NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE

Foundational Research Capability (FRC) Studies

The Foundational Research Capability (FRC) Studies are a series of studies commissioned by NRF and led by study teams consisting of members of the Singapore research community to systematically identify areas for fundamental research capability building in Singapore and recommend how these could be grown. Such areas could include i) important nascent areas of foundational science and technology that are emerging in the world, ii) potential peaks of excellence that could emerge from capability already seeded in Singapore, which could benefit from additional capability and resources, or iii) areas where research capability is needed to fulfil near/long term needs of Singapore.

2024 – 2025 FRC Rapid Studies

Topic	Overview	Link
Marine Science and Oceanography	This report explains that Singapore faces increasing marine environmental pressures from development, climate change, and biodiversity loss, necessitating science-based planning for sustainable coastal management. Building on Singapore's strong marine science foundation, including the successful Marine Science R&D Programme which has produced over 200 publications and trained numerous researchers, the report recommends establishing a National Initiative for Marine and Ocean Sciences (NIMOS) as a coordinating consortium. NIMOS would focus on biodiversity research, climate adaptation, ecosystem resilience, marine technologies, policy governance, and ocean literacy to support Singapore's marine sustainability and strengthen regional collaboration in Southeast Asia. NRF would like to thank the team led Prof Koh Lian Pin from NUS, and Assoc Prof Huang Danwei from NUS, for their efforts in this study report.	https://go.gov.sg/frc-report-marine-science [QR code] https://go.gov.sg/frc-report-marine-science
Augmented reality and industrial metaverse	This report explains that the Industrial Metaverse represents an emerging field integrating virtual and augmented reality to enhance productivity, efficiency, and collaboration across manufacturing, logistics, construction, education, and healthcare sectors, with projections indicating a global market of $100 billion USD by 2030, necessitating strategic investment to maintain Singapore's global competitiveness in the digital economy. Building on Singapore's robust foundation of world-class research institutions including NTU, NUS, A*STAR, SMU, SUTD, and SIT, which have cultivated decades of expertise in critical technologies spanning immersive interaction, extended reality, AI, and seamless communication systems, the report identifies key opportunities for Singapore to leverage Industrial Metaverse capabilities to overcome physical space constraints through unlimited digital environments. The Industrial Metaverse would focus on enabling AI-assisted smart manufacturing, sustainability through digital twins, real-time collaboration in service and maintenance, and construction optimisation, whilst addressing technical challenges in scalability, real-time interactions, and data security to transform Singapore's industrial landscape and ensure future competitiveness in AI-driven technologies. NRF would like to thank the team led by Assoc Prof Yuen Chau from NTU, and Prof Lin Weisi from NTU, for their efforts in producing this study report.	https://go.gov.sg/frc-report-augmented-reality [QR code] https://go.gov.sg/frc-report-augmented-reality
Biological-based information transmission and encryption	This report explains that biological-based information transmission and encryption leverages DNA and other biomolecules for ultra-high-density data storage, with findings indicating DNA's capability to store up to 455 exabytes per gram compared to conventional methods, necessitating strategic investment to capitalise on this emerging technology. Building on Singapore's strong biotechnology ecosystem and the presence of major industry players like Illumina and Oxford Nanopore Technologies, the report identifies key opportunities for Singapore to lead in this field through advanced biological data storage capabilities. The technology would focus on encoding digital data into biological sequences, reading through advanced sequencing technologies, and writing via enzymatic synthesis methods, whilst addressing technical challenges in data retrieval speed, error correction, and cost-effectiveness to transform Singapore's position in next-generation data storage	https://go.gov.sg/frc-report-biological-information [QR code] https://go.gov.sg/frc-report-biological-information

	solutions. NRF would like to thank the team led by Dr Chew Wei Leong from A*STAR GIS, and Assoc Prof Poh Chueh Loo from NUS, for their efforts in producing this study report.	
Neurodegenerative diseases; Fundamental brain science	This report explains that Singapore faces rapidly increasing global prevalence of neurodegenerative diseases like Alzheimer's and Parkinson's, with healthcare costs expected to triple by 2030, whilst current treatments remain largely symptomatic with poor long-term prospects, necessitating strategic coordination to address these challenges. Building on Singapore's existing clinical-translational research capabilities, the report identifies the need to overcome fragmentation within its distributed neuroscience ecosystem of fewer than 100 researchers compared to over 1000 in Boston, and recommends establishing a Singapore Neuroscience Initiative as a coordinated response. The Initiative would focus on blood-brain barrier research, brain-body interactions, neural transplantation, and neurotechnology to position Singapore as a global hub for translational neuroscience research and improve treatment outcomes for neurodegenerative diseases. NRF would like to thank the team led by Prof Lim Kah Leong from NTU, and Prof Tan Eng King from NNI, for their efforts in producing this study report.	https://go.gov.sg/frc-report-neurodegenerative-diseases
The Frontiers of Complex Systems	This report explains that complex systems science studies systems with emergent, self-organising properties that cannot be reduced to simple components, focusing on adaptive behaviours and critical transitions rather than complicated assemblies of parts, necessitating strategic investment to address the "wicked problems" facing developed economies. Building on Singapore's strategic position to lead in quantum complexity research, the report identifies current frontiers including integrating AI with complexity science, modelling higher-order interactions beyond simple networks, quantum-enhanced approaches, and applications to health systems, supply chains, and economic development. The Initiative would focus on leveraging complexity science methodologies to tackle complex societal challenges whilst ensuring careful evaluation to distinguish genuine complexity research from superficial applications and position Singapore as a leader in this emerging field. NRF would like to thank the team led by Assoc Prof Mile Gu, NTU, and Assoc Prof Cheong Siew Ann, NTU, for their efforts in producing this study report.	https://go.gov.sg/frc-report-complex-systems
Digital Identity and Consensus Mechanisms	This report explains that the growing transition of government and commercial services online necessitates secure digital identities, whilst existing centralized and federated identity management systems face increasing vulnerabilities with billions of compromised records in recent cyberattacks, requiring blockchain-based solutions to address these security challenges. Building on the promising potential of decentralized identity (DI) and Self-Sovereign Identity (SSI) technologies, which empower users to retain control of their personal data and reduce dependence on centralized authorities, the report identifies opportunities to enhance privacy and security whilst minimizing single points of failure. The technology would focus on addressing implementation challenges including complex user experience with private key management, regulatory compliance issues like GDPR's right to be forgotten, scalability concerns, and resistance from businesses that profit from centralized user data collection, to enable widespread adoption of secure decentralized identity systems. NRF would like to thank the team led by the SAEng and Prof Dusit Niyato from NTU, for their efforts in producing this study report.	https://go.gov.sg/frc-report-digital-identity

National Research Foundation
Prime Minister's Office
Singapore

Remote Sensing, Image Processing, and Satellite Imagery	This report explains that remote sensing and satellite imagery represents a rapidly growing global industry forecast to reach $1.8 trillion by 2035, driven by AI advancements and environmental monitoring needs, necessitating strategic focus to leverage Singapore's positioning as a regional hub with over 2,000 professionals across 60+ companies. Building on Singapore's strong capabilities through NUS CRISP's ground station operations, NUS STAR's constellation research, NTU SARC's satellite platform development, NTU EOS's hazards monitoring expertise, and the Office for Space Technology and Industry's coordination of over 15 satellite launches including X-SAT, TeLEOS series, and multiple SAR satellites, the report identifies opportunities to advance toward higher resolution imaging, hyperspectral capabilities, and improved SAR systems. The technology would focus on food security monitoring, air quality assessment, vegetation studies, maritime applications, and urban remote sensing to serve strategic government agencies including NEA, MSS, SFA, MPA, NParks, PUB, SLA, HDB, and LTA, whilst tackling challenges in data volume management and sensor miniaturisation to strengthen Singapore's position in this growing sector. NRF would like to thank the team led by SAEng and Dr Liew Soo Chin from NUS, for their efforts in producing this study report.	https://go.gov.sg/frc-report-remote-sensing
Bio-inspired cybersecurity	This report explains that the increasing levels of connectivity and complex communication protocols in current and next-generation systems provide growing opportunities for attackers to exploit novel attack surfaces, necessitating investigation of human-like intelligence in designing secure systems to address both AI-driven threats and bio-inspired defensive capabilities. Building on the observation that biological systems like human immune systems demonstrate robust adaptation to unforeseen threats, the report identifies opportunities to develop computing systems that can similarly adapt to novel attack surfaces whilst leveraging bio-inspired computing for enhanced security protection. The report would focus on investigating AI-driven attack surfaces and advancing bio-inspired security systems, with findings revealing minimal existing investment in top cybersecurity venues, positioning Singapore to pioneer this field through SUTD's world-class cyber-physical infrastructures and AI faculty expertise. NRF would like to thank the team led by SAEng, Prof Zhou Jianying from SUTD, and Assoc Prof Sudipta Chattopadhyay from SUTD, for their efforts in producing this study report.	https://go.gov.sg/frc-report-bio-inspired-cybersecurity

Acronym

NRF	National Research Foundation
NTU	Nanyang Technological University
NUS	National University of Singapore
A*STAR	Agency for Science, Technology and Research
NNI	National Neuroscience Institute
SAEng	Singapore Academy of Engineering
SUTD	Singapore University of Technology and Design