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Executive Summary of

The Report on the Feasibility Study on Establishing an Artificial Intelligence Supercomputing Centre in Hong Kong

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Background

1.   Commissioned by the Office of the Government Chief Information Officer ("OGCIO") of the Government of Hong Kong Special Administrative Region ("HKSAR"), this Summary presents a feasibility study conducted by Deloitte Advisory (Hong Kong) Limited on establishing an Artificial Intelligence Supercomputing Centre ("AISC") in Hong Kong (the "Study").

2.   The Study evaluates the demand and supply for artificial intelligence ("AI") supercomputing services, their social-economic benefits and costs, and the business case for establishing an AISC in Hong Kong. It also recommends the operation model, institutional setup, scale of investment, and an implementation strategy.

3.   The envisioned AISC is set to serve as a strategic digital infrastructure, providing AI supercomputing services to local universities, research and development ("R&D") centres, government departments, AI start-ups and related industry sectors, thereby enhancing local R&D capabilities and advancing industry ecosystems.

Rationale for establishing an AISC

4.   Digital economy drives innovation, competitiveness and growth globally. In view of this, the HKSAR Government has proposed to study the establishment of an AISC to foster AI related scientific research, technological innovation, and the commercialisation of R&D outcomes. The AISC is expected to accelerate research, enable complex simulations, and facilitate data-intensive tasks, particularly in the pillar domains, including Life & Health Technology, AI & Data Science, Advanced Manufacturing, etc. The Study aligns with the National 14th Five-Year Plan, which aims to support the development of Hong Kong into an international Innovation & Technology ("I&T") centre. The 2023 Chief Executive's Policy Address and the Budget 2023-24 underscore this goal by allocating substantial resources to support I&T development and accelerate development of digital economy in Hong Kong.

Projected impact is significant to Hong Kong

5.   Recognising the crucial role of digital innovation in today's global landscape, the Study emphasises the need and importance of establishing an AISC in Hong Kong. The establishment of an AISC in Hong Kong would significantly enhance regional competitiveness by positioning Hong Kong as a technology leader in the digital economy era, especially in comparison with neighbouring cities. Addressing the present constraints in R&D due to a local shortage and scattering of supercomputing power, the AISC would serve as a catalyst to accelerate complex research tasks, foster interdisciplinary

collaboration, and enable significant advancements in scientific and AI research. Not only would this initiative support broad industrial and commercial applications, the establishment of AISC would also stimulate growth in the digital economy and catalyse the I&T industry by attracting tech-based businesses and promoting economic diversification. Additionally, the AISC is expected to foster innovation at the intersection of key domains, such as life and health technology, AI & data science, and advanced manufacturing, leading to cross-domain synergy. It would also encourage the development of specialised skills in fields such as computational science, data analytics, and machine learning, aligning with the 14th Five-Year Plan and contributing to the I&T landscape. As the use of supercomputing for R&D purposes and in support of various sectors like health, advanced manufacturing, digital economy, smart city, etc. continue to populate and expand rapidly, the demand for AISC is expected to rise, highlighting the need for this strategic digital infrastructure build.

Latest Development in AI Supercomputing

6.   The technology trend of AI advancements has been transformative, with significant breakthroughs in machine learning, natural language processing, computer vision, robotics, etc. This is partly due to the shift from Central Processing Unit ("CPU")-based to Graphics Processing Unit ("GPU")-based supercomputing. GPUs offer superior parallel processing, higher memory bandwidth, and specialised architectures that are critical for intensive computational demands of modern AI tasks. In the realm of performance metrics, AISCs typically employ PFLOPS[1] to measure computing power, indicating a move towards more high-capacity computational benchmarks. The ecosystems surrounding GPUs have matured, offering robust support for AI development. Concurrently, advancements in AI chipset technology are providing viable alternatives to established systems, fostering a diverse and competitive technological landscape.

7.   One of the most striking advancements in AI has been in Large Language Models ("LLMs") like OpenAI's ChatGPT-3 and ChatGPT-4. These models have redefined AI's potential, extending beyond specific, narrow applications to a vast array of versatile functionalities. They can generate human-like text, process complex enquiries, write programming code, and interpret multimedia files. This versatility has spurred the rise of AI-Generated Content ("AIGC"), revolutionising industries from creative content generation to complex scientific endeavours. Furthermore, the progression in natural language processing, exemplified by models like DeepMind's AlphaFold2, is reshaping fields like biomedicine, enabling rapid advancements in drug discovery and protein structure prediction. The demand for GPU-based computing power, spurred by the deployment of LLMs and other advanced AI models, has grown exponentially. AISCs are now faced with the challenge of providing the necessary

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[1] PFLOPS (or petaflops) is commonly used as the unit of measurement. One PFLOPS refers to 1,000 trillion (or one quadrillion or 10^{15}) calculations in floating-point operations per second.

resources, often requiring thousands of high-end GPUs, to support the immense computational needs of these models.

Current Landscape of Computing Power in Hong Kong

8.   The current landscape of computing power in Hong Kong, particularly within local universities or academic institutions, is a critical factor in the region's capacity to engage in advanced AI research and development. Although local universities and R&D centres collectively contribute a significant capacity of around 60 PFLOPS as at the writing of this report, this resource is dispersed and inadequate for the demands of large-scale and advanced AI initiatives.

9.   The development of LLMs and other sophisticated AI technologies further escalates the need for robust computing power. It is estimated that these endeavours require at least high-end GPUs providing no less than 1,000 PFLOPS computing power. This significant demand for computing power underscores the necessity for a consolidated computing infrastructure capable of supporting the intensive computational tasks associated with advanced AI development. In response to these challenges, the establishment of a sizeable AISC in Hong Kong emerges as a vital step. The AISC would not only pool the necessary computing power but also provide a platform for the successful development and implementation of advanced AI models. Additionally, it would ensure Hong Kong's competitive edge in the AI arena, in alignment with the global demand for supercomputing in AI research and application.

10.   The anticipated addition of some new computing facilities highlights an encouraging advancement in the region's computing capabilities. However, the known resources are dedicated for use by specific users or specific research projects, which are unlikely to meet the growing demands for AI development. Therefore, the consolidation of computing power through the AISC, coupled with fostering innovation and interdisciplinary collaboration among local academia and R&D centres, is imperative. This strategic initiative will address the current limitations and propel Hong Kong to the forefront as an international I&T centre for AI research and technological advancement in an AI-driven global landscape.

Overview of Global AI Supercomputing Establishments

11.   The report highlights the recent expansion of supercomputing facilities around the globe, the shift towards GPU-based systems in computing facilities and the growing chip manufacturers within the Mainland. The State considers supercomputing centres as strategic and new digital infrastructures playing important roles in its digital economy strategy and thus the Mainland is investing heavily in

supercomputing centres, with cities such as Shenzhen and Shanghai expanding the centres at an unprecedented rate. Other developed countries including the United States and Japan are also expanding their facilities to address the rising need of computing power.

GPU Manufacturing

12.   The GPU-based systems widely used in supercomputing facilities, particularly overseas, are predominantly products of individual major manufacturer, reflecting its significant market dominance due to its well-established ecosystem, tools, and libraries. On the other hand, the report also highlights the importance of the rise of the Mainland developed chips for technological independence and controllability in China, with the aim of reducing its reliance on foreign technology under the current geopolitical situation. The Mainland's chip manufacturing industry has made significant progress in recent years because of the intensive investment by the State in recent years. The development of semiconductor industry in China are likely to have significant implications for the global technology landscape in the years to come.

Operation Model

13.   Since the capital investment of building an AISC is significant, it is commonly observed that building of such digital infrastructure is largely funded by governments around the globe. Those establishments are normally operated by public organisations (e.g. Pengcheng) or public-private joint ventures (e.g. Hengqin). Besides, privately funded AISCs are also observed, such as SenseTime, Amazon Web Service, Google, Microsoft, Tencent, etc., which offer computing power as service for quite a premium pricing scheme. Most new supercomputing clusters, or supercomputing clusters planned for upgrade, are aiming at achieving a performance of 1,000 PFLOPS or above. For instance, Pengcheng Cloud Brain II in Shenzhen is offering at 1,000 PFLOPS scale of computing power and having plans of upgrade towards 16,000 PFLOPS in the next couple of years. It is expected that Shanghai city will host multiple supercomputing facilities, providing a total of ~36,000 PFLOPS by end of 2025.

Funding Source / Subsidy

14.   Most users (in particular those in R&D centres, academia or AI start-ups) demanding computing power for their R&D work are not financially capable of affording buying from commercial providers. It is commonly observed that local government subsidies significantly the use of computing power for eligible users (varying from 60% to 100%), acknowledging the social benefits and values associated with the outputs of such I&T or R&D development to the betterment of the society as a whole in mid-to-long term.

Highlights of Stakeholder Insights

15.   The stakeholder engagement process was conducted between July and November 2023, and involved over 200 stakeholders who were segmented into three main categories: Demand, Operations & Construction, and Influencers.   The engagement activities included interviews, focus group discussions, and tailored questionnaires designed to address the unique perspectives and requirements of each stakeholder group.   All opinions expressed by stakeholders reflects their personal views or those of their respective organisations (which should not be construed as representing the views of Deloitte's consulting team).   Below is a summary of stakeholders' opinions:

- "**Demand**" stakeholders, including academia, R&D centres, HKSAR government departments, and commercial R&D companies, expressed a strong interest in the development and urgent needs in the establishment of AI technologies and their potential applications in various industries, including healthcare, finance, and transportation.   They also highlighted the importance of ethical considerations, data privacy, and cybersecurity in the development and deployment of AI technologies.   They also suggested the establishment of a centralised platform, such as the AISC, to facilitate collaboration and knowledge sharing among stakeholders.

- "**Operations and construction**" stakeholders, including AISC industry experts and relevant companies in ICT and I&T industries, suggested that the AISC should have multiple routes of fast connectivity for redundancy, scalability, security, and tapping into a variety of global and local resources to support software & hardware integrations.   They also suggested that the AISC should have fast, flexible, on-demand, and secure access to data sets for machine learning and AI modeling.   The operations & construction stakeholders highlighted the need for skilled professionals to operate the AISC, involving managing various equipment, system administration, cluster management and business development.   They also suggested that a comprehensive technical support and maintenance service should be provided.

- "**Influencers**" stakeholders, including relevant public bodies or committees in the HKSAR Government, relevant professional bodies and industry associations, and Legislative Council members, emphasised the need for upskilling and training programmes to prepare the workforce for the changing job market in the era of AI.   The influencer stakeholders suggested that the AISC should be established with a long-term vision and strategy, involving collaboration with the Mainland and international partners and leveraging Hong Kong's unique advantages in the region.   The influencers also emphasised the need for high-level cybersecurity to protect sensitive data or commercial data.   They also highlighted the importance of public engagement and education to promote the responsible and sustainable development of AI in Hong Kong.

Social-economic Benefits

Economic Impacts in GDP

16.   The establishment of an AISC in Hong Kong can bring significant social-economic benefits to the city. It can foster the development of I&T, R&D, and AI-related industries, maintain the competitiveness of Hong Kong as a smart city and foster the digital economy, and align with the strategic development of Hong Kong as the international I&T centre. According to year 2023 publication of the "White Paper on China Computing Power Development Index", increasing computing power has a significant impact on economic development in both the Mainland's and overseas cities. From 2016 to 2022, a 46% average annual increase in computing power in the Mainland resulted in a 14.2% growth in the digital economy and an 8.4% growth in GDP. Similarly, globally speaking, a 36% average annual increase in computing power led to an 8% growth in the digital economy and a 4.7% growth in GDP. Additionally, the 2021 edition of the "White Paper on China Computing Power Development Index" revealed that for every 1 yuan invested in computing power had the potential to generate 3-4 yuan of economic output in terms of nominal GDP, which is based on the evaluation of computing power development situations in the Mainland and major countries in the world and the assessment on their impacts on the domestic economy. Considering Hong Kong's strategic position as an international I&T centre and its role as a bridge connecting the Mainland and the world, these findings are particularly relevant. The potential nominal GDP generated from the establishment of an AISC, with a computing power capacity of 3,000 PFLOPS, will result in a nominal GDP ranging from HK$6 billion to HK$16 billion over a period in the forthcoming 3 to 5 years. However, the actual outcome will depend on various factors, including the pace of technology adoption, industry collaboration, and market conditions.

Economic Impacts in Job Creation

17.   In terms of job creation, the establishment of an AISC in Hong Kong is expected to create over 1,000 jobs approximately through its direct and indirect effects. These jobs will be created within the centre itself and are typically associated with its operations, management, and maintenance under the direct impact, as well as in AI-related R&D among universities, research institutes, AI-related corporations and start-ups that can immediately benefit from the resources and support provided by an AISC under the indirect impact. The establishment of an AISC can align with the strategic development of Hong Kong as the international I&T centre. AISC promotes the collaboration among researchers, industry and government, and translating research outcomes into practical, market-ready solutions, which can facilitate digital transformations. AISC also facilitates in building a skilled talent pool specialising in AI through providing training programmes that can drive digital transformation in various sectors of the economy in Hong Kong.

Demand Analysis

18.   The report provides a comprehensive analysis of the demand for computing power in Hong Kong, with a particular focus on the development of AI. The analysis employs four distinct methodologies to estimate the demand for computing power, including (i) bottom-up analysis evaluating the specific requirements of potential user groups across academia, government, and commercial sectors; (ii) resource estimation in the Smart City development perspective; (iii) resource estimation in AI model development perspective; and (iv) comparative study with similar economies. From the consistent estimation results yielded by all four approaches, highlighting the substantial need for AI supercomputing resources in Hong Kong, the study concludes that an estimated short-term additional demand for computing power in Hong Kong over the next two to three years will be around 3,000 PFLOPS by taking into consideration of the upcoming provision by other organisations. This demand is substantiated by the rapid evolution of AI research, the emergence of LLM, cross-domain collaborations, and Hong Kong's strategic commitment to technological leadership. In the light of the urgency, it is recommended to launch the capacity of at least a few hundred PFLOPS within 2024 as early as possible to meet the demand for computing power. With reference to multiple study findings, it is affirmatively expected that the demand of computing power will grow in an exponential manner in view of the large model development, especially LLM. The analysis estimated that the capacity of the AISC needs to be progressively upgraded with additional computing power up to 15,000 PFLOPS in the long-term.

Implementation Agent

19.   Given the AISC's significant role and the time-sensitivity, it is crucial to establish or engage an independent and neutral body (the "Implementation Agent") to develop and operate the AISC with a clear objective and public mission for the initial establishment. After carefully evaluating various factors, including a track record of promoting the advancement and application of AI-related technologies, the ability to foster tech start-up ecosystems through a global network, experience and expertise in providing digital infrastructure services and supporting facilities like data service platforms and data centres, as well as the availability of necessary infrastructure such as space, power supply, cooling facilities, and high-speed outbound connectivity, we recommend Cyberport to take up the role as the Implementation Agent considering its suitability. With Cyberport's extensive network of tech firms, start-ups and entrepreneurs, its dedication to digital technology development, and its potential to attract more AI enterprises and talents, it fully aligns with the strategic objectives of the AISC. Furthermore, as an independent and neutral body, Cyberport can ensure fairness in resource allocation and project prioritisation, provide specialised knowledge, and promote innovation.

Recommendations

20.   We recommend that Hong Kong leverages its conducive environment, robust legal system, cosmopolitan nature, and strategic location to foster its standing in AI development through the establishment of an AISC. This AISC should serve as a bridge between Mainland and global AI development and local implementation. The AISC should also foster dialogues between local AI practitioners, Mainland and global experts, encouraging more frequent regional and international collaborations and partnerships to enhance the quality and competitiveness of Hong Kong's I&T industry.

21.   In view of the shortage of computing power as reflected in the stakeholder analysis, it is recommended that building an AISC as core digital infrastructure in Hong Kong is of utmost importance. In the short-term, we recommend establishing an AISC in Hong Kong as soon as possible, targeting a scale of 3,000 PFLOPS of computing power within 2-3 years, through the Cyberport with readily available infrastructure.

Implementation Roadmap

22.   A two-phased approach is recommended for implementation, starting with a setup of around 300 PFLOPS to ease the immediate shortage in 2024, followed by an upgrade to an aggregate of 3,000 PFLOPS capacity by 2025 to 2026. We also recommend the prompt adoption of global mainstream core AI-GPU technologies during this short-term implementation.

23.   In the medium and long terms, we foresee significant growth in AI development in Hong Kong, with the cumulative demand for computing power estimated to rise to 15,000 PFLOPS in 7 years, provided that pre-defined key performance indicators ("KPIs") in utilisation and other economic factors be tracked and largely fulfilled.

24.   The next stage development of AISC represents a further expansion of infrastructure and computing power. Given the demanding technical requirements, a purpose-built facility is necessary. It is recommended that the Northern Metropolis, aligned with the Hong Kong I&T Development Blueprint, could be considered as a suitable location for the next stage expansion of AISC at the scale of upscaling to 15,000 PFLOPS in the next 7 years. While the next stage implementation may be in a different physical location, it is crucial to ensure optimal strategic synergy among all centralised digital infrastructures. Cyberport as the recommended Implementation Agent should play a central role in driving and achieving this synergy.

Inclusion of the State's Independently Developed Technologies in AISC Expansion Phases

25.   Regarding the technical setup of AISC, the global mainstream core AI technologies, including GPU, should be the foundation of the AISC establishment in the short-term taking into consideration of demand and preferences from most users, while the inclusion of the State's independently developed technologies should be gradually introduced for the AISC establishment in the long-term given the consideration of geopolitical situation. In the meantime, the Implementation Agent should actively promote the awareness and adoption of these technologies. Such long-term strategy does not only capitalise on their technological advancements but also foster closer ties with these Mainland technology enterprises, potentially leading to fruitful collaborations and exchange of expertise. Furthermore, it will provide an opportunity for these enterprises to demonstrate their technological advancement and AI capacity to the rest of the world through Hong Kong which also aligns with the national development plan in AI technologies. In addition, having a strategic focus on the State's independently developed technologies could also provide an opportunity for Hong Kong to be a leading hub in the region for AI R&D that utilises and promotes these technologies. This could attract more Mainland and international enterprises to set up their AI R&D centres in Hong Kong, further bolstering its position as a regional AI supercomputing hub.

26.   We also recommend fostering effective data sharing and cross-domain collaborations, conducting ongoing technological reviews, and implementing energy-efficient technologies and practices for sustainability. Risk management, including the establishment of the next stage of AISC in different location as a contingency, should be an essential aspect of the long-term strategy. These strategic recommendations will ensure Hong Kong's continued leadership in AI research and development while maintaining operational resilience and sustainability.

Governance of AISC

27.   To establish the organisational structure of AISC, it is recommended to form a Steering Committee who will be responsible for providing strategic directions and overseeing the operations, governance and controls of the AISC and the support scheme. This Steering Committee should be composed of representatives from the Implementation Agent and HKSAR Government, specialists from industry and academia with expertise in IT governance, R&D, risk management, compliance, etc. Besides, to effectively run AISC operations, the Implementation Agent must establish a well-structured and organised entity that ensures sustainable operation, business development and growth of the AISC. Moreover, establishing robust governance and control mechanisms is of the utmost importance for the AISC to maintain its operational efficiency, security, and compliance, while independent governance assurance also plays a key role within this framework. It is recommended that an effective governance mechanism should cover: (i) audit and assurance; (ii) risk management; (iii) control

framework; (iv) performance measurement; (v) establishment of independent governance committee; and (vi) compliance and regulatory consideration, which should make reference to and align with the relevant international guidelines and industry best practices, and the Control Objectives for Information and Related Technologies ("COBIT") framework with measurable KPIs, including KPIs on facilities utilisation, R&D output, talent development, infrastructure, support, etc., to be established and tracked. Evaluation of the effectiveness of the governance and control should be done on a regular basis to align with the market, user and control dynamics of operating an AISC.

Charging Scheme

28.   The AISC should have a purpose-oriented business development plan and charging scheme, considering factors such as operating costs, scientific impacts of sponsored works, and social-economic benefits. A differential charging scheme is recommended, supporting specific domains with I&T development, addressing the needs of prioritised and eligible stakeholders, and fostering cross-disciplinary collaboration. Taking both global market for computing resources and the common practice of nearby supercomputing facilities in the Guangdong-Hong Kong-Macao Greater Bay Area into consideration, the reference price to be offered by the AISC is recommended at substantial discounted subscription rate. In addition to the basic (on demand) charging scheme, other schemes such as long-term subscription charging scheme, project-based charging scheme and spot charging scheme are also recommended with different discount rates on top of the basic scheme.

Subsidy Scheme

29.   Subsidy schemes, administered and managed by the recommended Implementation Agent, should be offered to academic or societal well-being research projects while charging commercial use cases at market-rate. It is recommended that the Government should consider subsidising up to 90% of computing power in the early stages of operation of the AISC, and providing subsidy up to 90% of the market price to the qualified users, such as R&D centres, local universities, AI related corporations and government bureaux and departments. The Government should also consider providing annual funding to the Implementation Agent directly with effective governance mechanism in place to enable a purpose-driven but sustainable operation and business model.

Support Measures

30.   Other than the subsidy schemes, it is recommended to adopt a number of support measures including –

   (i)   Nurturing talent and advancing researches – (a) promoting collaboration with academic and industry stakeholders to formulate an AI curriculum or training framework for training and

nurturing talent; (b) fostering partnerships between academic and industry stakeholders to cultivate talent through real-world training and internship opportunities; (c) supporting proof-of-concept R&D activities for pioneering innovation within AI and talent incubation programmes.;

(ii) Industry and community promotion – (a) promotion and facilitation for AI-related companies to land in Hong Kong; (b) support for research institutions and AI start-ups with networking events and business matching assistance.

(iii) Publicity and awareness campaign – (a) collaboration with academic partners and AI industry to promote the awareness of AI supercomputing and develop interest in AI and data science through training, seminars, workshops, and competitions, as well as large-scale events and campaigns for the members of the public, particularly the youth.

(iv) Government support policy – (a) formulating and enforcing policies related to AI ethics, ensuring responsible development and application of AI technologies; (b) supporting large AI initiatives in Hong Kong, such as LLM and generative AI; (c) implementing strategies to attract non-local enterprises, providing a conducive environment for major Mainland and international AI companies to operate in Hong Kong.

Conclusion

31.   In conclusion, this report has provided a comprehensive analysis of the feasibility and potential impact of establishing an AISC in Hong Kong. Given the rapid global advancement in AI capabilities, it is crucial for Hong Kong to establish an AISC to maintain competitiveness and drive innovation. We recommend Cyberport as the ideal Implementation Agent for building and operating the AISC, and believe that with appropriate business model, charging and funding schemes in place, the AISC will be a significant step to take in marching forward in the field of AI and bringing positive contributions to the development of Hong Kong into an international I&T centre.

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