of the development electric vehicle and SME supports

By addressing mutual challenges and capitalizing on complementary expertise, these partnerships are not only advancing technological capabilities but also setting benchmarks for ethical, inclusive, and sustainable digital ecosystems worldwide. These collaborations highlight the strategic importance of global digital cooperation in shaping the future of the digital economy and society.

7.2 THEMATICS: RELEVANCE PER COUNTRY

This chapter highlights core thematic areas (which are of particular relevance to the INPACE TWGs), and identifies the degree of development and overall interest manifested by each of the concerned partner countries, as well as the elements in country-related Indo-Pacific Digital Partnerships.

- **Standardisation:** Japan and Singapore show particular strength in standards development, exemplified by Japan's leadership in robotics standardization through the Robot Revolution & Industrial IoT initiatives. Japan and Singapore are also aiming to build a unified, all-encompassing digital framework through Japan's Society 5.0 Initiative and Singapore's Trade Principles Initiative. South Korea's contribution through ETRI and relevant MSIT-sponsored programmes have been crucial in 5G policy and digital standards development, as well as policy alignment. India's role in digital standards, particularly through MeitY initiatives, and payment standardization via the UPI program demonstrates its growing influence. Singapore's Singpass and APEX play a crucial role in establishing standards for digital governance, security, and economic efficiency. The EU-Singapore Digital Partnership and EU-Japan Digital Partnership both emphasise standards alignment, particularly in AI, IoT and 6G development. The EU-Korea Digital Partnership specifically focuses on standardization in quantum technologies and AI semiconductors.

- **Regulation, legislation, policy**: Policy cooperation forms a cornerstone of EU-Indo Pacific partnerships. The EU-Japan Digital Partnership prioritises AI governance and data protection policies, while Singapore-EU collaboration focuses on digital trade regulations through their comprehensive Digital Partnership Agreement. South Korea's Digital New Deal 2.0 aligns with EU digital policies, particularly in AI regulation. The EU-India Trade and Technology Council emphasises regulatory cooperation in emerging technologies. Each country brings unique strengths: Singapore's AI Governance Framework serves as an international model following a collaborative approach, integrating efforts from public sectors, policymakers, academia, and industry, similar to AI initiatives in the EU, US, and China. Japan's Cross-Border Privacy Rules demonstrate sophisticated approaches, Korea's $49 billion digital investment plan shows policy-backed commitment and India's Digital Personal Data Protection Act 2023 reflects evolving digital governance.

- **Joint programming**: Joint programming: EU collaboration mechanisms with Indo-Pacific partners have evolved significantly through Digital Partnerships. Japan and EU share multiple joint programmes through JST-EU cooperation, particularly in quantum technologies and AI research. South Korea's participation in Horizon Europe as an associated country enables deeper research integration. Singapore-EU research cooperation focuses on AI and

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green technologies through initiatives like A*STAR-EU programmes. The EU-India TTC facilitates joint research in strategic technologies, with specific programmes in semiconductors and 6G development.

- **Digital education and skills**: this topic is important across Indo Pacific partnerships. India's comprehensive digital skilling through NASSCOM's FutureSkills programme aligns with EU Digital Skills initiatives. Singapore's SkillsFuture and TeSA programmes actively collaborate with European institutions for curriculum development to create comprehensive reskilling courses tailored to various proficiency levels. The EU-Korea Digital Partnership emphasises joint AI talent development, while the ROK-EU Summit 2020 strengthened efforts for digital skill development through education and training protocols. Japan's METI-supported digital transformation training programmes and Society 5.0 workforce development demonstrate holistic skill development strategies. The EU-Singapore Digital Partnership specifically includes provisions for mutual recognition of digital certifications.

- **Smart cities and communities**. Singapore's Smart Nation and Digital Economy programme has deployed over 1,000 sensors and cameras citywide for traffic, environment and security monitoring. Its Virtual Singapore digital twin project enables advanced urban planning. South Korea's smart city initiatives in Sejong and Busan integrate AI, IoT and blockchain, with the K-City project providing a testing ground for autonomous vehicles. Japan's Super City Initiative in places like Aizuwakamatsu demonstrates integration of AI, robotics and data analytics in urban management. India's 100 Smart Cities Mission has implemented IoT-based solutions in cities like Bhubaneswar and Pune, focusing on intelligent transport and waste management.

- **Digitalisation for sustainable ecosystems**: Environmental technology cooperation is central to EU-Indo Pacific partnerships, and for different Indo-Pacific countries. Japan's Green Innovation Fund supports digital solutions for environmental monitoring, with projects like JAXA's climate monitoring satellites. Singapore's Green Plan 2030 integrates digital twin technology for environmental management and its NEWater smart water management system demonstrates advanced resource optimisation. Singapore's Singpass digital identity has become a global leader concerning easy access to government services to the general public. South Korea's Green New Deal includes smart grid deployment and AI-powered renewable energy management systems. India's AgriStack platform and Digital Agriculture Mission showcase technology application in sustainable agriculture, serving over 140 million farmers.

- **Digitalization of industry**: Japan's Connected Cooperative & Automated Mobility (CCAM) partnership initiative and Mitsubishi Electric's e-F@ctory demonstrate advanced industrial IoT implementation and aligns with EU's Industry 4.0 frameworks, exemplified by joint projects between Mitsubishi and European manufacturers. South Korea's Smart Factory initiative has transformed over 19,000 manufacturing sites through digital solutions, and includes technology exchange with European industrial automation leaders. Singapore's Smart Industry Readiness Index has become a global benchmark, adopted by the World Economic Forum. India's Industry 4.0 adoption, particularly in IT services through companies like TCS and Infosys, showcasing digital transformation at scale. The EU-Singapore Digital Partnership promotes industrial IoT standardization. India's manufacturing digitalization receives EU support through the TTC's focus on supply chain resilience.

- **Trusted AI**: AI governance frameworks feature prominently in EU-Indo Pacific cooperation. Singapore's Model AI Governance Framework aligns closely with EU's AI Act principles, and Singapore's Model AI Governance Framework and FEAT Principles for AI in financial services provide practical guidelines adopted internationally. Moreover, Singapore's Digital Trust Center (DTC) further addresses research and development efforts for trust technologies, including trustworthy and responsible AI. Japan's AI Strategy emphasises human-centred development, exemplified in Honda's collaborative robotics research, as an example. Korea's K-AI development standards harmonise with EU AI requirements through their Digital Partnership, and South Korea's AI Ethics Standards and K-AI development through companies like Samsung showcase responsible innovation. The EU-India TTC includes specific working groups on responsible AI development and ethical guidelines; India's responsible AI framework, developed by NITI Aayog, guides AI deployment across diverse societal contexts in the country.

- **Data technologies**: Cross-border data flows are prioritised in EU-Indo Pacific Digital Partnerships. Singapore's National AI Strategy includes five national AI projects and its AI Marketplace facilitates data sharing; Singapore and EU collaborate on data governance through their Digital Trade Agreement. Japan's Data Free Flow with Trust initiative, promoted at G20, establishes international data governance norms, complement EU's data protection standards. The EU-Korea Digital Partnership includes provisions for secure data sharing, and South Korea's Data Dam project, with $12 billion investment, creates AI training datasets across industries. India-EU cooperation through the TTC focuses on data protection frameworks and digital public infrastructure, and India's Data Empowerment and Protection Architecture enables secure data sharing while protecting privacy.

- **High-performance computing**: Supercomputing collaboration strengthens EU-Indo Pacific ties. Japan's Fugaku supercomputer, developed by RIKEN and Fujitsu, achieved world-leading performance in 2020, and includes European technology partnerships. The upcoming successor aims at exascale computing by 2025. The EU-Korea Digital Partnership emphasises quantum computing cooperation, and South Korea's NURION supercomputer at KISTI supports national research initiatives. Singapore's National Supercomputing Centre collaborates with European counterparts, and Singapore's National Supercomputing Centre powers climate modelling and genomics research. Singapore's A*STAR programmes additionally oversee key organizations such as the Institute of High-Performance Computing (IHOC) which leverage knowledge and promotes domestic advancements and partnerships. India's supercomputing programme includes technology exchange with EU research institutions.

- **Advanced computing**: Semiconductor collaboration is central to EU-Indo Pacific Digital Partnerships. Advanced computing, including logic devices and memories, is an important area for EU-Indo Pacific cooperation. South Korea's memory chip industry, led by Samsung and SK Hynix controlling 70% of the global DRAM market, engages in extensive research cooperation with EU semiconductor manufacturers. The EU-Japan Digital Partnership emphasises semiconductor supply chain resilience, with specific projects between Renesas Electronics and European partners. Japan's semiconductors materials industry, including companies like Shin-Etsu Chemical, supplies 50% of global silicon wafers and supports EU chip production. Singapore's specialised chip design expertise through IME partners with European research institutions, and excels in semiconductor design and testing, with companies like GlobalFoundries investing in specialised production. India's Semiconductor Mission, with $10 billion incentive scheme, attracts global manufacturers like Micron. The EU-India TTC includes a dedicated semiconductor Memorandum of Understanding signed in 2023, focusing on talent exchange, joint research, and manufacturing capabilities, while India's Centre for Development of Advanced Computing (C-DAC), dedicated to advanced ICT research and innovation in emerging technologies, demonstrate growing supercomputing capabilities.

- **Advanced functionalities**: Specialised technology collaboration, including sensors, power devices, energy harvesting for autonomous electronic systems and flexible electronics, strengthens EU-Indo Pacific ties through multiple channels. Japan's robotics industry, including companies like FANUC and Keyence, hold 60% of the global industrial robot market, and maintains extensive cooperation with EU automation leaders through joint

ventures and research programmes. South Korea's innovations in display technology through Samsung and LG define industry standards; the EU-Korea Digital Partnership facilitates display technology development, with LG and Samsung collaborating with European research centers on next-generation displays. Singapore's strengths in specialised chips for autonomous systems and IoT devices are demonstrated through institutes like IME and align with EU's Chips Act priorities, particularly in IoT and autonomous systems. India's growing electronics manufacturing through the PLI scheme shows promise in sensor production.

- **Ground-breaking technologies**: Cooperation in alternative materials, technologies and computing architectures features prominently in all EU-Indo Pacific Digital Partnerships. Japan's Moonshot Research Programme invests in quantum computing through RIKEN and NTT, with ¥100 billion investment, and collaborates directly with EU's €1 billion Quantum Flagship initiative on quantum computing and sensing. Japan's Council for Science, Technology and Innovation (CSTI), through programs such as PRISM and BRIDGE, aims to develop innovative technologies (such as construction and infrastructure maintenance and disaster prevention), as well as emerging bio- and quantum technologies. South Korea's five-year quantum technology development plan includes $40 million annual investment, and the EU-Korea Digital Partnership includes a €50 million joint quantum computing development programme. Singapore's Centre for Quantum Technologies, National Quantum Office, A*STAR and Quantum Engineer Program pioneer quantum cryptography research, and Singapore-EU cooperation through the Centre for Quantum Technologies focuses on quantum cryptography research and quantum internet development. India's National Quantum Mission, with its $1 billion funding, focuses on quantum computing and communications, and includes technology exchange programmes with EU institutions and joint research projects in quantum communications.

- **5G and beyond**: Telecommunications cooperation is traditionally prioritised across partnerships. South Korea, through various initiatives including those of the Ministry of Science and ICT, achieved 28 million 5G subscribers by 2023, leading global adoption, and Korea's 5G leadership facilitates EU technology exchange. Japan's Beyond 5G promotion strategy allocates $2 billion for 6G research, and the EU-Japan Digital Partnership emphasises 6G research collaboration. Singapore's 5G@Sentosa testbed enables advanced applications development and serves as a testbed for EU-Asia connectivity solutions. India's indigenous 5G stack and participation in the O-RAN Alliance demonstrate technological sovereignty, and the EU-India TTC includes working groups on telecommunications standards and 6G development. India's Bharat 6G Alliance boosts

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innovation in next-generation technologies, including 6G network development and capacity for the present and future.

- **Internet trust and security**: Cybersecurity frameworks align across EU-Indo Pacific partnerships. Anchored by the Cyber Security Agency of Singapore, the Cybersecurity Strategy 2021 and Critical Information Infrastructure protection framework set regional standards, and harmonises with EU's NIS2 Directive, whereas the Smart Nation and Digital Economy programme aims to accelerate development of cybersecurity measures across strategic industries, research institutes and government. Japan's Cross-Border Privacy Rules certification system facilitates secure data flows, and Japan-EU cooperation focuses on secure data flows. Japan's National Institute of Information and Communications Technology (NICT) provides special focus to the development of cybersecurity networks and solutions for strategic areas. South Korea's K-ISMS certification ensures robust information security, and ROK's information security standards complement EU frameworks. India's CERT-In handles over 1.4 million cybersecurity incidents annually; India-EU collaboration emphasises critical infrastructure protection.

- **Cloud Edge IoT**: Digital infrastructure cooperation strengthens EU-Indo Pacific ties. Japan's Robot Revolution and Industrial IoT initiatives and edge computing initiatives align with EU's cloud strategy. South Korea's Naver Cloud Platform leads in AI cloud services across Asia, and partner with European providers. Singapore's edge computing initiatives through Digital District showcase urban applications; the EU-Singapore Digital Partnership promotes cloud infrastructure development. India's growing cloud services market, growing at 24% annually, emphasises edge computing for rural connectivity and this growing market facilitates EU service provider(s) entry.

7.3 THEMATIC RECOMMENDATIONS

To deepen the strategic partnerships between the European Union (EU) and its Indo-Pacific counterparts — Japan, the Republic of Korea (ROK), Singapore, and India — focused efforts are needed in key areas. These initiatives aim to enhance innovation, sustainability, inclusivity, and resilience across digital ecosystems while addressing shared global challenges.

The key recommendations are:

1. Innovation and Emerging Technologies

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Joint research and development in cutting-edge areas like semiconductors, artificial intelligence (AI), quantum computing, and next-generation networks such as 5G/6G are essential. Establishing shared platforms, such as research forums, expert groups, and innovation hubs, will enable collaboration between academic institutions, industries, and governments. These initiatives can foster technological breakthroughs while ensuring that innovations are scalable and applicable across regions.

2. Digital Governance and Standards

The alignment of regulatory frameworks in data privacy, cybersecurity, and AI ethics is critical for promoting trust in digital systems. Collaborative efforts should focus on developing and advocating for global standards to ensure interoperability, secure data flows, and ethical deployment of technologies. Building consensus in international fora, such as the OECD, ITU, and G20, can amplify the collective influence of the EU and its partners in shaping the future of digital governance.

3. Sustainable Digital Transformation

Digital technologies offer significant potential for advancing green transitions. Partnerships should prioritize the deployment of digital tools in areas like smart cities, clean energy systems, and climate resilience projects. Initiatives such as integrating IoT in energy-efficient urban planning and leveraging AI for disaster management can drive sustainable development while addressing environmental challenges.

4. Capacity Building and Inclusion

Investments in digital skills, education, and infrastructure are vital to ensure equitable access to digital transformation benefits. Programs that enhance digital literacy, especially among underrepresented groups, can bridge the digital divide. Collaborative capacity-building initiatives, such as digital maturity centres in universities and training programs, can prepare workforces for emerging technological landscapes and ensure inclusive economic growth.

5. Trade Facilitation and Economic Integration

The establishment of robust digital trade frameworks is essential to enable seamless cross-border transactions while safeguarding intellectual property and consumer rights. Efforts should focus on harmonizing regulations, reducing trade barriers, and integrating advanced technologies like blockchain for transparent and efficient trade processes. These measures will empower small and medium-sized enterprises (SMEs) to expand globally and contribute to economic growth.

By fostering cooperation in these priority areas, the EU and its Indo-Pacific partners can jointly build a resilient, secure, and inclusive digital future. These partnerships aim to not only drive technological and economic advancement but also establish benchmarks for sustainable development and ethical governance, benefiting societies and economies worldwide.

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8 CONCLUSION

The digitalization in every sector has been rapidly evolving, presenting both challenges and opportunities. This document has explored the strategic partnerships established between the European Union (EU) and key Indo-Pacific countries – Japan, South Korea, Singapore, and India. These collaborations aim to harness the collective strengths of these regions to navigate this transformation and build a secure, inclusive, and sustainable digital future.

Key Achievements of the Partnerships:

1. Joint Research and Innovation: Collaborative efforts are underway in critical areas like artificial intelligence, quantum computing, semiconductors, and next-generation networks. This fosters technological advancements and ensures their scalability across regions.

2. Alignment of Standards: Partnerships emphasize harmonizing regulations in data privacy, cybersecurity, and AI ethics. This builds trust in digital systems and promotes interoperability.

3. Sustainable Digital Transformation: The focus on deploying digital tools in smart cities, clean energy systems, and climate resilience projects paves the way for environmentally conscious technological development.

4. Capacity Building and Inclusion: Investments in digital skills, education, and infrastructure bridge the digital divide and equip workforces for emerging technologies.

Recommendations for Strengthening the Partnerships:

1. Reinforced Innovation Efforts: Establishing shared platforms for research and fostering collaboration between academic institutions, industries, and governments can accelerate breakthroughs and support practical application.

2. Global Standards Advocacy: Joint efforts can advocate for global standards in international fora, ensuring technology deployment aligns with ethical and secure practices.

3. Prioritizing Green Technologies: Partnerships should foster the development and use of digital solutions for sustainable development, like using AI for disaster management or IoT for energy-efficient urban planning.

4. Inclusive Growth Initiatives: Collaborative capacity building programs and digital literacy initiatives can empower underrepresented groups and ensure all segments of society benefit from digital transformation.

5. Streamlined Trade Facilitation: Harmonization of regulations, reduction of trade barriers, and integration of advanced technologies can create robust digital trade frameworks that benefit businesses of all sizes.

The partnerships serve as a model for international cooperation, demonstrating the power of collective action in addressing global digital challenges and building a more prosperous and sustainable future.

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Annex I – Thematic Working Groups (TWG)

Cluster	TWG
Cluster 1. Digital dialogues, policies and education.	1. Standardisation
	2. Regulation, legislation, policy
	3. Joint (bidirectional) programming
	4. Digital education and skills
Cluster 2. Innovation and entrepreneurship for sustainable well-being	5. Smart cities and communities
	6. Digitalization for sustainable ecosystems
	7. Digitalization of industry, infrastructures and services
Cluster 3. Digital technologies - Trustworthy decision support	8. Trusted AI
	9. Data technologies
	10. High performance computing
Cluster 4. Enabling technologies - chips for the future	11. Advanced computing
	12. Advanced functionalities
	13. Ground-breaking technologies
Cluster 5. Digital technologies - Future networks	14. 5G and beyond
	15. Internet of trust and security / Cybersecurity
	16. Cloud Edge IoT