Editor’s Message

In the midst of global crises such as the Russo-Ukrainian war, the Israel-Hamas conflict, and the global supply chain disruptions, the competition for technology sovereignty among major countries is also intensifying. In this context, the Korean government is responding strategically by selecting 12 National Strategic Technologies in 2022 and establishing National Strategic Technology Roadmaps in 2023, and strengthening International Cooperation in Science and Technology to accelerate technological innovation. In addition, as major countries are increasing their diplomatic efforts to secure the advanced technologies, Korea is also trying to use S&T Diplomacy as an important policy tool.

In particular, 2023 is the first year in which major mid- and long-term plans such as The 5th Science & Technology Basic Plan (2023-2027) and the National Research and Development Mid- and Long-Term Investment Strategy (2023-2027) are promoted in earnest, and it is necessary to discover specific and propulsive policy issues to realize the government’s policy agenda. Therefore, KISTEP has identified 10 policy agendas that the S&T community should pay attention to and focus on in 2023 and presented them as the ‘KISTEP Think 2023’ STI policy agendas. The main keywords of the policy agendas include Implementation Strategy for fostering National Strategic Technologies, Securing Core Human Resources, Basic Research Investment Strategy, S&T Diplomacy Strategy, and Mission-oriented R&D Investment and Evaluation.

Recently, in a situation where technology blocking and competition for hegemony are intensifying, the United States has responded with the ‘CHIPS and Science Act of 2022’ and the ‘Inflation Reduction Act of 2022 (IRA)’. Japan with the ‘Economic Security Promotion Act’, and China with the ‘State-led Industrial Development Policy’. Korea is also responding by enacting the ‘Special Act on National Strategic Technologies Development’ in March 2023, and has established roadmaps in the areas of Secondary Batteries, Semiconductors, Displays, and Advanced Mobility to specify policy directions for each strategic technology field.

In ‘KISTEP R&D and Beyond 2023’, the article ‘Directions for Korea’s S&T Diplomacy in the Competition for Technological Hegemony’ was selected, and articles such as ‘Korea-Germany Technology Sovereignty Forum held’, ‘2023 KISTEP-ISTIC STI Training Program held’, ‘KISTEP signed MOU with Uzbekistan’s Scientific and Technical Information Center’, and ‘KISTEP attended 18th Trilateral Science and Technology Policy Seminar’ were selected. In addition, the infographic visualizes the ‘Publication and Citation of Korean S&T Papers in 2021’ in line with this situation.

As mentioned above, ‘KISTEP R&D and Beyond 2023’ provides various S&T-related information such as the 10 S&T Policy Agendas for 2023, Mission-oriented Strategic Roadmaps, R&D Infographics, Technology Trends, and KISTEP News. Through the publication of ‘KISTEP R&D and Beyond 2023’, KISTEP will further develop into a global think tank and strive to lead the future of S&T in Korea.
History

1987 JAN.
Establishment of Center for S&T Policy (CSTP), an affiliated organization of Korea Institute of Science and Technology

1993 MAY.
Reorganized CSTP and renamed it S&T Policy Institute (STEP)

1999 FEB.
Establishment of KISTEP

2001 JUL.
Reorganized and strengthened planning function of KISTEP

2005 JAN.
Redirected KISTEP’s main functions to national S&T planning, coordination and R&D evaluation

2007 NOV.
Establishment of Korea Institute of Human Resources Development in S&T (KIRD) affiliated with KISTEP

2009 FEB.
10th anniversary of KISTEP

2011 MAR.
KISTEP’s affiliation was transferred to National Science & Technology Council (NSTC) from the Ministry of Education, Science and Technology

2013 MAR.
KISTEP’s affiliation was transferred to the Ministry of Science and ICT from NSTC

2019 FEB.
20th anniversary of KISTEP

2020 JAN.
Relocation to Chungbuk Innovation City

2022 OCT.
The establishment of Office of Future Technology Strategy

2023 JAN.
KISTEP was designated as ‘the Center for S&T Diplomacy Strategy’

Vision and Strategy

Vision
A global institute that contributes to economic growth and public welfare through strategic S&T planning and R&D evaluation

Mission
Improving the effectiveness of R&D investment through expertise in S&T policy planning and R&D evaluation + Contributing to the development of innovative growth engines by identifying future agendas and strategies

Strategy
Identifying Future Agendas and Strategies for Enhancing National STI Capacity
Advancing and Designing the Foundation of National R&D systems
Creating Innovation Ecosystems by Fostering Innovative Growth Engines

4 Core Functions of KISTEP

- National S&T Policy Planning and Future Strategies
- Budget Allocation and Coordination of Government R&D Programs
- Survey, Analysis, Evaluation and Performance Distribution of Government R&D Programs
- Preliminary Feasibility Studies of Government R&D Programs
Key Achievements

2023
Established ‘Mission-oriented Strategy Roadmaps’

2022
Established ‘The 5th Science and Technology Basic Plan’

2021
Established ‘S&T Diplomacy Forum’ and ‘S&T Diplomacy Academy’

2020
Established ‘The 4th Government R&D Performance Evaluation Basic Plan’

2019
Established ‘The 2nd Mid- to Long-term Government R&D Investment Strategy’

2018
Established ‘The 4th Science and Technology Basic Plan’

2017
Suggested 20 Policy Projects for STI of New Government

2016
Ranked ‘Excellent’ in Mission-oriented GRI Evaluation

2015
Announced KISTEP 10 S&T Policy Issues of 2015

2014
‘The Road to Creative Economy’ Forum in Celebration of KISTEP’s 15th Anniversary
KISTEP Think 2023: STI Policy Agendas

Background

Analysis of the Latest Changes in the Innovation Environment Using Big Data Keywords

Agenda Selection Procedure

10 STI Policy Agendas

Conclusion

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KISTEP Think 2023: STI Policy Agendas

Background

As the Pax Technica era dawns, the global value chain is rapidly evolving as a result of the US-China technology competition and the digital transformation of industry is accelerating with the arrival of the Fourth Industrial Revolution and the lingering effects of the COVID-19 pandemic, threatening an increasing risk of a shrinking job market. The world’s collective efforts for carbon neutrality, its response to climate change, and other such major changes in industry and commerce observed today, together with the increasing espousal of sustainable development paradigms, indicate that innovation of science and technology is no mere help to economic growth but a solution to social issues.

In Korea, many economic and social issues arose including a shrinking productive population due to low birth rates and an aging society, worsening of inequality from regional and digital divides, and a potential long-term recession from rising raw material prices and a stagnant global economy. There is an urgent need for S&T responses to changes in the innovation environment, such as an upgrade of Korea’s National Innovation System (NIS) in line with Korea’s heavy R&D spending, valued at KRW 100 trillion for public/private R&D and at KRW 30 trillion for government R&D a year.

In 2018, KISTEP laid out its roles and responsibilities as a STI policy think tank, a step up from its functioning in R&D planning and evaluation support, in its paper “Redefining the Roles and Responsibilities for R&D Innovation”, released August 2018. Since 2021, KISTEP has been identifying and announcing “KISTEP Think innovation agenda” each year. As a STI policy think tank of Korea, KISTEP set and announced 15 policy agendas in 2022 on December 9, 2021. The corresponding 15 policy tasks were incorporated into the new government’s S&T policy in 2022, and executed as research projects by KISTEP, which saw their finer points explored in detail and policy alternatives suggested.

The year 2023 is a momentous one, the first year in which the new government’s major mid- to long-term plans, including the Fifth S&T Basic Plan (2023-2027), announced December 2022, and the Mid- to Long-term Funding Strategy for National R&D (2023-2027), announced February 2023, will receive budgetary support and be executed. It is a time in which focused and on-time discovery and suggestion of policy issues are needed to support the new government’s success with its policy agenda. This paper, KISTEP Think 2023: STI policy agenda, refers to the agenda that has been set for the 15 STI policies in considering environmental changes and new policy directions to summarize the policy tasks requiring the attention and focus of those in S&T in 2023.
Analysis of the Latest Changes in the Innovation Environment Using Big Data Keywords

1. Outline of Analysis

Big data-enabled text mining of press articles, science and technology policy, trend analysis reports in science and technology and industry, and other material was performed to analyze recent changes in the innovation environments of Korea and other countries. The procedure of analysis was collection of big data, analysis and visualization of the collected big data, and interpretation of implications. The first step in the big data analysis was the collection and refining of 1,045,545 items of data. Said data included 1,035,326 items of press articles from the last 3 years, 390 agendas proposed by the Presidential Advisory Council on Science & Technology (PACST) and other official committees in the last 4 years, and 9,829 items of material on science and technology policies and on trends in technology and industry issued by major Korean institutions in the last four years. Keywords, identified by the frequency at which certain terms appeared in documents and together in sentences, were used to build network data, which was then comprehensively reviewed by topic modeling and linguistic network map analysis. Data visualization was achieved through word clouds, inter-topic distance maps, and network maps, prepared using VOSviewer and Python, for an intuitive understanding of the relations between the keywords.

2. Key Findings of Analysis

The eight areas overarching the findings of the topic modeling and linguistic network analysis performed on the press, policy, and trends material were "foreign diplomacy", "R&D innovation", "technological hegemony", "corporate innovation support", "digital transformation", "fostering talents", "regional sovereignty", and "mission-oriented R&D (carbon neutrality, post-COVID-19, etc.)". Findings in "R&D innovation" and "mission-oriented R&D" overlapped in the other six areas at a high frequency. This was attributed to the national tasks and the S&T policy of the Yoon administration established in 2022 being covered in various agendas, press articles and trend reports. The meaning of the eight areas and the urgency of the policies related to said areas having been considered, internal and external expert committee meetings and review were performed to set the three core areas to identify STI policy agenda for 2023.

The three core areas were "securing S&T sovereignty in the age of technological hegemony", including areas related to talent development in strategic technology, R&D innovation and S&T diplomacy to respond to technological hegemony, "mission-oriented national R&D system reform", including areas related to mission-oriented R&D and digital transformation as envisioned by the new government in its S&T policy, and "private- and region-led innovation ecosystem", including areas related to corporate R&D support and regional innovation for improving the innovation capacity of the private sector.
Agenda Selection Procedure

1. Identification of Agendas

The agenda for 2023 was set through a review of the three core areas and related issues, and of the new government’s S&T basic plan, mid- to long-term funding strategy for national R&D, and other science and technology policies.

Eighty-six candidates were identified through expert advisory meetings, identification of policy issues by clients of external experts, and survey of demand for KISTEP’s internal experts. Those were narrowed down to 31 and then to a final 12 agendas.

2. Selection of 10 Major STI Policy Agendas

In view of the direction and urgency of Korea’s S&T policy recognized in the wake of the establishment of the new government, expert advisory meetings, discussions among KISTEP’s policy experts, and other means of comprehensive consideration were employed in the setting of KISTEP Think 2023: “agenda for the 10 major STI policies” and its 3 core areas.
10 STI Policy Agendas

1. Science and technology sovereignty in the age of technological hegemony

① National strategic technology development implementation plans for strengthening technology sovereignty

- Strategic R&D funding for National Strategic Technology and Mission-oriented R&D
  - Task 1: National strategy technology mission-oriented strategic roadmapping
  - Task 2: Design and implementation of national strategy technology projects
  - Task 3: Strengthening tech intelligence capacity

② Fostering talent development for super-gap technology leadership

- Systemization of human resources development for national strategic technology
  - Task 1: Analysis of core research personnel in areas of national strategy technology and planning of human resources development
  - Task 2: Systemization of deployment of core personnel in similar areas of strategic technology for national strategy technology R&D
  - Task 3: Analysis of jobs in areas of national strategy technology and creation of new jobs

③ Investment strategy for basic research in national strategic technology

- Improved strategy in basic research for response to the technology competition and to environmental changes
  - Task 1: Improved strategy in basic research for acquisition of core technology for response to technological hegemony
  - Task 2: Reform of portfolios for funding of basic research at universities in response to environmental changes

④ Strategic S&T diplomacy for global leadership

- Strengthening S&T diplomacy and international cooperation capacity
  - Task 1: Establishment of national science and technology diplomacy strategy
  - Task 2: Design of research security system for international cooperation in national strategy technology

2. Mission-oriented national R&D system reform

① Creation of funding platforms and evaluation systems for mission-oriented R&D

- Advancement of R&D funding and evaluation systems for strengthening mission-oriented R&D
  - Task 1: Advancement of funding for platform-enabled R&D budget allocation and adjustment
  - Task 2: Establishment of mission-oriented R&D evaluation systems

② Creation of R&D execution strategies and systems for carbon neutrality

- Creation of a national base for carbon neutrality
  - Task 1: Innovative technology strategy roadmapping for policy implementation
  - Task 2: Formation of specific execution strategies for contribution to emissions reduction
  - Task 3: Advancement of governance for carbon neutrality and strengthening of public-private cooperation

③ Strengthening of the base for R&D innovation policy for the digital transformation

- Tailored support and policy for the digital transformation of industries
  - Task 1: Digitalization of the main industries
  - Task 2: Creation of new digital convergence industries
  - Task 3: Creation of a policy base for the digital transformation

3. Private and region-led consolidation of the innovation ecosystem

① Systemic improvement for promotion of technological innovation by the private sector

- Creation of a system for supporting technological innovation by the private sector
  - Task 1: Improvement of the R&D tax deduction system to promote private funding of R&D
  - Task 2: Creation of a system for a stronger connection between regulatory sandboxes and R&D, and for rational regulation
  - Task 3: Advancement of the national system for commercialization of R&D achievements

② Innovation of the corporate R&D support system for greater innovation capacity of businesses

- Strengthening of SMBs and venture companies’ innovation capacity and provision of R&D support in line with demand
  - Task 1: Improvement in custom R&D support provided in line with companies’ innovation capacities and demand
  - Task 2: Diversification of R&D support for companies

③ Region-led innovation and growth for balanced development

- Improvement of regional capacity for innovation and growth
  - Task 1: Reform of the R&D budgetary support system to strengthen regional sovereignty in science and technology
  - Task 2: Conversion of the provinces into innovation bases
  - Task 3: Establishment of testbeds for validation and commercialization of products of specialized local industries
Conclusion

Today, the technology of a country translates into its national power and influence on the global economy. The governments of powers such as the US, China, and Japan are accelerating the race for technological hegemony and continuously increasing their R&D spending as needed.

In particular, the rivalry between the US and China is shifting the paradigm of global hegemony from the geopolitical, centered on military might and economics, to the technopolitical. With the entire world facing such social issues as the digital transformation, carbon neutrality, population drops, and extinction of provinces, seeking recourse to technological innovation for solutions is necessary. Signs of crisis on the horizon are rising for Korea, and it needs to innovate its science and technology to proactively respond to post-COVID-19 uncertainty and create new value.

With this in mind, KISTEP has outlined the issues and focus of the science and technology community in 2023 in KISTEP Think 2023: 10 major science and technology innovation policy agendas. To better implement KISTEP Think 2023, the following are required.

First, as the impacts experienced by society will only intensify over time, necessitating crucial policy decision-making, those in the field of science and technology must establish an effective system of cooperation. Convergence research undertaken in the research sector, breakdown of barriers between government departments, and dramatic improvement in cooperation between government ministries are all required. Public-private cooperation also needs to evolve. In an age in which the private sector accounts for 77% of the KRW 100 trillion being spent on R&D each year, the relationship between the public sector and private sector should evolve from one between benefactor and beneficiary into one enabling the fullest cooperation. This would require the Office of Science and Technology Innovation to strengthen its functions to enable the better implementation of policies.

Second, Korea now ranks among the world’s top five R&D spenders due to the R&D spending increases over the last few years. Korea should continue its R&D spending stably and over the long term. Notwithstanding any future uncertainty, a long-term commitment to R&D spending, for example 5% of the total national budget to R&D, should be maintained through administration changes.

Last, the Special Act on Promotion of National Strategic Technologies, the Regional Science and Technology Innovation Act, and other relevant laws should be revised to reflect changes in the current policy environment. Legislation on science and technology should be improved and updated so that policies formed are not confined to just R&D but applied to a wider range of activities, including resolving economic and social issues, and responding to future crises. It would be fitting to update the Framework Act on Science and Technology to the Framework Act on Science and Technology Innovation for the implementation of policies for the innovation of the base for science and technology activities.
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Mission-oriented Strategy Roadmaps

Focusing on the Mission Setting Procedure and Core Issues in the Areas of Rechargeable Batteries, Semiconductors, Displays, and Advanced Mobility

At the August 29 meeting of the Presidential Advisory Council on Science & Technology (PACST), a meeting of the special committee on national strategy technology was convened, during which a provisional strategic roadmap focused on national strategy technology missions was established. With the emergence of technology blocs and escalating competition for technological hegemony, key countries have introduced response measures, such as the “CHIPS and Science Act” (US), “Inflation Reduction Act” (US), “Economic Security Promotion Act” (Japan), and the “State-led industrial development policy” (China). In alignment with these developments, Korea enacted the Special Act on the Development of National Strategic Technology in March. Subsequently, the PACST established the special committee on national strategy technology and a mediation committee for individual technologies. The STI center then formulated a roadmap for the areas of advanced mobility, rechargeable batteries, semiconductors, and displays to specify a policy direction for each strategic technology.

The solution to the challenges Korea faces today, such as technological hegemony and the digital transformation, lies in mission-focused R&D innovation that can be achieved within a set time frame.

As the R&D market grows ever larger and enjoys autonomy, strategic planning of R&D involving selection and focus enabled by the definition of major missions and cooperation with businesses and government agencies has become important.

Consequently, a strategic roadmap has been developed to set the national missions to be performed in each area of strategic technology, and to prepare a pan-governmental technology acquisition strategy. The roadmap will be applied as a set of guidelines in policy-making, budget allocation, evaluation, and other related activities.

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The National Strategic Technology Development Plan (Oct. 2022) and the 5th S&T Basic Plan (Dec. 2022) have designated 12 strategic technologies, including rechargeable batteries, semiconductors, displays, and advanced mobility. Within those 12 strategic technologies are 50 key technologies. The key technologies within the strategic technology of rechargeable batteries include lithium-ion batteries and core materials, next-generation rechargeable battery materials/cells, rechargeable battery modules/systems, and secondary battery reuse/recycling. The key technologies within semiconductors include high-density/resistance-based memory, high-performance/low-power artificial intelligence semiconductors, advanced semiconductor packaging, power semiconductors, next-generation high-performance sensors, semiconductor materials/parts/equipment. The key technologies within displays include inorganic light emitting displays, freeform displays, and display materials/parts/equipment. The key technologies within advanced mobility are autonomous driving systems, urban air mobility, and EVs/FCEVs. After setting the strategic technologies, the special committee on nationally strategic technology of the PACST formed a technological mediation committee for each area of rechargeable batteries, semiconductors, displays, and advanced mobility. Members of these technological mediation committees included industrial, academic, and research experts and representatives of the relevant government departments. The roadmap was formulated by the technological mediation committees with the aid of working-level experts.

The roadmap does not aim simply to acquire as much technology as possible, but instead it identifies the core technologies essential to achieving technological hegemony. Employing a top-down approach, it analyzes the economic and social challenges facing in relation to each key technology, economic security issues, and other conditions. It establishes the mission that Korea must fulfill to gain advantages as a nation by 2030. The roadmap identifies core elemental technology of high technological and security priority necessary for accomplishing these missions. Furthermore, it suggests key areas that require funding and outlines ways to establish a strategic technology ecosystem, encompassing international cooperation, talent acquisition, and systemic improvement.

Rechargeable batteries, serving as a power source (IT devices, EVs, etc.) and storage solution (energy storage systems, etc.), are core technologies for overcoming space-time restrictions in the use of energy. With the global shift toward carbon neutrality and the digital transformation gaining momentum, the use of rechargeable batteries is expanding and there is a notable spike in demand. Advances in rechargeable battery technology are poised to impact not only the rechargeable battery industry but also a wide spectrum of other fields, including IT, EVs, urban air mobility, and national defense.

Despite challenges related to core minerals and resources, Korea stand as a global leader in the lithium-ion battery market, alongside Japan and China leveraging its advanced technology.

The global market for rechargeable batteries for EVs has grown almost fourfold in the last three years. Market research company SNE Research has predicted its growth will reach fivefold by 2035. With the global shift to carbon neutrality in progress, the importance of energy storage systems (ESS) is increasing, and the ESS market is expected to grow by an average of 35% a year until 2030.

With China growing in sway over the entire rechargeable battery value chain and markets outside of China, the US and EU are restructuring the global rechargeable battery supply network. This restructuring is in response to the threat of China’s technological hegemony, with the US and EU aiming to center the network around themselves.

The US, recognizing rechargeable batteries as a core technology, has adopted the strategy of building a Trusted Value Chain (TVC) in the US and its FTA partner countries for all processes involved in the R&D, manufacturing, and distribution of rechargeable batteries. This strategy is clearly outlined in Section 13401 of the Inflation Reduction Act (IRA), addressing the key minerals and parts for rechargeable batteries, effective as of August 2022. In essence, Section 13401 stipulates over 40% of the core minerals used in the manufacturing of rechargeable batteries (as of 2023, subject to yearly increase), such as lithium, nickel, manganese, and cobalt, must be extracted and processed in the US or its FTA-partner countries for EV tax deduction benefits. The same section also requires that over 50% of battery parts, including cells, modules, electrode active materials, and electrolytes (as of 2023, subject to yearly increase), be manufactured or assembled in North America for tax deductions. The EU is also committed to strengthening its manufacturing capacity and building a circular economy in the rechargeable battery sector. In 2022, it outlines top five priorities in the expansion and strengthening of its rechargeable battery industry, including running academies for rechargeable battery professional development in Europe, support for large-scale research...
and innovation projects, and enactment of the Critical Raw Materials Act (CRMA). In March 2023, the CRMA, the EU-equivalent of the IRA, came into effect to restrict imports of core raw materials from third countries to under 65% of total consumption in the EU by way of strengthening supply networks within the EU.

Today, the competitive landscape of the global rechargeable battery industry is changing. As the rechargeable battery market expands rapidly into such high-tech industries as EVs, ESSs, urban air mobility, robots, drones, and national defense, the strategic importance of rechargeable batteries is only increasing. The US and EU will likely continue pursuing a strategy that will leverage domestic and regional demand to foster growth in manufacturing capacity and technological leadership. This approach aims to maintain competitiveness in the rechargeable battery market. Meanwhile, Japan seeks to enhance its competitive position, aspiring to lead in the markets for lithium-ion batteries as well as next-generation batteries such as solid-state batteries. China capitalizing on the rapid growth of the rechargeable battery market for affordable EVs is expanding its market dominance, and aggressively investing in personnel development and technology to outpace competitors such as Korea and Japan. Korea remains focused on the high-quality market and uses its manufacturing competitiveness to establish early dominance in foreign markets. It is also committed to developing next-generation technology, and enhancing the competitiveness of its materialsthrough funding and policy support. As global competition for the next-generation rechargeable battery market intensifies, the next 10 years will be a crucial period for all competitors.

2) Core issues and challenges

Considering the high dependence on the import of the core minerals (lithium, nickel, manganese, etc.) and the four major materials (anode materials, cathode materials, separators, electrolytes) needed to manufacture rechargeable batteries, the growing resource nationalism of resource-producing countries and achieving supply network autonomy is a critical task. Considering that the amount of minerals expected to be acquired by Korean companies by 2030 is below the amount required thereafter, and that reuse and recycling of minerals have not been implemented, the task of achieving supply network autonomy now requires policy support more than ever. Korea needs to respond to the IRA of the US, which aims to relocate US supply networks to the US and its partner countries, and the CRMA of the EU, limiting the influence of certain countries on the EU’s supply networks. Korea should review these control measures as an opportunity for sustainable growth—and take advantage of them.

As the rechargeable battery market’s creation and growth were triggered by the strengthening of carbon neutrality policies around the world, the eco-friendliness of the technology involved in the manufacturing and recycling of rechargeable batteries is becoming increasingly important. The EU, a leader in environmental regulation, stipulates in its CRMA that parties seeking to participate in the EU market must prove full-life-cycle eco-friendliness of rechargeable batteries, including production through recycling. As carbon emission control extends to every aspect of life, there is a growing need for low-carbon, eco-friendly manufacturing and processing technology over the long term. While Korea currently enjoys the upper hand in the market for ternary lithium-ion batteries, maintaining its top position requires enhancing the safety and pricing competitiveness of its products. To provide high performance and safety at competitive prices, it is crucial to develop and improve core materials, and the design and operation of modules, packs, and systems must be advanced and optimized.

As the market for affordable EVs must grow for EVs to replace internal combustion engine vehicles at a faster rate, carmakers around the world will likely to intensify their competition in the development of affordable EVs. The expansion of China’s share of the rechargeable battery market, both within China and globally, is largely attributed to the growing affordable EV market. This underscores the necessity for Korea to enter the affordable rechargeable battery market. Additionally, Korea should also focus on progressively replacing expensive metals such as cobalt with alternative materials in the luxury vehicle market, which will require the development of necessary materials and manufacturing technology.

The rechargeable battery market, centered around the lithium-ion battery, is expanding gradually. However, a market for next-generation rechargeable batteries that surpass the limits of current materials is expected to emerge around 2030. Korean, Chinese, and Japanese companies as well as the US and the EU are actively participating in a competition race to achieve early market dominance through early commercialization. Various next-generation batteries present unique merits and challenges. The companies and countries that overcome those challenges and succeed in mass production will likely secure a significant share of the new market. Beyond rechargeable batteries, other areas of next-generation technology with substantial commercialization potential owing to ultra-high performance, high safety, and raw material independence should be identified. In those areas, core and source technologies such as electrode materials and solid electrolytes and scaling upproduction capabilities will be essential to attain market leadership in next generation technology.
3) Targets and funding focus by key technology

In the area of lithium-ion batteries, “enlargement of the super gap by leadership in the material and manufacturing technology for high-performance, high-safety, eco-friendly lithium-ion batteries” has been set as the mission, with targets identified as “performance competitiveness”, “pricing competitiveness”, and “eco-friendly materials and processes”. Under “performance competitiveness”, the advancement of the four core materials for high energy density (350 Wh/kg) and high safety has been set as the sub-target, which will require the improvement of energy density using cobalt-free high-nickel anode materials and silicon-based anode materials (Si > 20%), and the acquisition of technology for high-performance electrolyte additives, functional thin film separators (thickness of 10 um or less), and more. Under “pricing competitiveness”, preparation for the low-price lithium iron phosphate market, lower pricing of cathode materials through the development of technology for high-content manganese with reduced cobalt (an expensive mineral) content, and reduced dependence on imports of high-performance electrode materials such as CNT conductive materials and binders have been set as the sub-targets. Under “eco-friendly materials and processes”, the development of technology for eco-friendly materials and dry electrode processing that will reduce carbon emissions by 50% in manufacturing processes has been set as the sub-target. To achieve these targets in the field of lithium-ion batteries, there will be focused funding for next-generation materials and process development along with the establishment of validation infrastructure.

In the field of next-generation rechargeable batteries, “acquisition of technology for commercialization in the core areas to achieve early dominance of the next-generation market for high-performance, high-safety rechargeable batteries” has been set as the mission, and “overcoming of performance limits”, “acquisition of ultra-safe materials”, and “raw material independence” as the targets. The sub-targets set were the acquisition of technology for the stabilization of lithium metal cathodes and the commercialization of lithium sulfur batteries for “overcoming of performance limits”, the development of solid electrolytes and large-area electrodes for “acquisition of ultra-safe materials”, and the development of sodium-ion battery material and manufacturing technology (220 Wh/kg) using non-rare metals for “raw material independence”. To meet these targets, a strategy has been devised for focused funding of early validation based on industrial cooperation and market demand. In addition, the development of source technology for non-lithium-ion batteries has been outlined.

In the area of modules and systems, “acquisition of technology for the design and management of new-concept modules, packs, and systems of high efficiency and safety” has been set as the mission, and “new conceptualization of high efficiency”, “advanced safety”, and “long-lifespan systems” as the targets. The sub-targets set were an increase of battery pack energy density by 30% through cell-to-pack design and lighter parts, acquisition of zero-fire risk technology, and the development of an intelligent integrated management system for increasing battery lifespan by 20% and the accuracy of battery lifespan prediction. A strategy has been set for focused funding of joint research of the related development and validation of efficiency and safety by businesses, universities, and research institutions to achieve the mission and targets set for the area of modules and systems.

In the area of reuse and recycling, “development of core technology for reuse and recycling of used rechargeable batteries for the creation and promotion of a used rechargeable battery market” has been set as the mission, and “acquisition of technology for residual value assessment”, “promotion of the reuse industry”, and “competitiveness of the recycling industry” as the targets. Under “residual value assessment”, residual value and safety assessment at higher speeds and lower costs and the advancement of non-destructive diagnosis (97% accuracy in diagnosis under 10 minutes) have been set as the sub-target. In the “promotion of the reuse industry”, the sub-target is the development of technology for condition diagnosis and lifespan prediction of used batteries. This aims to improve the safety and marketability of used batteries. Under “competitiveness of the recycling industry”, eco-friendly recycling (wastewater from processing down by 90% and carbon emission down by at least 25%) through improved purity of recovered metal of value, reduction of wastewater and carbon emission, and other means has been set as the sub-target. Large-scale validation of high-speed diagnosis and safety improvement, and data collection and utilization will take place to achieve the targets for the area of reuse, and focused funding for the acquisition of innovative technology for low-cost processing and high-sale wastewater reduction will take place to achieve the targets for the area of recycling.

4) Formation of a strategic technology ecosystem

Development of core personnel, strengthening of international cooperation, and installation of systems and infrastructure were set as the three main directions of the formation of ecosystems in the area of rechargeable batteries.

The development of core personnel will involve running courses for existing rechargeable battery professionals and curricula on contracts between major companies and universities, among other such projects that reflect the demand in the rechargeable battery industry. Improved international cooperation will be achieved by the mapping of core mineral supply/demand, operating an alliance for rechargeable batteries, systemized package support for the acquisition of minerals, and other means of supply network strengthening. Systems and infrastructure will include an integrated system for used batteries maintained by parties involved in the manufacturing of finished vehicles. Such systems and infrastructure will allow Korea to set the global standard for next-generation rechargeable batteries and maintain a competitive market position.
2. Semiconductors

1) Strategic importance of technology

Accounting for over 20% of all of Korea’s exports, semiconductors are a mainstay of the Korean economy. On a rebound now from the effects of endemic COVID-19, the global semiconductor market is expected to continue its growth. Semiconductors are a core technology in the context for technological hegemony, and are increasing in value in the context of security.

Countries around the world are coming up with a range of policies to improve their semiconductor production capacities and achieve early dominance in the next-generation semiconductor market. The intensifying competition among key countries for the technological hegemony that will allow them to build supply networks around themselves is worth noting. For example, the US has enacted the CHIPS and Science Act (Aug. 2022) in support of domestic research, development, and manufacturing of semiconductors, and implemented control of advanced semiconductors (Oct. 2022) to install technology blocs that will allow it to domesticate semiconductor industry development and semiconductor supply networks. Semiconductors, a core technology for the super-gap industry ecosystem that will lead the digital transformation, extend beyond the semiconductor market in importance and closely tie into the entire ICT industry of Korea.

Technologies such as super-giant AI, autonomous driving, EVs, and 6G use unprecedentedly massive amounts of data and computing and are changing the paradigm of the semiconductor industry. AI semiconductors are rising in importance for their role in big data processing performance maximization and achieving lower energy consumption for high efficiency as necessary to produce information storage devices that are smaller but can hold more information. New-concept, next-generation memory devices and the pre-processing technology required for them are also increasing in importance. Global ICT companies are responding by designing their exclusive semiconductors for specialized computing. Apple has long been designing its own M1 and M2 semiconductors, the application processors found in Apple smartphones, Tesla is developing the D1 exclusive semiconductors for specialized computing. Apple has long been designing its own M1 and M2 semiconductors, the application processors found in Apple smartphones, Tesla is developing the D1 exclusive semiconductors for specialized computing.

2) Core Issues and Challenges

The CHIPS and Science Act aims to restore the US’s leadership in memory semiconductor and control the export of its semiconductors, a move expected to reshape the global division of labor and create blocs within supply networks. Semiconductor technology blocs will necessitate departure from a neutral position in a technological alliance, change semiconductor export and development strategies, and raise the barrier to semiconductor technology. Taiwan Semiconductor Manufacturing Company and Samsung, the world’s number one and number two semiconductor fabrication plant operators, are in heated competition for market leadership, and physical limits to the micronization of semiconductor processes have left the development of high-performance semiconductors stagnant. Korean companies still lack competitiveness in system semiconductors, their share of the domestic market for system semiconductors is the same as it was 10 years ago, and the issue of reliance on the import of the core materials, parts, and equipment for semiconductors remains, raising the point that concentrated imports from certain countries needs to be reduced. To maintain memory supply network competitiveness, core materials, parts, and equipment technology should be acquired in response to supply network uncertainty, the limits on micronization processes should be overcome to acquire the source technology that will enable Korea to surpass competitors by a super gap, and a total ecosystem should be developed through a stronger alliance among businesses.

Only a handful of foreign companies possess the high-performance intellectual property and advanced packaging technology needed for the high-performance, low-power AI semiconductors to be applied to super-giant AI and autonomous driving, making it likely that the barrier to such technology will rise exponentially. It is imperative that Korea pursue the domestication of such technology. In response to a sharp rise in demand for the automotive semiconductors used in software-defined vehicles, equipped with such technology as high-precision/supersmart sensors and power semiconductors, Korea should develop the technology needed to manufacture and package AI semiconductors and related devices in order to maintain its peak competitiveness in the areas in which it is performing strongly, and develop next-generation AI semiconductors and power conductors for new industries to create new technology gaps.

In a technological alliance, change semiconductor export and development strategies, and raise the barrier to semiconductor technology. Taiwan Semiconductor Manufacturing Company and Samsung, the world’s number one and number two semiconductor fabrication plant operators, are in heated competition for market leadership, and physical limits to the micronization of semiconductor processes have left the development of high-performance semiconductors stagnant. Korean companies still lack competitiveness in system semiconductors, their share of the domestic market for system semiconductors is the same as it was 10 years ago, and the issue of reliance on the import of the core materials, parts, and equipment for semiconductors remains, raising the point that concentrated imports from certain countries needs to be reduced. To maintain memory supply network competitiveness, core materials, parts, and equipment technology should be acquired in response to supply network uncertainty, the limits on micronization processes should be overcome to acquire the source technology that will enable Korea to surpass competitors by a super gap, and a total ecosystem should be developed through a stronger alliance among businesses.

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3) Targets and funding focus by key technology

In the area of highly integrated, resistance-based memory, "acquisition of AI-specialized future technology to reach the global number-one position" has been set as the mission, and "maintenance of a super gap in commercial memory" and "development of new devices for next-generation memory" as the sub-targets. To maintain a super gap in the commercial memory market, 3D DRAM and other highly integrated DRAM and NAND flash technology will be acquired. To develop new devices for next-generation memory, technology for commercializing magnetic and resistance-based devices (MRAM, PRAM, RRAM) and new-concept devices (FeRAM, etc.) optimized for AI will be developed. All this will require process and equipment funding related to the development and early validation of source technology for memory devices specialized for AI.

In the area of high-performance, low-power AI semiconductors, "development of low-power, high-performance AI semiconductors and platforms specialized for AI learning" has been set as the mission, and "development of device circuits", "low-power, high-efficiency platforms", and "AI semiconductor software" as the sub-targets. For the development of device circuits, the development and validation of ultra-high-performance AI semiconductor devices and circuits using complementary metal-oxide semiconductor technology, currently commercialized, will take place. To develop low-power, high-efficiency platforms, next-generation low-power AI semiconductor designs (PIM-NPU platform) and base technology will be developed to achieve an efficiency of over 10TFLOPS/W* even in low-power environments. Development of AI semiconductor software will follow the development and validation of software optimized for applying Korean-made AI semiconductors to cloud computing. Development and commercialization of software using Korean-made AI semiconductors will create an AI value chain, and funding will be provided to develop AI semiconductors specialized for new technologies such as autonomous driving, as well as the necessary personnel.

In the area of advanced semiconductor packaging, "domestication of core technology and materials/parts/equipment for heterogeneously integrated chiplets" has been set as the mission, and "acquisition of design technology" and "heterogeneously integrated processing platforms" as the sub-targets. Design technology will be acquired through the advancement of 2.5D/3D packaging designs and the development of technology for increased energy efficiency (high protection against heat). Heterogeneously integrated platforms will follow the development of technology for increasing the density of heterogeneous packaging electrode bonding and ultra-fine wiring processes, such as hybrid bonding and next-generation interposer technologies. This will require the expanded development of the core and source technologies for the design and processing of heterogeneously integrated chiplets, and the funding of testbeds in line with manufacturer demand.

In the area of power semiconductors, "acquisition of compound-based next-generation technology for use across the value chain" has been set as the mission, and "diversification of materials" and "device designs and processes" as the sub-targets. Diversification of materials will be achieved by developing technology for the mass production and application of compounds (SiC, Ga203) that will replace silicon materials. Device designs and processes will be achieved through the acquisition of technology for ultra-high-voltage power devices and integrated (drive circuit-integrated) devices. Funding will be required to develop source technology for compound-based devices and have it validated through cooperation with businesses, all in advance of Korea's competitors.

In the area of next-generation high-performance sensors, "commercialization of next-generation high-reliability sensors and strengthening of supply networks" has been set as the mission, and "low-power, independent sensors" and "high-precision, supersmart sensors" as the sub-targets. Acquisition of low-power, independent sensors will involve the development of technology for low-power and power-independent sensors to be used under the extreme conditions found in space and national defense. Acquisition of high-precision, supersmart sensors will follow the upgrading of technology for the design and manufacturing of the high-precision sensors used in smart devices and of the performance of advanced mobility sensors (radars, LIDAR, vision sensors). The above will be achieved through funding for social overhead capital, national defense, and other areas.

In the area of semiconductor materials, parts, and equipment, "independence in the core technology for pre-processing of ultra-fine semiconductors of 3 nanometers or less" has been set as the mission, and "photo process", "etching process", and "deposition process" as the sub-targets. Photo process capacity will be achieved through increased independence in the core materials and parts (photosensitive materials, masks, etc.) used in photo processes and the acquisition of source technology for next-generation lithography for achieving "beyond extreme ultraviolet" (BEUV), ultrafine etching. Etching process capacity will be achieved through the development of the parts and equipment technology to be used in atomic layer etching processes for high-K materials. Deposition process capacity will be achieved through increased independence in the processing equipment used for atomic layer deposition. As such, funding for the development of source technology for the materials, parts, and equipment to be used in next-generation micronization processes and the establishment of the attendant ecosystems will be required.

4) Formation of a strategic technology ecosystem

In the field of semiconductors, funding for essential infrastructure providing electricity, water, and other necessities, the establishment of high-tech R&D bases, such as the Nano institute of technology, and the creation of early market demand are needed to induce the independence of the semiconductor ecosystem. Development of high-caliber semiconductor professionals is supported by the recruitment of convergence talent from schools, the operation of postgraduate programs in the key technologies through industrial-academic cooperation, and the recruitment of talent from around the world. Further endeavors
needed include the provision of internships and startup support through industrial-academic cooperation, running of postgraduate programs in AI semiconductors that include the opportunity for joint research with foreign universities, and the development of postgraduate qualification holders in advanced packaging in targeted numbers. In the area of international cooperation, joint research with foreign research institutions, increased exchanges of professionals, and better networking of companies involved with core materials, parts, and equipment are needed for value chain stabilization.

3. Displays

1) Strategic importance of technology

Korea has maintained a dominant position in the global display market since the early 2000s. Displays account for a large portion of Korea’s economy and exports, and for the second-largest facility spending in Korea. The structure of the global display supply network is highly volatile. Large enterprises such as Samsung and LG as well as SMBs in materials, parts, and equipment pervade the display value chain, contributing significantly to the Korean economy. However, latecomers to the industry from Taiwan, which acquired the once-thriving Japanese LCD company Sharp in 2016, and China with its aggressive spending on its OLED industry caught up with and dethroned Korea from its global number-one position in the world display market. This serves as a wake-up call that Korea must actively respond to if it is going to regain its market leadership. Advanced digital technologies such as autonomous driving, 6G, and AI, and convergence industries are changing the paradigm of industry. The display industry is a core industry that will continuously expand possibilities in application and innovation, and create new markets, as evident in the hitherto development of the markets for smartphones and other mobile devices, home theaters, and virtual and augmented reality technology. Demand for TVs and monitors, mostly limited ranges of large-range market (LCD market), and if supply networks become restructured in favor of China moving forward, China could weaponize its dominant position in the display market against Korea, a scenario which must be avoided at all costs. China has replaced Korea as the world’s number-one supplier of displays after Korea’s 17-year reign (2004-2020), and is now hot on its trail in the very promising market for OLED display products of small to medium panel sizes, such as smartphones and wearable devices. In the high-added-value market for products such as foldable display devices, Korea is encountering plenty of competition from other countries, and is pressed to acquire both technological and pricing competitiveness in order to establish the premium market. Korea will need to provide high-performance (efficiency, luminance, reliability, etc.) products at competitive prices, a feat which will require it to develop core materials and parts, and advance mass production and process technologies. Because Korea is still dependent on imports for key material/part/equipment technology, maintaining competitiveness and stabilizing supply networks will require domestication of and independence in core technology. Thus, the rate of Korea’s material/part/equipment independence, at 65% as of 2022, will need to be increased post-haste.

As AR/VR and advanced mobility technologies are developing, slowly but surely, Korea needs to take action to achieve early dominance in the next-generation display market.

The metaverse, yet to be fully commercialized, is of increasing applicability not only to entertainment but also national defense in the form of helmets for close-range combat or fighter jet pilots, so Korea needs to stay proactive with respect to metaverse developments for the sake of national security. For a share of such new markets, Korea must acquire source technologies that break new ground in display performance (resolution, lifespan, etc.) and can be commercialized soon.

3) Targets and funding focus by key technology

In the area of inorganic light emitting displays, “achievement of the number-one position in key next-generation products and technology, including micro LED and quantum dots” has been set as the mission, and “advancement of light source technology performance” and “acquisition of mass production technology” as the sub-targets. Advanced performance of light source technology will be achieved by acquiring high-efficiency (less than 5μm) and high-color-reproduction light source devices with the performance and pricing competitiveness needed for commercialization. Mass production technology will be achieved by acquiring high-productivity processing technology that can achieve high-speed transfer (more than 10,000 chips per second), ultra-fine pixel inspection, and other merits. Early commercialization of such products and services will require funding for the infrastructure needed to validate essential technology, such as light source and process technologies, and other technologies.

2) Core issues and challenges

China-Korea competition is intense in the display market. Korea has lost its leadership in the low- to mid-range market (LCD market), and if supply networks become restructured in favor of China moving forward, China could weaponize its dominant position in the display market against Korea, a scenario which must be avoided at all costs. China has replaced Korea as the world’s number-one supplier of displays after Korea’s 17-year reign (2004-2020), and is now hot on its trail in the very promising market for OLED display products of small to medium panel sizes, such as smartphones and wearable devices. In the high-added-value market for products such as foldable display devices, Korea is encountering plenty of competition from other countries, and is pressed to acquire both technological and pricing competitiveness in order to establish the premium market. Korea will need to provide high-performance (efficiency, luminance, reliability, etc.) products at competitive prices, a feat which will require it to develop core materials and parts, and advance mass production and process technologies. Because Korea is still dependent on imports for key material/part/equipment technology, maintaining competitiveness and stabilizing supply networks will require domestication of and independence in core technology. Thus, the rate of Korea’s material/part/equipment independence, at 65% as of 2022, will need to be increased post-haste.

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In the area of freeform displays, “maintenance of the number-one position in the foldables/rollables market and achievement of a technology gap of five years in stretchables” has been set as the mission, and “commercialization of high transformability” and “advancement of freeform function” as the sub-targets. Commercialization of high transformability will be achieved through the commercialization of a wide range of transformation technologies other than foldable technology. Advancement of freeform function will be achieved through performance upgrade (flexibility and resolution) and process technology development needed to create displays that conform to curved surfaces. All of this will require funding for the acquisition of core and source technologies for displays of new materials and concepts based on corporate demand.

In the area of display materials, parts, and equipment, “achievement of over 80% independence in core OLED materials, parts, and equipment” has been set as the mission, and “high-added-value materials and parts”, “manufacturing and inspection equipment”, and “eco-friendly processes and materials” as the sub-targets. “High-added-value materials and parts” will see the acquisition of ultra-high-resolution OLED-on-silicon technology and high-efficiency, high-reliability light emitting materials and parts for OLED performance advancement. “Manufacturing and inspection equipment” will bring about independence in core equipment essential to large-area OLED production, such as exposure machines and deposition machines. “Eco-friendly processes and materials” will see the reduction of toxic substances in production processes and the development of quantum dot materials free of heavy metals. Accordingly, funding for the development of substitutes for imports such as exposure machines and fine metal masks, and next-generation source technology such as OLED-on-silicon and eco-friendly materials will be needed.

4) Formation of a strategic technology ecosystem

In the area of displays, Korea needs to encourage R&D by private companies by providing stronger tax incentives for future and core technologies, and strive for leadership in the global standardization of new technologies and applications, including freeform and micro LED. Talent development will be focused on the practical training of workers who can quickly be deployed to the sites of new industries, while high-caliber personnel will be developed through programs that offer guaranteed employment on completion, and support for basic and source research at universities. International cooperation strategies specifically developed for downstream panel industries and upstream material/part/equipment ecosystems will need to be implemented, in addition to global research networking and technical cooperation to resolve core issues in different technologies and achieve competitiveness.

4. Advanced Mobility

1) Strategic importance of technology

Advanced mobility is essential infrastructure directly connected to people’s lives, and is a market in which key countries are going head to head in a battle to achieve early dominance. Advanced mobility is an extremely important technology for enhancing national competitiveness.

Key countries are focused on attaining leadership in the rapidly growing advanced mobility market, whose include offerings such as autonomous driving, urban air mobility, and EVs and FCEVs. As they strive to build supply networks around themselves, the competition for technological hegemony among them is intensifying. For instance, the US is using its Inflation Reduction Act to develop its EV and battery industries and domesticate supply networks. As mobility is indispensable in daily life, it is closely associated with economic security, industrial growth, and public safety.

The paradigm of the mobility industry, once the exclusive domain of vehicle and aircraft manufacturers, is changing with the increasing involvement of IT companies (smartphone manufacturers, carriers, etc.) due to mobility digitalization. Autonomous driving, smartphones, and other IT applications are changing the traditional ownership-centric car industry to a sharing-centric mobility ecosystem. The global shift toward carbon neutrality, together with advances in battery technology, is improving pricing competitiveness, and the popularization of green cars is not far off. TCO-parity (TCO: total cost of ownership) of EVs and internal combustion engine cars has been predicted to occur between 2025 and 2030, and the International Energy Agency, in its sustainability scenarios, estimates global EV sales will exceed 30 million in 2030.

Advanced mobility in national defense and security will enable manned-unmanned teaming (MUM-T) featuring autonomous flying and remote control to improve mission execution capacity. Korea is actively
applying unmanned and autonomous technologies in response to the issue of decreasing military power and for the success of missions in extreme environments. The 2023-2037 Basic Plan for National Defense Science and Technology Innovation names “manned-unmanned combination” technology as one of the 10 major national defense technologies, and the Korean military is trialing “smart, multi-purpose unmanned vehicles”. Hydrogen- and electricity-powered eco-friendly military vehicles are under development, in part because they are quieter and less vulnerable to detection than internal combustion engine vehicles. The US has announced the US Army Climate Strategy (Feb. 2022), which aims to cut down the US Army’s carbon emissions by 50% by 2030.

2) Core issues and challenges

The US’s IRA and the EU’s Carbon Border Adjustment Mechanism (CBAM) are examples of a rising trade barrier resulting from a stronger commitment to climate change response and trade protectionism. With fuel and exhaust gas regulation toughening, a competitive stance in the market can only be maintained with the core EV and FCEV technologies. The future mobility market also demands electric vertical take-off and landing (eVTOL) technology for urban air mobility. Compared to other developed countries, Korea is currently competitive only in EV and FCEV technology lagging behind in other mobility technologies. It is imperative that Korea catches up to its competitors by achieving technology domestication and other necessary targets.

When considering the drive of the software behind the changing paradigm of mobility, maintaining competitiveness in the automotive industry requires the advancement of platforms that use software and communications, and support needs to be provided to ensure that said advancement ties into the domestication of the related modules and parts, and the improvement of national defense capacity. The aviation industry, a crucial element of national defense capacity, is at present divided between the US and Europe; however, for urban air mobility, in which electric propulsion, communication, and software technologies figure prominently, it is possible for Korea to preempt the core technology.

As mobility technology inherently requires applicability and safety, user-friendly technology and safety management technology is crucial for enabling the safe and convenient use of mobility solutions. As the traditional mobility industry becomes a convergence industry and service industry, infrastructure related to service technology will need to be formed. At present, Korea is executing or planning the validation of an integrated mobility service which combines mobility with autonomous driving platforms, communication and precision maps, and urban air mobility and other means of transport, such as buses, trains, and aircraft.

3) Targets and funding focus by key technology

In the field of autonomous driving systems, “advancement of self-driving cars and incorporation of autonomous driving service into daily life” has been set as the mission, and “Level 4+ driving automation” and “establishment of industrial standards” as the sub-targets. Level 4+ driving automation will be achieved with the commercialization of reliability-confirmed Level 4 autonomous driving by 2027, and high-performance AI and software, and automotive computing technology will be developed with the goal of achieving Level 4+ fully autonomous driving by 2030. To establish industrial standards, a certification system based on international safety standards will be formed to achieve the safety of autonomous driving AI, which will lead to the establishment of safety-related national standards applicable to the development of cybersecurity technology specialized for autonomous driving and of technology for the detection of hazardous conditions. Thus, focused funding for the advancement of core technology, such as AI, and for R&D in the development and early validation of road and traffic systems will be required.

In the field of urban air mobility, “advancement of urban air mobility growth phase technology and establishment of a stable operating system for popularization” has been set as the mission, and “advancement of navigation and traffic management systems and aircraft/part performance” and “establishment of urban air mobility infrastructure” as the sub-targets. Traffic systems required at the initial stages of urban air mobility operation, such as operating routes, will be established. Aeronautical communications, navigation, surveillance and information (CNSI) technology will be developed, and high-density operating environments, where 100 or more aircraft operate, will be validated by simulation. High-performance, eco-friendly, and low-noise technology will be developed for aircraft and parts.
technologies and materials, and certification systems essential for improving the applicability and safety of urban air mobility, such as a ground control system for multiple flying objects (m:N operation), will be developed. Vertiports will be installed, integrated aircraft management technology will be developed, and core materials independence will be increased to build a stronger urban air mobility ecosystem. Thus, funding will primarily take place in the development of traffic management, infrastructure, and certification technologies essential to early commercialization of urban air mobility.

In the area of EVs and FCEVs, “proactive response to the future global market centered on green cars” has been set as the mission, and “improvement of driving performance, durability, and safety”, “advancement of charging and storage”, and “proactive response to global regulation” as the sub-targets. Accordingly, technology for increased power output of EV drive systems, prevention of thermal runaway, high-density battery system management, high-speed, high-efficiency charging, and increased energy storage density will be developed. As a proactive response to regulation by life cycle assessment, source technology for carbon-neutral fuel vehicles will be developed. Thus, funding in the area of EVs and FCEVs will be focused on achieving independence in core technologies for driving systems, such as drive motors, an area in which Korea needs to catch up to the leading countries.

4) Formation of a strategic technology ecosystem

Safety standards, insurance, operating guidelines, national standards, and other control measures are being developed in preparation for driving automation. Test sites are being established across Korea, and the support extended to allow for freedom of validation includes the issuing of temporary driving automation permits. Safety certification guidelines being prepared for urban air mobility include technological standards for type certification, production certification, and standard airworthiness certification. Planning is underway for items such as operator requirements and distribution of operating rights to facilitate the commercialization of urban air mobility. To support the popularization of EVs and FCEVs, charging infrastructure is being expanded across Korea. The focus of this expansion is on real demand-based accessibility of charging, improved service quality, and fire safety. In advanced mobility personnel development, software convergence professionals are being cultivated to achieve competitiveness in core mobility technology, and training systems are being developed ahead of urban air mobility trials. In international cooperation related to advanced mobility, activities are being undertaken to establish international standards and certification standards.

Conclusion (Implications)

The roadmap will be applied to policies, budgets, and assessments related to strategic technology R&D. In the policy domain, the screening of candidates for national strategic technology projects involves assessing the extent to which a candidate contributes to the missions and core technologies outlined in the roadmap. This enables the referencing of the core technologies outlined in the roadmap during the planning stages of projects. Preliminary feasibility studies related to the missions outlined in the roadmap refer to the roadmap in reviewing fast-tracking potential or policy appropriacy. This referencing is necessary for pan-governmental distribution and adjustment of budgets based on the 12 major strategic technologies and their priority rankings. This includes assessments of the degree to which such assessment include evaluating the likelihood of the missions and targets set out in the roadmap taking place. This ensures that consulting can be provided to assist in reaching project targets and supplementing project plans.

At present, the 12 major strategic technologies are divided into the three categories of future innovation, essential, and giant/public. Roadmapping has started in future innovation, with plans to follow in the remaining two categories. As roadmapping times vary by strategic technology, and set targets may need to be adjusted or supplemented in line with new developments, it will be necessary to observe moving targets. Decisions about the times and frequency of updating the roadmap should consider the nature of changes in technology.

In the field of rechargeable batteries, rapid developments in technology and market require a flexible setting of targets, strategies, and priorities. The domains of semiconductors and displays are the one most impacted by supply chain disruptions in the age of competition for technological hegemony, necessitating the immediate formation of response measures upon such impact. In the domain of advanced mobility, major issues, especially those related to user safety, are rapidly gaining attention, and the industrial paradigm is subject to cataclysmic change in response to the strategies of major global companies.

Therefore, a rolling planning of this roadmap for each field of rechargeable batteries, semiconductors, displays, and advanced mobility is required.
Directions for Korea’s S&T Diplomacy in the Competition for Technological Hegemony

Abstract

Background

S&T Diplomacy and Economic Security in the Age of Technological Hegemony Competition

Perception and Concept of S&T Diplomacy

Response to S&T Diplomacy and Future Tasks

List of KISTEP Issue Paper Publications
Directions for Korea’s S&T Diplomacy in the Competition for Technological Hegemony

Abstract

Background

・ With the rapid growth of China’s technological competitiveness and the expansion of its role in global trade, there are concerns that the influence of the United States will decrease, and thus the US intends to exclude China from the supply chain of high-tech technologies including semiconductors and electric vehicles and enhance the competitiveness of its own industries

・ As the Biden government shifts from an America First strategy to one of alliances with like-minded countries, it seeks to respond to science and technology diplomacy, such as technological cooperation with major countries as well as the US

S&T Diplomacy and Economic Security in the Age of Competition for Technological Hegemony

・ As the competition for technological hegemony between the US and China intensifies, the role of S&T is expanding
  ● Competition between the US and China has intensified due to the strengthening of US containment efforts following the rise of China, and China’s response
  ● The evolution of major US policies to contain China, including trade sanctions, technological sanctions, to sanctions on the high-tech industrial ecosystem, confirms the US dependence on imported semiconductors and the uncertainty of techno-politics

・ The role and current status of S&T diplomacy in major countries
  ● Major advanced countries use S&T diplomacy for various purposes, such as improving relations with hostile countries, partnerships with allies, and improving their status as advanced countries in the developing countries
  ● The US and Japan use S&T diplomacy programs, the EU focuses on cooperation among member countries, and China focuses on building networks based on the Belt and Road

・ With economic security emerging as a priority as the economy, security, and technology converge, economic security issues are becoming more important in areas of S&T such as climate change/energy, space/marine, and security of technology
  ● In line with China’s economic rise, the US is pursuing new forms of economic security policies, such as trade policy, reorganization of the global value chain, and strengthening of industrial policy
  ● A number of security issues are involved in the S&T sector, such as the dual-use characteristics of space technology, the weaponization of resources such as secondary batteries, supply chain issues related to climate change such as a carbon border tax, and expansion of the scope of technology regulation due to the security of technology
Establishment of the Concept of S&T Diplomacy Regarding our Situation

Definition of S&T diplomacy and current state of S&T diplomacy in Korea
- Over the past 15 years, S&T diplomacy has been discussed as a strategic and multidimensional concept and a phenomenon with a clearer diplomatic purpose distinct from general international cooperation in science and technology, but there is still no consensus on the concept.
- Summarizing various discussions on the concept of S&T diplomacy, it is commonly defined as international partnership to solve common problems faced by mankind, such as global challenges, and recently has been discussed in consideration of international politics.
- Korea's S&T diplomacy is active in the type of “diplomacy for science” (international cooperation in science and technology), the perceptions of S&T diplomacy in the S&T group and diplomacy group are generally similar, but there are differences in terms of goals and important S&T areas.

Directions of S&T Diplomacy Strategy and Future Tasks

Directions of response according to four types of S&T diplomacy in the competition for global technology hegemony
- (Diplomacy for science) corresponds to the existing S&T international cooperation activities, including national strategic technologies, involves a more systematic cooperation strategy, and requires a bilateral/multilateral international joint research program led by Korea.
- (Science for diplomacy) as science and technology diplomacy approached from the level of public diplomacy, it is necessary to promote expertise in science and technology in connection with the Indo-Pacific strategy.
- (Science in diplomacy) is a type of multilateral-oriented cooperation, such as solving global problems such as climate change and energy and achieving the UN's SDGs, and it is necessary to strengthen its role by leading agendas suitable for its economic scale and global status.
- (Diplomacy in science) is a newly defined type of multilateral-oriented cooperation that requires strengthening cooperation with the friendly bloc and continuing cooperation with the other bloc under rules-based regulation to secure strategic materials, rare resources, and stable supply chains.

The US-China competition for technological hegemony is expected to continue for a considerable period of time, and the role of diplomacy in science considering economic security is expected to expand in the future.
- Reinforcing bilateral cooperation within the bloc, such as technical standards, human resources development, and research security for emerging technologies such as quantum and artificial intelligence through the Korea-US/Korea-Japan economic security dialogue and the Korea-US critical emerging technology dialogue and so on.
- (Small) multilateral cooperation within the friendly bloc through IPEF, Chip 4, Quad, etc., is important, and promoting multi-layered S&T diplomacy strategies by utilizing existing cooperation frames such as Korea-US-Japan and Korea-China-Japan cooperation.

I Background

China’s rapid growth in technological competitiveness and growing role in global trade have left the US with concerns about its diminishing global influence. The US now seeks to exclude China from its high-tech supply chains, including semiconductor and EV supply chains, and improve the competitiveness of American industry.

- China has come up with made in China 2025 and other strategies to advance its science and technology, and manufacturing industry; it is making visible strides in academic achievements also.

As the Biden administration shifts from the America First policy to the focus on cooperation with friendly nations, it is in Korea’s best interests to explore new opportunities in science and technology diplomacy, including technological cooperation with the US and other advanced countries.

- Aln a departure from the Trump administration’s America First policy, the Biden administration is networking with allies to exclude and contain China, and demanding that Europe, Japan, Korea, Taiwan, and other countries participate.
- Response to the changing US policy is being made in national interests, as demonstrated by the EU’s promotion of strategic autonomy based on technological sovereignty, Japan’s shift toward economic security-centric policy, and Taiwan’s stronger cooperation with the US.

- Korea is also responding, from multiple angles that include technology, industry, economy, security, and diplomacy; as advanced technology plays a core role in today’s world, the direction Korea should take in its science and technology diplomacy response is herein suggested.

- As no defined concept of science and technology diplomacy exists at this time, the concept of science and technology diplomacy is suggested, based on which the direction of the response to be taken is suggested.
S&T Diplomacy and Economic Security in the Age of Technological Hegemony Competition

Growing role of science and technology amid intensification of US-China rivalry in technological hegemony

† Directions of response according to four types of S&T diplomacy in the competition for global technology hegemony

• Made in China 2025 (May 2015) envisions China’s evolution into a manufacturing superpower, and S&T strategy and technological innovation were emphasized in both the Chinese government’s 14th Five-year Plan (2021-2025) and the report on the 20th National Congress of the Chinese Communist Party (Oct. 2022).
  * The Chinese government has already overthrown the US in R&D funding and patents in each high-tech area (except biotechnology). China continues to pour astronomical amounts of funds into new technology such as AI and quantum computing.
  * The Chinese government is sharing defense technology with the private sector to simultaneously achieve economic growth and military modernization.

• China’s Belt and Road Initiative aims for in-depth cooperation with developing countries, policy communication (communication on internet development strategy and policy), infrastructure connection (connection of internet communication networks, data centers, and other infrastructure), trade and commerce (e-commerce), financial integration (finance-currency-economy integration), and people-to-people connectivity (connection of people in the digital space, digital talent training) in forming digital alliance.

• The US has enacted the Innovation Competition Act (passed by the Senate Jun 8, 2021), the COMPETES Act (passed by the House of Representatives Feb 4, 2022), the CHIPS and Science Act (Aug 9, 2022), and the InfraRed Act (Aug 16, 2022) to contain China, grow its technological competitiveness and reform supply chains.

• The fact that the US is employing trade sanctions, technological sanctions, and high-tech industry ecosystem sanctions is proof of the US’s dependence on semiconductor imports and of its technopolitical uncertainty.

• The US is reforming its semiconductor supply chains, providing semiconductor and battery subsidies, and taking other measures to contain China and cooperate with allies to acquire advanced technology.

• At its March 2023 National People’s Congress, China established the Central Science and Technology Commission to be subject to the communist party of China’s centralized direction as outlined in a proposal for the innovation of State Council organizations. The Chinese government is providing intensive support with the Ministry of Science and Technology’s important science and technology projects in line with its “science and technology self-reliance and self-empowerment” strategy.

• Installation of a new communist party organization above the Ministry of Science and Technology, a State Council organization, for President Xi’s direct oversight of science and technology activities.

• To gain superiority in the contest for technological hegemony, Korea has selected its 12 major national strategic technologies and formed a pan-governmental strategy (Oct. 2022) and the Special Act on Promotion of National Strategic Technologies (Feb. 2023), which addresses the formation of strategies and roadmaps to acquire the 12 major technologies

II S&T Diplomacy and Economic Security in the Age of Technological Hegemony Competition

Overview of Major Countries’ S&T Diplomacy

† Key developed countries use S&T diplomacy for a variety of purposes, including the improvement of relations with hostile countries, formation of partnerships with friendly countries, and improvement of status in relations with developing countries.

• US: Execution of a number of S&T diplomacy programs to improve its relations with Middle Eastern and Southeast Asian countries

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<th>Classification</th>
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<tr>
<td>Overseas Private Investment Corporation funds</td>
<td>The Overseas Private Investment Corporation operated a global technology innovation fund which collected USD 2 billion in funding for technological development by the global Muslim community</td>
</tr>
<tr>
<td>US Agency for International Development and US Department of State have agreed on the establishment of the Asia Regional Climate Change Center (ARCC) and initiated projects aimed at tackling water shortages</td>
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<tr>
<td>The National Academy of Sciences runs the Frontiers of Science Program to induce networking among young scientists of the US and Southeast Asia</td>
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<tr>
<td>The US Department of State jointly executes agricultural, environmental, and public health projects with research entities in Jordan, Tunisia, Israel, and other countries by way of funding basic research, applied research, and international cooperation in science and technology in the Middle East</td>
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</tr>
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† Europe: Science and technology cooperation among EU countries

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<tr>
<td>European Commission</td>
<td>* Sponsors multi-party research and innovation partnerships to identify solutions in response to digital and innovation crises; suggests research cooperation strengthening strategies for science-based policy-making and other core targets</td>
</tr>
<tr>
<td>EU Science Diplomacy Alliance</td>
<td>* Established in 2021 to strengthen S&amp;T cooperation among EU countries; approaches S&amp;T diplomacy as practice in the resolution of global tasks, promotion of understanding of scientific agendas, and promotion of national influences and development</td>
</tr>
<tr>
<td>Inventing a shared Science Diplomacy for Europe (InSciDE)</td>
<td>* The first interdisciplinary consortium on Europe’s science and technology diplomacy and a stakeholder-participated program; financed under the H2020 framework and participated in by scientists, diplomats, and policy-makers for expanding the basis for S&amp;T diplomacy</td>
</tr>
</tbody>
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† The role of science and technology diplomacy rises in importance as international politics and science and technology are closely correlated.
China: Establishment of a global science and technology diplomacy network through the Belt and Road Initiative

Table 3. Japan’s science and technology diplomacy

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<th>Classification</th>
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<tr>
<td>Council for science, technology and innovation</td>
<td>Internally recognizes that “diplomacy for S&amp;T” and “science in diplomacy” have been achieved to a degree; now emphasizes a need to focus on “science and technology for diplomacy.”</td>
</tr>
<tr>
<td>Ministry of Foreign Affairs</td>
<td>Promotes a brand image of Japan that paints it as a nation of peace with a 70-year history of S&amp;T for diplomacy, and a global S&amp;T power; pursues public diplomacy to strengthen Japan’s soft power.</td>
</tr>
<tr>
<td>Science and Technology Research Partnership for Sustainable Development (SATREPS)</td>
<td>Operates to increase the capacity of researchers and research entities in developing countries; the Japan Science and Technology Agency, Japan International Cooperation Agency (JICA), and other agencies execute international research cooperation suited to needs of developing countries.</td>
</tr>
<tr>
<td>Strategic International Collaborative Research Program (SICORP)</td>
<td>Executes joint research in strategic research areas prioritized by the Ministry of Education, Culture, Sports, S&amp;T, and with key countries based on international science and technology cooperation agreements.</td>
</tr>
<tr>
<td>Sakura science exchange program</td>
<td>Hosts foreign students, researchers, and scientists under the age of 40 over a short term in Japan to promote Japan’s advanced science and technology abroad, ongoing exchanges between scientists of Japan and other countries, and globalization of Japanese education and research institutions.</td>
</tr>
<tr>
<td>Japan International Cooperation Agency (JICA) R&amp;D Program</td>
<td>Future leaders of developing countries are hosted in Japan to exchange experience and knowledge in modern development and other areas of society as part of official development assistance.</td>
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Japan: Execution of a variety of public diplomacy programs focused on “S&T for diplomacy”

Table 4. China’s S&T diplomacy

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<th>Classification</th>
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<tr>
<td>Overview</td>
<td>International S&amp;T cooperation relations formed with 151 countries/regions and 32 organizations (as of 2023); 114 S&amp;T cooperation agreements concluded, and participated in over 200 S&amp;T-related international organizations and multi-party mechanisms (as of 2020); S&amp;T diplomats posted in some 70 countries around the world (as of 2017).</td>
</tr>
<tr>
<td>Belt and Road initiative project for S&amp;T innovation and cooperation in construction</td>
<td>Executes international cooperation with key countries and locales; pursues science, technology, and humanities exchanges, establishment of united laboratories, technology transfers, and more.</td>
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Table 5. France’s S&T diplomacy

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<th>Classification</th>
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<tbody>
<tr>
<td>Ministry for Europe and Foreign Affairs</td>
<td>Views international S&amp;T cooperation as a core element of science diplomacy policy of international influence; supports researchers and research programs, provides official development assistance, forms offshore research facilities, and more by way of science and technology diplomacy.</td>
</tr>
<tr>
<td>PHC (Hubert Curien Partnerships)</td>
<td>Fosters scientific partnerships between S&amp;T research teams in France and other countries; currently active in 60 countries and a diverse range of areas, including natural science and physics; engages in international cooperation with African countries to strengthen their international expertise and promote scientific excellence.</td>
</tr>
<tr>
<td>Make Our Planet Great Again</td>
<td>Sponsors students, researchers, and businessmen seeking to engage in joint international research in various areas such as climate change and sustainability in France with scholarships and post-doctoral fellowships.</td>
</tr>
<tr>
<td>German Federal Foreign Office</td>
<td>Approaches S&amp;T diplomacy as fundamental to international S&amp;T cooperation and international stability.</td>
</tr>
<tr>
<td>German Federal Ministry for Education and Research</td>
<td>Recognizes the need for global S&amp;T research cooperation in the response to climate change, extinction of species, and other issues; considers S&amp;T diplomacy to be an activity conducive to lasting partnerships based on international and inter-regional trust, international stability, and solutions to the challenges humanity faces.</td>
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Table 6. Germany’s S&T diplomacy

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The convergence of the economy, security, and technology raises the issue of economic security in areas where S&T cooperation takes place, such as climate change, energy, space, ocean, and strategic resource control.

In response to China’s economic rise, the US is implementing policy to achieve economic security through trade policy, supply chain reform, industrial policy update, and other new measures. In response to China’s economic rise, the US is implementing policy to achieve economic security through trade policy, supply chain reform, industrial policy update, and other new measures. Economic security is the degree to which a country can sufficiently access and utilize national resources and markets to maintain its power and wealth at a certain level.

1. Based on information covered at the 2022 science and technology diplomacy platform meeting
2. See analysis of the concept of economic security and recent economic security trends (2022) for further details.
In the context of international politics, the traditional concept of economy-security relations binds the economy to security, validating the use of economic means to fulfill the ultimate objective of national security.

Post-2000s, globalization and global supply chain expansion have consolidated the economy-security link.

General Agreement on Tariffs and Trade (GATT) Article 21 security exceptions allows countries discretion in imposing trade restrictions based on national security interests (the actual number of cases in which said Security Exceptions were invoked is very low).

The Trump administration changed the conventional economy-security relations; the economy is no longer prioritized over security.

With an economy-security balance needed, the US-led Indo-Pacific Economic Framework’s application not only to trade but also to labor, environment, and competition is expected to develop new relations.

The range of technology regulation is widening in response to the dual use of space technology, the weaponization of rechargeable batteries and other resources, supply chain issues caused by the Carbon Border Adjustment Mechanism and other climate change-related matters, and the implications of technology in security; security has become a major issue in S&T.

Not only knowledge in science and technology but also an understanding of changes in the geopolitical environment and other international affairs is required to act on Korea’s national interests effectively, necessitating a strategic response in science and technology diplomacy.

Climate change: Climate change response technology meeting regulation and the financial market has resulted in the Carbon Border Adjustment Mechanism, ESG management, and other such measures; as global competition in carbon reduction intensifies, Korea, a major exporter, must implement a system for a low-carbon switch.

The advent of ESG has created a mass preference for renewable energy and green technology; financial institutions, investment banks included, have decided to eliminate the funding of coal power plants.

With funding from commercial financial institutions having dried up, coal power plants have turned to private equity funds for loans, resulting in many coal power plants operating as they always have; this is a hidden aspect of carbon neutrality (as interest rates are connected with inflation, companies that have proclaimed ESG become negligent in ESG as return on investment suffers from ESG).

Energy: Availability and production of raw materials for rechargeable batteries are concentrated in certain regions; restrictions on production increases can potentially cause a supply-demand imbalance and the weaponization of resources, rendering reliance on certain countries for the supply of core minerals and raw materials inappropriate.

Korea’s participation in US efforts for supply line diversification and cooperation with friendly countries will be beneficial to Korea’s resource security; the US’s increased support and supply chain reform will be an opportunity for Korean companies in the areas Korea in which is competitive, such as semiconductors and rechargeable batteries.

Potential gains include the substitution of Chinese products with Korean products and greater tax benefits for Korean companies in the US; however, intensified competition over the long term from the growth in capacity of US companies is also a possibility.

Space: The International Traffic in Arms Regulations (ITAR), one of the US export control policies, affects satellite and launch vehicle parts exported by Korea and is a major issue in Korea-US cooperation.

US external policy on launch vehicles does not support or recommend independent development of launch vehicles by other countries; US-Korea coordination will be required to relax US export control policy.

Space technology is strategic technology subject to export controls; funding and demand guarantees are needed to secure technological sovereignty in source technology in the area of space technology.

Ocean: In climate regulation, biogeochemical material cycles, food resources, and many other areas, the ocean is at the core of human survival; as the ocean belongs to the entire world, international and joint efforts are needed in the area of the ocean.

As the movement of pollutants by ocean and air can cause environmental issues with neighboring countries, transparent joint scientific investigations and diplomatic cooperation among the countries concerned are required.

Strategic resource control: From the Coordinating Committee for Multilateral Export Controls of 1949 to the Wassenaar Arrangement of 1996, a number of multi-party export control systems have been established.


Export controls apply to breaches of strategic resource export control, unauthorized exports, and other instances necessary for the purposes of security, diplomacy, import/export, and protection of businesses.

Export controls contribute to international peace and security, prevent issues in international trade of companies from developing into international disputes, improve the transparency of trade of strategic resources, promote the import of high-tech resources, prevent trade retaliation as response to export control breaches, and support the safety of exports by companies.
Definition of S&T diplomacy and how S&T diplomacy is perceived in Korea

For the last 15 years or more, attempts have been made to define S&T diplomacy as a concept or phenomenon of strategic and multi-dimensional diplomacy, as distinct from general S&T cooperation between international parties; however, no agreed definition exists as of yet. (see table 7)

Table 7. Various definitions of S&T diplomacy

<table>
<thead>
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<th>Classification</th>
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<tbody>
<tr>
<td>Nina V. Fedoroff (2009)</td>
<td>Science diplomacy is the use of scientific collaborations among nations to address the common problems facing humanity in the 21st century, and to build constructive international partnerships</td>
</tr>
<tr>
<td>The Royal Society &amp; AAAS (2010)</td>
<td>Divides science diplomacy into the three aspects of science in diplomacy, informing foreign policy objectives with scientific advice, and diplomacy for science, thus facilitating international science cooperation, and science for diplomacy, using science cooperation to improve international relations between countries</td>
</tr>
<tr>
<td>T.Flink and U. Schnaitter (2010)</td>
<td>Science diplomacy is not only an important expansion of and an additional resource to a nation’s science policy but also an agent for the strengthening of scientific research and innovation capacity through international cooperation aimed at mutual benefit in all areas of science for diplomacy and diplomacy for science</td>
</tr>
<tr>
<td>Vaughan C. Turekian II (2015)</td>
<td>Science diplomacy is the process of a country’s representing itself and its interests in relation to knowledge and activities achieved by scientific means on the global stage, and an important area of resolving global issues, promoting international cooperation, and using the influence one country has over another</td>
</tr>
<tr>
<td>Daryl Copeland (2016)</td>
<td>Science diplomacy is a transformative tool for soft power used to offer an outlook on shared interests to overcome political limits and increase global cooperation</td>
</tr>
<tr>
<td>P.D. Gluckman II (2017)</td>
<td>Science diplomacy can be a base for a practical framework of foreign diplomacy, and can be thought of as comprising the three practical categories of measures for acting on national needs, measures for fulfilling interests that transcend borders, and measures for meeting global needs and completing innovative tasks</td>
</tr>
<tr>
<td>M. Rentezi (2018)</td>
<td>Because science diplomacy has overlapped with science as well as political science, economics, and sociology, among many disciplines, and developed through interaction over the years, it is a polycentric concept</td>
</tr>
<tr>
<td>C. Kasotkin and M. Auito (2018)</td>
<td>Science diplomacy is a frame of reference for an array of different interactions occurring within the global politics-science interface, and a heuristic tool to navigate and distinguish between different types of interactions</td>
</tr>
<tr>
<td>Paul Arthur Berkman (2019)</td>
<td>Science diplomacy between the US and Russia, and between the US and Europe maintains a balance between national and common interests, prevents political conflict, and creates new international spaces between hostile and friendly countries</td>
</tr>
<tr>
<td>T. Flink and N. Ruffin (2019)</td>
<td>Science diplomacy contains the logic of both international cooperation and international competition, and can be expected to be a sustainable phenomenon in international politics and foreign diplomacy</td>
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</table>

The different definitions of S&T diplomacy that have been given are consistent in identifying it as global partnership for resolving common issues facing humanity and as related to international politics. The three aspects of science diplomacy suggested by the Royal Society in 2010 allow for wide-ranging discussion of the definition of science diplomacy, but should reflect international developments such as technological hegemony competition and economic security (see table 8)

The European External Action Service and EU Science Diplomacy Alliance have suggested S&T diplomacy strategies based on the three aspects of science diplomacy defined by the Royal Society

Table 8. Three types (areas) of S&T diplomacy

<table>
<thead>
<tr>
<th>Area 1 of S&amp;T diplomacy: Diplomacy for science</th>
<th>Area 2 of science and technology diplomacy: Science in diplomacy</th>
<th>Area 3 of S&amp;T diplomacy: Science for diplomacy</th>
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<tbody>
<tr>
<td><strong>Nature</strong></td>
<td>Activities of international S&amp;T organizations (actual S&amp;T organizations and other international organizations)</td>
<td>Use of S&amp;T to resolve major diplomatic issues</td>
</tr>
<tr>
<td>Purpose</td>
<td>Economic growth through an increased capacity for S&amp;T (acquisition of advanced technology, development of personal, exchange of information, etc.)</td>
<td>Sharing of expert knowledge and participation in the setting of agendas for international organizations for the management of problems occurring in the areas of the environment, energy, health, and more</td>
</tr>
<tr>
<td>Function of S&amp;T</td>
<td>A source of economic growth and increased profit</td>
<td>Expert knowledge for diagnosing and resolving current issues</td>
</tr>
<tr>
<td></td>
<td>A bridge for post-ideological, rational, and universal relationships</td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td>Two-party S&amp;T agreements, two-party joint research and personal exchanges, multi-party international joint research</td>
<td>Intergovernmental Panel on Climate Change activities, International Atomic Energy Agency activities, activities of other international organizations related to deep sea, space, and polar regions; S&amp;T advice of the Organisation for Economic Co-operation and Development and UN</td>
</tr>
<tr>
<td></td>
<td>S&amp;T cooperation between Western countries and Islamic countries, and between North and South Korea; official development assistance in S&amp;T, etc.</td>
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</table>

*Source* The above-described nature, purpose, and examples of S&T diplomacy, and the function of S&T used in S&T diplomacy, are based on the three aspects of S&T diplomacy defined by the Royal Society (Bae, Y. J, 2015)
The top three common activities in S&T diplomacy were found to be “diplomacy for S&T” (94.9%), “S&T for diplomacy” (72.9%) and “S&T in diplomacy” (71.2%).

The top five common activities in diplomacy for S&T were found to be “inter-institutional exchanges, such as concluding MOUs” and “information exchanges” (99.9%), “joint research” (96.1%), “personnel exchanges such as the dispatch of personnel to foreign research centers” (50.8%), and “personnel exchanges such as the recruitment of foreign research personnel” (49.2%).

The top three most common activities in S&T diplomacy were found to be “official development assistance in S&T” (62.7%), “North-South Korean S&T cooperation” (23.7%), and “S&T cooperation with countries with no or stressed diplomatic relations” (18.6%).

The top three most common activities in S&T for diplomacy were found to be “S&T advisories to international organizations such as the OECD and UN” (50.8%), “participation in or support of diplomatic activities such as inter-governmental councils (IPCC)” (47.5%), and “activities of international organizations related to space, ocean, and polar regions” (30.5%).

The areas with which respondents most strongly associated S&T diplomacy were “climate change” (91.5%), “energy” (89.9%), “digital” (64.4%), “health” (84.7%), and “supply chains” (74.6%).

Supply chains was also perceived as an important area of S&T diplomacy due to the US-China technology hegemony competition.

Of the respondents who identified climate change-related activities as a type of S&T diplomacy (n=54), most perceived S&T diplomacy to be “science used in the activities of international organizations and inter-governmental councils” (44.4%), followed by “diplomatic activities for S&T” (29.6%) and “S&T for diplomatic activities” (18.5%).

The respondents did not perceive the three types of S&T diplomacy to be disparate but correlated.
Regarding the areas of S&T that are important in Korea's S&T diplomacy, the respondents indicated "mobile communication, cybersecurity, aerospace, and advanced biotechnology" were the areas in which the highest degree of importance was attributed to the other areas, which can be interpreted as meaning a higher relative difference in perception of S&T and diplomacy was reported. Higher relative importance of S&T was attributed to aerospace, while based on single rankings, "semiconductors and displays" (55.9%) was indicated as the most important, consistent with the single rankings (15.3%), and "mobile communication such as 5G and 6G" (8.5%).

The survey findings indicate that improvement of Korea's national status and diplomatic power should be given foremost consideration in forming S&T diplomacy targets in the future. The diplomatic community was found to perceive contribution to the international community as the most important consideration, evidence of their perception of S&T from the standpoint of public diplomacy.

Based on single rankings, the respondents indicated the targets to be reached in Korea's S&T diplomacy as "improvement of national status and diplomatic power to align with Korea's economy" (30.5%), "strengthening of Korea's S&T capacity" (25.4%), "contribution to the international community by participating in resolving global issues and other activities" (22.0%), and "securing Korea's national economic security" (20.3%).

Based on multiple rankings, "improvement of national status and diplomatic power to align with Korea's economy" (54.2%) was ranked the highest, followed by "contribution to the international community by participating in resolving global issues and other activities" (22.0%) and "strengthening of Korea's S&T capacity" (24.4%).

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Because S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined. S&T diplomacy is perceived as encompassing the two separate components of international cooperation in S&T and public diplomacy in S&T in Korea, the concept of S&T diplomacy needs to be defined.
No official definition of S&T diplomacy exists, and one needs to be made and applied to S&T diplomacy and policy-making. As control of economic security and technology tightens as the US-China competition for technological hegemony intensifies, diplomacy for S&T and S&T for public diplomacy are becoming increasingly integrated.

Forming in S&T diplomacy are areas, such as the area of climate change, where scientific advice is used in diplomacy, and where efforts are made to acquire stable supply chains and respond to technology control in consideration of economic security and technological security (see fig. 11).

The new convergence area of S&T diplomacy related to economic and technological security is suggested as “diplomacy in science”, a new type of S&T diplomacy. “Diplomacy in science” counts as activities related to the control of S&T related to economic security and technological security for the securing of foreign/strategic resources, securing of supply chains, etc. (see table 9).

Directions for Korea’s S&T Diplomacy in the Competition for Technological Hegemony

Table 9. Types of S&T diplomacy

<table>
<thead>
<tr>
<th>Classification</th>
<th>S&amp;T as the objective (diplomacy as a means)</th>
<th>Diplomacy as the objective (S&amp;T as a means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperative means (standardization and control)</td>
<td>Diplomacy in science - Standardization-based control activities for securing S&amp;T resources in relation to economic security - Securing of foreign/strategic resources, securing of supply chains, etc.</td>
<td>Science in diplomacy - Imposition of obligations on others through control measures such as S&amp;T standards and systems - S&amp;T as scientific advice</td>
</tr>
<tr>
<td>Persuasive means (cooperation and competition)</td>
<td>Diplomacy for science - Cooperation through persuasion and assertion based on S&amp;T achievements - International cooperation in S&amp;T: Joint research, joint S&amp;T committees, etc.</td>
<td>Science for diplomacy - Use of S&amp;T as a persuasive resource for inducement and compensation - ODA in S&amp;T, North-South Korean S&amp;T cooperation, etc.</td>
</tr>
</tbody>
</table>

[Source] Prepared by the authors based on types of policy objectives and coerciveness of means, i.e., persuasive means vs. imperative means.

Figure 11. Areas of S&T diplomacy related to economic security

- Forming in S&T diplomacy are areas, such as the area of climate change, where scientific advice is used in diplomacy, and where efforts are made to acquire stable supply chains and respond to technology control in consideration of economic security and technological security (see fig. 11).

- The new convergence area of S&T diplomacy related to economic and technological security is suggested as “diplomacy in science”, a new type of S&T diplomacy.

- “Diplomacy in science” counts as activities related to the control of S&T related to economic and technological security for the securing of technological sovereignty, supply chains, and other desirables.

- The type of S&T diplomacy that aims for S&T (purpose) but employs such imperative means as the control of S&T for economic and technological security is defined as “diplomacy in science.”

- While “diplomacy for science” has been noted in cooperation and competition, “diplomacy in science” involves the acquisition of technological sovereignty and stable supply chains through standardization and control (see table 9).
IV Response to S&T Diplomacy and Future Tasks

Response of the four types of S&T diplomacy in the age of global competition for technological hegemony

- Diplomacy for science: Conventional international cooperation activities in S&T, including national strategic technology, that require a more strategic approach; Korea-led bilateral/multilateral international joint research programs required
  - Shifting from the catch-up strategy employed as a latecomer to mutually beneficial joint research aimed at initiative-driven pursuit of creative innovation and greater S&T leadership
  - Higher levels of activity than in other types of S&T diplomacy; strong government interest in international cooperation in S&T for securing the 12 major national strategic technologies
  - Cooperation in trade and public diplomacy important due to economic security issues and other factors, but limits to inter-departmental cooperation remain

- Science for diplomacy: An area of rising importance mainly pursued by the Ministry of Foreign Affairs from a public diplomacy angle; requires focus on improving S&T expertise and connection with the Indo-Pacific strategy
  - Korea’s Indo-Pacific strategy (Dec. 2022) is a regional strategy; regional strategies in S&T diplomacy are also required
  - Cooperation with India and Asean countries should be sought in substitution for the Chinese market as response to the US-China technological hegemony competition, which will require demand-based cooperation such as official development assistance in S&T
  - Inadequacy of multi-party cooperation in the Indo-Pacific from a focus on two-party cooperation; Korea’s global leadership in the Indo-Pacific is required
  - Moving forward, S&T diplomacy roadmapping should incorporate a two-party cooperation strategy as well as an Indo-Pacific multi-party cooperation strategy

- Science in diplomacy: Korea’s stronger global leadership (agenda leadership) in multi-party cooperation, such as the tackling of global issues (climate change, energy, etc.) and the achievement of the Sustainable Development Goals, are required to align with Korea’s economy and global status
  - Role of S&T is increasing in global issues such as climate change and carbon reduction as well as space waste (space diplomacy) and sea environment improvement (maritime diplomacy)
  - Consideration of economic security in multilateral cooperation in tackling global issues such as climate change also makes US and China blocs a possibility with this type of S&T diplomacy.
  - Even if the formation of a US bloc or a China bloc occurs to a degree, a response to agenda-centric S&T diplomacy, such as in climate change response, should be pursued to keep a channel of communication with China open

- Diplomacy in science: A newly-defined type of multilateral cooperation in relation to economic security; under standardized control, cooperation with friendly countries should be strengthened and cooperation with other blocs should continue to secure rare resources and stable supply chains
  - A response to domestic and foreign control systems that apply to strategic resources (technologies) related to security that includes access to rare resources such as rare earth elements is important

<table>
<thead>
<tr>
<th>Table 10. Response by type of S&amp;T diplomacy</th>
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</thead>
<tbody>
<tr>
<td><strong>Diplomacy for science</strong></td>
</tr>
<tr>
<td>Korea to pursue strategies that are more systematic, such as the acquisition of nationally strategic technology, and Korea-led bilateral/multilateral international joint research programs</td>
</tr>
<tr>
<td><strong>Diplomacy in science</strong></td>
</tr>
<tr>
<td>Under standardized control, cooperation with friendly countries should be strengthened and cooperation with other blocs should continue to secure strategic resources, rare resources, and stable supply chains for economic security</td>
</tr>
<tr>
<td><strong>Science for diplomacy</strong></td>
</tr>
<tr>
<td>A form of public diplomacy to be pursued to improve expertise in S&amp;T and in line with the Indo-Pacific strategy</td>
</tr>
<tr>
<td><strong>Science in diplomacy</strong></td>
</tr>
<tr>
<td>Korea to strengthen its agenda leadership to align with its economic and global status, e.g., resolution of global issues and fulfillment of the SDGs</td>
</tr>
</tbody>
</table>

US-China technological hegemony competition will likely continue into the future; the role of “diplomacy in science” which supports economic security will likely expand

- A response to issues in S&T diplomacy such as the guardrail articles of the CHIPS and Science Act and the battery subsidies prescribed by the Inflation Reduction Act (US) is required
  - Should the US Department of Commerce receive government funding on March 22, expansion of the production capacity of China and other countries will be restricted by 5% for advanced semiconductors and over 10% for general-purpose semiconductors
  - General-purpose semiconductors include 28 nm logic semiconductors, 16nm DRAM, and 128-layer NAND flash
  - Currently, Samsung Electronics produces semiconductors more high-tech than general-purpose semiconductors in China (about 40% of all NAND flash), while SK Hynix produces about 40% of DRAM and 20% of NAND flash in China
  - The Inflation Reduction Act allows the issuing of battery subsidies on the condition of acquisition of EV battery materials such as lithium and cobalt from the 22 partner companies of the US, or assembly of EV batteries in the US
  - Three Korean battery manufacturers, LG Energy Solution, Samsung SDI, and SK ON, import materials from China or have assembly plants in China

- Inter-departmental cooperation on issues related to economic security is important, as such issues are areas in which the activities of the Ministry of Science and ICT, Ministry of Trade and Industry, and Ministry of Foreign Affairs overlap; a comprehensive approach focusing on diplomacy in science is required
  - Technological standardization, personnel development, research security activities, and other activities in new technology such as quantum technology and AI are to take place through Korea-US/Korea-Japan economic security talks and Korea-US core emerging technology talks by way of strengthening bilateral cooperation in the bloc.
Supply chain stability in the areas of semiconductors and batteries will be achieved through diversification of cooperation in the securing of rare resources (rare earth elements) supply chains, and cooperation with India and ASEAN countries.

Multi(Mini)-lateral cooperation in the bloc will be achieved through IPEF, Chip 4, and Quad, and more importantly, existing cooperation frameworks (Korea-US-Japan and Korea-China-Japan cooperation) will be utilized in the pursuit of multi-tier S&T diplomacy strategies.

Multilateral cooperation systems for global issue management and Korea-led multilateral international joint research programs to sustain Korea’s cooperation with countries outside the bloc, such as China.

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KISTEP News

1
Korea-Germany Technology Sovereignty Forum held

2
2023 KISTEP-ISTIC STI Training Program held

3
KISTEP signed MOU with Uzbekistan’s Scientific and Technical Information Center

4
KISTEP attended 18th Trilateral Science and Technology Policy Seminar
Vice Minister for Science, Technology and Innovation at the Ministry of Science and ICT (MSISIT) Young-Chang Joo announced he had met with German Parliamentary State Secretary Jens Brandenburg at the Federal Ministry of Education and Research (BMBF) in Berlin on May 25, and discussed ways to foster collaboration between Korea and Germany in the area of strategic technologies. This year marks the 140th year of Korea-Germany diplomatic relations. On May 21, Korean President Suk-Yeol Yoon and German Chancellor Olaf Scholz held a summit, in which the two saw eye to eye on the need to deepen solidarity and cooperation in response to the global issues of today.

The meeting with Jens Brandenburg followed swiftly on the heels of the summit of the two state leaders, and was inspired by the need to expand horizons in S&T cooperation and bring the efforts of Korea and Germany together in technology hegemony competition. The two parties at the meeting found similarities in the two countries’ policies in the response to technology hegemony competition, and agreed that collaborative research efforts are needed to develop a strategic technologies policy between Korea and Germany.

Starting with joint research activities by the two countries’ S&T policy think tanks, the strategic partnership on strategic technologies and other such areas will be strengthened. On the day of the meeting, Vice Minister Joo attended the Korea-Germany Technology Sovereignty Forum, at which he reaffirmed Korea’s interest in continued cooperation.

Jointly organized by the Korea Institute of S&T Evaluation and Planning (KISTEP) and the Fraunhofer ISI (Institute for Systems and Innovation Research), the Korea-Germany Technology Sovereignty Forum saw in-depth discussions among Korean and German experts on the Korea-Germany S&T cooperation strategy to secure technology sovereignty. In his keynote speech, Vice Minister Young-Chang Joo stressed the importance of Korea-Germany cooperation in the quest for technology sovereignty, and of the Forum as a pivot point towards that end. In a statement release, the Ministry of Science and ICT stressed that “the visit to Germany gave Korea an ideal partner in the pursuit of technology sovereignty”, and added that “the 7th Meeting of the Korea-Germany Joint Committee on the S&T Industry scheduled for the second half of the year and other avenues of inter-governmental cooperation will be used to continuously develop plans for cooperation”.

KISTEP held the ‘2023 KISTEP-ISTIC STI Training Program for High Level Policy Makers’ at the Grand InterContinental Seoul Parnas from July 25 to 28, in collaboration with ISTIC under UNESCO.

The 2023 program was attended by 14 S&T policy makers from 13 countries, including Asia (Malaysia, India, Indonesia, Myanmar, Thailand, Uzbekistan), the Middle East (Iran), Africa (Egypt, Ethiopia, Mauritius, Nigeria, Zimbabwe) and South America (Brazil).

This year’s program consisted of lectures on Technology Foresight, S&T Basic Plan, HR in S&T Policy, R&D Program Budget Allocation and Coordination, R&D Program Evaluation, COSTII, (Special sessions) History and Future Directions of S&T Policy in Korea, Key Issues in the Era of GVC Challenges and Technology Hegemony, How to Increase R&D Productivity and its Fruits, and presentations on the S&T innovation policies of the participating countries.

Commenting on the program, President Byung-Seon Jeong said “We are delighted to be able to invite participants to Korea and meet them in person by holding the program offline, which had been held only online due to COVID-19”, and that “Korea achieved remarkable development based on S&T innovation by acquiring S&T know-how and experience from advanced countries and establishing a ministry dedicated to S&T in the 1960s, but as a world-class S&T powerhouse, Korea still has various concerns, such as the transition to a mission-oriented R&D system, the creation of a research environment centered on researchers, and the creation of high-quality research results”. He added, “We will continue to share Korea’s success experiences and concerns, and seek continuous knowledge transfer systems and cooperation plans so that developing countries can promote national development by strengthening their S&T innovation capabilities, solve global problems, and contribute to the universal values of mankind, such as improving the quality of life”.

http://www.ikbc.co.kr/article/view/kbc202305260010

https://www.kistep.re.kr/board.es?mid=a10202030000&bid=0002&act=view&list_no=43447
The 18th Trilateral S&T Policy Seminar hosted by the Chinese Academy of Science and Technology for Development (CASTED) took place in Beijing on November 1 and 2.

Attended by representatives of five S&T policy think tanks from Korea, China, and Japan (Korea Institute of S&T Evaluation and Planning (KISTEP), Science and Technology Policy Institute (STEPi); Chinese Academy of Sciences Institutes of Science and Development (CASISD), Chinese Academy of Science and Technology for Development (CASTED); and National Institute of Science and Technology Policy (NISTEP)), the Seminar has been held annually since 2006 to explore the S&T policies of the three countries, major research achievements of the think tanks, and potential avenues for cooperation. From 2020 to 2022 the event was held online due to the pandemic, making this year's in-person event a return to normal that saw the participants gathered in one brick-and-mortar environment for in-depth discussions.

Held under the theme of “Sustainable Development and Scientific and Technological Innovation”, this year’s event consisted of six sessions that delivered presentations on △ the major research activities and achievements of the institutions in 2023, △ technological innovation measurement and STI policy, △ development, transfer, and cooperation of S&T personnel, △ new growth engines and S&T policy, and △ STI policy-making through S&T foresight and a strengthened commitment to the sustainable development goals.

President Byung-Seon Jeong said “the Trilateral Science and Technology Policy Seminar has become a venue for exchanges and cooperation in the exploration of roles and solutions in S&T policy that brings the major S&T policy think tanks of Korea, China, and Japan together each year to discuss common issues”, and that “KISTEP looks forward to collaborating with the other institutions in joint research projects, personnel exchanges, and case studies concerning the three countries to pursue future talent development and networking, sustainable development, and STI, as addressed at this year’s event”. The 19th Trilateral Science and Technology Policy Seminar will be hosted by the National Institute of Science and Technology Policy (NISTEP) in Japan.

KISTEP signed an MOU with Uzbekistan’s Scientific and Technical Information Center (STIC) on Friday, July 28 for the purpose of promoting exchange and cooperation.

STIC is a center under the Ministry of Innovative Development and was established with the goal of promoting Uzbekistan’s S&T innovation activities in Central Asia. The center is actively involved in information analysis related to national projects, building electronic databases, and developing scientometric indicators.

Based on this agreement, the two organizations plan to cooperate in various fields of common interest such as establishing S&T information services and evaluating national S&T innovation capabilities by ▲ promoting cooperative projects including joint research, seminars, and consultations and ▲ activating human networks and information exchange between researchers.

“KISTEP is very pleased to have signed an MOU with STIC, a S&T innovation hub in Uzbekistan and Central Asia”, President Jeong said. “With the signing of this MOU, we hope to transfer KISTEP’s know-how, such as information analysis and database construction in the field of S&T innovation, and to promote mutual cooperation”, he added.

KISTEP R&D AND BEYOND 2023 KISTEP News
Publication and Citation of Korean S&T Papers in 2021

SCI Paper Citation by Country

SCI Papers Published by Korea

SCI Paper Citation by Area of Research
Publication and Citation of Korean S&T Papers in 2021

KISTEP uses the Science Citation Index (SCI) of Clarivate Analytics to analyze and disclose conditions in published research activities. The following is an outline of published S&T research achievements and citations recorded by Korea and other key countries.

Source: Publication and Citation of Korean S&T Papers in 2021, KISTEP (Sep. 2023)

### SCI Paper Citation by Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Papers</th>
<th>Papers in the World in 2021 by Share(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>535,192</td>
<td>1st (18.68%)</td>
</tr>
<tr>
<td>US</td>
<td>521,072</td>
<td>2nd (15.17%)</td>
</tr>
<tr>
<td>Korea</td>
<td>524,643</td>
<td>12th (2.44%)</td>
</tr>
</tbody>
</table>

### SCI Papers Published by Korea

- 2021: 28,714 papers
- 2020: 58,976 papers
- 2019: 76,822 papers

### SCI Paper Citation by Area of Research

- Most papers published by Korea among the 22 standard categories in 2021: Clinical medicine (15,173 papers)
- 18% of all Korean papers published

Korea’s largest share in all papers published in the world: Material science (5.9%)

- Number of papers 7 of the world’s top 10 categories: 22 subjects all within the top 20 rankings