NARLabs

2022
Annual Report

國家實驗研究院
National Applied Research Laboratories

NARLabs

2022
Annual Report

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MESSAGE FROM THE CHAIRPERSON

Founded in 2003, the National Applied Research Laboratories will be 20 years old in 2023. In these last two decades, NARLabs has carried out many important tasks for the past National Science Council, the Ministry of Science and Technology, and now, the National Science and Technology Council. As a member of the Executive Yuan and Chairperson of NSTC, I organize the work that goes into national science and technology development from my position in the Executive Yuan. NSTC itself is responsible for supporting universities in exploring forward-looking technologies and facilitating the R&D of technologies in their upstream to midstream phases. However, it is also responsible for ensuring the smooth alignment of all stages of technological development, from upstream all the way downstream to industries.

As an agency under NSTC, NARLabs naturally should support NSTC by linking research output from the upstream academic sector with startups, playing the role of an intermediary so that academic research can continue to move downstream and transform into technological industries through the assistance of organizations under the Ministry of Economic Affairs such as the Industrial Technology Research Institute. If every player, including NARLabs, can clearly understand this overall system, divide the work well, and pass the baton, it will help Taiwan establish a good ecosystem for technological development.

Given the limited resources, funding, and manpower of the seven research centers under NARLabs,

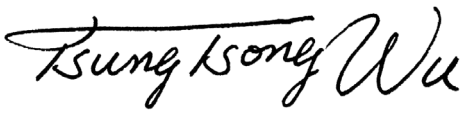
it is imperative to collaborate with top university and Academia Sinica professors so that NARLabs' thorough and systematized research service system can systematically and sustainably assist professors in producing top-quality, internationally competitive research. Moreover, NARLabs can link upstream research to midstream startups, which can later be transformed to downstream industries. NARLabs should have a good understanding of its own resources and positioning, play its role well, and amplify value, not only to drive the development of frontier technology, but also to promote social well-being.

In addition to NARLabs' initiative to seek out cooperation with professors, I hope that professors will also take the initiative to seek out cooperation with NARLabs, as well as with the other three agencies under NSTC: the National Synchrotron Radiation Research Center, the National Science and Technology Center for Disaster Reduction, and the Taiwan Space Agency. This would certainly allow them to obtain even more successful results than if they had conducted their research alone.

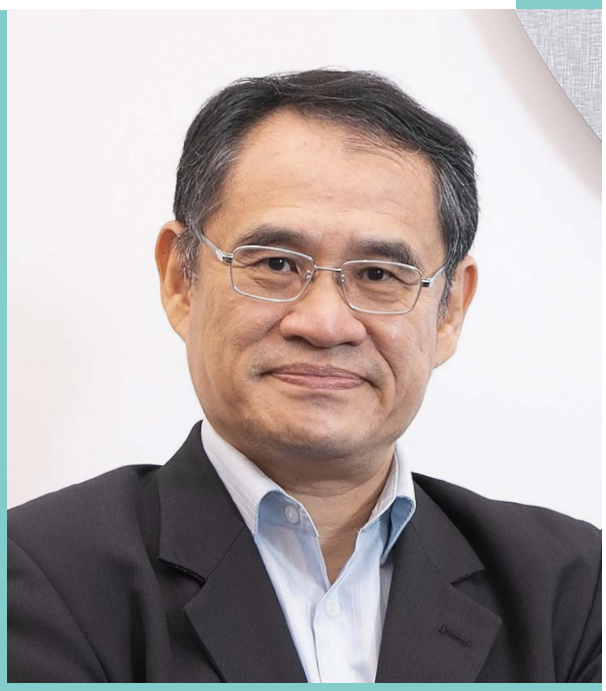
International cooperation is also very important, as we can see with the recently popular ChatGPT. If Taiwan had attempted such a project with solely its own resources, even with cooperation from top scholars and NCHC, it would most definitely not be able to outperform large international companies. But when it comes to Chinese language, we have an even better niche than China. Considering our alliance with democratic countries, if we can enlarge this niche and seek cooperation with international companies, through public-private partnership and international cooperation, we will have the opportunity to develop a new, exclusive business model for Taiwan. However, when engaging in international cooperation, the best results can only be obtained if all Taiwan's forces across ministries and departments are united and integrated.

Taiwan's technological vision for 2035 features three main axes: "forward-looking innovation," "democracy and inclusivity," and "resilience and sustainability." "Forward-looking innovation" encompasses both the economy and technology, "democracy and inclusivity" includes politics and society, and "resilience and sustainability" relates to the environment. In other words, while developing technology and the economy, we must meet the needs of society and the environment, as well as give consideration to international geopolitical influences. I hope that all my colleagues at NARLabs can elevate their level of thinking, consider the country as a whole in everything they do, focus on the five STEEP factors (social, technological, economic, environmental, and political), and search out their own strengths and amplify them in order to provide the greatest help to NSTC, and together, allow Taiwan's science and technology to experience the best possible development.

Chairperson



MESSAGE FROM THE PRESIDENT



2022 was a year of change for the National Applied Research Laboratories. First, the Ministry of Science and Technology was restructured to form the National Science and Technology Council (NSTC), with NARLabs becoming a foundation under NSTC. Second, the National Space Organization, which was originally part of NARLabs, went independent and is now a non-departmental public entity directly under NSTC. In the future, some adjustments will be made to NARLabs' duties. NARLabs will continue to proactively work in accordance with national science and technology policy, integrate the R&D capabilities of its centers, and support academic research and promote forward-looking technology. In addition, we will put even more emphasis on connecting with various government institutions, as instructed by Chairperson Wu, to contribute to social welfare with the power of science and technology.

NARLabs serves as a provider of technological R&D platforms needed by Taiwan's science and technology experts in the innovation economy. In addition to building large-scale research apparatuses and facilities which local universities are unable to install on their own, such as supercomputers, large seismic stations, and the research vessel Legend, NARLabs has also established many research platforms which integrate software and hardware and also include service by professional staff to assist research communities in conducting R&D for cutting-edge technologies. In 2022, NARLabs held its second R&D Service Platform Achievement Awards,

selecting five outstanding teams to receive awards (one High Distinction, two Excellence, and two Honorable Mention Awards), with the goal of encouraging industry, government, academia, and research sectors to use these Taiwan-made R&D service platforms even more readily and produce globally competitive R&D results through related activities.

NARLabs' efforts in popular science also yielded dazzling results in 2022. Our educational drama series, "Next, AI," produced in collaboration with Dong Tai Communication, won the Golden Bell Award for Best Natural Science Documentary Show. In addition, NARLabs mentored a team from National Taiwan University who won first place in the Kibo Robot Programming Challenge (Kibo-RPC) organized by the Japan Aerospace Exploration Agency (JAXA) and the National Aeronautics and Space Administration (NASA), as well as a team from National Tsing Hua University, who won the championship of the Student Cluster Competition, the largest international high-performance computing competition.

Looking ahead, TSRI will see a significant increase in funding to invest in the development of forward-looking technologies in response to the rapid advancement in semiconductor process technology, especially innovation in next-generation transistors, heterogeneous packaging, MRAM, silicon photonics, power chips, and compound semiconductors. NCHC will build the Taiwania 4 and 5 supercomputers to expand large-scale computing, supporting important work such as decreasing carbon emissions to net zero, big data in healthcare, and biological databases.

TORI and NCREE will also support research for net-zero emissions. TORI will utilize the R/V *LEGEND* to survey the seafloor off Taiwan, while NCHC will use Taiwania 4 and 5 to analyze the collected data in order to find saline aquifers suitable for carbon sequestration or locations to install foundation piles for offshore wind turbines. NCREE will assist Taiwan Power Company in monitoring seafloor soil liquefaction near offshore wind turbines, and NCHC will also analyze which sites have more serious soil liquefaction to be on guard for.

NLAC will assist NSTC in promoting the 3Rs (Replacement, Reduction, Refinement) in animal experimentation techniques across various government organizations and develop organs-on-chips to replace animal experiments. SPTI will assist NSTC in policy discourse and proactively train personnel with the relevant skills. Lastly, TIRI will continue to refine its core technologies and provide custom instrumentation for cutting-edge scientific research, promoting the effective use of national scientific and technological resources and sustainable operations.

President

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R&D SERVICE PLATFORM ACHIEVEMENT AWARDS

List of Award Recipients

With the vision of "Global Excellence, Local Impact" and under the support and guidance of the National Science and Technology Council (NSTC), NARLabs provides various professional R&D service platforms and implements high-cost software and hardware facilities that are difficult for domestic universities to cover in order to assist the academic and research community in advancing scientific knowledge and developing cutting-edge technology, which will ultimately benefit our citizens. To commend industries, government agencies, research institutions, and academicians for employing NARLabs' R&D service platforms to achieve cutting-edge scientific results, NARLabs inaugurated the R&D Service Platform Achievement Awards in 2021. The year 2022 was the second time the Awards were presented, and a total of five outstanding teams were awarded the honors. Today's advanced scientific and technological research relies mostly on teamwork and state-of-the-art software and hardware equipment, representing precisely the strengths of the various R&D service platforms established by NARLabs. We hope these awards will encourage the academic and research institutions in Taiwan to collaborate with NARLabs more readily and take advantage of R&D service platforms created through national resolve and the country's most advanced resources to achieve globally competitive research results.

High Distinction

Achievement

Heterogeneous IGZO/Silicon CFET stacked three-dimensional integration in SRAM and RF Applications

Platform

TSRI's Advanced Semiconductor Manufacturing and High Frequency Measurement Technology Services

Team Members

Hsin-Hui Hu Professor
Department of Electronic Engineering, National Taipei University of Technology

Yao-Jen Lee Professor
Institute of Pioneer Semiconductor Innovation, National Yang Ming Chiao Tung University

Yeong-Her Wang Distinguished Professor
Department of Electrical Engineering, National Cheng Kung University & Director, NCKU-TSMC Research Center

Shu-Wei Chang Ph.D. student
Department of Electrical Engineering, National Cheng Kung University

Darsen Lu Associate Professor
Department of Electrical Engineering, National Cheng Kung University

Excellence

Achievement

Research on Topological Properties of Advanced Two-dimensional Materials and Applications in Spintronics

Platform

NCHC's Taiwania 1 Supercomputer

Team Members

Feng-Chuan Chuang Distinguished Professor & Chair
Department of Physics, National Sun Yat-sen University

Zhi-Quan Huang Postdoctoral researcher
Department of Physics, National Sun Yat-sen University

Chia-Hsiu Hsu Postdoctoral researcher
Department of Physics, National Sun Yat-sen University

Gennevieve Morillo Macam Postdoctoral researcher
Department of Electrical Engineering, National Cheng Kung University

Rovi Angelo Beloya Villaos Postdoctoral researcher
Department of Physics, National Sun Yat-sen University

Liang-Ying Feng Ph.D. candidate
Department of Physics, National Sun Yat-sen University

Marku Nyevel R. Perez Ph.D. student
Department of Physics, National Sun Yat-sen University

Aniceto Maghirang III Ph.D. student
Department of Electrical Engineering, National Cheng Kung University

List of Award Recipients

Excellence

Achievement

Video Compression Based on Generative Models

Platform

NCHC's Taiwania 2 AI Supercomputer

Team Members

Wen-Hsiao Peng Professor
Department of Computer Science, National Yang Ming Chiao Tung University

Hsueh-Ming Hang Professor Emeritus
Department of Physics, National Sun Yat-sen University

Hsu-Feng Hsiao Associate Professor
Department of Computer Science, National Yang Ming Chiao Tung University

Ching-Chun Huang Associate Professor
Department of Computer Science, National Yang Ming Chiao Tung University

Wei-Chen Chiu Associate Professor
Department of Computer Science, National Yang Ming Chiao Tung University

Honorable Mention

Achievement

High-performance Data Converters for Next-generation Communications

Platform

TSRI's IC Design Process Tape Out Services

Team Members

Tai-Haur Kuo Distinguished Professor
Department of Electrical Engineering, National Cheng Kung University

Tsung-Chih Hung Senior Engineer
MediaTek

Hung-Yi Huang Senior Engineer
MediaTek

Jia-Ching Wang Ph.D. candidate
Department of Electrical Engineering, National Cheng Kung University

Hsin-Yu Chen Engineer
MediaTek

Honorable Mention

Achievement

Development of CMOS-MEMS Tactile Sensors

Platform

TSRI's CMOS-MEMS Circuit Design and Tape Out Services

Team Members

Wei-Leun Fang Chair Professor
Department of Power Mechanical Engineering, National Tsing Hua University

Sheng-Kai Yeh Ph.D. recipient
Department of Power Mechanical Engineering, National Tsing Hua University

Jia-Horng Lee M.S. recipient
Department of Power Mechanical Engineering, National Tsing Hua University

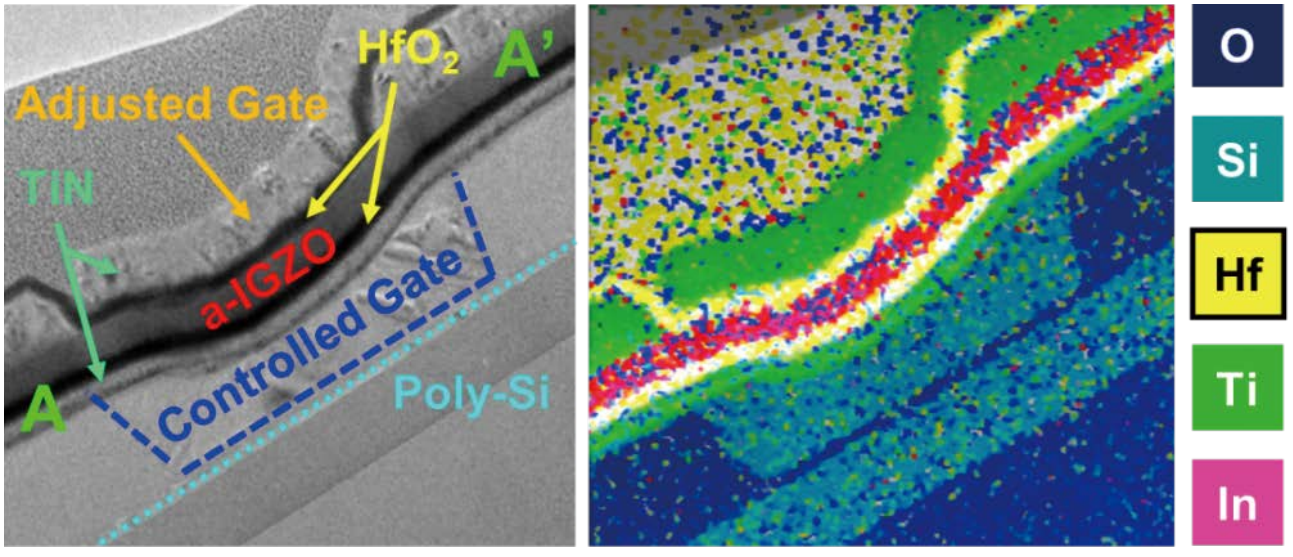
Yen-Lin Chen M.S. recipient
Department of Power Mechanical Engineering, National Tsing Hua University

Heterogeneous IGZO/Silicon CFET Stacked Three-dimensional Integration in SRAM and RF Applications

By incorporating the experience with manufacturing processes of the team led by National Yang Ming Chiao Tung University Professor Yao-Jen Lee and the simulation expertise of Associate Professor Darsen Lu of National Cheng Kung University (NCKU), Professor Hsin-Hui Hu of National Taipei University of Technology and NCKU Ph.D. candidate Shu-Wei Chang produced the world's first heterogeneous channel stacked complementary field-effect transistor (CFET) under the overall guidance of Dr. Yeong-Her Wang, NCKU Distinguished Professor. The research team's stacked architecture consists of an upper and a lower layer, with the lower layer being a p-type polycrystalline silicon thin-film transistor and the upper layer being an n-type indium gallium zinc oxide (IGZO) thin-film transistor, which solves the problem of IGZO being difficult to integrate into logic circuits.

The stacked structure can also reduce the inverter's area down to the size of a single transistor and apply it to the inverter and 6T static random-access memory (6T-SRAM), all of which are then integrated into an under-1-nm process, further increasing the density of the device. The transistor's low leakage can reduce power consumption and conserve energy output. With the transistor's adjustable threshold voltage gate, the requirements for SRAM read/write auxiliary circuits can be simultaneously reduced. The same process enabled the production of IGZO radio frequency devices and extended to the production of high-frequency devices above the second layer of multilayer circuits.

These achievements demonstrate that different channel materials and multi-functional components can be integrated onto the same substrate in an integrated process, fully realizing the future requirements for system-on-panel (SoP) and monolithic 3D-IC technologies. The team expressed appreciation to TSRI for its Advanced Semiconductor Manufacturing and High Frequency Measurement Technology Services platform, which has provided world-class manufacturing process and measurement equipment, allowing the team to realize their research ideas in a clean room. The platform is the most remarkable boost to efforts to enhance research capability in semiconductor device technology.

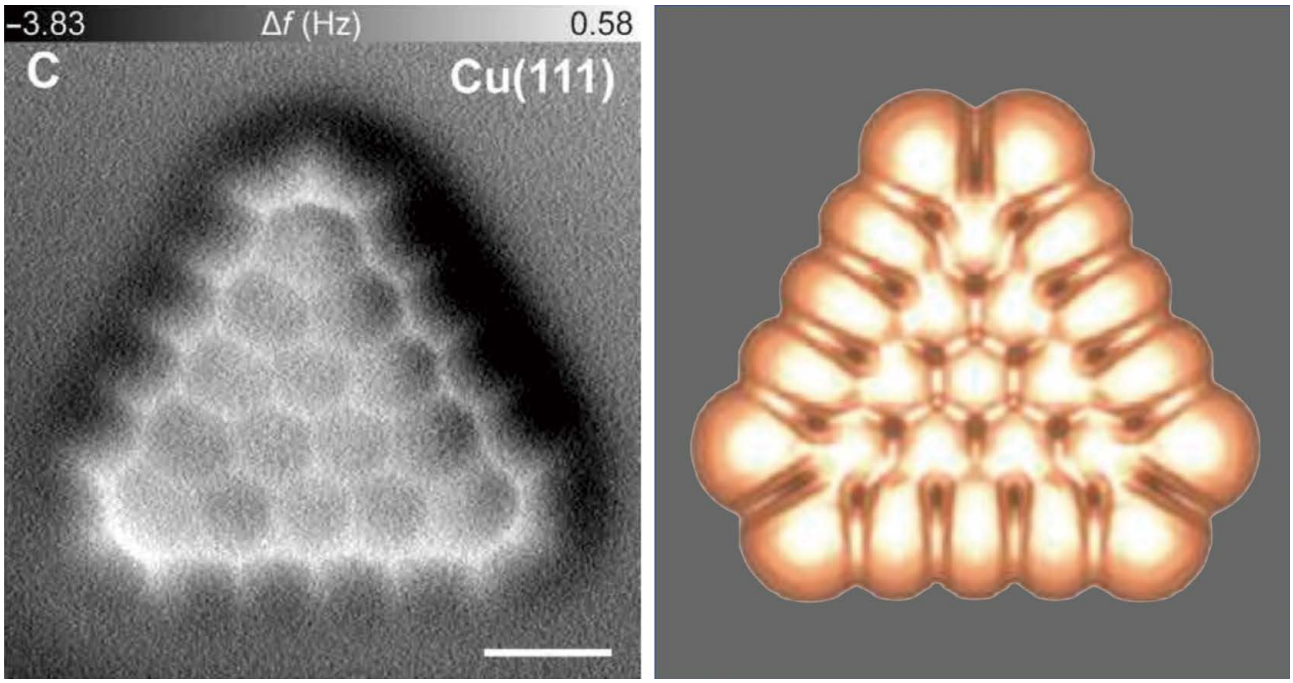


▲ Heterogeneous IGZO/poly-Si stacked complementary field-effect transistor structure

Research on Topological Properties of Advanced Two-dimensional Materials and Applications in Spintronics

The computational materials research team led by Dr. Feng-Chuan Chuang, a Distinguished Professor at National Sun Yat-sen University, employed NCHC's supercomputer Taiwania 1 to simulate the properties of novel quantum materials based on theoretical foundations. The team has published more than 40 research papers since 2019 on topics including the exploration of the physical properties of carbon-based qubits and their quantum spins in two-dimensional materials, adsorption on atomic surfaces, use of thickness to control electronic properties of two-dimensional materials, and the effects of doping on changes in physical properties. Compared with the parallel computing facilities previously built by the team, Taiwania 1 provides more powerful computing resources and breaks through the memory limitations of previous systems for simulating materials.

In addition to the vast resources required by simulation computing, the team has also benefited from today's powerful computational efficiency in the search for novel materials by bringing together quantum mechanics and high-throughput methods. These approaches have become an important technology in the field of computing materials. Using NCHC's platform, the computational time is decreased, and the usefulness and applicability of a large number of materials may be determined quickly, thus reducing situations where, given that the properties of the material are not yet known, a large number of experimental resources are unnecessarily wasted and repeated in traditional experiments on synthetic materials. Then, by learning from experience, the development processes can be corrected, and their development time can be reduced. With the help of artificial intelligence (AI) and big data, a database created with past research data can be used as the basis for future research and development so that the properties of novel materials can be predicted and the development of novel materials can be accelerated through systematized research processes.

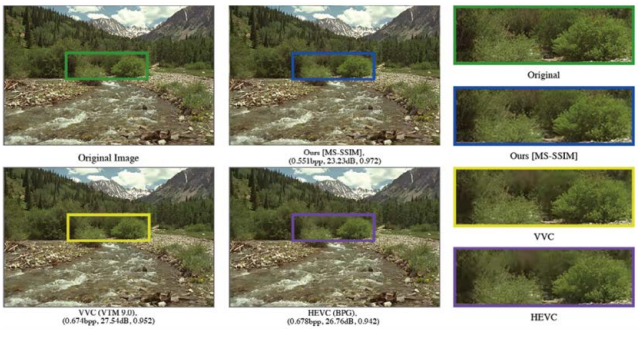


▲ Results of simulated triangular graphene calculations

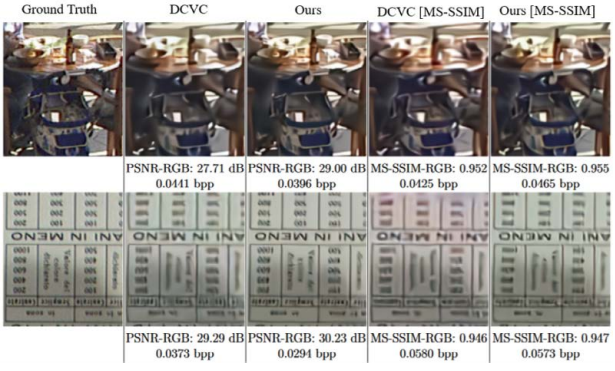
Video Compression Based on Generative Models

Image and video compression is an important research topic in the multimedia industry, the objective being to reduce data transmission volume while maintaining visual quality in order to support various modern digital applications. However, conventional video compression technology has plateaued for a while, and the basic framework remained unchanged over the past decade until the rise of deep learning in recent years. Research on machine learning-based image compression technology has begun to advance at a rapid pace and has gradually matured in the last two years. Standards organizations and global technology corporations are now paying close attention to the development of this technology. As they work to create standard specifications, they are preparing to make a splash in the industry. Prof. Wen-Hsiao Peng's research team at National Yang Ming Chiao Tung University has proposed three innovative approaches. The first two are end-to-end learned image and video compression systems, and the third employs deep learning technology to assist conventional compression systems. First, ANFIC, an end-to-end learned compression system for images, is the first image compression system proposed to employ Augmented Normalizing Flows (ANF) as a foundation, and it is capable of expanding existing compression systems in this new framework and taking advantage of the best of both worlds. Various tests have shown that ANFIC has achieved the most advanced performance of learned image compression.

Secondly, CANF-VC extends ANFIC to the video compression system, which incorporates the novel concept of conditional coding, becoming the first video compression system based on conditional augmented normalizing flows (CANF). It is ahead of traditional methods and other learned approaches regarding compression efficiency. Lastly, the team developed a framework that combines deep learning with conventional compression technology, which retains the architecture of conventional video compression systems and employs enhanced learning technology to fine-tune its parameters to achieve better results. Its compression outperforms traditional and other augmented-learned techniques while maintaining the target bit rate.



▲ Subjective visual quality in image compression

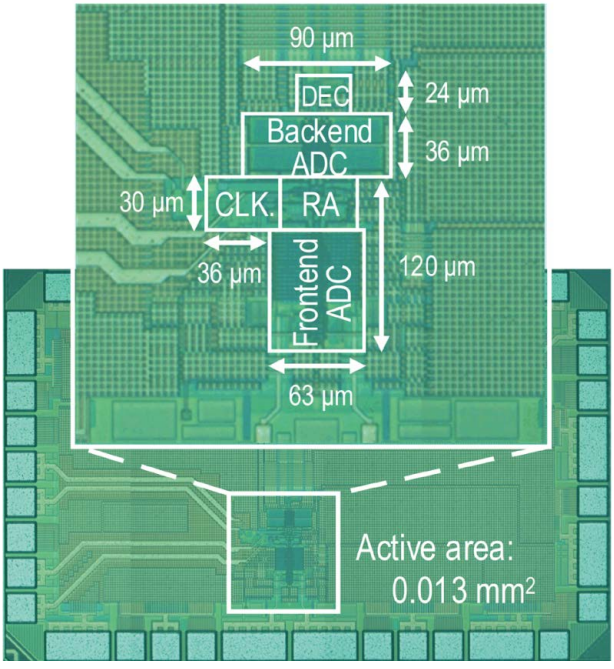


▲ Subjective visual quality in video compression

High-performance Data Converters for Next-generation Communications

Employing TSRI's chip design and production platform and measurement services, a team led by Dr. Tai-Haur Kuo, a Distinguished Professor of the Department of Electrical Engineering at National Cheng Kung University, successfully developed a series of high-performance data converters, including analog-to-digital converters (ADCs) and digital-to-analog converters (DACs). This is one of the fields in semiconductor IC design with the longest history and the most intense competition, and it represents a key research and development area greatly valued by countries worldwide. The team successfully developed a number of technologies to improve the speed and resolution of communications chips and has achieved important results in a number of key specifications. Their efforts have received international recognition.

In addition to realizing high-speed and high-resolution chip specifications, the team also stressed the importance of developing chips with low power consumption and low costs. Their R&D achievements surpassed those of existing products and research papers in top-tier academic journals and pointed directly to the specifications of future communications applications. These achievements include extremely low electrical power consumption, and the chip's excellent performance technology can extend the battery life of mobile phones several times. The team's research papers were presented at the IEEE International Solid-State Circuits Conference (ISSCC), known as the "IC Olympics," and a number of full-length papers have also been published in the widely recognized flagship journal *IEEE Journal of Solid-State Circuits* (JSSC). The five chip designs realized over the past few years have set records as having achieved the most outstanding performance among similar technologies in the world, and they are highly sought after by the industry. There have also been multiple technology transfers associated with these chips, and the results have been very fruitful. Dr. Kuo and his associates have been recognized as the most advanced research team globally in related fields over the past three years.



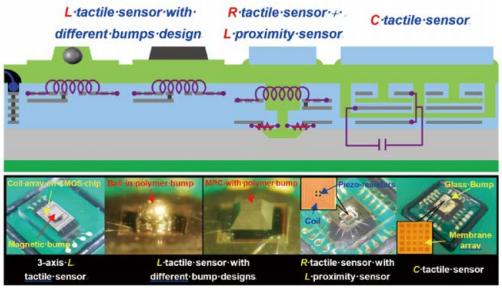
▲ High-resolution 130MSPS pipelined SAR ADC

Development of CMOS-MEMS Tactile Sensors

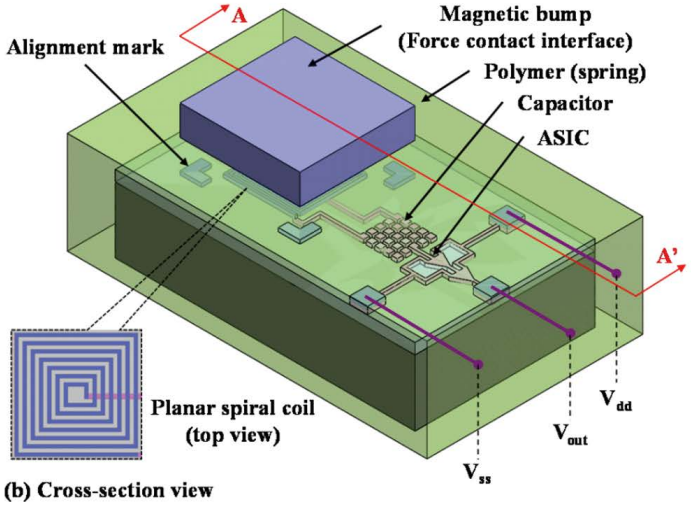
The tactile sensor is an important human-machine interface, and it is also a key component indispensable for applications such as the forthcoming metaverses and robotics. Robots have recently advanced from performing simple, repetitive tasks to collaborating with humans in open environments. For this reason, tactile sensors that help robots to understand their surroundings now play a crucial role. Signals from the sensors are used to control the magnitude of contact force. The change in the proximity distance can be used as a trigger signal to avoid unnecessary damage to the target object or injury to people in the vicinity.

The research team led by Dr. Weileun Fang, Chair Professor of National Tsing Hua University, therefore chose the TSMC 0.18μm 1P6M and TSMC 0.35μm 2P4M CMOS process platforms provided by TSRI to overcome the limitations of common process platforms: printed circuit boards and polymer substrates being plagued by their bulkiness and complicated assembly. These platforms feature the ability to produce chips with very small sizes, stacked multilayered films, and sub-micron linewidths, which facilitate the design and realization of single axial/tri-axial sensor chips for contact force with the use of different sensing technologies, including capacitive, piezoresistive, and inductive. In addition, proximity and temperature sensors can be further integrated into the same chip to establish a vital core technology for future applications, such as robotics, machine tools, and consumer electronics.

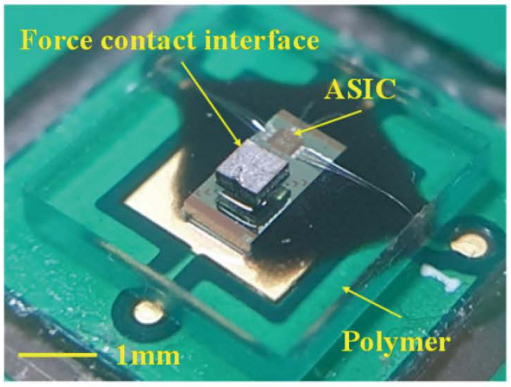
The team developed the world's first tactile force sensing chip without a suspension spring structure by combining a sensing coil chip with a polymer force sensor. Apart from the advantage of a simple manufacturing process, the device's reliability is also greatly improved, significantly contributing to the commercialization of contact force sensing chips. Their research on these tactile sensors has not only been published in journals and seminars in the field of MEMS, but it is also the Outstanding Student Paper Award Winner, First Place Winner of the Best Student Paper Award, and the Excellent HIWIN Thesis Award winner awarded by IEEE MEMS, IEEE Sensors, and the HIWIN Education Foundation, respectively, all of which represent a great acknowledgment of the team's achievements.



▲ CMOS-MEMS tactile sensors



▲ The first non-suspended CMOS tactile force and ASIC sensor SoC

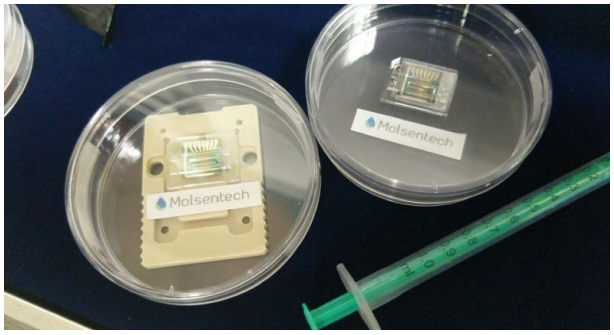


HIGHLIGHTS

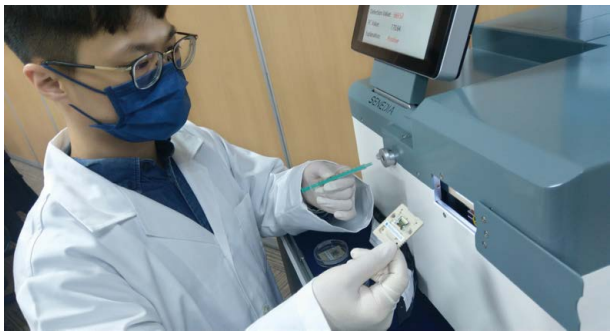
TIRI

Molsentech, Academia Sinica, TIRI, and KSVGH Co-develop World's First COVID-19 Rapid Test Chip

TIRI provided guidance to biomedical technology company Molsentech and collaborated with Academia Sinica and Kaohsiung Veterans General Hospital to develop the world's first COVID-19 rapid test chip, enabling patients in the early stages of infection or with no symptoms to obtain test results within 20 minutes at an accuracy rate of 95% or higher. The technology was granted an emergency use authorization from the Taiwan FDA and is now on the market.



▲ COVID-19 Rapid Test Chip



▲ Operation of COVID-19 rapid test instrumentation

NCREE

Updated Seismic Design Provisions for Buildings Go into Effect

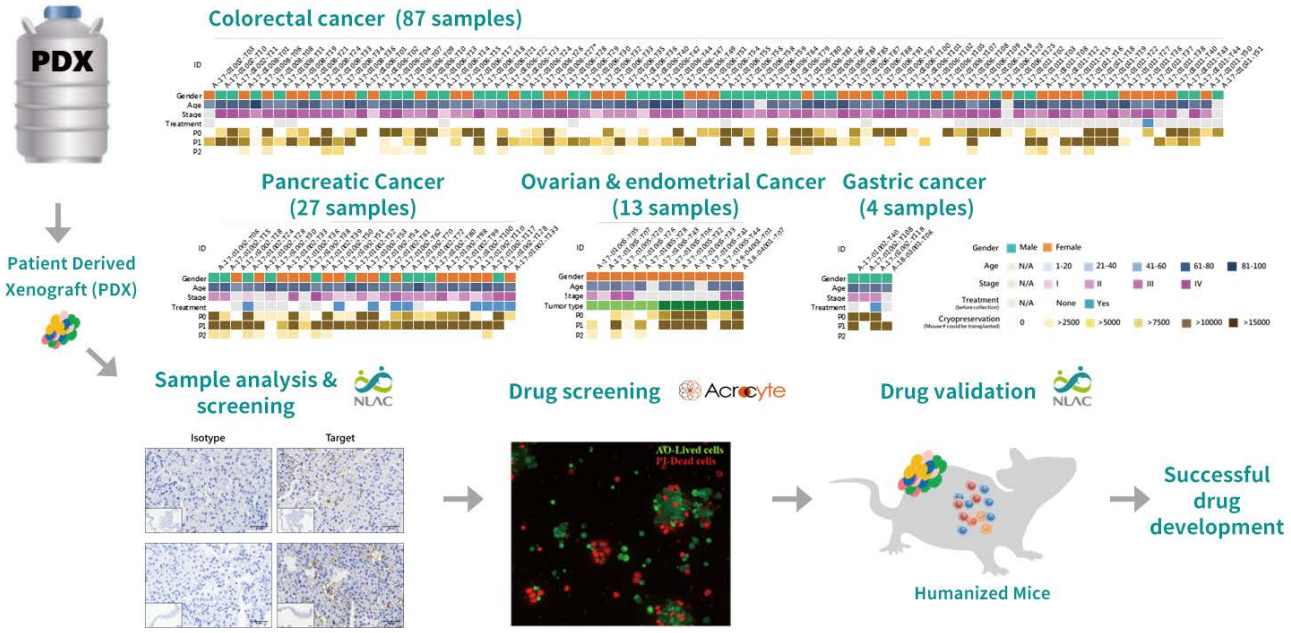
Seismic design provisions are the first line of defense to protect buildings nationwide. After years of effort from the Ministry of the Interior's Construction and Planning Agency and NCREE, an updated version of the "Seismic Design Provisions and Commentary of Buildings" was officially enacted by the Ministry of the Interior on June 14 and took effect on Oct. 1. The new provisions contain four major revisions: improving the seismic safety of adjacent fault areas, improving the earthquake resistance of buildings with weak-stories, improving the soil liquefaction map and anti-liquefaction design, and ensuring the design quality and performance of energy dissipating components. These revisions are expected to improve the seismic resistance of Taiwan's buildings and effectively protect the safety of living in Taiwan.

▲ NCREE Associate Researcher Yuan-Tao Weng introduces updated seismic design provisions for buildings

▲ (From left) Associate Researcher Yuan-Tao Weng, NARLabs Vice President Bou-Wen Lin, Construction and Planning Agency Director-General Hsin-Hsou Wu, NCREE Director-General Chung-Che Chou,Deputy Director General Juin-Fu Chai, and NARLabs Operation and Promotion Office Director Lung-Yao Chang

PDX bank

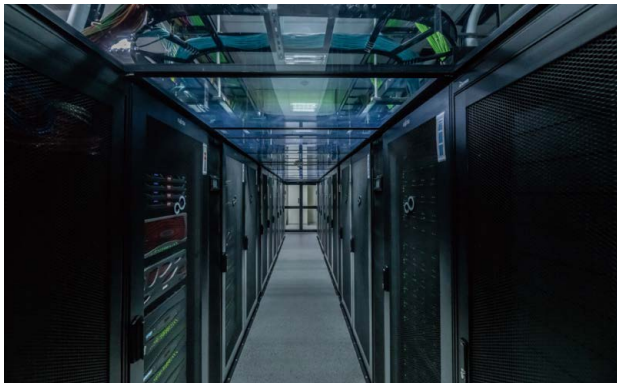
NLAC has established a patient-derived xenograft (PDX) model bank by grafting tumors from patients into advanced severe immunodeficient (ASID) mice. Currently, 131 models of colorectal cancer, pancreatic cancer, ovarian cancer, endometrial cancer, and gastric cancer have been established, and liver cancer models are being accumulated. NLAC has also constructed an in vitro method to screen drug-targets for appropriate tumor selection and provided various immune humanized mice to verify drug efficacy. Overall, NLAC aims to accelerate the development of anti-cancer drugs and precision medicine in Taiwan with its multiple services.



▲ Tumor avatar medical platform is seamlessly integrated, creating triple win

Taiwania Supercomputer Services Accelerate R&D

NCHC's Taiwania supercomputers drive national scientific research and connect with industry. In 2022, Taiwania served over 6,000 users, logged more than 18 million hours of weighted service time, and supported more than 1,800 research projects. Its users have published over 900 academic papers in the fields of physics, chemistry, mathematics, atmospheric science, engineering, and life science, helping to achieve many breakthroughs.



▲ Taiwania series mainframe

Science and Technology White Paper Charts Taiwan's Outlook for 2035

STPI assisted NSTC in drafting a 2023-2026 science and technology white paper. The paper takes into account global trends and challenges facing Taiwan and outlines the nation's 2035 outlook for science and technology development with the visions of "foresight and innovation, democracy and inclusiveness, and resilience and sustainability." Responding to the needs of people and society, the paper also discusses cutting-edge strategic technologies and the country's all-around development, defining 10 general objectives and five strategies for social, research, environmental, economic, political, and strategic responses through inter-ministerial collaboration, cross-domain consultation, and inter-think tank teamwork.

▼ Ministry representatives and opinion leaders provide input at kick-off meeting

▲ Preliminary details of Science and Technology White Paper presented to public at roundtable conference

▲ Inter-ministerial meeting to discuss strategies in various areas

NSPO

Research Rocket Missions at Short-Term Launch Site

NSTC has established a short-term launch site for research rockets at Xuhai Village of Mudan Township, Pingtung County. On July 10, a team from National Yang Ming Chiao Tung University's Advanced Rocket Research Center became the first to complete a launch mission at the site. National Cheng Kung University's interdisciplinary hybrid rocket team also held a successful launch on Nov. 8.

▲ The second stage test launch of the research rocket HTTP-3A

▲ NCKU's interdisciplinary hybrid rocket team holds test launch

TORI

Supporting Ocean Research and Instilling Hope for Ocean Education

TORI considers itself a vanguard in supporting marine science research and works on the front lines of various future-oriented experiments. It also acts as a cultivator of marine education, using diverse and creative ways to organize marine science activities, rearing talent and spreading knowledge in the field. On Nov. 29, TORI received the Marine Education Contribution Award from the Ministry of Education, the highest honor for those who promote marine education. TORI will continue to work even harder to obtain local materials for marine education to share and spread the message of "knowing, approaching, and loving the sea" to the nation.

▲ Visit from Earth Science Training Program for Indigenous Senior High School Students

▲ Secret Bases of Scientists lecture

Frontier Process Design Services in Northern Taiwan

In order to expand technical services and talent training for frontier chip design, TSRI established a new chip design laboratory in cooperation with NCHC and National Taiwan University. Joining the existing Hsinchu and Tainan bases, the new laboratory, located in northern Taiwan, will help reduce travel time for research teams as well as provide students with access to high-level processes while they are still in school. The laboratory will also strengthen researchers' practical chip design capabilities to help the overall development of Taiwan's semiconductor industry.

▲ Opening ceremony for TSRI's chip design laboratory in northern Taiwan

Shalun Smart Green Energy Science City: Ground Broken for Cybersecurity & Smart Technology R&D Complex

A groundbreaking ceremony for the second-phase building of NSTC's Cybersecurity & Smart Technology R&D Complex, operated by NARLabs, was held on May 29. NSTC anticipates the Cybersecurity & Smart Technology R&D Complex to be a center of development in the areas of smart health, smart transportation, and smart living, with cybersecurity at their foundation. The complex will also connect with technology hubs in surrounding areas, together forming the Southern Taiwan Technology Corridor.

▲ Groundbreaking ▼ Group photo from groundbreaking ceremony

04

R&D AND SERVICE ACCOMPLISHMENTS

R&D Building Construction Commencement Ceremony

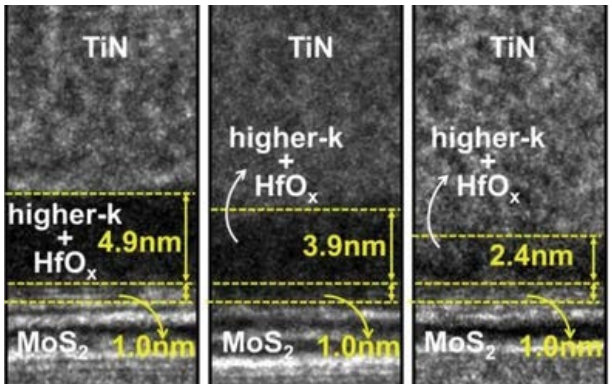
With a history of 50 years, TIRI is the only R&D organization in Taiwan capable of providing interdisciplinary, customized, and advanced instruments and equipment in the fields of natural sciences, engineering, healthcare, and agriculture in academia. In order to undertake the nation's missions and to support government policies and programs, TIRI has engaged in large-scale advanced equipment R&D, such as developing high-resolution remote sensing instruments and next-generation semiconductor manufacturing processes and testing for forward-looking projects. To support these endeavors, TIRI began to implement its plan to construct a new R&D complex in 2020, and the building's groundbreaking ceremony was finally held on Dec. 12 after a long delay due to various factors attributable to the COVID-19 pandemic, such as labor shortage and rising costs of construction materials.

▲ Ceremony for commencing construction of new R&D building presided over by NARLabs President Faa-Jeng Lin, attended by Hsinchu Science Park Bureau Director-General Wayne Wang and other distinguished guests

TIRI

Breakthrough on Applications of 2D Materials Based on TSMC-TIRI Collaboration on ALD Presented at International Conference

Teams from TSMC and National Yang Ming Chiao Tung University collaborated with TIRI's Atomic Layer Deposition (ALD) Joint Laboratory to develop a high-coverage ALD process, successfully producing a device with a two-dimensional material with an effective 1 nm oxidation, in addition to developing a nanosheet gate-all-around (GAA) transistor made with a two-dimensional semiconductor material. Both achievements were jointly reported at the 2022 International Electron Devices Meeting (IEDM) and are critical pieces of research required to achieve "More than Moore" technology.



▲ Record for thinnest effective oxide layer in ultrathin dielectric film produced on a 2D material

NCHC

Formosa Open eXchange Enhances Cross-network Transmission and Backup Capabilities

The Formosa Open eXchange (FOX) created by NCHC improves the cross-network transmission performance and backup capabilities of the country's public service networks by providing high-speed interconnection among the government network GSN, academic network TANet, research network TWAREN, and Academia Sinica's ASNet. FOX reduces the round-trip time (RTT) of transmission packets to less than 12 ms, increases the available bandwidth by up to 9.98 times during peak hours, and boosts the available bandwidth by up to 8.2 times during off-peak hours.

▲ Formosa Open eXchange (FOX) mainframe

Premier Su Inspects TRITON Satellite Mission

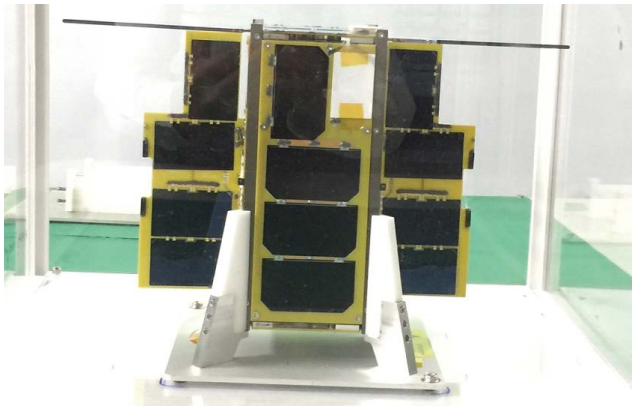
Taiwan's first domestically manufactured weather satellite, TRITON (Formosat-7R), has undergone the final stages of complete functional tests. Premier Su Tseng-chang arrived at NSPO on Nov. 7 for an inspection and commended the staff for their hard work. The Premier said that the government fully supports the space industry and looks forward to TRITON taking on a leadership role in this field.

▲ Premier Su Tseng-chang views TRITON satellite

Space-grade GPSR Independently Developed by NSPO Functionally Validated

The space-grade GPS receiver (GPSR) independently developed by NSPO was launched in mid-January along with the CubeSat IRIS-A developed by National Cheng Kung University into a satellite orbit 500 km above the earth's surface. The space-grade GPSRs are now operating normally, successfully passing the tests of a harsh environment in space and acquiring the necessary flight heritage. In addition to withstanding the strong vibratory force during rocket launch and the severe temperature fluctuations in the vacuum of space, the space-grade GPSRs should also be capable of locking GPS signals in a stable manner in high-speed motion.

▼ NSPO's independently developed GPS receiver (circuit board with details masked)



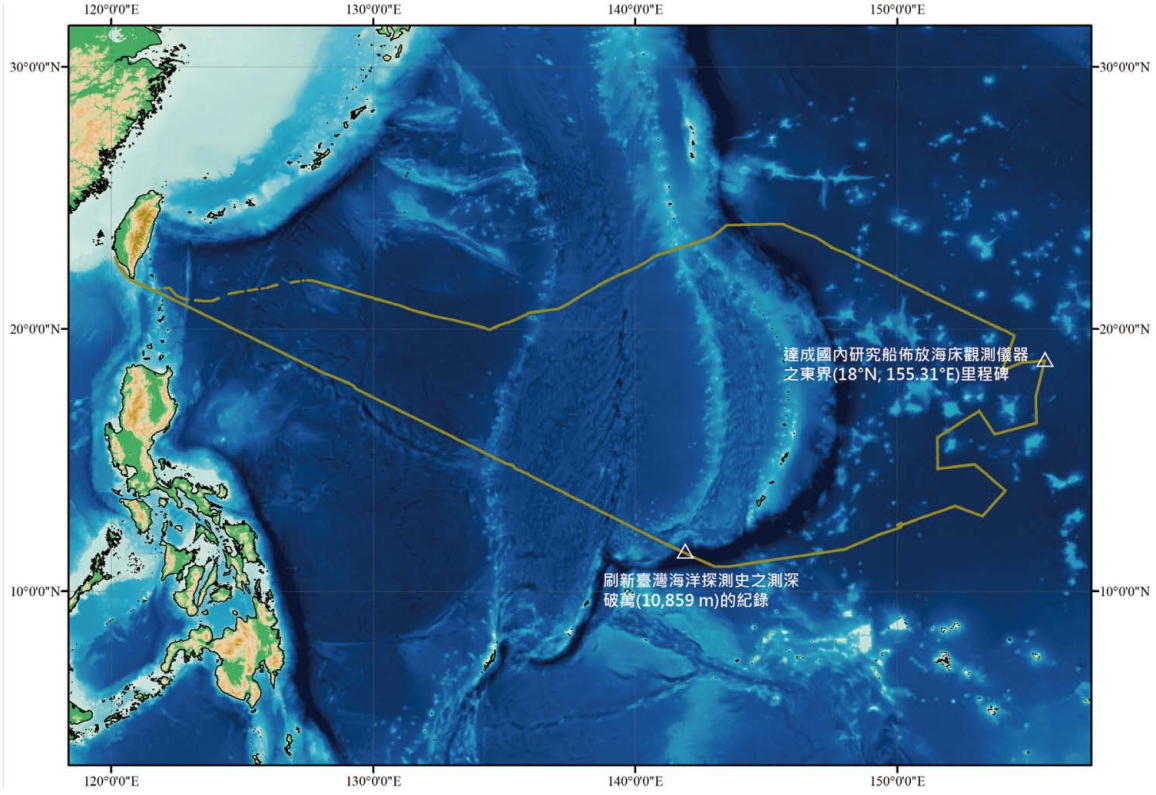
▲ CubeSat IRIS-A developed by National Cheng Kung University

▲ NSPO's independently developed GPS receiver

R/V *LEGEND* Breaks Three Major Records in Marine Exploration

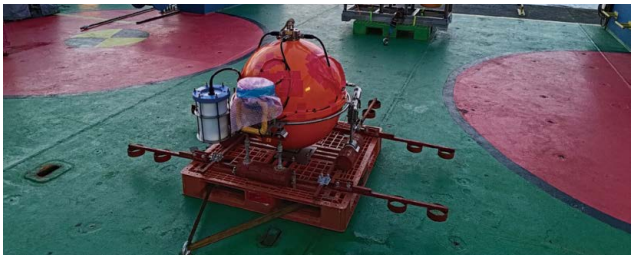
TORI joined forces with an international team consisting of researchers from Academia Sinica, National Central University, and the University of the Philippines to carry out the "New Southbound Nations Earth Sciences Key Technological Cooperation Research Deepening Project" and the "Taiwan-Philippines VOTE (Volcano, Ocean, Typhoon, and Earthquake) Project" in March. This was the first time a Taiwanese research vessel had performed a 30-day non-stop service cruise without docking at any port.

In September, R/V *LEGEND* provided support to Academia Sinica's project "Exploring the Earth System–Pacific Expedition." A team of international researchers from Taiwan, Japan, and South Korea traveled to the Pacific Plate and successfully deployed, as a Taiwanese research vessel, a seabed observation apparatus at a milestone eastern boundary (155°18'37"E) at a 1,965-nautical mile (equivalent to 3,640 km) straight-line distance from Cape Eluanbi. While crossing the Mariana Trench on October 1, the vessel's multibeam sonar system recorded in real time an ocean depth of -10,859 meters, which was the very first time in Taiwan's marine exploration history that a depth exceeding 10,000 meters had been measured.



▲ The LGD2212 navigation path. The total mileage of the voyage was 5,260 nautical miles, about nine times the distance from northern to southern Taiwan.

▲ Multinational team on LGD2201 cruise goes 30 consecutive days without calling at port



▲ Deployment of ocean bottom seismometer (OBS) and ocean bottom electro-magnetometer (OBEM) from the University of Tokyo results in new milestone for seafloor observation instruments

Independently Developed New Underwater Glider Unveiled

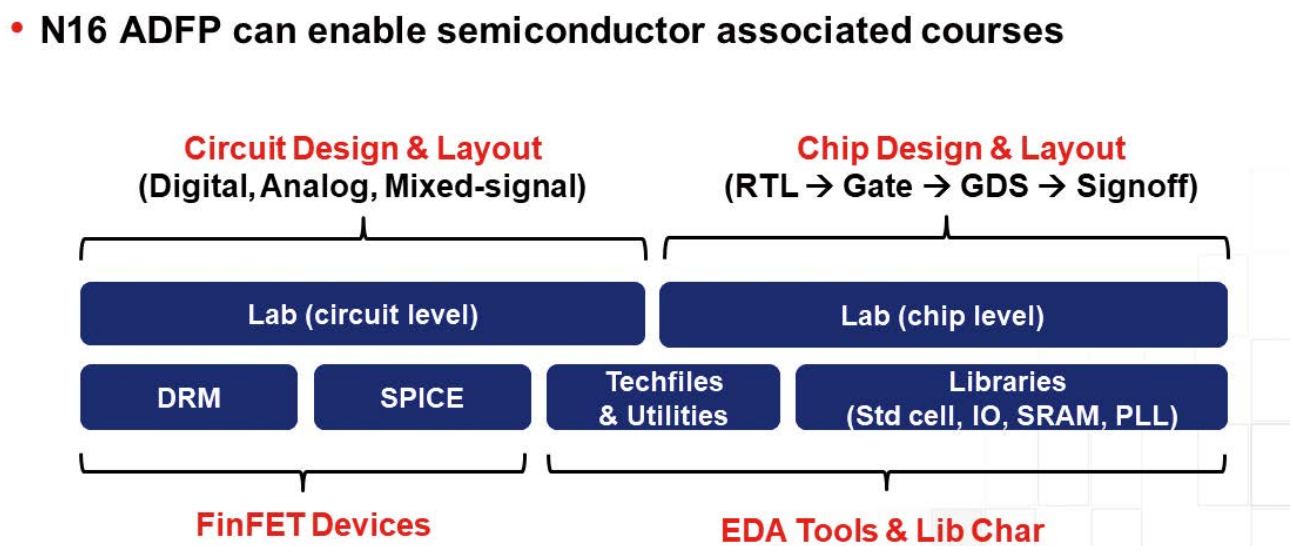
The underwater glider is one of the most important submarine observation vehicles for wide-area ocean observation. TORI and the Institute of Undersea Technology at National Sun Yat-Sen University jointly developed an underwater glider prototype capable of operating at 1,500 m deep and conducting long-distance and wide-ranging observation missions. The glider's buoyancy engine completed deep-water testing, and gliding tests were successfully performed on several round-trip cruises under actual marine conditions. In the future, the glider will be deployed on research vessels to carry out official missions.

▼ Underwater glider's in-water form

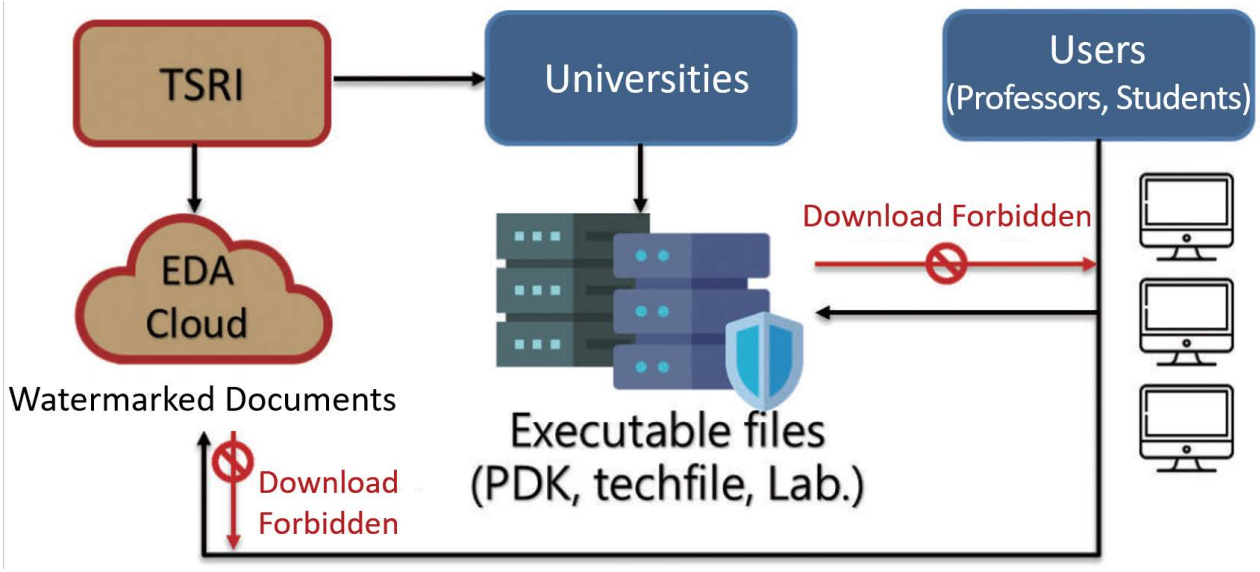
▲ Real sea testing of underwater glider

N16 ADFP - Academic Design Incubation Kit for 16nm FinFET Process

To improve the country's cutting-edge chip design capabilities and cultivate high-level design talent, TSRI has adopted the Academic Design Foster Package (N16 ADFP) for the 16nm FinFET virtual process. This package consists of training-oriented technical files and documents required for the industry's fin field-effect transistor (FinFET) design. Through the package's supportive pedagogical process, students at universities will be able to acquire skills relevant to real-world practices in the industry, including digital/analog/mixed-signal circuit design, layout, and other techniques. Since the introduction of the package in February 2022, 10 Taiwanese universities have submitted applications for its adoption.



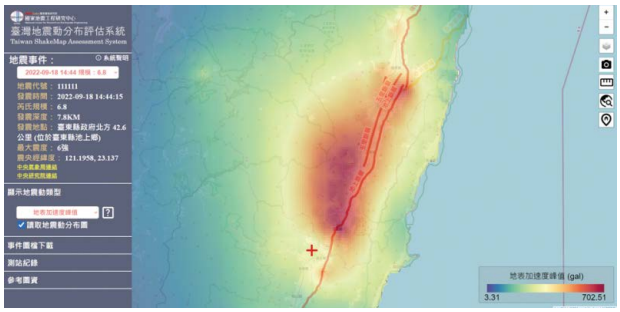
▲ N16 ADFP can be applied to semiconductor-related courses at universities and college-level institutions (Sourced from 2022 VLSI Design/CAD)



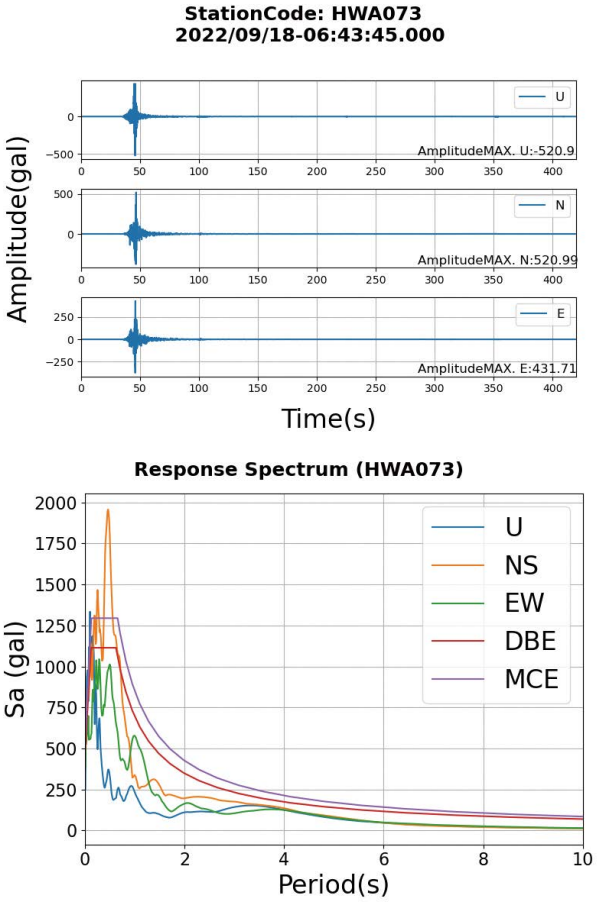
▲ N16 ADFP information security structure with unidirectionality to ensure security of sensitive process data

Taiwan ShakeMap Assessment System

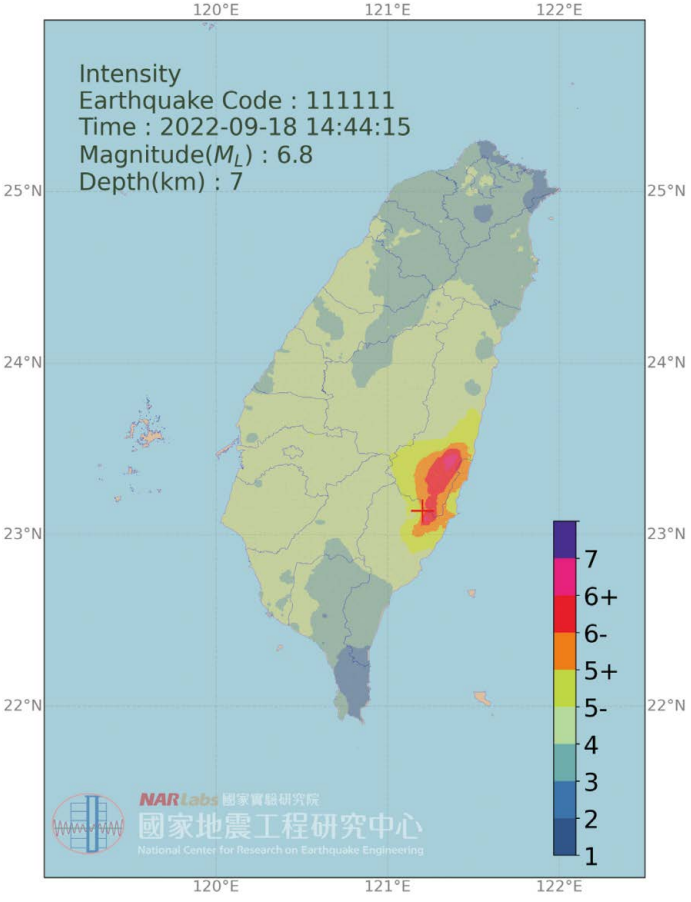
NCREE has developed the "Taiwan ShakeMap Assessment System" to support loss estimations and emergency responses after large earthquakes. The system combined the advanced ground motion prediction equation, earthquake source models, local site parameters, and a spatial correlation model to automatically generate a high-resolution shake map, which is the distribution of ground motion intensities, shortly after an earthquake happens. The estimation is based on field observations from the strong motion networks of the Central Weather Bureau (CWB) and NCREE. All the shake maps of earthquakes that occurred in Taiwan are graphically visualized through a GIS web service.



▲ A shake map of the 2022 Taitung Chishang Earthquake presented on the website



▲ An example of acceleration waveforms and response spectra observed by a strong motion station



▲ Types of nationwide seismic distribution maps available for download

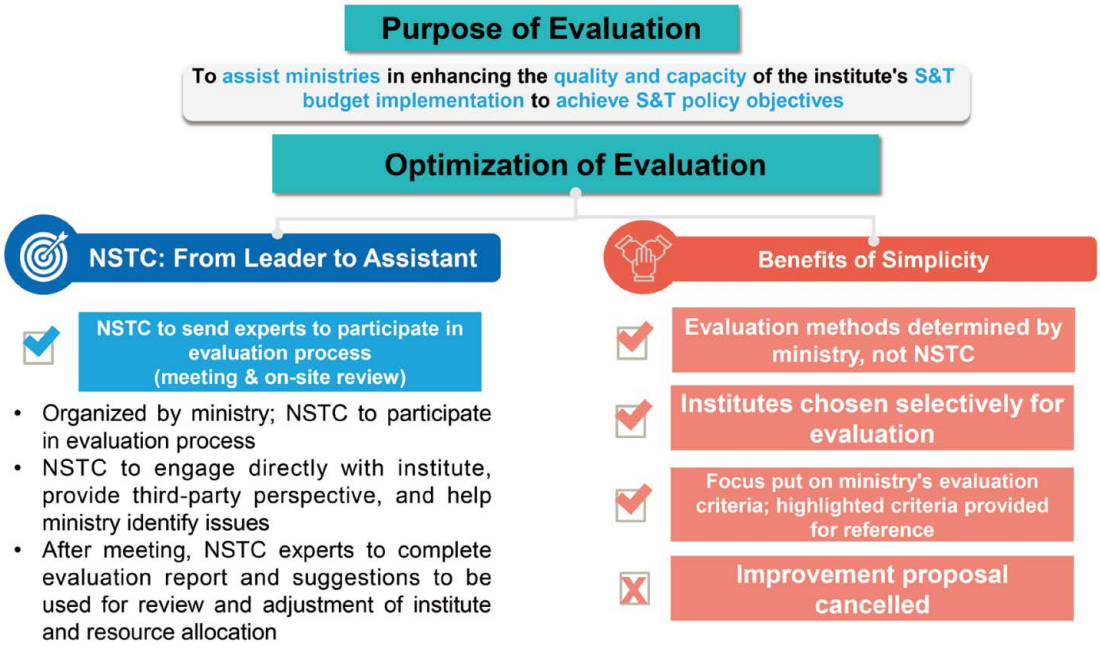
Supporting the Creation of Taiwan Net Zero Technology R&D Policy Proposal and Transition towards 2050 Net Zero Goal

STPI provided support to Academia Sinica in the drafting of the Taiwan Net Zero Technology R&D Policy Proposal, which contains recommendations on the country's R&D roadmap towards 2050 net zero carbon emissions from the perspectives of technology development. Meanwhile, in coordination with the government's social, economic, and governance-related measures, STPI has endeavored to assist the government in driving energy supply and demand systems and industrial transformation, as well as in establishing the country's capacity to mitigate the effects of climate change and the resilience to adapt to these effects.

Overhauling Performance Evaluation for Research Institutions to Enhance Nation's Research Capacity and Quality

To enhance the research capacity and service quality of Taiwan's research institutions so that the country's scientific and technological policies can be achieved effectively, STPI provided assistance to NSTC in its plans to overhaul the performance evaluation mechanisms for research institutions.

By shifting the leadership role of NSTC, simplifying the review processes, improving evaluation approaches, and making other changes, STPI provided third-party evaluation perspectives and opinions external to government ministries and helped them to discover issues and problems. These efforts will help government ministries improve the management of their research institutions and enhance their research capacity and quality.

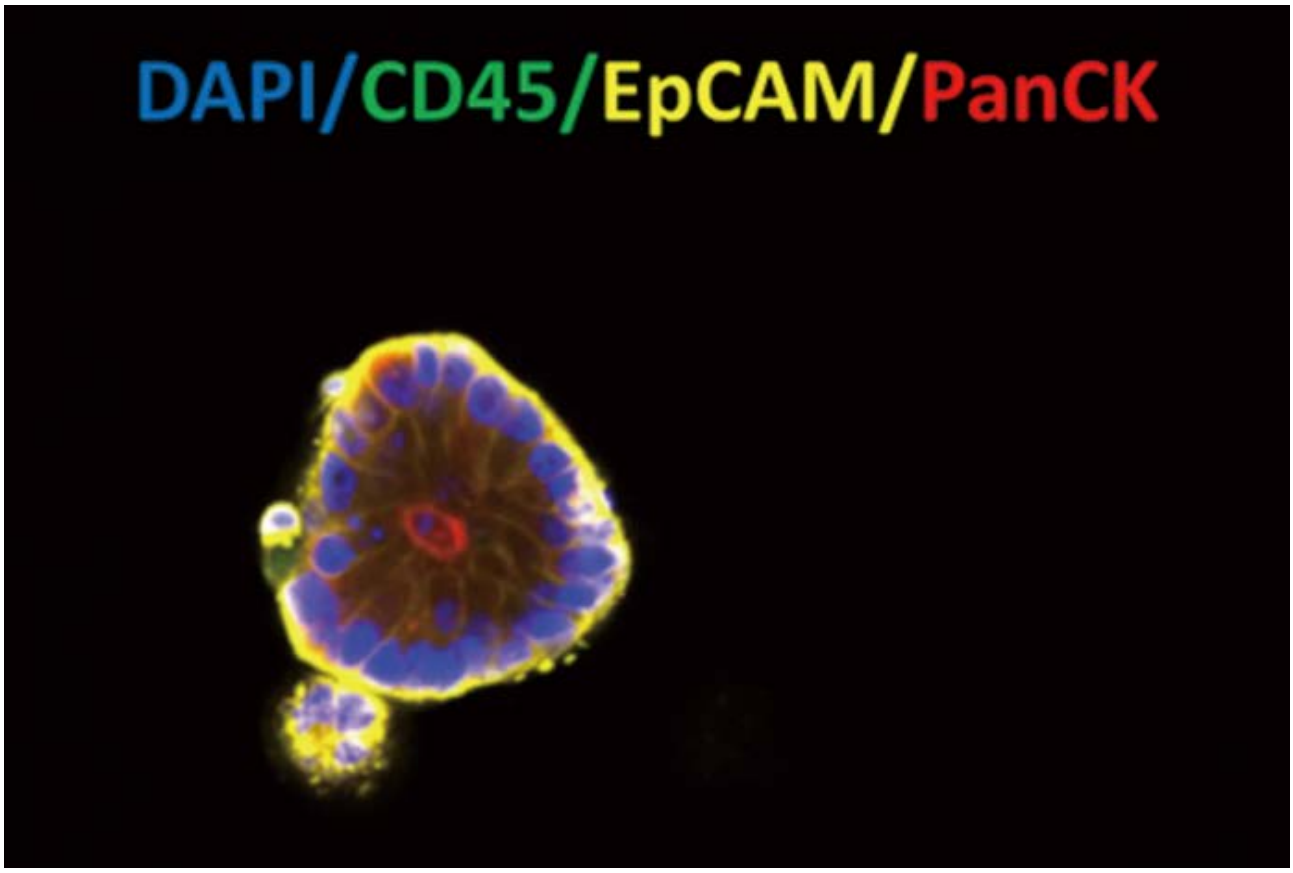


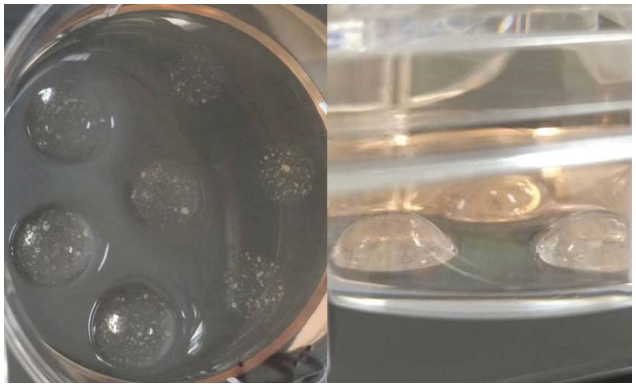
▲ Transformation framework for research institutions performance evaluation

3D Tumor Cell Culture

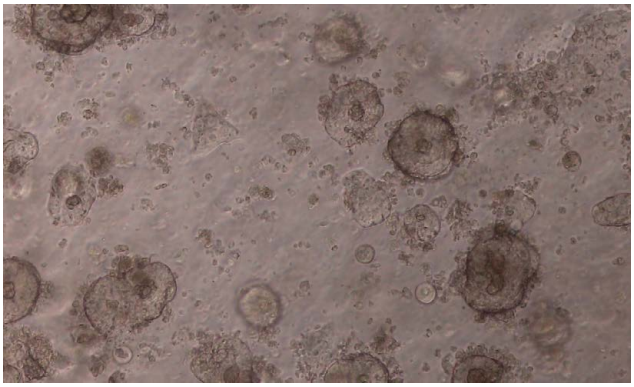
Patient-derived 3D tumor organoids (PDO 3D) maintain the heterogeneity of primary tumors. Compared with tumor animal models, the higher take rate, shorter culture time, and lower cost of PDO 3D culture systems facilitate the development of large-scale drug screening. A unique PDO 3D culture method (R3CE), as an animal replacement platform, was developed by NLAC in collaboration with AcroCyte Therapeutics Inc. To solve the unmet need of a drug screening system for precision medicine, this platform could further apply to tumor-on-chip for high-throughput clinical drug screening.

▼ Biomarker representation of 3D cells under fluorescence microscope





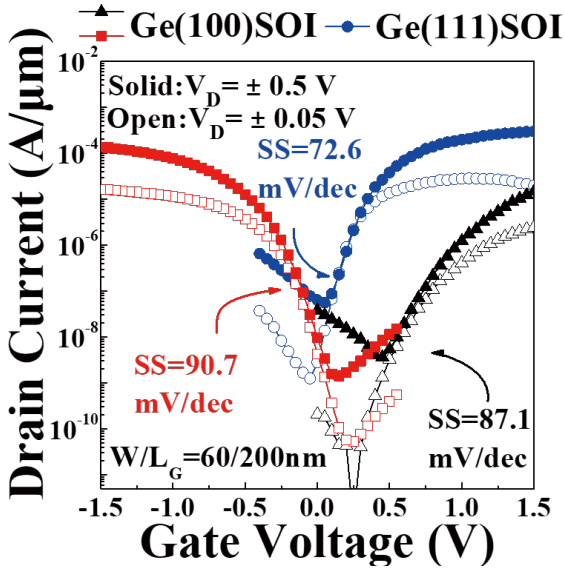
▲ Top and side views of hemispherical 3-D cell culture



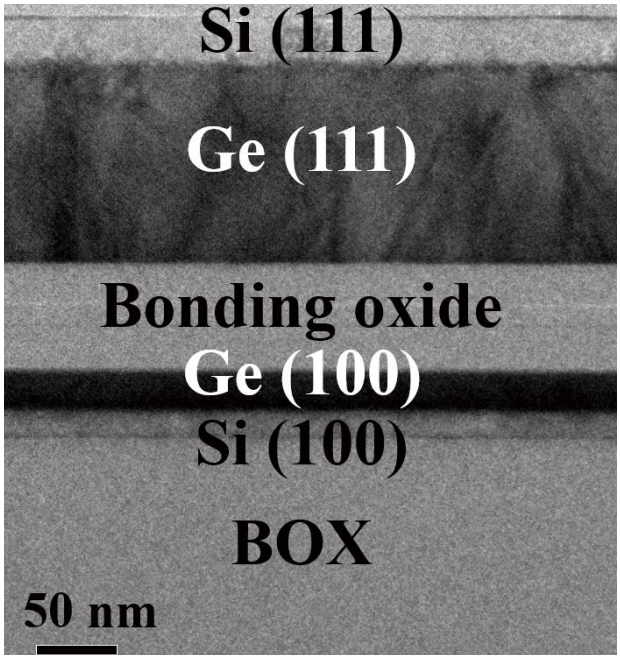
▲ 3D tumor cell under microscope

Vertically Stacked Germanium CFETs with Different Wafer Orientations

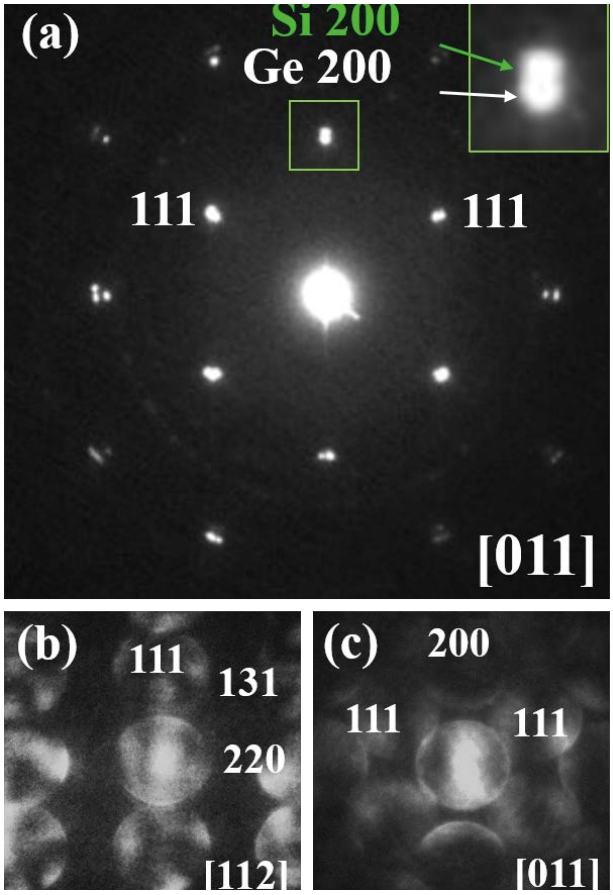
Complementary field-effect transistors (CFETs) can reduce the footprint of elements and are considered to be next-generation semiconductor devices. The low-temperature wafer bonding technology developed by TSRI can directly bond germanium substrates with different wafer orientations into one substrate, which can be applied directly to the production of CFET devices. In this technology's double-layer nanosheet stack structure, the upper layer is a 111-oriented Ge N-type device, and the lower layer is a 100-oriented Ge P-type element, constituting a brand new CFET structure. The results of this research have been published at the IEEE Symposium on VLSI Technology and Circuits.



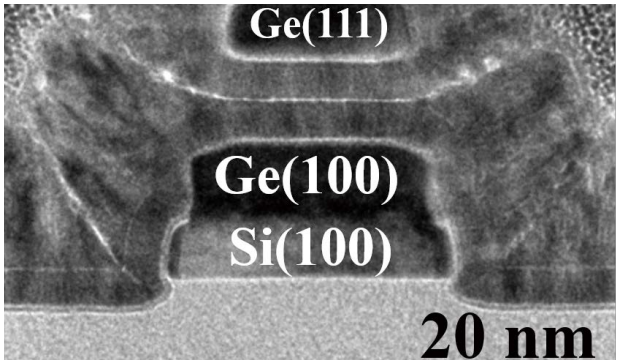
▲ Electrical properties of Ge(100) and Ge(111)



▲ TEM of germanium substrates with different crystal orientations after bonding



▲ The selected area diffraction pattern of Ge (100)/Si (100) and the converged beam electron diffraction patterns of (b) Ge (111) and (c) Ge (100)

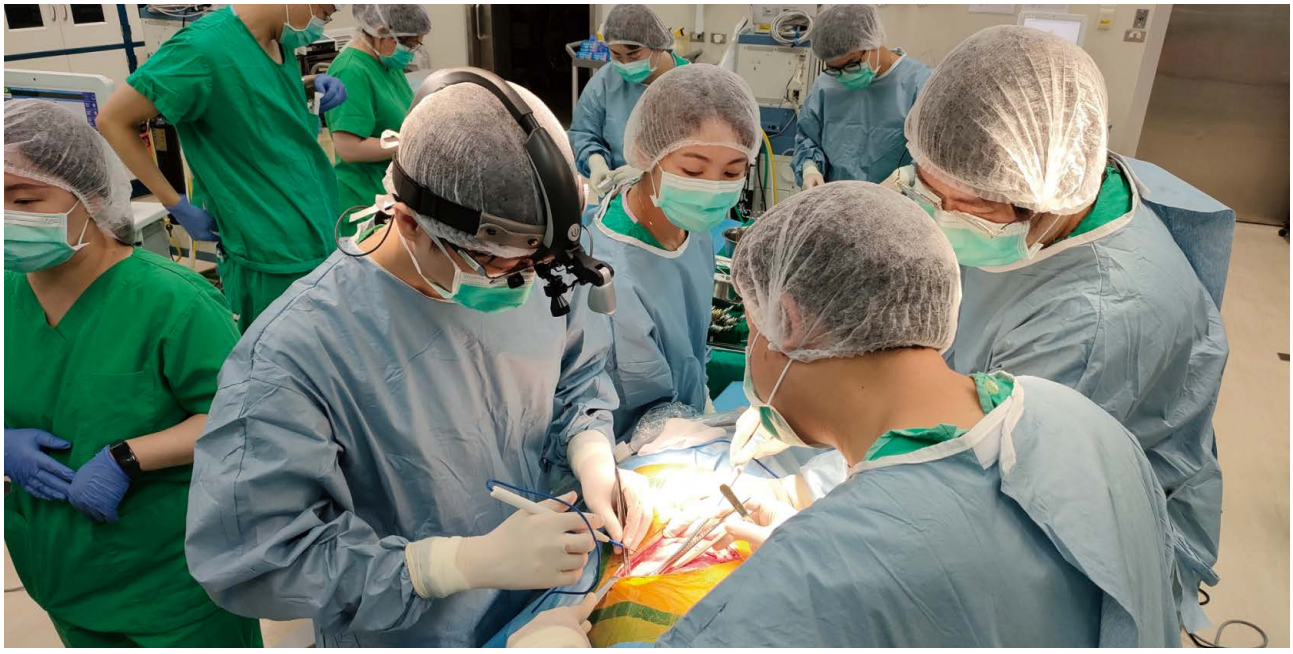


▲ TEM of Ge(100)/Ge(111) CFET device

Verification of Safety and Efficacy Counter-pulsation Ventricular Circulatory Assist Device in Laboratory Goat

NLAC provided assistance to 3R Life Sciences Taiwan Ltd. in verifying the effectiveness of its Dual-pulsation bi-Ventricular Assist Device (DPbi-VAD). A laboratory goat underwent the implantation of a Para-aortic Blood Pump (PABP), following physiological monitoring and continuously optimized postoperative care 24 hours a day until the predetermined endpoint was achieved after 60 days. Good Laboratory Practice (GLP) tests will then be conducted, and the results will be submitted to the Medicines and Healthcare products Regulatory Agency (MHRA) in the UK for review. In the future, it is hoped that this technology will help patients with early-stage heart failure by relieving clinical symptoms, improving the quality of their lives, and facilitating their transition to heart transplant surgeries.

▼ Specialists perform difficult implant surgeries



▲ Counterpulsatile ventricular assist device implantation completed

▲ Continued optimization of post-operative care for laboratory goat

NCHC

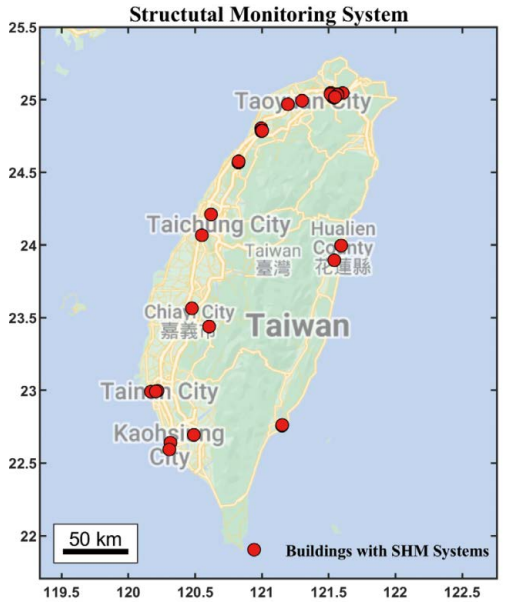
National-level Friendly Biomedical Data Analysis and Sharing Platform Facilitates Development of Precision Medicine

The national-level friendly biomedical data analysis and sharing platform constructed by NCHC provides an information infrastructure environment where healthcare big data can be stored and shared in a sustainable fashion with highly secure biomedical computing and storage equipment. In support of NSTC's Department of Life Sciences, the platform has collected biomedical data in four different categories from eight medical centers. The formats of the data have been checked and corrected both manually and via automatic means to ensure their compliance, thus laying a solid foundation for the utilization and development of digital biomedical data applications in this country.

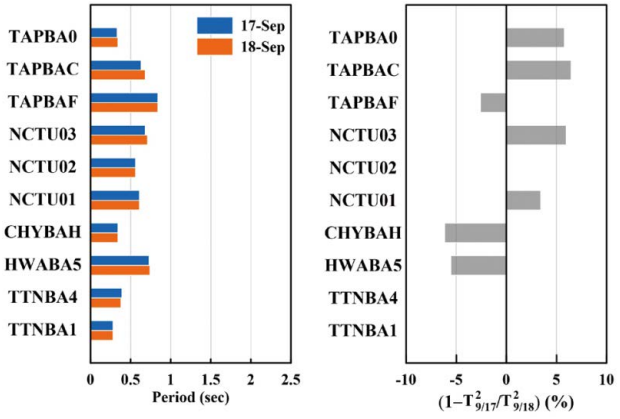
NCREE

Taiwan Structural Monitoring Data Hub (TSMOD)

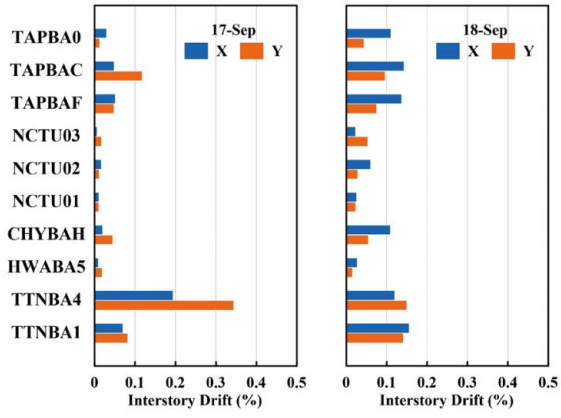
NCREE cooperates with the Central Weather Bureau (CWB), the National Yang Ming Chiao Tung University, the National Laboratory Animal Center (NLAC), the Freeway Bureau of MOTC, etc., to install the structural monitoring systems in selected buildings and bridges in Taiwan. The structural monitoring system measures and records structural vibration responses to provide early warning service and to evaluate the structural health status after an earthquake occurs. The website "Taiwan Structural Monitoring Data Hub (TSMOD)" is established to present the data of structural monitoring systems.



▲ Spatial Distribution of Structures with Health Monitoring Systems



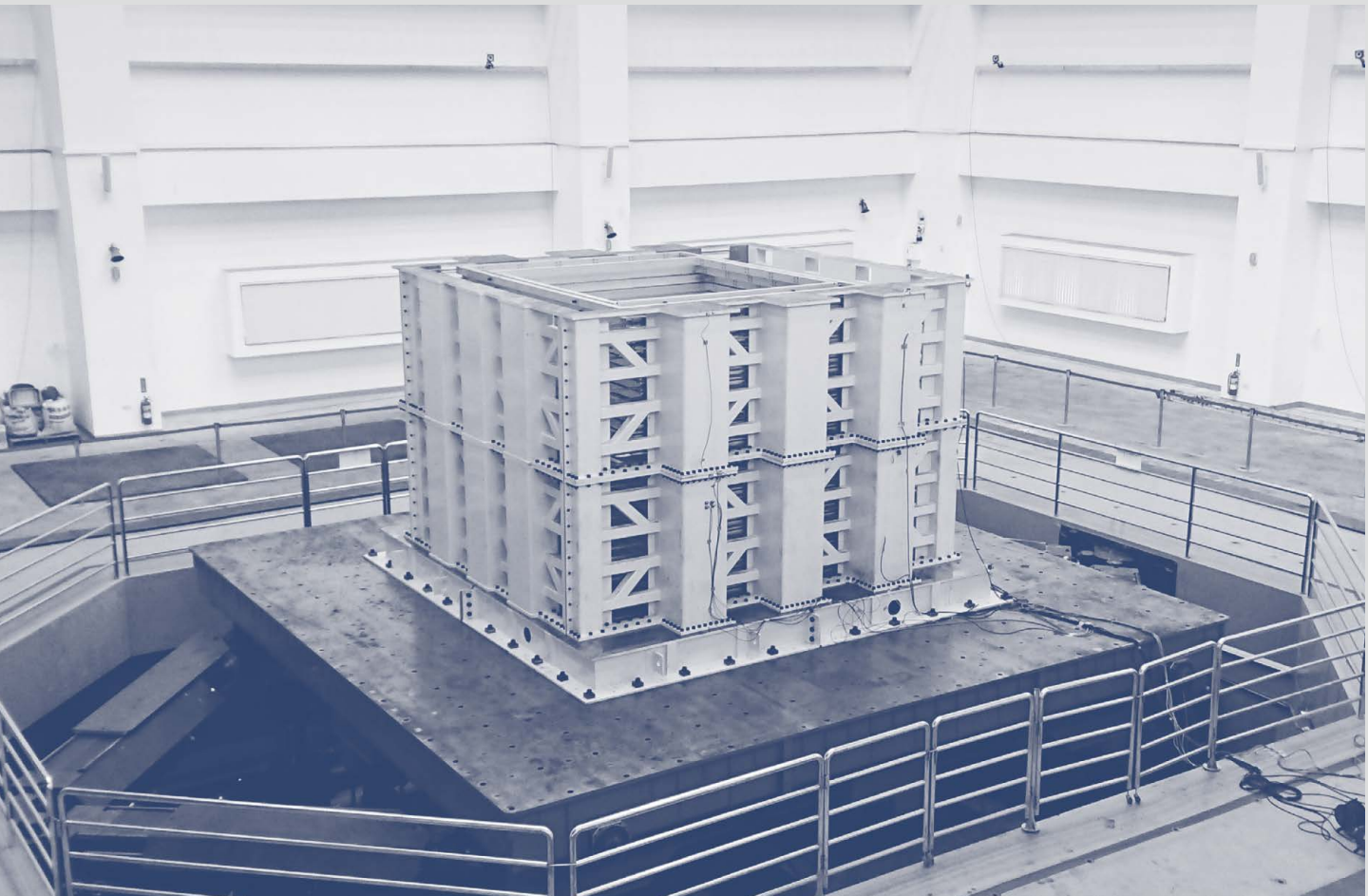
▲ Identified Structural Fundamental Periods in the 2022 Guanshan and Chihshang Earthquakes in Eastern Taiwan



▲ 2022 estimated interstory drift ratio of structures in Guanshan and Chishang

05

DEVELOPMENT PLANS



NCHC

Taiwania 4 and 5 Supercomputers Aim to Upgrade HPC Services

NCHC will build Taiwania 4, a supercomputer with a total computing power of 3.4 petaFLOPS, and combine its high-speed computing system management and application development capabilities to support forward-looking foundational research, break through existing computing scales and limits, and accelerate results to enhance Taiwan's international competitiveness in science and technology. In addition, NCHC is formulating plans for Taiwania 5 and the establishment of a sensitive data environment to meet the needs of data centers for diversified computing and storage of sensitive data for government and other projects.

TSRI

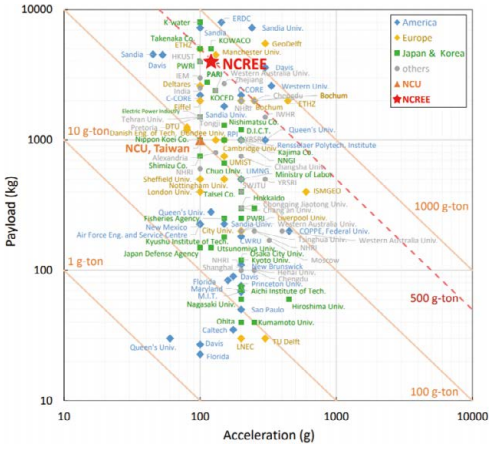
Promoting Taiwan's Quantum Computer Projects

Quantum computing is one of the country's most important technological development focuses. In addition to assisting the national quantum team in the development of quantum computers, TSRI also continues to strengthen related facilities and build up R&D capabilities. Three low-temperature systems with differing functions have been built, and progress has been made in low-temperature transistor modeling and low-temperature circuit design. Circuit blocks such as digital to analog converters (DACs) and 18 GHz mixers that can operate at an ultra-low temperature of 4K and be applied to quantum computer control have been developed. TSRI works closely with national team to provide verification services for the technology. In addition, TSRI develops semiconductor spin qubit technology, aiming to progressively build up even more capabilities to continue to help promote quantum computer technology in Taiwan.

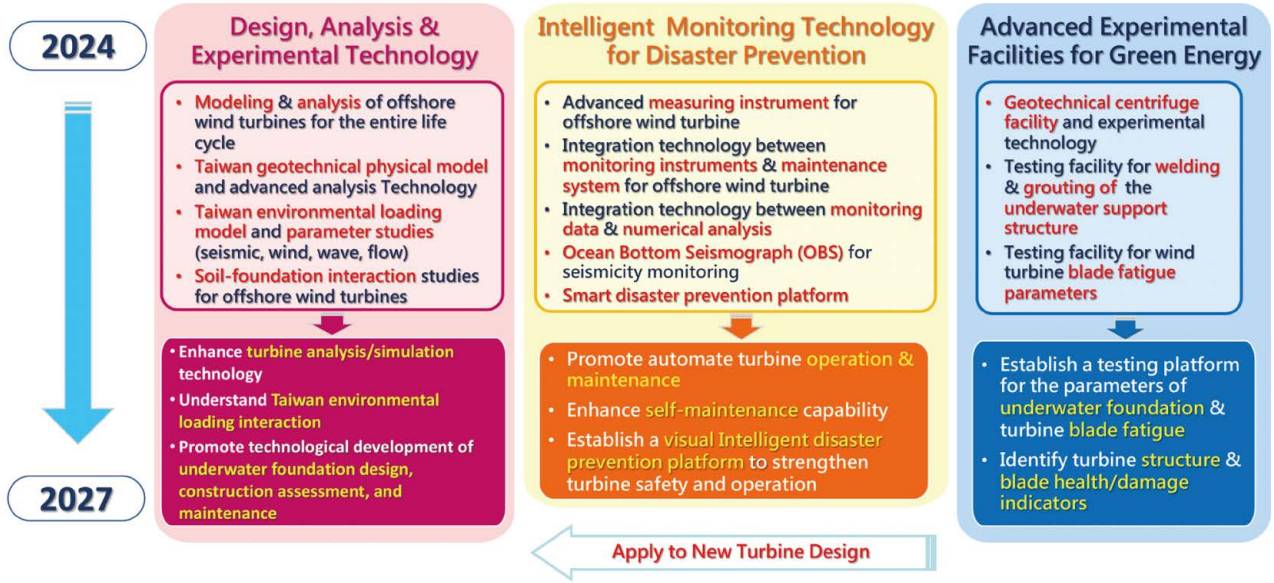
▲ Three cryogenic systems with differing functions installed by TSRI

Intelligent Disaster Prevention Technology for Offshore Wind Turbines

To achieve Taiwan's goal of "2050 Net-Zero Emissions" and implement government policy for renewable energy, NCREE will promote the research and development of intelligent disaster prevention technology for offshore wind turbines. NCREE is also commencing the construction project of the "Green Energy Facilities Testing Laboratory" to provide an essential service platform for academics and research, assist in the crucial technological development of national infrastructure and energy policy, and promote industry-academia cooperation and technological development to achieve energy autonomy and environmental sustainability.



▲ Global centrifuge specifications



▲ Reacher and development of intelligent disaster prevention and monitoring platform for offshore wind turbines

▲ Centrifuge and wind turbine fatigue testing facilities supported at the expert's meeting

NCHC

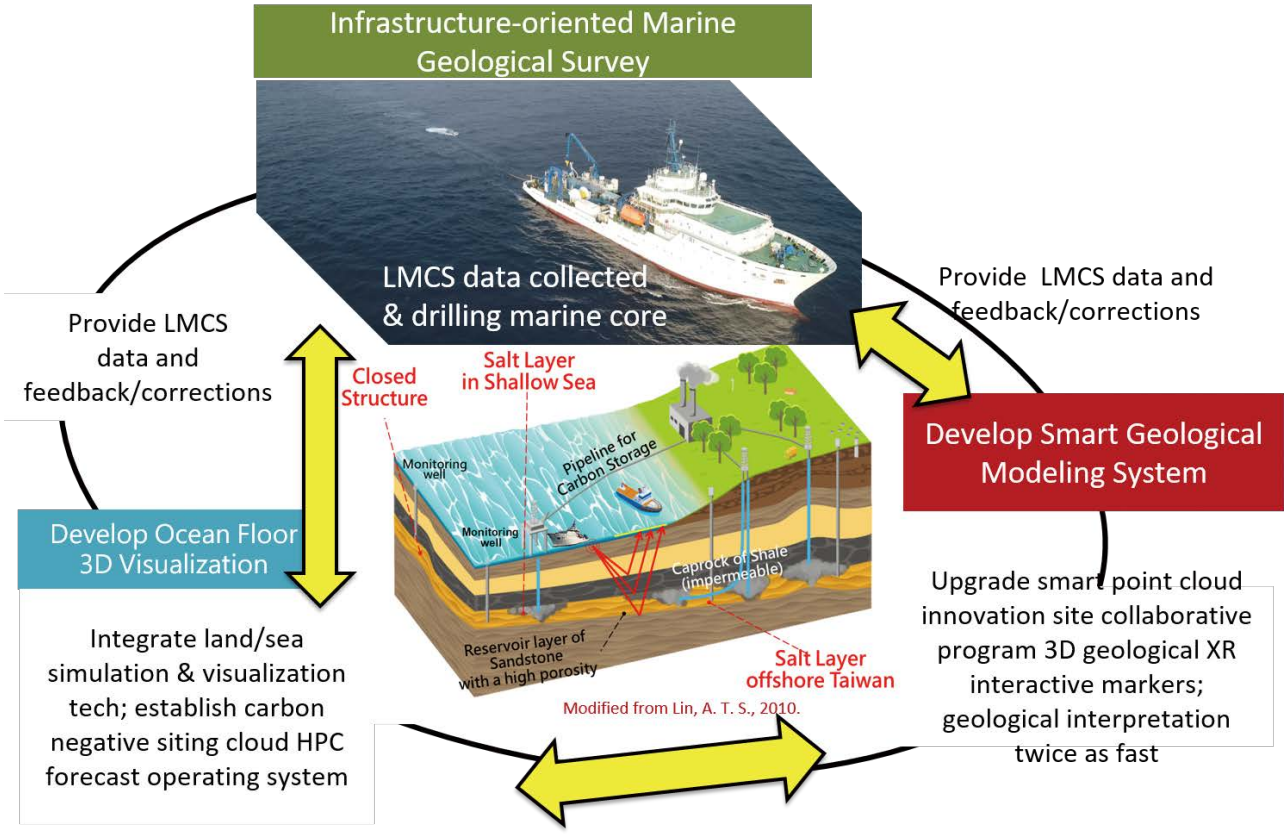
North-South Fiber Optic Network to Perfect Taiwan's Network Infrastructure

NCHC will continue to enhance Formosa Open eXchange operations, upgrade network security and stability, and maintain a network packet round-trip time (RTT) of less than 12 ms and an availability rate higher than 99.92%. The first phase of the new backbone fiber optic network linking the north and the south will be completed in 2023. The second phase will then be carried out to perfect Taiwan's network infrastructure.

TORI

Driving a Net Zero Future

TORI expects to conduct a geological survey of a maritime carbon sequestration potential site in 2024 using its Long-offset Multi-Channel Seismic System. It is hoped that rock core sampling equipment (such as shallow drills) can be used to collect samples in the future to provide seismic stratigraphic images and physical parameters of rock cores, which can be used as a basis for selecting future carbon sequestration sites. TORI has also worked with NCHC to develop a smart geological modeling system and 3D simulated seafloor visualization technology.



▲ Framework of TORI and NCHC's participation in the net-zero carbon emissions program

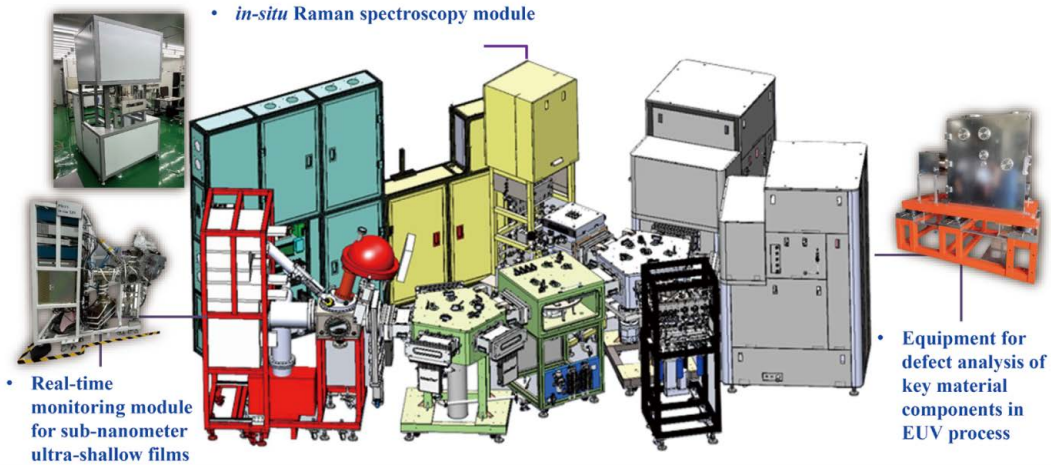
3R Principles in Animal Experimentation

To support innovation in relation to the 3R principles (Replacement, Reduction, and Refinement), NLAC promotes scientific advancement and animal research optimization. NLAC is incorporating alternatives for the animal medication and chemicals safety test. NLAC is facilitating inter-field cooperation to develop organs-on-chips, exploring AI options and aim on using cell/tissue models for experimental animal replacement. Education is also a fundamental mission of NLAC's as to refine professional training, promote humane animal experimentation techniques by implementing the 3R principles.

▲ Promoting organ-on-chip development

Developing Frontier Semiconductor Process Inspection Equipment

TIRI plans to develop a field monitoring and inspection module for cluster equipment, which can be applied to the inspection of advanced 2D semiconductor process materials. The technology can also assist domestic semiconductor wafer manufacturers in establishing standards for the use of extreme ultraviolet light components for domestic semiconductor inspection companies to develop the technology. The cluster semiconductor inspection technology and equipment developed will enable the most accurate surface information to be obtained without sample contact with the air.



▲ On-site inspection equipment for cluster semiconductor process technology

COLLABORATION CONNECTING INDUSTRY, ACADEMIA, & RESEARCH

Developing Robotic Surgery for Lung Cancer

NLAC provides professional anesthesia service and perioperative monitoring to large experimental animals. With imaging assistance from TIRI, NLAC supported a research team from Brain Navi Biotechnology Co., Ltd. in the development of a robotic system for biopsy and surgery of lung cancer in preclinical animal model. Combining a respiratory rate warning system with dynamic, real-time lung tumor detection and a real-time correction mechanism for intraoperative needle location and angle, researchers have developed a method to accurately puncture lung cancer lesions during surgery, thus aiding in early treatment.

▼ Verifying location of patient's thoracic cavity by CT imaging

▲ Robots guide doctors to remove lesions

▲ Creation of lesion sites with contrast medium

NCHC

LIONS Supports Research on Molecular Mechanisms of Oncogenes in Neuroblastoma

Using NCHC's LIONS cloud platform, National Taiwan University Hospital, in collaboration with a team from National Yang Ming Chiao Tung University and National Taiwan University, conducted research on the molecular mechanisms of the oncogene SNHG1 in neuroblastoma. Through gene sequencing data analysis, the team demonstrated that the SNHG1 gene manipulates properties of neuroblastoma through chromatin regulation. Their results were published in the prominent journal *Cell Death and Disease*.

NSPO

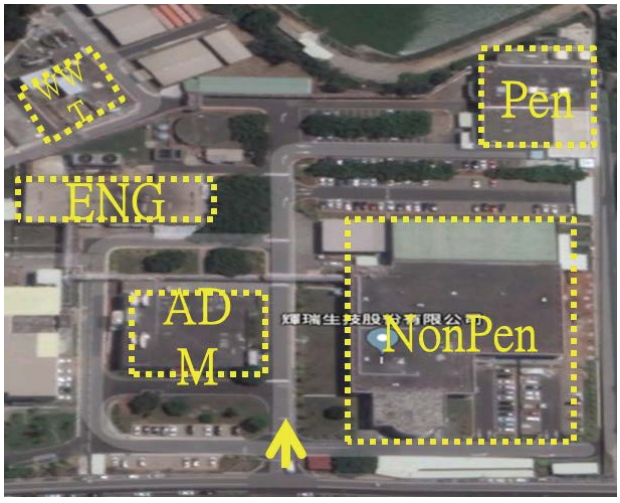
NSPO and CPC Sign Memorandum of Cooperation on Space-grade Composite Component R&D

NSPO and CPC Corporation joined hands in R&D planning for space-grade composite material products, combining their strengths in developing carbon fiber composite materials. On July 8, an optical payload composite cylinder and high-pressure fuel tank/valve pipe coating technology were delivered to NSPO at the CPC Building in Taipei. Both parties also signed a memorandum of cooperation with the Metal Industries Research and Development Centre in Kaohsiung, demonstrating their determination to jointly promote the satellite industry and enhance Taiwan's technological capabilities.

TIRI

Environmental Monitoring Facilities for GSK Pharmaceuticals

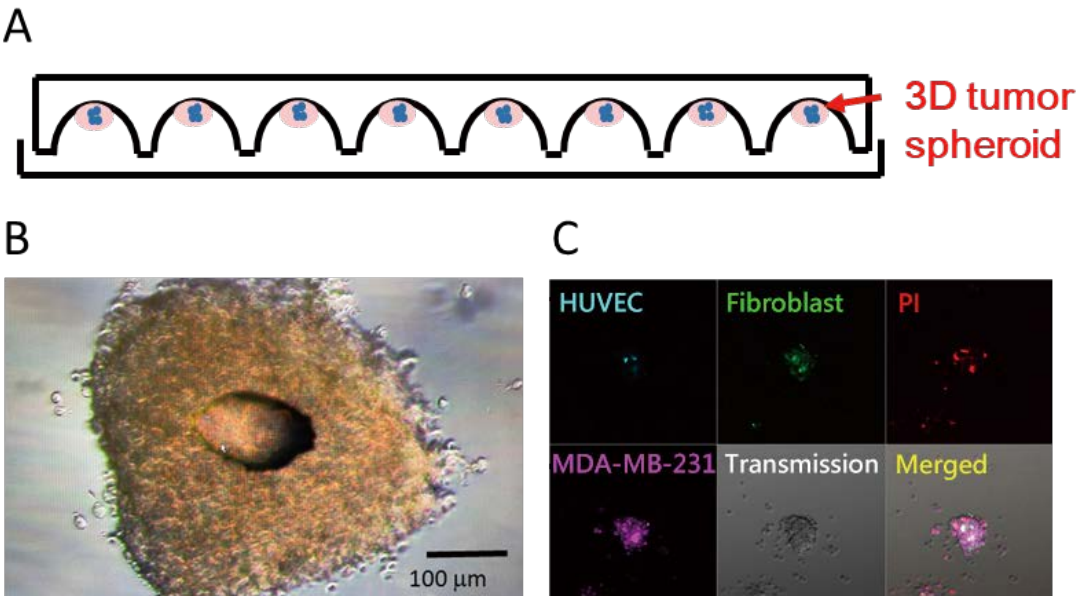
TIRI has been working with Professor Meng-Shiun Tsai of the Department of Mechanical Engineering at National Taiwan University to develop statistical and machine learning methods for big data analysis and extend the results to the industrial sector. It has also used industrial IoT-related technologies to assist GlaxoSmithKline Pharmaceuticals in establishing environmental monitoring facilities in its plants, to help collect, integrate, and visually present data, and to ensure data transmission safety during the integration process. In this way, TIRI has assisted in the creation of the company's digital corporate image and enhanced its competitiveness.



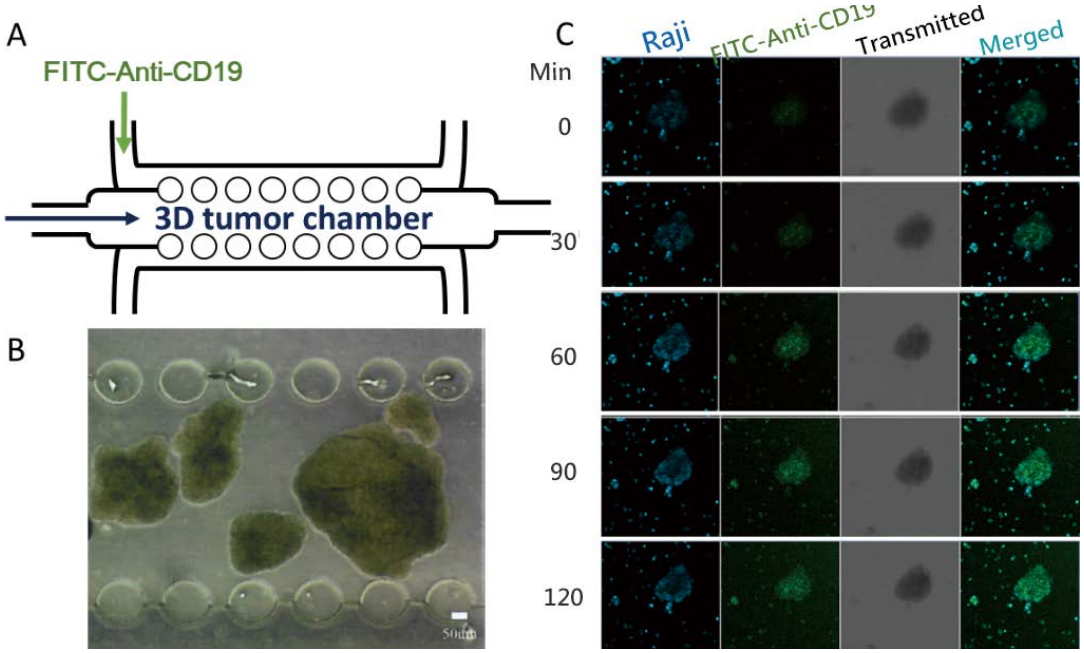
▲ Assisting GSK Pharmaceuticals set up environmental monitoring facilities

Tumor-on-Chip Development

Due to the high diversity of tumors, finding a single standard therapeutic strategy is never easy. Therefore, development of precision treatment based on specific tumor characteristics is the key to improve the success of tumor therapy. NLAC has established a 3D tumor cell culture method and collaborated with the Institute of Applied Mechanics at National Taiwan University to develop a tumor-on-chip platform. This preclinical in vitro testing platform will lead to the establishment of an in vitro high throughput testing platform for tumor avatars.



▲ Spheroid culture cell hanging drop culture



▲ Tumor-on-chip for testing antibody infiltration

07

FOSTERING OF SCIENTIFIC AND TECHNOLOGICAL TALENT

TSRI

Cultivating Professionals for Crucial Semiconductor Industry

TSRI has set up an integrated, interdisciplinary semiconductor R&D and manufacturing service platform. The platform provides both professors and students with practical training courses and software and hardware equipment needed for undertaking cutting-edge research and testing within various academic fields. By launching the Joint Developed Project (JDP), TSRI integrates higher education institutions and industry manufacturers to cultivate high-quality talent necessary for the industry. The JDP builds ties between semiconductor professionals and every sector of this highly crucial field, from manufacturing, design, and packaging to software and hardware verification, training 2,000 individuals per year and introducing a growing number of master's and doctoral graduates with a background in science and engineering into the semiconductor industry to help fill important positions that are currently in high demand.

▲ Clean room training

NLAC

Reengineering Approaches to Animal Experiments with the 3R Principles

NLAC has created an educational ecosystem for laboratory animal science. The Center provides specialized courses for caretakers, technicians, researchers, and facility managers to ensure humane practices in practical applications. NLAC also offers foundational courses that bridge theory and practice for students in biology-related graduate programs. The Center also provides on-the-job training, clinician instruction, and winter and summer internships for college students. The concept of the 3Rs (Replacement, Reduction, and Refinement) is introduced to the general public through popular science activities.

▲ Instruction on experimental mouse handling technique

Students' Award-winning Motor Carried on SpaceX Rocket for Space Evaluation

Established in 2009 by TIRI to cultivate new young inventors for the island's thriving tech industry, the NARLabs Instrument Technology Innovation Competition (*i*-ONE) has been the source of many interesting self-made devices. Among them are the proud winners of the ninth season of *i*-ONE's secondary school grouping and their engineering masterpiece, called the "Spherical Induction Motor," which was then commercialized and even led the students to found their own tech company. This year, the Spherical Induction Motor was carried on a SpaceX rocket for further in-space evaluation, demonstrating the effectiveness of the competition's goal of cultivating leading talent in instrument technology. Additionally, it also received special sponsorship from KYMCO, Taiwan's leading manufacturer of vehicular motor technology, when its electric scooter, also named "i-One," won an award as well.

▼ 14th *i*-ONE competition Kymco special award

▲ 14th *i*-ONE competition cultivates new generation of instrumentation talent

Youth Space Industry Training Program

Space is a massive industry filled with opportunity, and NSPO has coordinated with National Central University and Wenzao Ursuline University of Languages to arrange a series of training courses aimed at getting talented individuals between the ages of 18 to 35 acquainted with the proper channels that can help launch their space careers. As a result of this ambitious program, four female trainees stood out for their outstanding performance and traveled with NSPO to participate in the 28th session of the Asia-Pacific Regional Space Agency Forum (APRSAF-28), held in Hanoi, Vietnam, in November.

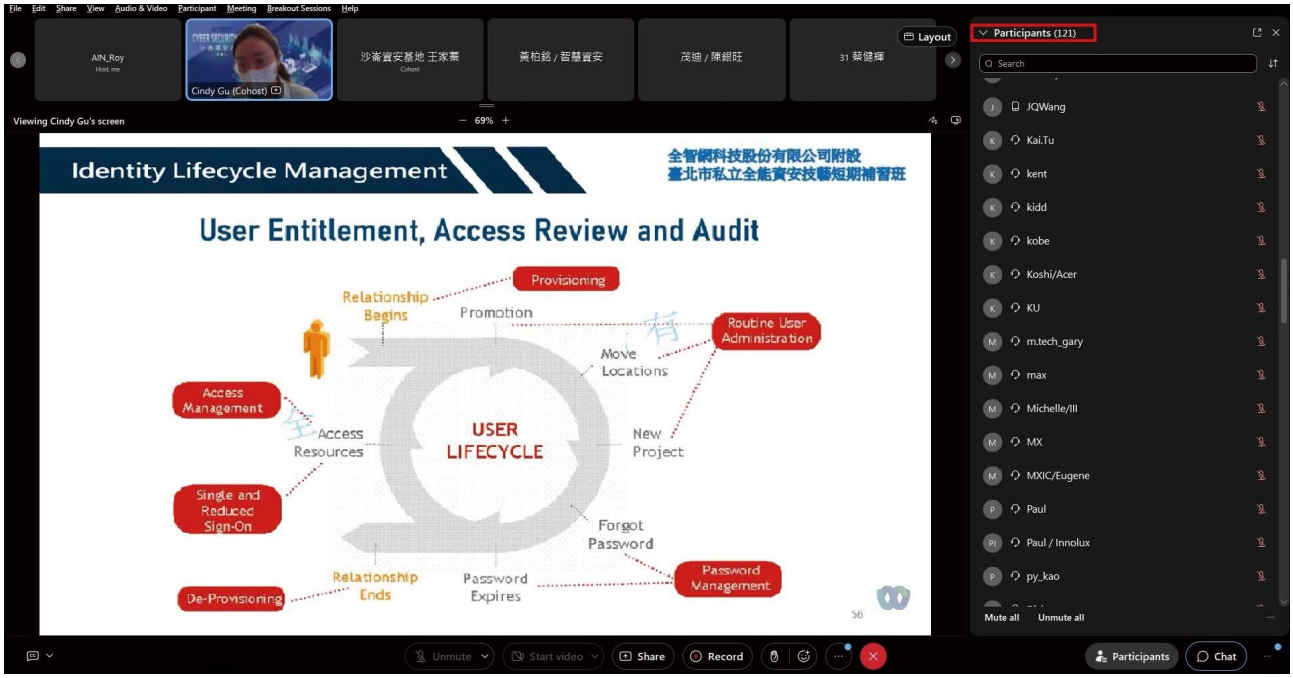
▼ Space affairs youth training program participants

▲ Space affairs youth training program selects four to participate in APRSAF Annual Meeting

Shalun Science City Offers Training Courses in Cyber Security

To promote national cyber security awareness and reduce similar risks faced by enterprises, the Shalun Smart Green Energy Science City's cyber security base regularly launches well-rounded training courses on the topic. With the support of the Cyber Security Innovation Habitat Project, participants of these courses are currently fully subsidized and the courses are conducted online and in person, providing the benefits of both long-distance and hands-on learning. In 2022 alone, 20 comprehensive courses were launched, which trained 2,663 individuals. Shalun's cyber security base will continue to train all interested participants from Taiwan's industry, university, and research sectors to strengthen protection for businesses and the general populace.

▼ Cybersecurity base personnel training



▲ Cybersecurity training course information

STPI

STPI & NSTC Promote Local and Global Entrepreneurial Ecosystems

To assist Taiwan's government in fomenting ecosystems ripe for scientific research and innovation, STPI has worked with NSTC in recent years to implement relevant programs that select and train research and entrepreneurial teams to successfully establish companies. The two entities have further assisted these pioneering teams in acquiring international funding to begin actively participating in the global entrepreneurial ecosystem and building an international brand. In 2022, STPI supported several Taiwanese startup teams participating in exhibitions in Europe, North America, and other locations. Their research achievements have been recognized and celebrated by the international startup community. As it keeps tabs on the needs of Taiwan's startup teams, STPI will continue to gather resources essential to domestic innovation and entrepreneurship, which will then empower these groups' capabilities and assist them in creating market value.

▲ Presentation on international fundraising by Taiwanese research startup team at London Tech Week

NCHC

1st HiPAC Fosters Innovative Applications in High-speed Computing

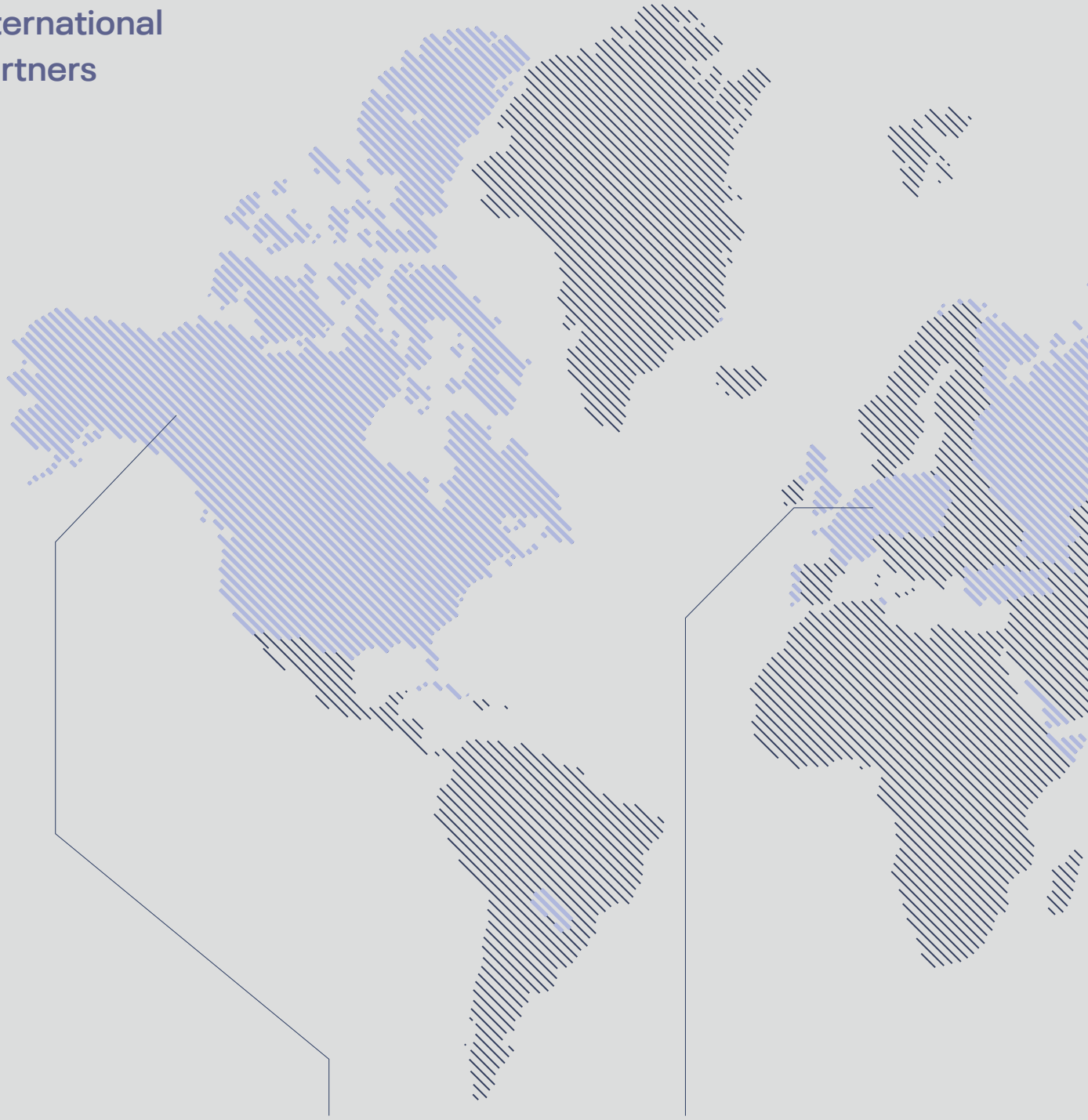
NCHC has long promoted the cultivation of talent in the field of high-speed computing in Taiwan. With this mission in mind, NCHC held its first "High-Performance Application Competition" (HiPAC) to provide robust resources and support through its Taiwania supercomputer system, encourage students to try various acceleration and parallel processing technologies, and combine innovative applications to drive Taiwan's outstanding progress in high-speed computing. NCHC also offered resources and educational training to students from National Tsing Hua University, who in 2022 proudly represented Taiwan as they won a hard-fought championship at the Student Cluster Competition (SCC), the largest international supercomputer competition in the world.

▲ Director-General Chao-Lyan Chang of NCHC and SCC champion team from NTHU in the U.S. at display booth

08

INTERNATIONAL COLLABORATION

International Partners



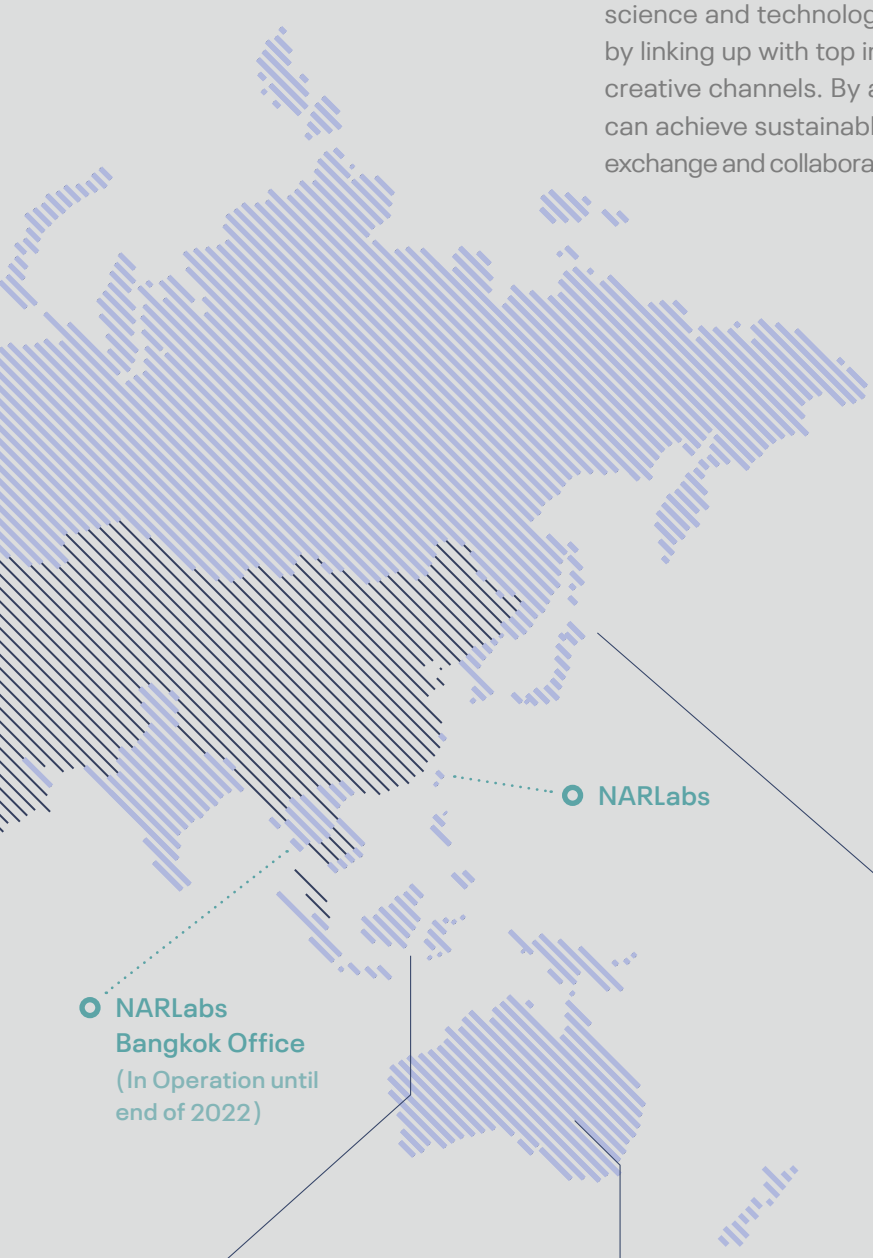
AMERICA

Semiconductors,
Medical Technology,
Smart Cities,
Disaster Prevention Technology,
Ocean Exploration

EUROPE

Semiconductors,
Medical Technology,
Ocean Exploration,
Space Industry

With the vision of "Global Excellence, Local Impact," NARLabs is committed to promoting the development of frontier technologies and nurturing science and technology professionals with international perspectives by linking up with top international institutions through a wide range of creative channels. By adopting a people-focused approach, NARLabs can achieve sustainable global development, and utilize technological exchange and collaboration to tackle emerging issues and challenges.



SOUTHEAST ASIA

Disaster Prevention Technology,
Biomedical Technology,
Semiconductors

OCEANIA

Information & Communication Technology,
Earth Observation,
Semiconductors

NORTHEAST ASIA

Artificial Intelligence,
Technology Policies,
Ocean Exploration,
Disaster Prevention Technology,
Semiconductors

AMERICA

Semiconductors, Medical Technology, Smart Cities,
Disaster Prevention Technology, Ocean Exploration

UNITED STATES

- Argonne National Laboratory
- ASME, American Society of Mechanical Engineers
- Duke University
- George Mason University
- iCAIR, International Center for Advanced Internet Research, Northwestern University
- IEEE Instrumentation and Measurement Society
- IMPC, International Mouse Phenotyping Consortium
- MIT, Massachusetts Institute of Technology
- MTS Systems Cooperation
- NCSA, National Center for Supercomputing Applications
- NIH, National Institutes of Health
- NSF, National Sanitation Foundation
- Stanford University
- SEM, Society for Experimental Mechanics
- PRAGMA, Pacific Rim Application and Grid Middleware Assembly
- UCB, University of California, Berkley
- UCF, University of Central Florida
- UCSD, University of California, San Diego
- University of Hawaii System
- University of Houston
- UM, University of Michigan
- UTA, University of Texas at Arlington
- UW, University of Washington
- WHOI, Woods Hole Oceanographic Institution

CANADA

- NRC, National Research Council Canada
- UBC, University of British Columbia
- University of Toronto
- WATERLOO.AI, Waterloo Artificial Intelligence Institute

PARAGUAY

- NEMO, National Emergency Management Organization

EUROPE

Semiconductors, Medical Technology, Ocean Exploration, Space Industry

AUSTRIA

- AIT, Austrian Institute of Technology

BELGIUM

- imec, Interuniversity Microelectronics Centre

CZECH REPUBLIC

- CAS, Czech Academy of Sciences
- Charles University
- Czech Technical University

FRANCE

- CEA, Commissariat A L'energie Atomique Et Aux
- Energies Alternative
- CNES, National Centre for Space Studies
- Ifremer, National Institute for Ocean Science R/V *Marion Dufresne*
- Inserm, National Institute for Health and Medical Research
- OECD, Organization for Economic Cooperation and Development

GERMANY

- GEOMAR, Helmholtz Centre for Ocean Research Kiel; R/V *Sonne*
- HLRS, High-Performance Computing Center Stuttgart
- MARUM, Zentrum für Marine Umweltwissenschaften
- Max Planck Institute for Security and Privacy, Germany

HUNGARY

- ZalaZONE Automative Proving Ground

LITHUANIA

- NanoAvionics

PORTUGAL

- INESC TEC, Institute for Systems and Computer Engineering, Technology and Science

RUSSIA

- International Academy of Engineering

TURKEY

- TÜBİTAK, Scientific and Technological Research Council of Turkey

UK

- MRC, Medical Research Council
- Clarivate Analytics

SWITZERLAND

- CERN, the European Organization for Nuclear Research

POLAND

- Wrocław University of Environmental and Life Sciences

SLOVAKIA

- Slovak Investment and Trade Development Agency

NETHERLANDS

- Economic Board Utrecht

ASIA & PACIFIC

NORTHEAST ASIA

Artificial Intelligence, Technology Policies, Ocean Exploration, Disaster Prevention Technology, Semiconductors

JAPAN

- AIST, National Institute of Advanced Industrial Science and Technology
- CIEA, Central Institute for Experimental Animals
- JAEE, Japan Association for Earthquake Engineering
- JAXA, Japan Aerospace Exploration Agency
- JAMSTEC, Japan Agency for Marine-Earth Science and Technology
- JST, Japan Science and Technology Agency
- Kumamoto University
- Kyoto University
- Kyushu University
- Nagoya University
- NICT, National Institute of Information and Communications Technology
- NIED, National Research Institute for Earth Science and Disaster Prevention
- RIKEN, Institute of Physical and Chemical Research
- Tohoku University
- Tokyo Institute of Technology
- University of Tokyo

KOREA

- KISTEP, Korea Institute of S&T Evaluation and Planning
- KISTI, Korea Institute of Science and Technology Information
- NST, National Research Council of Science and Technology
- sesteC, Seismic Simulation Test Center
- STEPI, Science and Technology Policy Institute

OCEANIA

Information & Communication Technology, Earth Observation, Semiconductors

AUSTRALIA

- ANFF, Australian National Fabrication Facility
- ANU, Australian National University
- CSIRO, Commonwealth Scientific and Industrial Research Organization
- University of Technology Sydney

NEW ZEALAND

- QuakeCoRE, The NZ Centre for Earthquake Resilience

SOUTHEAST ASIA

Disaster Prevention Technology, Biomedical Technology, Semiconductors

INDIA

- IIT, Indian Institute of Technology, Roorkee
- IITG, Indian Institute of Technology Guwahati
- ISR, Institute of Seismological Research

INDONESIA

- Institut Teknologi Bandung

PHILIPPINES

- De La Salle University
- DOST, Department of Science and Technology
- University of the Philippines

SINGAPORE

- NAMIC, National Additive Manufacturing Innovation Cluster

THAILAND

- AIT, Asian Institute of Technology
- EECi, Eastern Economic Corridor of Innovation
- GISTDA, Geo-Informatics and Space Technology Development Agency
- KUMTT, King Mongkut's University of Technology Thonburi
- NARLabs Bangkok Office
- NSTDA, National Science and Technology Development Agency
- Thai-BISPA, Thai Business Incubators and Science Parks Association
- Thammasat University

VIETNAM

- MONRE, Ministry of Natural Resources and Environment
- VNU, Vietnam National University, Hanoi

NCREE

The Shaking Table Test on Three-Story Steel Frame

NCREE has cooperated with four universities, including the University of California at San Diego (UCSD), the University of Texas at Arlington (UTA), the National Taiwan University (NTU), and the National Cheng Kung University (NCKU). The research object was a three-story buckling-restrained brace frame, and the energy-dissipating sliding floor was adopted to carry out the shaking table test for the very first time in Taiwan to compare the results of this new type of energy-dissipating sliding floor with the results of the seismic performance of the traditional fixed floor frame.

▲ International cooperation unit for the shaking table test on three-story steel frame

NARLabs

NARLabs and NSTC Visit European Research Institutes, Expand Bilateral Cooperation

From Nov. 15 to 25, a NARLabs delegation travelled to France and Germany to deepen scientific cooperation and exchanges between Taiwan and key European countries. In addition, in order to further promote cooperation in AI, quantum technology, hydrogen energy development, and other forward-looking fields, NARLabs President Faa-Jeng Lin led members of TSRI, NCHC, and the NARLabs International Affairs Office to visit the University of Paris-Saclay, the French Academy of Sciences, and the French Alternative Energies and Atomic Energy Commission (CEA). There, they discussed opportunities to work together in frontier research projects, particularly hydrogen energy development, which will help Taiwan achieve its goal of net-zero emissions in the future.

▲ NARLabs visits Chemistry Research Institute of French Academy of Sciences in Paris

▲ NARLabs visits University of Paris-Saclay

TIRI

Hyperspectral Microscopic Imaging Tech Developed with imec Wins Metrology R&D Innovation Award

TIRI developed a hyperspectral microscopic image analyzer and a hyperspectral microscopic image calibration method in collaboration with the Interuniversity Microelectronics Centre (imec) of Belgium and National Yang Ming Chiao Tung University. Their technology won the 17th Metrology R&D Innovation Award.

▲ Hyperspectral microscopic image analyzer

NCHC

Training Gen3 Data Platform Task Force with NIH

NCHC has been implementing the Big Data Health Sustainability Platform and held exchanges with the National Institutes of Health (NIH), sending staff to the U.S. to train the Gen3 data platform team. There, they mastered the technical details of system architecture, functional maintenance, software and hardware interfaces, system integration, account management, and development of new functions to help build a high-quality environment for biomedical data analysis. In addition, NCHC established follow-up collaboration plans with NIH to ensure the long-term operation and service quality of the platform.

NLAC

NLAC Signs MOU with Kumamoto University Research Unit

NLAC signed a memorandum of understanding (MOU) with the Institute of Resource Development and Analysis (IRDA) at Kumamoto University to promote cooperation in fields of mutual interest including technology development, R&D, information exchange, and personnel training in laboratory animal science.

TORI

TORI and IIT Guwahati Sign Memorandum of Cooperation

TORI signed a memorandum of cooperation with the Centre for Intelligent Cyber-Physical Systems at the Indian Institute of Technology Guwahati, establishing a bridge for cooperation between Taiwan and India by facilitating staff visits and co-organizing seminars.

09

SOCIAL ENGAGEMENT

NARLabs

“Next, AI” Returns to the Golden Bell Awards

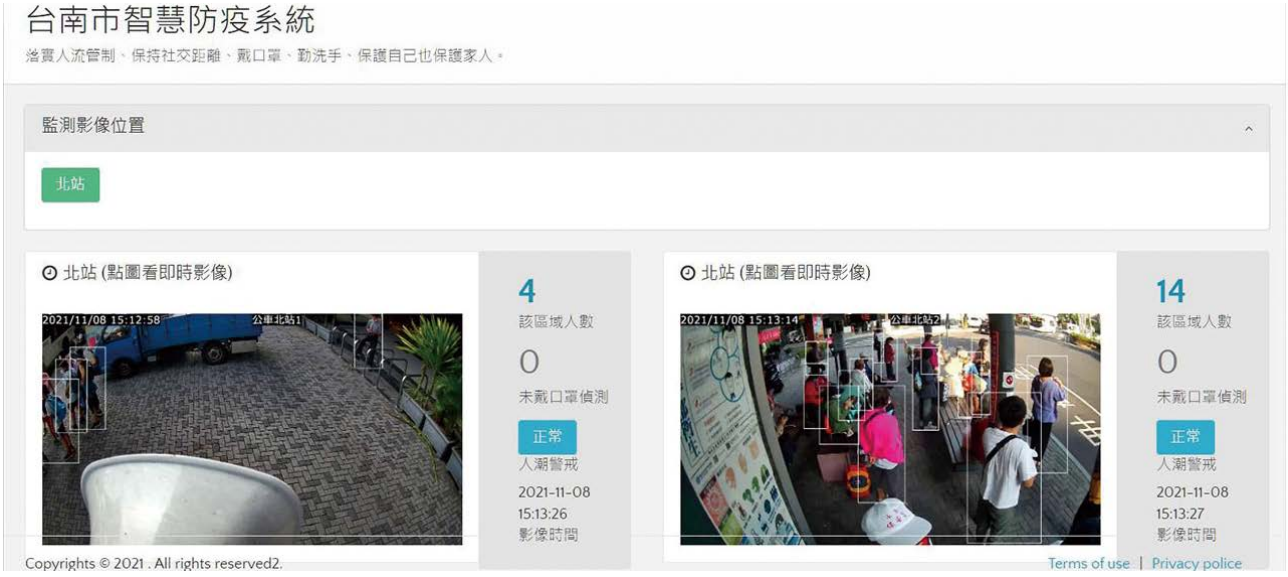
The popular science series "Next, AI" was shortlisted for the 57th TV Golden Bell Awards for Best Natural Science Documentary Show, Best Directing for a Television Show, and Best Art and Design for a Television Show. The series was honored with the Golden Bell Award for Best Natural Science Documentary Show, the second Golden Bell award won by a film jointly produced by NARLabs and Dong Tai Communication. The 150-minute film is divided into three heartfelt episodes, surrounding a love story that touches on eighteen aspects currently ongoing in AI research, from the initial research of AI, its recent explosion in real-world applications, and finally, the exploration of whether machines can possess the human gift of self-awareness. This work perfectly combines the field of popular science with cinematographic drama.

▲ Representatives from winning team receive award onstage

NCHC

AIoT Breakthrough Improves Video Recognition Accuracy, Expands Local Application

NCHC has developed an advanced AIoT image analysis tool that continues to be used in smart epidemic prevention and public safety management. The technology has improved the image recognition of non-mask-wearing individuals and crowd flows to a 95% accuracy rate and has expanded its capabilities to certain abnormal behaviors such as falls, climbing, and physical attacks. In 2022, this development will continue to be applied to Tainan's traditional markets, night markets, and bus stations in cooperation with local government authorities. The venue will be expanded from 24 to 80 locations, using innovative technology to improve epidemic prevention and optimize public services.



▲ Introducing video image analysis technology into traditional markets to optimize public services

NCREE

NCREE participates in 2022 National Defense Mobilization and Disaster Prevention and Rescue Drill

NCREE led teams from the 5D Smart City Disaster Prevention and Relief Platform, the Earthquake Early Warning System (EEWS), the Taiwan Earthquake Loss Estimation System (TELES), and others to participate in the 2022 National Defense Mobilization and Disaster Prevention and Rescue (Min'an No. 8) Drill. The experience provided an opportunity to implement the Center's significant research achievements as NCREE assisted the cities of Kaohsiung and New Taipei in improving their emergency and rescue response capabilities with smart disaster prevention technologies.

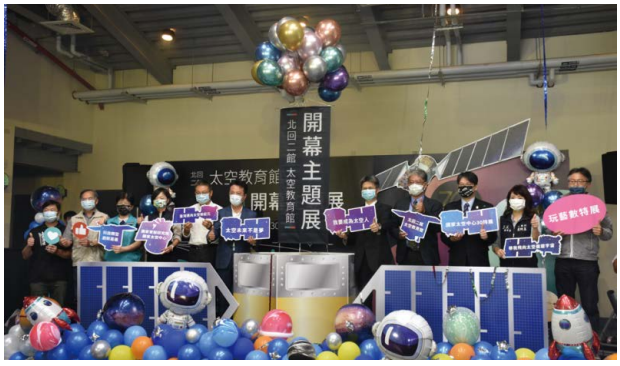
▲ NCREE participates in Kaohsiung City 2022 National Defense Mobilization and Disaster Prevention and Rescue (Min'an No. 8) Drill

▲ NCREE participates in New Taipei City National Defense Mobilization and Disaster Prevention and Rescue Drill

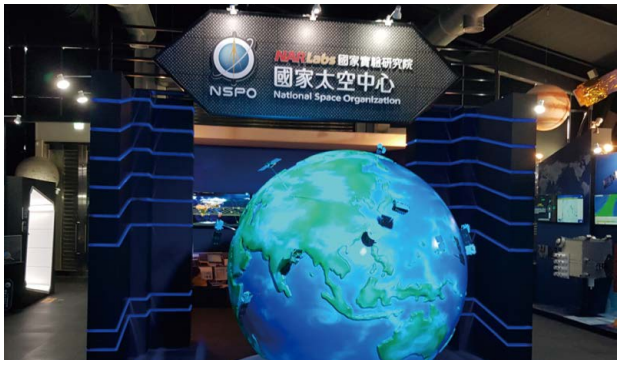
NSPO

NSPO 30th Anniversary Exhibition

NSPO has held a special exhibition commemorating its 30th anniversary, turning Beihui Hall in Chiayi County into a veritable space education museum, which opened on May 6. The exhibit showcased several institutional achievements, including the impressive strides made in Taiwan's space industry, the past achievements and current mission status of NSPO's FORMOSAT satellite project, the wondrous intricacies of the satellites' ground control systems, as well as activities based on current space-related themes. Aimed at sparking young students' senses and their curiosity for the universe beyond our atmosphere, the exhibition consisted of visual displays of our galactic neighborhood, a timeline of the space industry's continual progress into the unknown, and models inspired by FORMOSAT satellite stations.



▲ NSPO 30th Anniversary Special Exhibition opens



▲ NSPO 30th Anniversary Special Exhibition

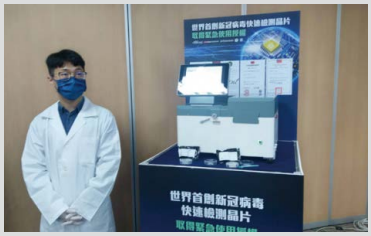
MILESTONES

01

01.20

The Space Development Act and its four sets of related regulations formally take effect.

01.25



TIRI develops the world's first COVID-19 rapid test chip in collaboration with Molsentech, Academia Sinica, and Kao-hsiung Veterans General Hospital.

03.14

TORI signs a memorandum of cooperation with the Centre for Intelligent Cyber-Physical Systems at the Indian Institute of Technology Guwahati.

03.31

TORI signs a cooperation arrangement with the Marine National Park Headquarters and National Sun Yat-sen University's Frontier Center for Ocean Science and Technology.

04.01

Dr. Chau-Lyan Chang, a senior research scientist from NASA, becomes Director-General of NCHC.

04.25

TSRI and National Taiwan University inaugurate the NARLabs-TSRI Chip Design Laboratory.

06

06.01

Dr. Faa-Jeng Lin, Chair Professor of Electrical Engineering and Dean of the College of Electrical Engineering & Computer Science at National Central University, becomes President of NARLabs.

06.24

STPI holds the first-round 2022 FITI x CIOT competition finals and awards ceremony.

JAN. MAR. & APR. JUN.

07

07.07

NCHC joins the Blockchain-applied Judicial Alliance for Digital Era (b-JADE), and a national-level blockchain platform takes shape.

07.10

The first rocket is launched from NSPO's short-term launch site in Xuhai Village, Pingtung.

07.13

NCHC holds the High Performance Application Competition (HiPAC) to foster high-speed computing talent.

JUL.

08.10

TIRI signs a memorandum of cooperation with the National Cheng Kung University Innovation Headquarters to promote added value in R&D technology and accelerate startup activity in the academic sector.

08.25

FORMOSAT-5 celebrates its 5th anniversary of launch.

AUG.

09

09.08

TORI and NLAC establish a joint laboratory, TOTI Focus, in the National Biotechnology Research Park for the TORI Focus Photomicrography system.

09.30

NLAC signs a memorandum of cooperation with the Institute of Resource Development and Analysis, a research unit under Kumamoto University.

SEP.

10

10.08

R/V *LEGEND* completes Pacific Ocean cruise LGD2212.

10.01

The updated version of the "Seismic Design Provisions and Commentary of Buildings" revised by the Construction and Planning Agency of the Ministry of the Interior with the assistance of the Central Weather Bureau officially takes effect.

10.03

Dr. Tuo-Hung (Alex) Hou, Chair Professor of the Institute of Electronics at National Yang Ming Chiao Tung University, becomes Director-General of TSRI.

10.21

The science drama series "Next, AI," produced by NARLabs and Dong Tai Communication and subsidized by NSTC, wins Best Natural Science Documentary Show at the 57th Golden Bell Awards.

10.28

STPI signs Taiwan's first allied open access contract with Elsevier, the world's largest academic publisher.

OCT.

12

12.16

STPI holds the annual "Win the PRIDE: Tell a Story with Indicators" competition and announces the list of winners.

12.27

NCREE Joint Appointment Research Fellow Cheng-Horng Lin leads a team from Taiwan Volcano Observatory-Tatun in the project "Verifying Taiwan's Active Volcanoes and Establishing the Taiwan Volcano Observatory-Tatun," winning them the 2022 Executive Yuan Award for Outstanding Science and Technology Contribution.

DEC.

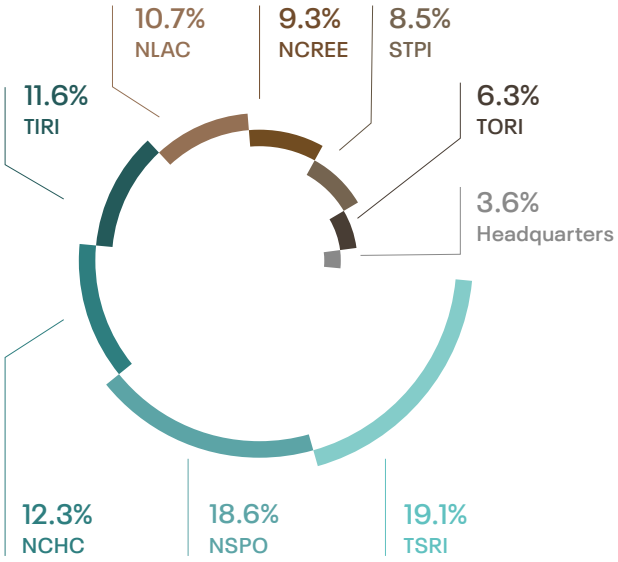
ANNUAL PROFILE

Human Resources

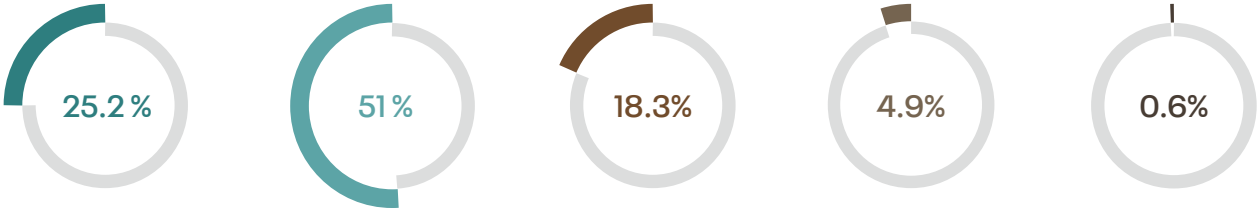
1,419 Employees

Number of Employees in Laboratories

Headquarters	51 People
TORI	89 People
STPI	121 People
NCREE	132 People
NLAC	151 People
TIRI	165 People
NCHC	175 People
NSPO	264 People
TSRI	271 People



Education Level



Doctoral Degree	Master's Degree	Bachelor's Degree	Associate's Degree	Others
(357 People)	(724 People)	(260 People)	(69 People)	(9 People)

Human Resources Profile

40.2%	21.8%	22%	16%
Researchers	Engineers	Technicians	Administrators
(570 People)	(309 People)	(313 People)	(227 People)

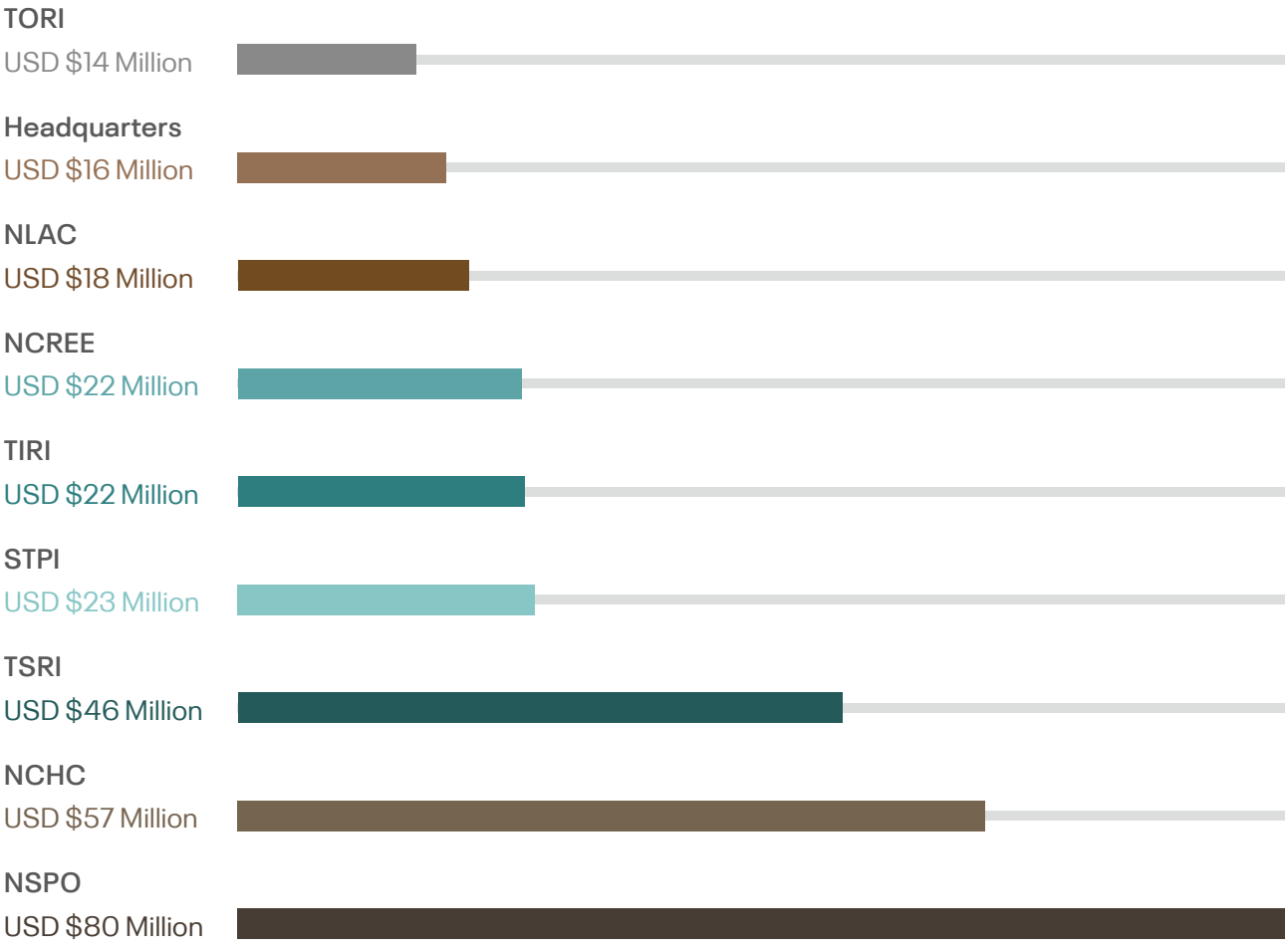
Financial Information

75% Grants

16% Funds Raised from Government Agencies

9% Funds Raised from the Private Sector

Revenue (FY 2022) (Rate: 1 USD = 27.73 NTD)



Locations

Headquarters

TAIPEI

NARLabs Headquarters

National Laboratory Animal Center

National Center for Research on Earthquake Engineering

Science & Technology Policy Research and Information Center

KAOHSIUNG

Taiwan Ocean Research Institute

HSINCHU

National Space Organization

National Center for High-performance Computing

Taiwan Semiconductor Research Institute

Taiwan Instrument Research Institute

Branches

HSINCHU

National Laboratory Animal Center

TAICHUNG

National Center for High-performance Computing

TAINAN

National Laboratory Animal Center

National Center for Research on Earthquake Engineering

National Center for High-performance Computing

Taiwan Semiconductor Research Institute

Organization

Board of Directors & Supervisors

Chairperson	Tsung-Tsong Wu
Managing Directors	Hong Hocheng, Dar-Bin Shieh, Huey-Jen Su
Directors	Yi-Chun Wu, Yi-Bing Lin, Mei-Yin Chou, Chien-Huang Lin, Jing-yang Jou, Yuan-Chen Sun, Charles Hsu, Kuo-Fong Ma, Pei-Ling Liu
Supervisors	Cheng-Chih Wu, Chan-Jane Lin, Yu-Yen Liao
Auditing Office / Director	Tai-Hsiang Wang

President's Office

President	Faa-Jeng Lin
Vice President	Bou-Wen Lin
Chief Operating Officer	Yu-Hsueh Hsu

Headquarters / Directors

Strategy & Planning Office	Hsiang-Yu Bau
Operation & Promotion Office	Lung-Yao Chang
International Affairs Office	Mei-Yu Chang
Administration Office	Ching-Yin Wang
Finance & Accounting Office	Shu-Chen Lin
Human Resources Office	Chi-Nung Yin
Information Technology Service Office	Jyun-Hwei Tsai

Laboratories / Director Generals

National Laboratory Animal Center (NLAC)	Hsian-Jean Chin
National Center for Research on Earthquake Engineering (NCREE)	Chung-Che Chou
National Space Organization (NSPO)	Jong-Shinn Wu
National Center for High-performance Computing (NCHC)	Chau-Lyan Chang
Taiwan Semiconductor Research Institute (TSRI)	Tuo-Hung Hou
Taiwan Instrument Research Institute (TIRI)	Cheng-Tang Pan
Science & Technology Policy Research and Information Center (STPI)	Bou-Wen Lin
Taiwan Ocean Research Institute (TORI)	Chau-Chang Wang

OUR LABORATORIES

Evolution

2003

National Applied Research Laboratories (NARLabs) was established with six founding labs:

- National Chip Implementation Center (CIC)
- National Center for High-performance Computing (NCHC)
- National Center for Research on Earthquake Engineering (NCREE)
- National Nano Device Laboratories (NDL)
- National Laboratory Animal Center (NLAC)
- National Space Organization (NSPO)

2005

Two more labs joined NARLabs:

- Instrument Technology Research Center (ITRC)
- Science & Technology Policy Research and Information Center (STPI)

2008

Taiwan Ocean Research Institute (TORI) was established.

2011

Taiwan Typhoon and Flood Research Institute (TTFRI) was established.

2019

- Taiwan Typhoon and Flood Research Institute (TTFRI) was merged into National Science and Technology Center for Disaster Reduction (NCDR).
- National Chip Implementation Center (CIC) and National Nano Device Laboratories (NDL) were merged into Taiwan Semiconductor Research Institute (TSRI).
- Instrument Technology Research Center (ITRC) was renamed Taiwan Instrument Research Institute (TIRI).

2023

The National Space Organization (NSPO) transitioned into a new legal entity under the NSTC and was renamed the Taiwan Space Agency (TASA)

National Center for Research on Earthquake Engineering

To meet the needs of earthquake preparation, response, and reconstruction, the National Center for Research on Earthquake Engineering (NCREE) focuses on developing three core technologies: "Structural Seismic Testing and Numerical Simulation," "Structural Seismic Design, Evaluations and Reinforcement Retrofitting," and "Earthquake Damage Assessments Loss Estimation." Leveraging its advanced seismic database, large-scale experimental facilities, and cutting-edge technologies, NCREE facilitates the collaboration between Taiwan's industry, government, and academic institutions, fostering cooperation with international partners in related fields.

In recent years, NCREE has produced notable results including advocating for and implementing seismic provisions and revisions, seismic assessment and retrofitting, seismic isolation and energy dissipation technology for pre-earthquake preparedness, early warning notification of strong earthquakes and early loss estimation to instantly examine structural safety and reinforce emergency response, post-quake rescue facilities, and rapid evaluation of structural damage status to assist with restoration. These accomplishments will gradually enhance Taiwan's seismic safety and lead towards a sustainable homeland.

National Space Organization

The National Space Organization was established in October 1991 as the executive entity for the island's space program in accordance with the 15-year "National Space Science and Technology Development Long-term Plan" approved by the Executive Yuan. The third phase of the space program (2019-2028) is being implemented with the mission of cultivating professional talent, developing cutting-edge technologies, and establishing a robust space industry. In 2022, the Legislative Yuan passed the third and final reading of the "National Space Center Establishment Act," which officially restructured the original National Space Organization into the Taiwan Space Agency on January 1, 2023, under the jurisdiction of the National Science and Technology Council.

National Center for High-performance Computing

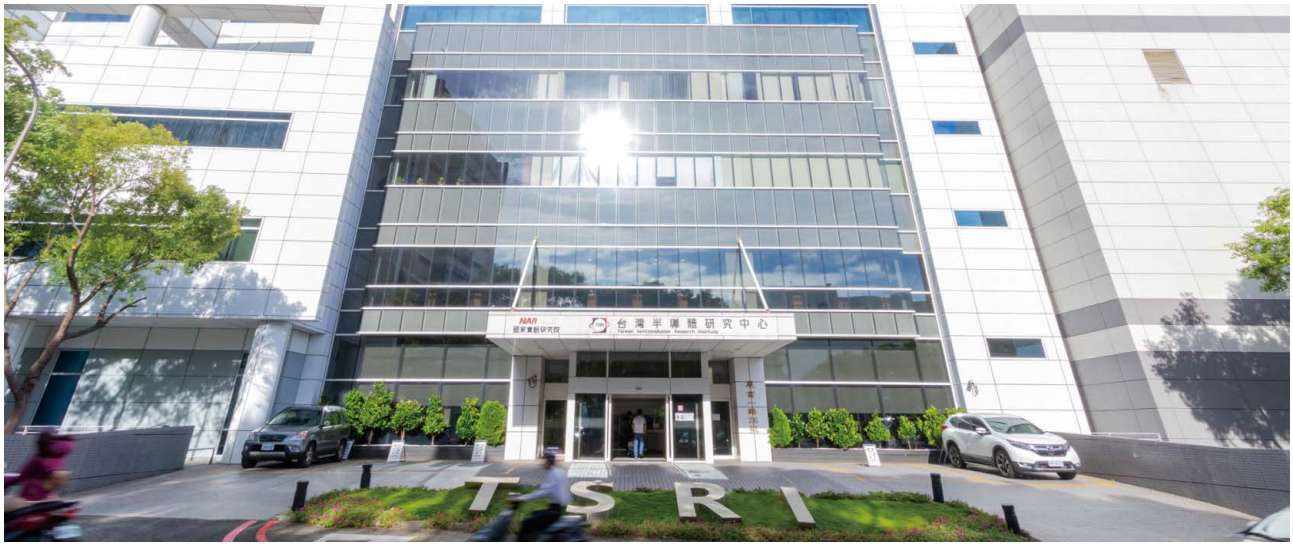
The National Center for High-performance Computing (NCHC) is the only research institution in Taiwan that provides a shared large-scale computing platform and academic and research network services. The Center provides cloud integration services, including high-speed computing, 100G high-quality academic and research networks, high-performance storage, and big data analysis. NCHC is deeply committed to enhancing Taiwan's high-speed computing capabilities by developing an ideal environment for its digital research and supporting scientific breakthroughs and innovations. Additionally, it is developing service platforms in biomedicine, environmental sciences, computing, data security, and smart tech as part of its long-term goal to become Taiwan's best value-added data service center.

Taiwan Ocean Research Institute

TORI actively engages in the independent design and R&D of marine exploration equipment and innovative technologies that serve the research needs of government, academia, and research institutes. By facilitating scientific research, marine engineering, and land investigation missions, TORI strives to propel the development of the marine industry. Moreover, TORI aims to reduce Taiwan's dependency on imported marine exploration equipment by acquiring core development technologies through independent R&D processes, which will also allow for more diverse research that goes beyond the constraints of commercial tools. This self-developed exploration equipment can contribute to research vessel exploration with greater precision. By realizing the "backing science with technology" strategy, TORI is devoted to developing and maintaining core facilities as well as managing the exploration teams essential for marine research and exploration.

Taiwan Semiconductor Research Institute

As a response to technological trends and the rise of emerging applications on the global stage, the Taiwan Semiconductor Research Institute (TSRI) focuses on integrating semiconductor manufacturing and design, providing "Device to System" one-stop semiconductor verification services, and establishing open information and service platforms in semiconductor manufacturing, packaging and testing, integrated circuit design, intellectual property cores, and system integration. Such platforms facilitate a smoother mode of sharing between Taiwan's industrial, academic, and research sectors and accelerate the development and evaluation of technological advancements. TSRI is actively involved in technical fields such as next-gen transistors, random-access memory, high-power components, 3D integrated circuits, and silicon photonics. Guided by its four strategic goals of cultivating talent, serving industry and academia, fulfilling international standards, and innovative R&D, TSRI is set to become a driving force behind the diversification of Taiwan's semiconductor industry. As a world-class semiconductor design and manufacturing research center, TSRI is creating the foundations for developing a thriving and competitive artificial intelligence industry.



Taiwan Instrument Research Institute

The Taiwan Instrument Research Institute (TIRI) specializes in the development of key technologies in cutting-edge optics, advanced vacuum technology, and intelligent biotechnology. TIRI offers an integrated, cross-domain service platform for the research and development of specialized instruments, making the Institute a key partner for academic teams' groundbreaking research. TIRI is currently Taiwan's only research institute capable of providing customized services in specialized instruments for a wide range of academic fields and is deeply dedicated to the development of "No.1 in Taiwan" and "world-leading" next-gen semiconductor processing equipment, cutting-edge systems in national defense and remote sensing instruments, as well as epidemic prevention-related instruments. The Institute aims to train high-caliber technical professionals in the industry and continually improve the effective use of national research resources.

National Laboratory Animal Center

The National Laboratory Animal Center (NLAC) supports the development of the biotechnology industry and biomedical research. The Center serves as an animal breeding and testing environment, conducts pre-clinical evaluation of new drugs and biotechnology products, and performs microbiota-related research and medical device validation. At the same time, NLAC also supports innovation in relation to the 3R principles (Replacement, Reduction, and Refinement) and promotes alternative methods and alternative technologies to animal testing. NLAC also provides specialized courses for caretakers, technicians, researchers, facility managers, and laboratory animal veterinarians to improve the development of biomedical research.

Science & Technology Policy Research and Information Center

The Science & Technology Policy Research and Information Center (STPI) is set to become a national-level science and technology policy think tank with a robust foundation of academic and empirical research that aims at providing comprehensive and rapid responses to the many issues faced in related fields. By fully grasping global S&T trends, STPI can provide timely, professional, and objective analyses and suggestions to support any government planning that may affect the industry. STPI's missions include supporting the government on S&T policy planning and the development of S&T industry, assisting in the evaluation and management of S&T programs, activating the innovation eco-system of R&D achievements and providing integrated information services. For many years, STPI has served as a think tank for the government's S&T policies. It has continued to support the National Science and Technology Council in drafting Taiwan's science and technology white paper and is also responsible for organizing the National S&T Conference. STPI is also highly committed to facilitating links between knowledge-based policy platforms, industry databases, professional talents, and indicators. Through dual-track policy research and innovative services, these tasks will assist the government in accelerating the national development of science and technology and the innovation of R&D achievements, enhancing the country's overall competitiveness.

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