Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3, 689-696
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i3.5283

Comparative study on national HPC core strategies for AI adaptation-focusing on South Korea and the United States

Hyungwook Shim[1], Minho Suh[2*]
[1,2]Korea Institute of Science and Technology Information, Korea; shw@kisti.re.kr (H.S.) mhsuh@kisti.re.kr (M.S.).

Abstract: This study compares high-performance computing policies in the United States and South Korea to derive an effective future policy model, an efficient governance structure, and key policy implications. By analyzing the National Strategic Computing Initiative and the 3rd National HPC Master Plan, the study examines their technology development and industrial promotion strategies based on five key criteria: policy priorities, implementation system, technology development strategy, infrastructure, and resource management. The findings reveal that the NSCI prioritizes global technological leadership, next-generation technology development, and cybersecurity, whereas the Master Plan focuses on AI-driven demand, technological independence, and industrial applications. These differences highlight the need for a concrete policy model with execution roadmaps, particularly for quantum computing resource development and core software technologies tailored to new architectures. Strengthening governance structures and enhancing resource management strategies will be crucial for ensuring sustainable growth and competitiveness in HPC. The study provides valuable insights for policymakers in designing more effective and future-proof HPC strategies.
Keywords: *AI, HPC, Master plan, NSCI, Strategy.*

1. Introduction

With the rapid advancement of generative AI models such as ChatGPT and DeepSeek, artificial intelligence (AI) technology has emerged as a key issue in the global competition for technological supremacy. High-Performance Computing (HPC) is gaining attention as a critical infrastructure supporting AI advancements, prompting governments worldwide to position HPC expansion as a core element of their national strategies. As AI models grow exponentially in scale, the importance of high-performance infrastructures, such as exascale supercomputers, has become even more pronounced. Consequently, major global players are making substantial investments and implementing strategic policies to maximize HPC performance and secure independent technological capabilities. The United States maintains its global dominance in HPC hardware and software technologies by fostering close collaboration with its domestic semiconductor companies, such as NVIDIA, Intel, and AMD. In 2024, the U.S. surpassed a 50% share of global HPC performance, solidifying its leadership. Additionally, it operates Frontier, the world's first exascale supercomputer, maintaining an unrivaled position in AI and scientific research. The European Union is driving HPC policy at a pan-European level through the EuroHPC Joint Undertaking, surpassing individual national efforts. Through this initiative, the EU has deployed exascale supercomputers in key countries such as France, Germany, Italy, and Finland. Furthermore, projects like Horizon Europe, the EU AI Act, and GAIA-X aim to reduce dependence on U.S. technologies and establish a self-sufficient AI semiconductor and data infrastructure. These policies seek to strengthen Europe's technological sovereignty while fostering AI startups and research ecosystems. In contrast, despite South Korea consistently ranking within the top 10 of the Top500 supercomputer list, it faces structural challenges due to its reliance on foreign core HPC hardware,

History: Received: 25 December 2024; Revised: 14 February 2025; Accepted: 17 February 2025; Published: 8 March 2025
* Correspondence: mhsuh@kisti.re.kr

including semiconductors, GPUs, and accelerators. In response, the Korean government is promoting foundational research and long-term strategies for HPC system independence. Recently, there has been a shift from a government-led to a private-sector-driven approach in HPC development. However, compared to the United States and the EU, the technological gap continues to widen, necessitating more sophisticated policy measures to advance Korea's HPC capabilities.

This study aims to provide an academic perspective on the landscape of global technological competition by comparing and analyzing the major HPC policies of different countries. Through this comparative analysis, we seek to explore strategic directions for Korea's HPC technology advancement and enhancing national competitiveness. HPC is not merely about supercomputer deployment; it serves as a core component in achieving diverse national policy goals, including scientific and technological competitiveness, industrial development, AI research, security, and disaster prevention. In particular, a comparative analysis of Korea's HPC policies and the U.S. strategy will go beyond simple policy evaluation to derive effective technological development pathways and maximize national competitiveness.

2. Literature Review

This study seeks to critically examine the achievements and limitations of existing research on key policy issues related to High-Performance Computing (HPC) through a comprehensive review of prior studies. By analyzing HPC policies across various nations, we underscore the necessity of strategic decision-making at the national level. To this end, we explore major studies addressing HPC policies, infrastructure, industrial applications, security, education, and government strategies. Kang, et al. [1] presents a framework for analyzing the generative AI ecosystem and its policy implications, focusing on Korea's AI development and platform strategies. It classifies key players, including app builders, technology partners, foundational AI models, cloud services, and chip manufacturers, emphasizing market competitiveness through localized services. The AI platform-squared, dominated by U.S. and Chinese firms, presents both opportunities and challenges for Korea, requiring a strategic approach to regulation and market entry. To strengthen its position, Korea should leverage its strengths in foundational AI and chip manufacturing while implementing policies that support, rather than restrict, AI platform development Kang, et al. [1]. Papyshev and Yarime [2] analyzes 31 national AI strategies using qualitative content analysis and Latent Dirichlet Allocation (LDA) topic modeling to examine the roles and functions of governments in AI governance. The analysis identifies thirteen state functions, grouped into three overarching themes: development, control, and promotion. While all national strategies contain these themes, their emphasis varies by region—post-Soviet and East Asian countries prioritize development, reflecting strong state involvement in AI innovation; the EU focuses on control, emphasizing strict regulations; and countries like the UK, US, and Ireland favor promotion, allowing the private sector to take the lead Papyshev and Yarime [2]. Škrinárová and Vesel [3] examined the challenges of HPC education in environments integrating grid computing, cloud computing, HPC clusters, and hybrid systems. By analyzing the High-Performance Computing Strategic Research Agenda in Europe alongside related studies from the United States, the research highlighted the critical role of workforce development in the HPC sector. Based on these insights, an education and training strategy model was devised to mitigate the supply-demand gap in HPC talent [3]. Further research has been conducted on industrial applications of HPC. Lee and Jeong [4] employed the Business Building Block Canvas methodology to assess strategic approaches for HPC service providers in supporting small and medium-sized enterprises (SMEs). The study also explored innovative business strategies that HPC service organizations could adopt when designing tailored user service models [4]. Security concerns in national HPC infrastructure have also been a focal point of research. Hamlet and Keliiaa [5] proposed solutions for enhancing the cybersecurity of national wide-area information infrastructure by integrating cybersecurity frameworks with HPC analytics. The study presented an actionable cybersecurity strategy and a roadmap to bolster national security systems through HPC-based solutions [5]. Additionally, Maleki, et al. [6] developed a strategic roadmap encompassing various HPC-related domains, including research activities, infrastructure development, data processing, regulatory standards, applied services, and business innovation. A notable contribution of this study was the introduction of the Supercomputing Development Readiness Index (SDRI), modeled after the Network Readiness Index (NRI), to assess the efficacy of petaflops-scale supercomputer service development [6]. In the context of South Korea's HPC policies, Choi, et al. [7] conducted an in-depth study on establishing a national HPC innovation strategy, proposing key policy measures centered on strategic HPC infrastructure expansion and the advancement of innovative HPC applications [7]. Furthermore, Besednjak Valič, et al. [8] examined collaborative efforts between academic HPC centers and SMEs in the Danube region's automotive and electronics industries. The research analyzed the influence of national innovation system components on university-industry cooperation and knowledge transfer, emphasizing the need for differentiated collaboration strategies tailored to national competitiveness levels [8].

A comprehensive review of previous studies reveals that HPC policies have been analyzed across various domains, including government policies, private sector engagement, technological approaches, security, education, and infrastructure development. Existing research has utilized diverse methodologies and case studies, such as developing policy evaluation indicators, analyzing industry impact factors, and applying assessment frameworks, to derive policy improvement directions. However, most prior research has focused on HPC policy analysis within individual countries, and comparative studies of core national policies remain relatively scarce. In particular, there is a lack of research comparing national policies in the context of AI development and HPC infrastructure expansion. This study aims to address this gap by comparing HPC policies in the United States and South Korea to derive policy implications for the Korean government and industry. Through this analysis, we seek to contribute to enhancing Korea's HPC technological competitiveness and establishing sustainable strategies in the global AI and supercomputing market.

3. National Strategic Computing Initiative

The NSCI is a national-level plan established by the U.S. government to develop HPC and supercomputing technologies. It was launched in 2015 through Executive Order (E.O. 13702) with the goal of advancing HPC infrastructure to drive scientific and economic progress, enhance national security, and develop next-generation computing technologies such as exascale computing. Additionally, it aimed to improve accessibility to HPC resources. Key Objectives of NSCI are below:

- Accelerate the development of exascale computing systems, which provide approximately 100 times the performance improvement, enabling their implementation across various applications.
- Enhance consistency between technologies used for modeling & simulation and those used for data analytics computing.
- Establish a viable pathway for next-generation HPC systems beyond the current limitations of semiconductor technology (i.e., the post-Moore's Law era).
- Expand national HPC ecosystem capacity and capabilities to ensure long-term sustainability and operational viability.
- Strengthen public-private collaboration among government, industry, and academia, ensuring that R&D outcomes benefit all sectors.

To maintain global technological leadership through the development and utilization of HPC technologies, the U.S. government established the following guiding principles:

- Broad deployment and application of advanced HPC technologies are essential for economic competitiveness and scientific breakthroughs.
- Public-private partnerships must be fostered to leverage the strengths of government, industry, and academia, maximizing the benefits of HPC.

- A whole-of-government approach should be adopted, utilizing the strengths of all federal agencies with expertise or vested interests in HPC while collaborating with industry and academia.
- A comprehensive technical and scientific approach is required to efficiently transition HPC research (hardware, system software, development tools, and applications) into development and deployment stages.

In 2019, the U.S. government updated the NSCI strategy to counter the expansion of China's HPC infrastructure and the rapid advancement of AI technologies. The revised strategy introduced several enhancements:

- AI and machine learning integration alongside traditional exascale computing development.
- Strengthened cybersecurity measures for HPC infrastructure, prioritizing HPC applications related to national security.
- Detailed strategies for quantum computing and next-generation computing architectures.
- Identification of HPC use cases applicable to industrial innovation.

A summary of the key updates is presented in Table 1 [9-11].

Table 1.
National Strategic Computing Initiative.

	Key Strategy
1. Enabling the Future of Computing	- Adoption of various hardware and software approaches to enhance HPC capabilities. - Support for integrated system development, enabling end-to-end application workflows for solving scientific, engineering, and national security challenges. - Maximization of benefits from innovative hardware, software, architectures, and new computing paradigms.
2. Providing a Strategic Foundation for Computing	- Strengthening of hardware and software infrastructure through investment in key infrastructure such as semiconductor manufacturing facilities, cyber infrastructure services, and usability improvements. - Enhancement of cybersecurity by developing cyber landscape modeling and simulation technologies. - Support for data usage and management, including end-to-end data management systems and standardized data tools.
3. Ensuring Collaborative and Coordinated Approaches	- Establishment of multi-year mechanisms to explore, develop, and deploy emerging technologies. - Encouragement of private sector R&D and integration of new technologies. - Implementation of an intergovernmental cooperation framework focused on future computing initiatives.

4. The 3rd National High-Performance Computing Promotion Master Plan

HPC has become a key research infrastructure driving innovation across science, technology, economy, and society. In the era of digital transformation, with the explosive growth of data and AI, HPC is now recognized as a strategic technological asset that underpins national competitiveness. South Korea requires enhanced national HPC capabilities to meet the rising demands for data and AI technologies. However, the current HPC infrastructure has limited utilization, and additional efforts are needed for industry integration and technological self-sufficiency. In response, the 3rd National High-Performance Computing Promotion Master Plan (2023–2027) (hereafter referred to as the Master Plan) was established in 2022. The Master Plan defines four key strategic directions, each comprising ten specific implementation strategies. By 2027, the plan aims to establish an HPC infrastructure of 1.4 exaflops (EF) and develop 18 leading HPC technologies. The key contents of each strategic direction are as follows:

4.1. Supporting Innovation in HPC Applications

This strategy is divided into Advancing HPC utilization systems, generating innovative HPC applications, and Enhancing industrial HPC adoption. To advance HPC utilization systems, the National HPC Center will allocate resources into four categories: Master research, Public and social

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 689-696, 2025
DOI: 10.55214/25768484.v9i3.5283

limitations, Industrial utilization, and Collaborative use. Additionally, R&D project selection and evaluation systems will be improved. Application software optimized for exascale computing will be developed, particularly in new demand areas such as healthcare, drug discovery, and energy. To generate innovative HPC applications, dedicated projects leveraging HPC for public and societal challenges will be expanded. Challenge-driven R&D will be promoted through specialized HPC centers, fostering new growth drivers. To enhance industrial HPC adoption, AI-driven modeling and simulation technologies for manufacturing will be expanded. Furthermore, key technologies will be developed for digital twins in fields such as healthcare, energy, construction, and defense.

4.2. Enhancing Access to HPC Resources

This strategy consists of: Expanding HPC infrastructure, and building a national shared HPC service system. Regarding infrastructure expansion, the 6th-generation supercomputer (600 petaflops) will be introduced by 2023, expanding the National HPC Center's core infrastructure. Planning for the 7th-generation supercomputer will begin in 2025. Specialized sector-based centers will be established to provide customized services, utilizing CPU and GPU-based resources to offer diverse computing options. Additionally, research networks will be upgraded, and integrated storage will be built to enhance HPC infrastructure connectivity. To build a national shared HPC service system, a one-stop cloud-based technology support service will be introduced. The supercomputing equipment acquisition system will also be improved to expand shared infrastructure.

4.3. Becoming a Global HPC Leader

This strategy includes: Achieving technological self-sufficiency, and laying the foundation for industrial growth. To ensure technological self-sufficiency, South Korea will develop indigenous HPC systems, establish a long-term self-reliance roadmap, and secure heterogeneous and low-power hardware technologies necessary for exascale computing. An industry-driven independent system development initiative will be launched through industry-academia-research consortia, progressing in two phases:

- Phase 1: Development of core components and system integration, and
- Phase 2: Development of a fully independent HPC system.

To bridge gaps in next-generation computing technologies and enhance future technology capabilities, quantum computing technologies will be developed, with six demonstration projects planned by 2035. To lay the foundation for industrial growth, domestic HPC products will be prioritized for government projects and later transferred to developing countries to expand R&D outcomes. An industry-academia-research ecosystem will be established to connect supply and demand through corporate-researcher networks. A testing and certification system for new HPC technologies will also be introduced to facilitate commercialization.

4.4. Expanding the HPC Ecosystem

This strategy consists of: Developing highly skilled professionals, Expanding the HPC talent pipeline, and strengthening the research ecosystem. To develop highly skilled professionals, an HPC graduate school will be established to train experts with both theoretical and practical experience. Additionally, specialized training programs will be provided to enhance expertise in the workforce, while career pathway support for researchers will be strengthened. To expand the HPC talent pipeline, educational programs will be introduced at the elementary, middle, and high school levels. Regional youth experience programs will be expanded to encourage future generations to engage in HPC. Public awareness campaigns will be enhanced through science exhibitions and media content development. To strengthen the research ecosystem, the Korean HPC Forum will be launched to support industry-academia-research collaboration. A comprehensive evaluation framework will be developed to assess HPC policy effectiveness, ensuring data-driven decision-making. Additionally, South Korea will work towards certifying national HPC-related statistics. The core aspects of this plan can be summarized in Table 2 [12-14].

Table 2.
The 3rd National High-Performance Computing Promotion Master Plan.

	Key Contents
1. Supporting Innovation in HPC Applications	- Implement strategic resource allocation and introduce a fast-track system. - Expand utilization through industry-tailored services development.
2. Enhancing Access to HPC Resources	- Secure world-class resource performance and diversity. - Establish a one-stop shared service system.
3. Becoming a Global HPC Leader	- Achieve technological self-sufficiency and develop independent HPC systems. - Foster industrial growth based on public-sector demand.
4. Expanding the HPC Ecosystem	- Improve expertise for both new and experienced HPC professionals. - Promote future talent engagement and public awareness initiatives. - Operate collaborative networks and secure policy-relevant data.

5. Analysis Results

The NSCI in the United States and Korea's Master Plan serve as key policy frameworks for developing and implementing national strategies focused on HPC. Both plans share a common goal of advancing HPC technology and applications to drive innovation in science, technology, industry, and society while strengthening national competitiveness. However, they differ in policy priorities, implementation frameworks, and strategic approaches. The key comparative analysis is as follows:

5.1. Policy Priorities

NSCI prioritizes technological leadership, national security, and economic power. It includes strategies to maintain a leading position in exascale computing, AI, and quantum computing, reinforcing national security through advancements in defense, cybersecurity, and semiconductor manufacturing. In contrast, Korea's Master Plan focuses on securing HPC infrastructure to meet rapidly growing AI demand and supporting industrial applications. It also emphasizes reducing foreign dependence and fostering independent technological development.

5.2. Implementation Framework

NSCI adopts a "Whole-of-Government Approach," enhancing inter-agency collaboration while promoting public-private partnerships with academia and industry. It strategically categorizes utilization into public, industrial, and shared applications to maximize efficiency, establishing specialized HPC centers with tailored services. Korea's Master Plan follows a sector-specific approach, clearly distinguishing between different application domains. It promotes industry-led R&D, encouraging independent system development through academia-industry-government consortia.

5.3. Technology Development Strategy

NSCI views exascale computing, quantum computing, AI, and machine learning as key next-generation technologies. It has a dedicated strategy for post-Moore's Law advancements, focusing on new computing architectures and quantum research. Korea's Master Plan prioritizes application software optimization for exascale computing and custom software development for emerging fields like medical biotechnology and energy. Additionally, it focuses on digital twin technologies, identifying potential industrial applications in manufacturing, healthcare, and construction.

5.4. Infrastructure & Resource Management

NSCI invests in sustaining an HPC hardware and software ecosystem, emphasizing standardized tools to maximize data usability. Korea's Master Plan aims to strengthen domestic HPC infrastructure, with plans to deploy a 6th-generation supercomputer (600 PF) by 2023 and a 7th-generation supercomputer by 2025. The plan also enhances resource accessibility through cloud-based shared services, improving research network connectivity with integrated storage solutions.

5.5. Talent Development & Ecosystem Expansion

NSCI provides broad workforce training covering areas from cable installation to R&D, energy management, and public outreach. It also establishes workforce retention strategies with incentives and productivity tools. Korea's Master Plan introduces customized training programs, including national and specialized HPC centers offering tiered educational courses and demand-driven training for industries and institutions. To foster hands-on expertise, a portion of national HPC resources is allocated for educational purposes.

The NSCI adopts a comprehensive approach to enhance U.S. global technological leadership and national security, focusing on next-generation technology development and cybersecurity.

In contrast, Korea's Master Plan emphasizes technological independence and industrialization to address growing data and AI demands. It takes a customized approach that reflects regional characteristics and industrial needs. The key difference lies in the strategic focus: The U.S. prioritizes broad-spectrum technology development to maintain global leadership. Korea focuses on domestic demand and technological self-sufficiency. To achieve supercomputing technology independence, the Korean government must establish a strong policy foundation for early quantum computing development, ensuring it does not become reliant on foreign technologies in future industries. Additionally, national security risks associated with integrating quantum computing into existing supercomputing security frameworks must be anticipated. Investments and regulatory support should be provided for quantum startups and related hardware/software companies to foster a self-sustaining quantum ecosystem. Ultimately, aligning quantum technology policies with broader national strategies will be critical for Korea's long-term competitiveness in HPC and emerging technologies.

6. Conclusion

This study compared the NSCI of the U.S. and Korea's 3rd National HPC Master Plan, analyzing the key differences in their policies and deriving insights for Korea's future direction. By comparing five major aspects—policy priorities, implementation frameworks, technology development strategies, infrastructure and resource management, and talent and ecosystem development—the study identified clear distinctions in technological advancement and industry promotion strategies between the two nations. Through this comparative analysis, it became evident that Korea must strengthen R&D efforts to achieve supercomputing technological independence while also establishing a proactive strategy to prevent future technological dependency in emerging industries. In particular, as quantum computing technology accelerates, Korea must establish a solid policy foundation to secure a competitive edge in its early stages. This requires long-term R&D investment and a systematic approach to technological leadership. Furthermore, strengthening cybersecurity measures for the quantum computing era is crucial to enhance Korea's existing HPC-based security infrastructure. Of course, there are limitations to deriving Korea's policy improvements solely from a direct comparison between the NSCI and the 3rd Master Plan. Additionally, since Korea's top-level supercomputing policies are formulated in five-year cycles, adapting swiftly to rapid AI innovation and industrial transformation poses challenges. Therefore, benchmarking more advanced policies is an effective strategy for policy enhancement. By comparing Korea's approach with those of leading technological nations, the policy implications derived from this study hold significant value. Future research will evaluate the annual implementation performance of the Master Plan, identifying practical policy improvements based on this study's findings. Ultimately, continuous research is necessary to ensure that Korea's HPC policies effectively respond to the rapidly evolving technological landscape and enhance its global competitiveness.

Funding:
This research was supported by Korea Institute of Science and Technology Information (KISTI). (No. K25L2M1C1).

Transparency:
The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

References
[1] H.-G. Kang, A. Moon, and S. Jeon, "Examining the generative artificial intelligence landscape: Current status and policy strategies," *Asia Pacific Journal of Information Systems*, vol. 34, no. 1, pp. 150-190, 2024. https://doi.org/10.14329/apjis.2024.34.1.150
[2] G. Papyshev and M. Yarime, "The state's role in governing artificial intelligence: development, control, and promotion through national strategies," *Policy Design and Practice*, vol. 6, no. 1, pp. 79-102, 2023. https://doi.org/10.1080/25741292.2022.2162252
[3] J. Škrinárová and E. Vesel, "Model of education and training strategy for the high performance computing," presented at the International Conference on Emerging eLearning Technologies and Applications, 2016.
[4] S. M. Lee and S. C. Jeong, "A study on strategy for invigorating utilization of HPC in industry based on business building blocks model," *Nonlinear Theory and Its Applications, IEICE*, vol. 11, no. 1, pp. 78-89, 2020. https://doi.org/10.1587/nolta.11.78
[5] J. R. Hamlet and C. M. Keliiaa, "National cyber defense high performance computing and analysis: concepts, planning and roadmap (No. SAND2010-4766)," Sandia National Laboratories (SNL), Albuquerque, NM, and Livermore, CA (United States), 2010.
[6] D. Maleki, M. R. Ahmadi, A. Mansouri, and E. Arianyan, "Designing development readiness indicators and roadmap for petaflops scale supercomputers," *International Journal of Web Research*, vol. 5, no. 2, pp. 9-18, 2022.
[7] Y. K. Choi *et al.*, "A study on the implementation method for the achievement of the Korea high-performance computing innovation strategy," *Journal of Information Science Theory and Practice*, vol. 10, pp. 76-85, 2022.
[8] T. Besednjak Valič, J. Kolar, U. Lamut, and A. Pandiloska Jurak, "Key policy mechanisms supporting the University–Industry collaboration in the Danube region: Case study of academic HPC centres and SMEs," *European Journal of Management and Business Economics*, vol. 32, no. 5, pp. 509-524, 2023. https://doi.org/10.1108/ejmbe-09-2022-0283
[9] Executive Office of the President, *National strategic computing initiative update: Pioneering the future of computing*. Washington, D.C: The White House Office of Science and Technology Policy, 2019.
[10] R. E. Bryant and W. T. Polk, "The national strategic computing initiative," in *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis*, 2015.
[11] R. Eigenmann and B. I. Schneider, "National strategic computing initiative," *Computing in Science & Engineering*, vol. 20, no. 5, pp. 5-7, 2018. https://doi.org/10.1109/MCSE.2018.05329812
[12] H. Shim and J. Hahm, "Development of a designation system for supercomputing specialized centers by application field," *Journal of Computing Science and Engineering*, vol. 17, no. 4, pp. 169-181, 2023. https://doi.org/10.5626/jcse.2023.17.4.169
[13] Y. Choi, H. Lee, H. Jeong, and J. Cho, "A study on the revitalization of high performance computing in Korea," *Journal of Internet Computing and Services*, vol. 17, no. 3, pp. 129-136, 2016. https://doi.org/10.7472/jksii.2016.17.3.129
[14] Ministry of Science and ICT, "Act on utilization and fostering of national super-computers, Republic of Korea," Retrieved: https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=60183&key=18&type=part, 2022.