

NAR Labs

National Applied Research Laboratories

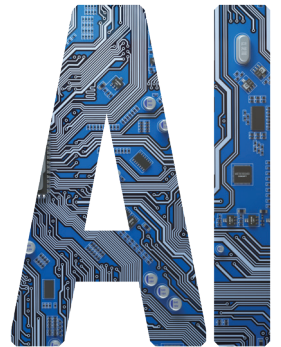
國家實驗研究院



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NCHC AI Supercomputer "TAIWANIA 2" Sets New Records

Ranked 20th in Computer Performance and 10th in Energy Efficiency Globally



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NARLabs "Scientists Secret Base" Exhibition Opened

Science is Fun! Let's DIY Together!



ANNUAL REPORT

National Applied Research Laboratories integrates technical capacities of 10 research laboratories to propose solutions for future societal challenges and to sustain with innovative technologies. The 2018 Annual Report is designed in the form of a "post"; through the use of different themes, it presents S&T research achievements and contributions to our society.



2003

NARLabs was established

Six labs were founding members of NARLabs

- 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 re-named "Taiwan Instrument Research Institute (TIRI)."

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COMMITMENT + PASSION + INNOVATION

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Message from the Chairman

Dear Partners,

In a silent night, faint moonlight sprinkled over the windowsill. I stood beside the window and realized that another year had passed by and so much had happened around us.

Chairman,

Liang-Gee Chu

In the challenging yet fulfilling year of 2018, Taiwan Ocean Research Institute (TORI)'s research vessel, *LEGEND* and National Center for High-Performance Computing (NCHC)'s supercomputer, TAIWANIA were officially launched. Built jointly by Quanta computer, ASUS, Taiwan Mobile and NCHC, Taiwan's self-developed and self-made AI supercomputer "TAIWANIA 2" is ranked the 20th in the latest 500 global high-speed computing hosts (TOP500), and the 10th in energy efficiency.

In a flash, the year 2019 arrived. With all the previous efforts we had made, the 3rd stage space technology long-term development program of National Space Organization (NSPO) received support from the Executive Yuan and started this year. National Chip Implementation Center (CIC) and National Nano Device Laboratories (NDL) were merged into Taiwan Semiconductor Research Institute (TSRI) before the Chinese New Year. National Laboratory Animal Center (NLAC) has moved into National Biotechnology Research Park in Nangang. Also, TAIWAN CAR Lab in Shalun, Tainan will begin its operation soon.

In the ongoing year, there are many important missions waiting for us. In the second quarter of 2019, FORMOSAT-7 will be launched to replace FORMOSAT-3. In the middle of the year, TAIWANIA 2 will begin operating and become an innovative base for pioneering

projects such as intelligence robots and AI research. Also, the Marine Scientific Research Area is expected to complete construction at the end of this year. Therefore, in this brand-new year, I hope everyone can stay calm and collected when facing various challenges to ensure these missions can progress steadily.

The philosophy of building a "science and technology-based nation" is why Taiwan can stand tall in the global waves. "Technology," "Innovation," and "Manpower" are the core of national competitiveness. What we are striving for is the accumulation of sustainable competitiveness for Taiwan's scientific research, industrial innovation and the next-generation talents.

This is our responsibility and honor. Let me recite one sentence from Li Bai's poem "Rugged Road [Xínglù nán 行路難]": "There will always be one day that I will brave the wind and the billows, hoisting a sail and advance bravely." I hope NARLabs in its "youth" can grasp the tides, brave the wind and the billows, writing a new page for Taiwan's "innovative ecology" in history.

Finally, I sincerely thank friends from different fields for their company. I am also grateful for all the partners of NARLabs. Many thanks to all of you!

GLOBAL EXCELLENCE
LOCAL IMPACT



Message from the President

NARLabs faced and managed many difficult tasks and challenges in 2018. With the efforts made by our staff, these hurdles and tasks were overcome and completed. I am thankful for the dedication of NARLabs' staff, and look forward to an even better performance in 2019. With the support from the Ministry of Science and Technology, NARLabs will continue to play the following roles: "a good partner of academia, a driving force for industries, and an excellent partner for international cooperation."

President,

Our four major missions are "to establish R&D platforms, support academic research, promote frontier science and technology, and foster high-tech manpower." In 2018, besides the first three missions, we put a lot of efforts into fostering high-tech manpower. We sent our award-winning popular science video

"Trailblazers-Stories from Laboratories" to all domestic elementary schools and high schools, which were well-received; "Taiwan

Railways of Popular Science," NARLabs' open house activities and "Scientists' Secret Base" exhibition have attracted a large number of people to join. These are the real practice of NARLabs in promoting popular science in Taiwan.

In 2018, Taiwan Ocean Research Institute (TORI) launched its research vessel *LEGEND* officially. Moreover, we have set up our first

overseas office in Thailand to reinforce our partnership and collaboration with ASEAN members. In the upcoming 2019, our super computer, TAIWANIA II will begin operating and satellite, FORMOSAT-7 is about to launch.

In the future, NARLabs will continue to strengthen our core capabilities and academic linkage while promoting international cooperation. Conforming with Chairman Chen Liang-Gee's

ACADEMIA COMPANION INDUSTRIAL DRIVING FORCE INTERNATIONAL PARTNERSHIP

strategies of "small country big strategy," "group fighting" and partners seeking, we will strive to elevate our research power and advance academic progress in Taiwan. In the belief of beginning with the end in mind, we will reinforce our innovative energy, transforming scientific research results into products and production values to benefit the society.

ANNUAL HIGHLIGHTS

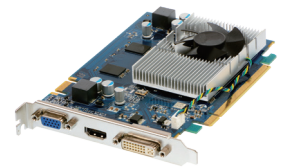
- National Applied Research Laboratories -

TSRI

Taiwan Semiconductor Research Institute Founded The World's First IDM-Lite Semiconductor Research and Development Center



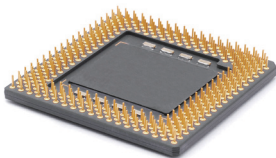
On January 1, 2019, Taiwan's National Chip Implementation Center and National Nano Device Laboratories were officially merged to create the Taiwan Semiconductor Research Institute (TSRI). In following with global technological trends and with the goal of providing a device-to-system one-stop service, the world's first IDM-Lite Center was launched, integrating industrial, academic and research



pursuits. This center focuses on innovative technology of the future and service application by conducting the following four strategic functions: personnel training, industry-academia services, international integration, and innovative research and development. We hope to be a driving force for the diversified development of Taiwan's semiconductor industry, completing the vision of a world-class semiconductor design and manufacturing research center.

CIC

Establishment of an Artificial Intelligence (AI) System Development Laboratory to Accelerate the Development of AI Chip Technology in Taiwan



The National Chip Implementation Center (CIC) cooperated with the Ministry of Science and Technology in 2018 to execute the Semiconductor MoonShot Project by introducing silicon IPs (Intellectual Properties), such as AI accelerator IP, high-efficiency processor IP, and peripheral IPs from major IC/EDA companies. Accordingly, the CIC established an AI SoC (System-on-Chip) platform and an AI system development laboratory named the AI Lab as well as developed various other applications and platforms. These

included Cadence Palladium and Synopsys ZeBu Server 3, which can greatly reduce the time required for system-on-chip design verification; the prototype verification platform Synopsys HAPS-80; the deep-learning computer NVIDIA DGX Station; and the automobile simulation package NVIDIA Drive PX2 and software system IPG CarMaker/HIL. These application platforms assist and encourage academia in developing AI chip systems, laying a solid foundation for Taiwan to promote the research and development of innovative AI applications.



"TAIWAN CAR Lab" Launched

An Autonomous Car Eco-village Created



The first autonomous vehicle proving ground "TAIWAN CAR Lab," which is integrated into the complex traffic environment in the Asia-Pacific region, was officially launched on February 25, 2019 in Shalun Smart Green Energy Science City in Tainan. TAIWAN CAR Lab provides a full range of testing services to assist the industry and academia in completing the research and development of autonomous technology.

TIRI

TIRI Initiates the MOU Signing between imec and NARLabs on Advanced Imaging and Optics Applications



Taiwan Instrument Research Institute (TIRI) and imec Taiwan Co. have been collaborating for joint R&D and have achieved fruitful results in various cooperation since 2014. This highly successful collaborative relationship with TIRI prompted imec to sign a memorandum of understanding with NARLabs to foster a closer partnership for future projects on advanced hyperspectral imaging technology and wearable device applications.

NCHC

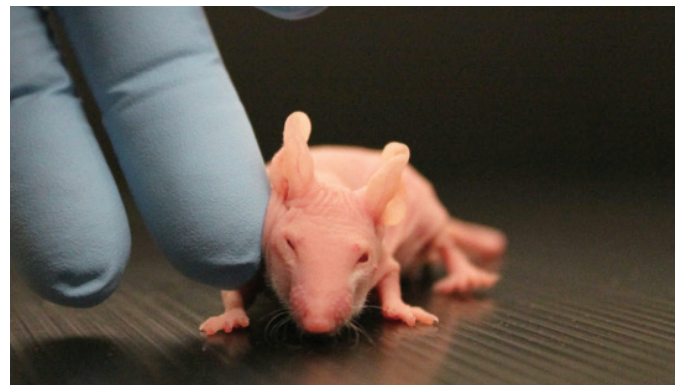
The Made-in-Taiwan AI Supercomputer TAIWANIA 2 Sets New Records

Ranked 20th in Computer Performance and 10th in Energy Efficiency Globally

TAIWANIA 2, the AI supercomputer developed by the National Center for High-performance Computing (NCHC), has achieved a remarkable computer performance of 9 peta floating-point operations per second (PFLOPS). This achievement has placed TAIWANIA 2 as the 20th most powerful computer system worldwide on the November 2018 edition of the TOP500 List, and the world's 10th most energy-efficient system on the Green500 List. Both rankings have rewritten the best records for local supercomputers, marking a significant milestone of Taiwan's technological development.



NLAC



NLAC's New Headquarters Settled in NBRP

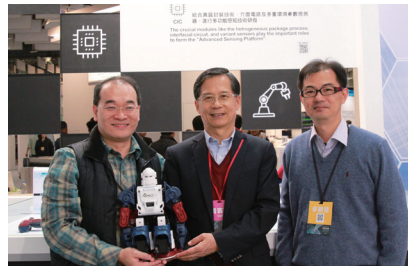
National Laboratory Animal Center (NLAC) focuses on providing services to support "translational medicine" and "drug evaluation." NLAC's new headquarters, completed in the National Biotechnology Research Park (NBRP), will expedite the translation process from basic research breakthroughs to in vivo and clinical trials. The Center started its relocation process in 2018 and has carried out various system verifications and hardware construction of the laboratories before the staff were stationed. The pre-relocation preparations were commenced in November, 2018, and the new building was officially opened on January 17, 2019.

NDL

Smart Robot - Application of Semiconductor Sensing Chip

Wins Best Popular Tech Award in Future Tech Expo 2018

National Nano Device Laboratories is seeing the application of self-developed wide bandwidth vibration sensor in smart machinery. This sensing chip has combined heterogeneous packaging, interface circuit, and multi-environmental sensors in its construction, resulting in its low cost, high sensitivity, and multi-functional characteristics. It is envisioned to fulfill the needs of smart manufacturing and smart living.



NCREE

The Guardian of Bridge Safety

Life-Cycle Based Bridge Management System for Disaster Prevention

Taiwan has nearly 28 thousand bridges; ensuring bridge safety is far more crucial than we could have imagined. Thereby, NCREE has developed the Life-Cycle Based Bridge Management System for Disaster Prevention, which aims to manage bridge safety and can automatically assess the health condition of bridges in their everyday uses. The system was inspired by health-care management for humans. Additionally, the cutting-edge, fully-automated system also transmits timely warnings to bridge safety management authorities before disasters strike. Therefore, the developed system is a driving force that can thrust forward Taiwan to achieving a new milestone in bridge safety management.



NSPO

FORMOSAT-5 WAS SUCCESSFULLY LAUNCHED ON AUGUST 25th, 2017



President Tsai Ing-wen Receives FORMOSAT-5 Team

On February 23, 2018, President Tsai Ing-wen received the FORMOSAT-5 Team, appreciating the team's efforts to build Taiwan's first indigenously developed remote sensing satellite. President Tsai also emphasized government's investment on space technology, stressing that along with the assistance of more comprehensive policies, Taiwan's technology industry will be able to join the supply chain of the international space market. FORMOSAT-5, as a brainchild of more than 50 teams in the domestic industries, academia and research institutes, shoulders the responsibility of safeguarding Taiwan. The president expressed her sincere gratitude for everyone contributing to the project and paid tribute to them on behalf of fellow citizens.



TORI

The Launch of the Research Vessel *LEGEND* Breaks New Ground for Marine Research

The research vessel named *LEGEND* has the capacity of up to 2,629 tonnages. A Singapore ship building corporation, Triyards Marine Services, had won the bidding of the *LEGEND* in December 2015. The construction began in January 2016, with the launching ceremony being held in Ho Chi Minh City on May 7 of the following year.

The construction of the vessel was eventually completed on December 31. R/V *LEGEND* arrived at Anping Harbor in Tainan on January 18, 2018, with the Maiden Voyage ceremony being held in Kaohsiung Harbor on May 23. The arrival of R/V *LEGEND* greatly enhances Taiwan's capability of conducting ocean explorations.



STPI

2018 Top Social Research Issues in Taiwan

In 2018 STPI scientifically prioritized top 100 most-concerned social issues in Taiwan using the way of online opinion polls. This research demonstrates not only the prioritized issues concerned by the general public but also the dissimilarity of issues in different generations. In the future, STPI researchers will reason out the solutions to respond to the needs and expectations of the public utilizing emerging technologies from the perspective of national sci-tech development. STPI hopes to propose coping strategies to respond to local needs, satisfy different generations, and create a sensible society where science and technology is advanced.

TTFRI


Unmanned Aircraft Base for Typhoon Monitoring in Northern Taiwan



Taiwan Typhoon and Flood Research Institute (TTFRI) has completed the assessment of the northern base for unmanned aircraft in 2018. TTFRI chose Chengnan campus of National Ilan University as the landing field and completed six monitoring missions. The tasks include feasible assessments such as off-site training, and aerial photographing of disaster damages in flood-prone areas. TTFRI also collaborated with National Central University to test the feasibility of joint observation of the atmospheric environment. TTFRI wishes to expand its service to atmospheric environment observation during non-flood periods as well as large-scale aerial photography of disaster damage during flood periods.

R&D AND SERVICE ACCOMPLISHMENTS

- National Applied Research Laboratories -



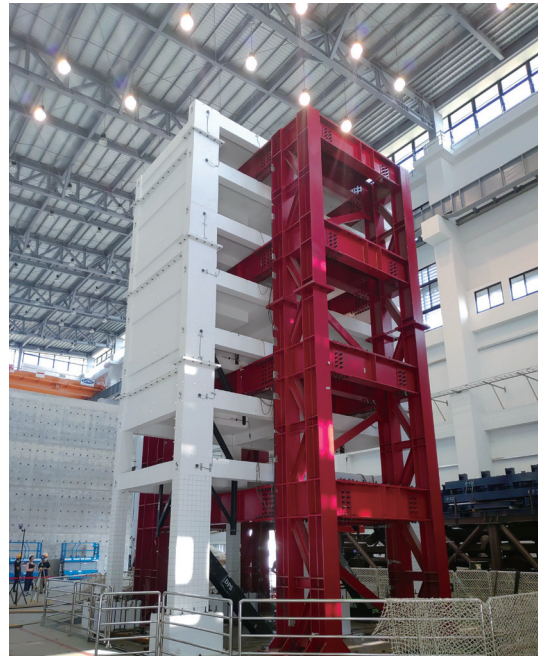
NARLabs is dedicated to creating cutting-edge scientific R&D platforms to facilitate application of academic research outcomes in industry, government and humanitarian causes. NARLabs plays an integral role in the development and establishment of technical, expensive and large-scale facilities that are unable to support by a single university. NARLabs platforms provide technical services for academic research, and help users operate high-accuracy instruments, modeling and analytical software systems to conduct fundamental and advanced studies.

[NCREE]

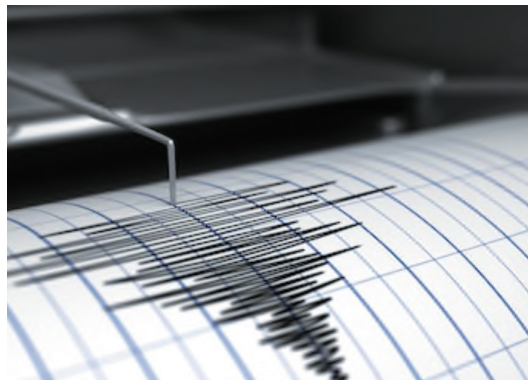
Developing Seismic Assessment and Retrofitting Techniques for Soft- and Weak-Story Buildings

Exploring the Impact of Near-Fault Earthquakes on Buildings

Taiwan has identified as many as 33 active faults in the island. The areas within ten kilometers on both sides of these faults are subjected to the impact of near-fault effects where more than 8.6 million people and 2.5 million buildings will be affected. The situation is more dangerous for buildings as near-fault ground motion are characterized by their large velocity pulses and large fault displacements. To resolve the problem, the National Center for Research on Earthquake Engineering (NCREE) has been continuing to develop seismic assessment and retrofitting techniques for soft- and weak-story buildings by conducting a series of large-scale shaking table collapse experiments. The aim was to explore the effects of near-fault earthquakes on soft- and weak-story buildings and devise solutions to mitigate such effects, in order to secure public safety.



Soft-and weak -story buildings collapse experiments

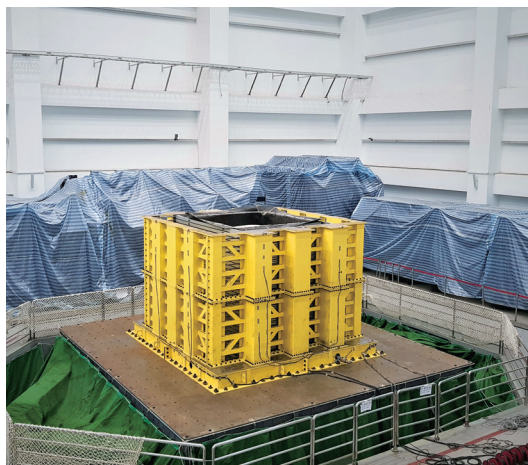


[NCREE]

Large-Scale Multiaxial Laminar Shear Box

An Apparatus Advancing Soil Liquefaction Experiment

The construction of a "large-scale multiaxial laminar shear box" was completed in 2018 in compliance with the government's green energy technology policy. The unique mechanism enables the soil specimen to move horizontally without torsion, thereby considerably reducing the boundary effect. The box will mainly be used in offshore wind foundation tests. Additionally, together with the earthquake simulator in NCREE's Tainan Laboratory, the box can be used to study the impact of near-fault earthquakes on geotechnical earthquake engineering. As a result, NCREE is able to further develop cutting-edge seismic technology and propel Taiwan to achieve the status as an earthquake-resilient country.



Performance test of shear box

[NSPO]

Both Payloads on FORMOSAT-5 in Full Operation

Providing Users with the Most Immediate and Economical Satellite Images

The FORMOSAT-5 has completed on-orbit verification, and its remote sensing payload has acquired more than 13,200 sets of black-and-white/color images globally. Its success rate of image data reception is over 96%. The commercial sales system was launched on September 21st, 2018. The Image Processing Center was open for visitors on the same day. The scientific payload continuously receives high-quality ionospheric parameters of over 100 megabytes per day. The data is processed by the Advanced Ionospheric Probe Science Data Center and then provided to users of scientific data at home and abroad. The smart agility (asynchronous imaging) function has been built into both the satellite's flight software and the ground image processing system. Having completed on-orbit verification, it will provide users with the most immediate and economical satellite images.

[NSPO]

The FORMOSAT-7 Constellation to Be Launched, with 6 Satellites Deployed

The 4th International Conference on GPS Radio Occultation Held in Taipei

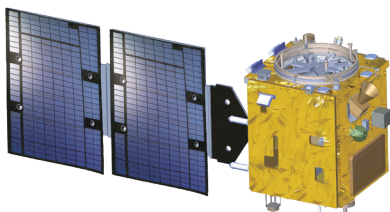


The 4th International Conference on GPS Radio Occultation

The FORMOSAT-7/COSMIC-2 (FORMOSAT-7) is a Taiwan-US science and technology cooperation project, aiming at establishing an operational meteorological satellite constellation system. Six satellites are expected to be launched in 2019. From April 18th to 20th, 2018, the 4th International Conference on GPS Radio Occultation was held in Taipei at Howard Civil Service International House, providing a forum to exchange ideas regarding the application of radio occultation and reflectometry. In the conference, issues concerning FORMOSAT-7 were also discussed, including the spacecraft verification, satellite instrument calibration, and cross-national scientific cooperation. This year, a total of 150 researchers from 14 countries attended the conference and presented more than 60 papers.

[NSPO]

Triton Mission Payload Successfully Passed Flight-Proof-Test



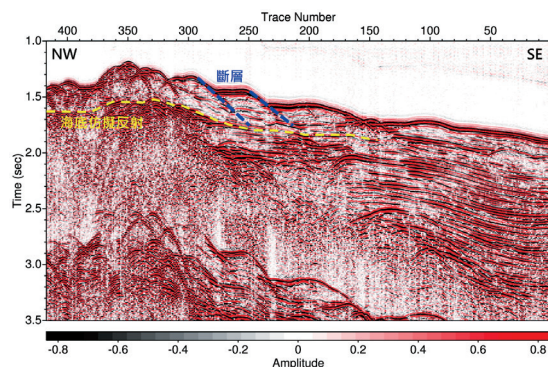
Triton is a 300kg class proof-of-technology satellite developed by NSPO. The mission payload is the Global Navigation Satellite System-Reflectometry (GNSS-R), designed and manufactured by Taiwan domestic team. In addition, the satellite also included 10 indigenous manufactured key components for technology verification. The Triton component level test and 1st system end-to-end test were completed in 2018. The satellite level comprehensive functional test and EMC test were completed in early 2019. The GNSS-R instrument on board a UAV to conduct a Flight-Proof-Test was also successfully completed. The flight-test data along with the real GNSS-R observation data from NASA CYGNSS mission will be used to validate the Triton data procession software.

[TORI]

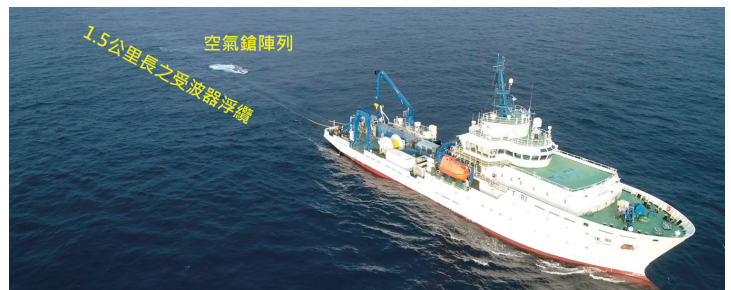
Marine Exploration of Structural Geology

Large-offset Multi-Channel Seismic (LMCS) System, GO!

Taiwan Ocean Research Institute (TORI) introduces the first Large-offset Multi-Channel Seismic (LMCS) in Taiwan. In 2018, the LMCS system, including air-gun volume of a 1,060 in³ (maximum capacity 3,200 in³) and a 3-km long streamer (maximum 6 km long), was set up and tested on R/V *LEGEND* to survey off SW Taiwan. The data was collected by the LMCS system and provides high-resolution images of the faults and BSR (Bottom Simulating Reflector) in that area. The images also describe the detailed structures at a depth of about 2 km below the seafloor. In other words, with the integration of the R/V *LEGEND* and full configuration of the LMCS, TORI will be able to provide geophysical exploration services ranging from faulted structures, potential earthquake generating structures, undersea land sliding to energy issues like oil-and-gas survey.



Seismic image with preliminary interpretations off SW Taiwan was collected in December, 2018.



LMCS system on R/V *LEGEND* was used for marine experiment.

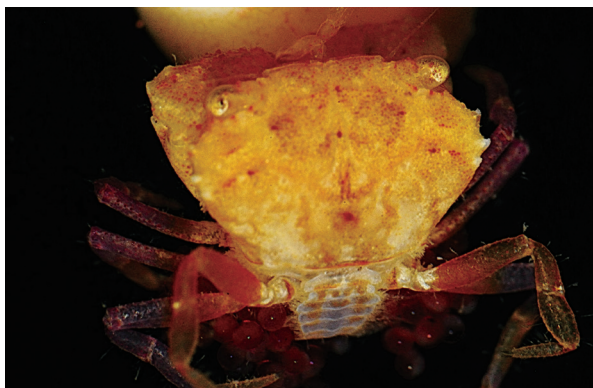


Figure 1: Dorsal view of crab



Figure 2: Ventral view of crab

[TORI]

A New Record Crab Species From Liuqiu, a Coral Reef Island

Liuqiu is the only coral reef isle in the coastal waters of Taiwan. For this uniqueness, Taiwan Ocean Research Institute establishes a long-term marine ecological monitoring program on the isle. Seasonal visits onto the isle and its surrounding waters are carried out every quarter. In October 2018, a small crab (carapace width <0.5cm), was recognized as a juvenile crab at the first glance, turned out to be a new record of the species *Nanocassiope tridentate* in Taiwan. The crab with red eggs under the abdomen is a proof that the species not only existing in that area but also becoming mature and reproducing the offsprings. This is a new record after the publication of "Taiwan Crab List" in 2017 that documents the 800 known species, or a symbolic crab showing the abundance of Taiwan crab species.

TORI Published the Longest Record of Sinking Particles

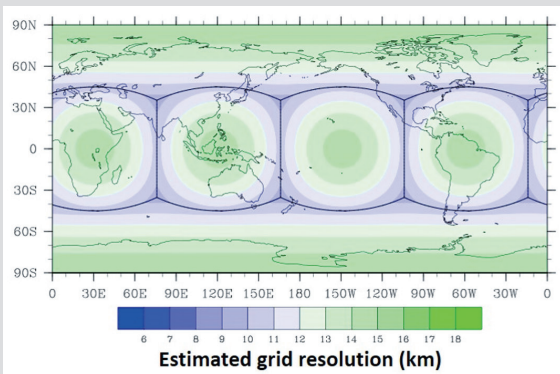


Deploying the mooring system of sediment trap

[TORI]

South East Asia Time Series Study (SEATS) Celebrates Its 20th Anniversary

South East Asia Time-Series Study (SEATS), a program launched in 1998 as part of the Joint Global Ocean Flux Study, was initially maintained by the National Center for Ocean Research. Starting from 2013, Taiwan Ocean Research Institute took the responsibility to maintain the operation, and persistently endeavors to provide the services of sampling requesting and archiving of sinking particles and the associated analytical parameters. A noteworthy result indicated from these long-term records is that both of the primary production and the flux of sinking particles are enhanced while the Kuroshio intrudes into the South China Sea. We are glad to announce the 20th anniversary, and will keep on providing the best quality of the services to the local and international research community for the years to come.



Global Mesh Graph, with resolution approximately 13 km

[TTFRI]

FV3 Dynamical Core Constructed

Understanding Global Weather Change Tendencies

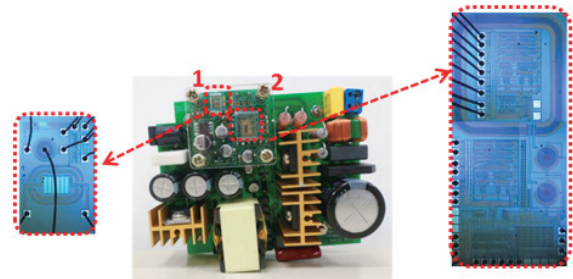
The Finite Volume Cubed-Sphere Dynamical Core (FV3) is the US National Centers for Environmental Prediction's (NCEP) model for the Next Generation Global Prediction System. This has been put to use in Taiwan where the TTFRI and the Central Weather Bureau, along with local academics have collaborated in building an FV3 test model using a finite-volume cubed-sphere grid dynamical core and the NCEP Global Forecast System's physical process module with a global spatial resolution of approximately 13 km. The test lasted from August 15 to September 30, 2017, and revealed a 500 hPa geopotential height forecast over the Asian region on its fifth day. The FV3 simulation result's correlation coefficient was approximately 0.88 – a positive result for its forecast capabilities.

[CIC]

Integration of Green-Energy Chip and Verification System

Accelerating the Research and Development of Green-energy High-voltage Chips and Reducing the Learning Curve

The National Chip Implementation Center offers the TSMC 0.5- μm 800-V ultra-high-voltage process and has self-developed the startup and gate driver silicon intellectual properties (IPs), thereby assisting academia in focusing on the development of control circuits. This has also accelerated the research and development of related applications and reduced the learning curve. In the future, GaN power transistors will be integrated to realize the high-level power integration designs.



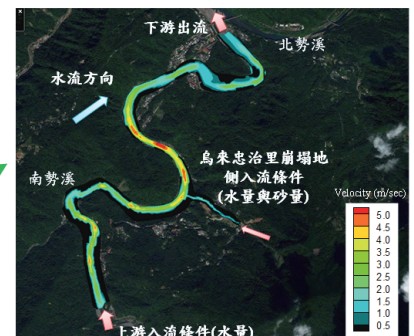
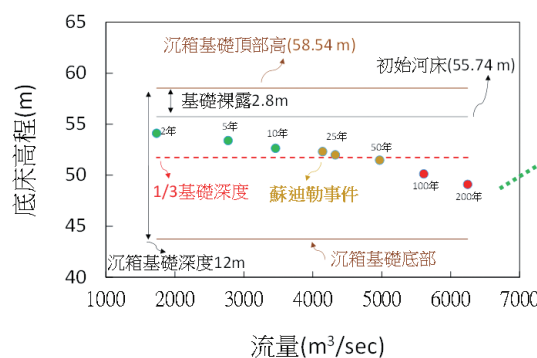
CIC power management circuit IPs

[TTFRI]

Physical Simulation Method for Flood Flow with Sediment Transport in the River Basin

Enhancing Bridge Closure Decisions during Floods

TTFRI incorporated the following models to develop the "physical simulation method for flood flow with sediment transport in the river basin": topography-based hydrological model, watershed sediment yield estimation model, sediment transport mobile-bed model, and scour-evolution estimation algorithm for cross-river structures. The catchment at Zhongzhi Village, Wulai District, New Taipei City was chosen as the study area to carry out a short-term riverbed evolution simulation for flood event "Typhoon Soudelor" in 2015. The results demonstrate that the proposed model can provide reasonable riverbed evolution with steep slope topography. Based on different scenario simulations, TTFRI also proposed a bridge safety curve representing scoured bed level-discharge relationship for Shangguishan Bridge in Nanshi River (as shown in the following figure). This proposed bridge safety curve can quickly evaluate scour-induced bridge failure and enables Directorate General of Highways to make a rational bridge-closure decision during flood periods.



The bridge safety curve and simulated velocity 2D contour using the proposed physical simulation method

[CIC]

PaS - Plug and Sense, Smart Sensing Device

Plug-In and Monitor the Environment at Anytime, Anywhere

PaS supports smart sensing of humidity, ultraviolet index, and alcohol concentration. By incorporating a series of core technologies to construct an embedded software-and-hardware design and several properties including low power consumption, energy storage, and AI self-calibration, PaS can eliminate problems of non-portability, inaccurate sensing, and power charging nuisances. Users can directly plug PaS into their smartphones (iOS and Android are supported) and start smart sensing the environment immediately. No extra settings are required.

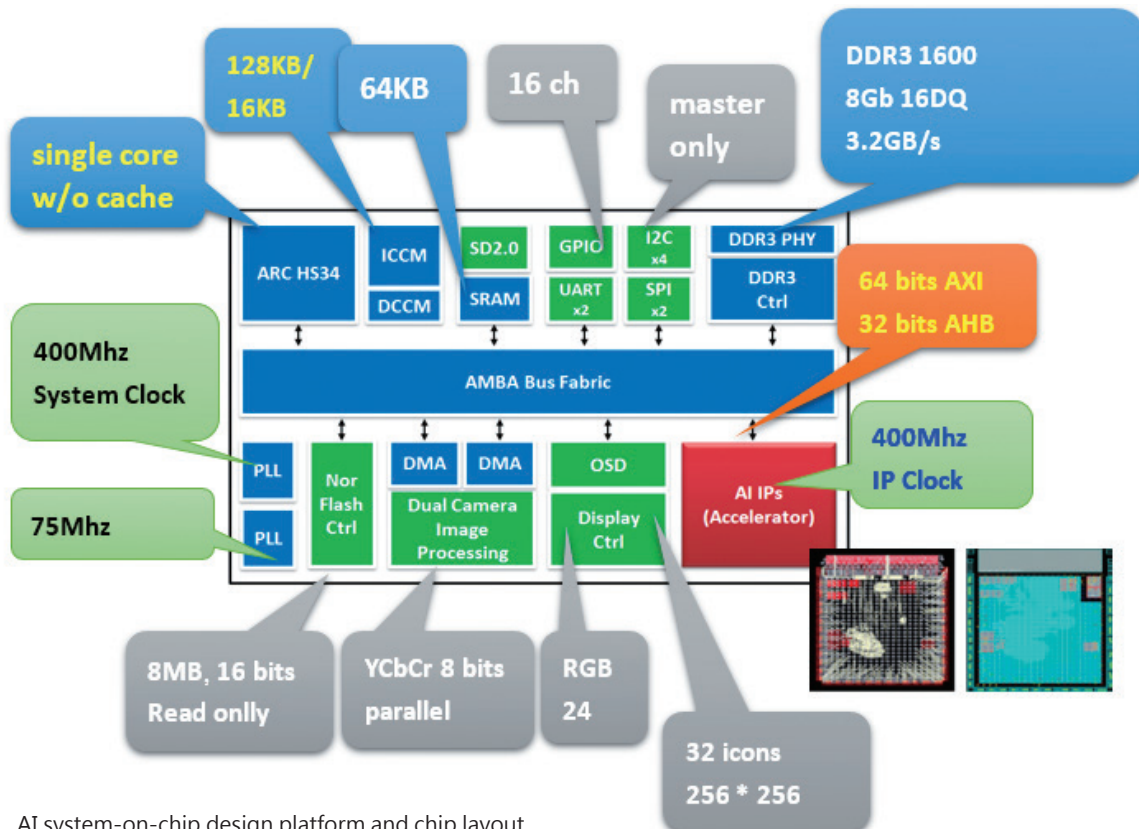


Using PaS with your smartphone to sense the environment

[CIC]

AI System-on-Chip Design Platform Assists Academia in Accelerating Its R&D

The AI System-on-Chip Platform based on Synopsys ARC HS34 was established in 2018. This platform has subsequently been used to design, tape-out, and manufacture Taiwan's first AI gene sequencing analysis chip. In addition, an AI chip verification platform was developed to help academia accelerate the research and development of the AI system-on-chip.



AI system-on-chip design platform and chip layout

[TIRI]

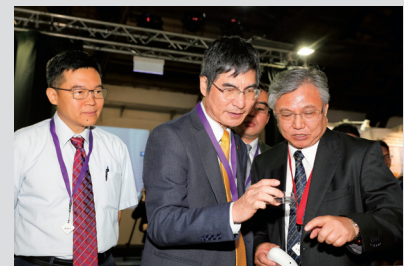
TIRI Showcases Joint R&D Fair and Exhibition of IoT Sensors and Smart Machinery Projects

Ushering in a New Era of AI Technology

TIRI facilitates the academia-research cooperation projects. On May 9, 2018, TIRI organized the Joint R&D Fair and Exhibition (i.e. demo and talk show) of the "IoT Sensors Service Platform Project" and the "Advanced Intelligent Robotic Module and System Integration". A total of 44 teams from 17 universities participated in the "IoT Sensors Service Platform Project". So far, four sets of wearable devices and sensor modules of personal care planning have obtained the permit to perform clinical trials in teaching hospitals and long-term care institutions. The devices are expected to enter mass production and hit the market in Taiwan within two years. Moreover, 8 teams from 11 universities have participated in the "Smart Machinery Service Platform Project". TIRI integrated inter-university machining equipment and showed the big data collection applied to smart manufacturing situation. The achievement of the platform will in turn trigger the domestic machinery manufacturing industry to transform its operating model.



Universities teams participated in the Joint R&D Fair and Exhibition.



Minister of Science and Technology Liang-Gee Chen attended the event.

[TIRI]

TIRI Jointly Develops "Biological 3D Printing Bone Reconstruction System" with 3D Global Biotech Inc.

Shortening Surgery Times while Retaining Patients' Facial Structures

Taiwan Instrument Research Institute (TIRI) and 3D Global Biotech Inc. have collaborated in developing the Biological 3D Printing Bone Reconstruction System for artificial bone construction. The use of this new technology, unlike traditional surgical procedures, does not require oral cancer patients to have mandible defects filled with segments of their fibula or radius. Surgery time is also cut in half, while 3D printed bones are custom-made to fit each patient, allowing for artificial bone replacements that fully conform to their particular mandibular defect, and retaining their original facial structure. This is a great step forward for those afflicted with oral cancer.



The Biological 3D Printing Bone Reconstruction System



[TIRI]

TIRI Assisted a Taiwan-Made Dental Handpiece to Speedily Attain US and EU Marketing Authorization

NARLabs Medical Device Alliance Gives a Boost to the Domestic Medical Devices Industry

With TIRI as its primary executive body, the NARLabs Medical Device Alliance has assisted the local startup MicroP Dental in attaining marketing authorization of the medical device ISO 13485:2016 quality management certification, the EU CE marking, as well as the US FDA 510(k) premarket within two years. This makes it the fastest ever Taiwan company to achieve this hat-trick of certifications. In addition, MicroP Dental has also received a purchase order from the renowned American dental instrument manufacturer AG Neovo Dental, clearing the path for its entrance into the North American market. This marks another success for this alliance in nurturing a local startup, showing its concrete contribution to Taiwan's medical devices industry.



Photo of contract signing ceremony. With the assistance of NARLabs Medical Device Alliance executed by TIRI, MicroP Dental and AG Neovo Dental had signed a purchase contract.

[TIRI]

NPM x NCTU's "Techathon" and MOST's "Future Tech Expo, FUTEX 2018" Exhibitions Successfully Realizes the Cross-field Integration of Culture and Technology

Floating Image Projection Meets Artistic Creation

TIRI has developed an innovative floating image projection exhibition cabinet that simulates images appearing to float in thin air. This new technology allows virtual images and concrete objects to exist in the same physical space, as the projections can be perceived with naked eyes. The system is comprised of a light source, a polarizer, a computing system, and a floating glass component with a sophisticated interwoven structure. Imaging signals are emitted from the light source to the floating glass. The light goes through the interactive reflection in the glass before refocusing in the air, forming a floating image. This technology was integrated with the artistic creation by National Chiao Tung University and showcased in "NPM x NCTU Techathon" at National Palace Museum and in the Ministry of Science and Technology's "Future Tech Expo, FUTEX 2018." Visitors could not help but marvel in this exhibition.



Winner of the Most Popular Technology of the Future Tech Expo, FUTEX 2018

[NCHC]

TAIWANIA 1: The First Petascale Supercomputer Available for Public Access

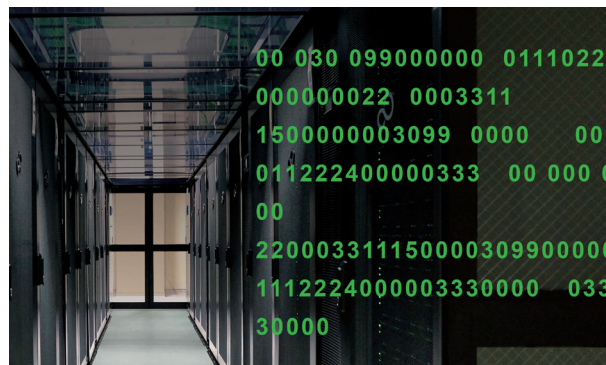
Providing Large-scale Computing Service for Taiwan's Key Technology Sectors



TAIWANIA 1 development team of NCHC

NCHC has developed TAIWANIA 1, the first public petascale supercomputer in Taiwan. It consists of 630 pure Central Processing Unit (CPU) compute nodes and another 64 CPU compute nodes equipped with Graphics Processing Unit (GPU) accelerators, enabling its computer performance to reach 1.7 PFLOPS. Serving as the new driving force of local research and development, TAIWANIA 1 will be able to promote the country's industrial and economic growth holistically. It can also support key technology sectors in large-scale computing, as well as boosting research in innovative areas such as big-data and AI. The goal is to expand local scientific research capacity by improving the nation's computing power. In this way, Taiwan's industrial development will burgeon with promise.

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[NCHC]

NCHC Launches Data Market Service Platform

A Continuously Expanding Pool of Diverse Data

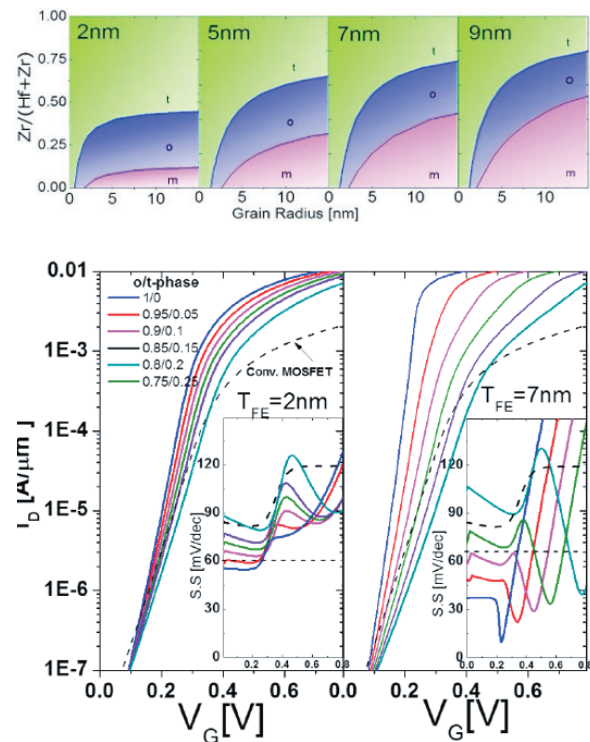
NCHC launched Data Market Service Platform in April 2018. At present, it provides more than forty thousand datasets online across diverse fields, including transportation, governance, everyday life, environment, scientific research, medical care, sound data, and information security. NCHC hopes to extract maximum value from the data collected and explore innovative data applications through this platform. All sectors in Taiwan are expected to benefit from the services the platform has to offer. In addition, NCHC has joined forces with National Taiwan University Hospital, Taipei Veterans General Hospital, and Taipei Medical University to develop a medical imaging project. The project seeks to establish a medical image management platform, which aims to serve as a pathology database with annotated medical images. The database will also be provided as a regular service on Data Market, which can be accessed by researchers through application.

[NDL]

Development of Verification and Exploration Technology for < 5nm Semiconductor Devices

Providing Application Needs of Low-energy-consumption Devices on Portable Electronics and Internet of Things (IoT) Devices

National Nano Device Laboratories (NDL) collaborated with research teams from National Chiao Tung University and National Cheng Kung University to develop 5-nm ferroelectric field-effect transistors and investigate how these transistors are affected by the scale effect and environmental stress. The project was led by NDL and was the first worldwide to explore ultrathin ferroelectric 2-nm HfZrOx gate stacks and the inference stress distribution of such stacks using surface morphology methods. This project was also the first worldwide in which surface morphology was employed to examine the stress distribution among ferroelectric interfacial layers. The research outcomes were published at the 2018 Symposia on VLSI Technology and Circuits in Hawaii. The project can serve as a valuable reference for the development of 3-nm technology and its application in low-power-consumption devices such as portable electronics and IoT devices.



Electrical properties of 2-nm and 7-nm ferroelectric field-effect transistors

[NDL]

Antibiotic Susceptibility Testing Chip Developed

The Epitome of Industry-Research Collaboration in the Medical Field

National Nano Device Laboratories cooperated with Taichung Veterans General Hospital in developing the Antibiotic Susceptibility Testing (AST) Chip using optoelectronic integrated electrokinetic technology. Through rapid preconcentration of bacteria, the AST Chip is capable of shortening the total testing time to 51 hours, saving two days of time compared to current standard diagnostic technique. It is a breakthrough achievement which could greatly improve patient rescue.



National Nano Device Laboratories and Taichung Veterans General Hospital co-held a press conference to demonstrate the newly-developed antibiotic susceptibility testing chip.

[NDL, CIC]

Groundbreaking Ceremony Held for Tainan Base of Nano-Chip Center

Enhancing Industry-university-institute Collaboration between North and South Taiwan

National Nano Device Laboratories has joined hands with National Cheng Kung University (NCKU) in establishing Tainan Base of Nano-Chip Center as a foundation to strengthen interdisciplinary technological integration and to boost Taiwan's nanotechnology research and development. Both sides have integrated their respective advantages in resources to promote the development and application of technology in various fields, including semiconductor, nanomaterial, and biomedical technology and medical device. In this way, they hope to cultivate high-level talents to meet the need of the industry and academia, enhance the breadth and depth of industry-university-institute collaboration between northern and southern Taiwan, and introduce new models to drive Taiwan's economy.



NCKU President Dr. Huey-Jen Su (left) and NARLabs President Yeong-Her Wang (right) inaugurated the building site.

[NDL]

Development of Advanced Monolithic Threedimensional Integrated Circuit Technology

To improve the circuit characteristics of monolithic three-dimensional integrated circuit (3D IC) technology, National Nano Device Laboratories (NDL) developed laser crystallization technology for controlling grain growth. In addition, the NDL applied its self-developed FinFETs to a single silicon grain to inhibit variation in device electrical properties caused by the polysilicon grain boundary. Using various bottom-etched profiles and the corresponding laser manufacturing procedures, the NDL created a 3D stackable silicon channel for controlling grain growth. This technology will be used in collaboration with National Chiao Tung University to produce high-quality single-grain FinFET and related application circuits. This progress will dramatically increase the likelihood of future monolithic 3DIC commercialization. With its monolithic 3DIC technology, the NDL collaborated with Prof. Meng-Fan Chang from National Tsing Hua University and Prof. Vijaykrishnan Narayanan from Penn State University to develop in-memory computing static random access memory (SRAM) with storage and computation functionality. A negative-capacitance device was employed along with circuit manufacturing technology to create ultralow-power-consumption in-memory computing SRAM that can be used to effectively inhibit transmission loss in device switches, circuits, and wires. Two papers were published at the 2018 International Electron Devices Meeting. This technology can be used to develop smart Internet of Things chips and artificial intelligence applications.

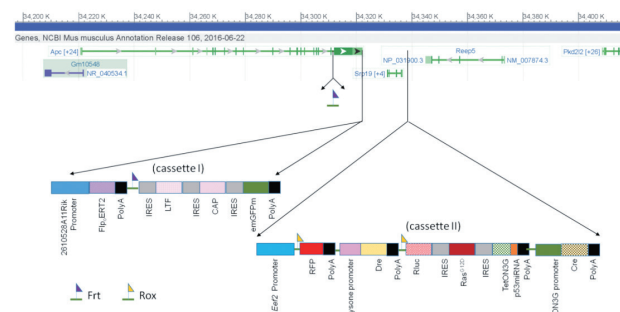
[NLAC]

Developing an Orthotopic Mouse Model of Metastatic Human Colorectal Cancer

Reconstructing the Serial Genetic Mutations in Human Cancer Growth to Create New Therapeutic Opportunities



Colorectal cancer has been the most common type of cancer in Taiwan for nine years running. This type of cancer metastasizes easily and has a considerably high mortality rate. The occurrence of colorectal cancer is associated with the chain reaction of multiple genes, while conventional genetic modification techniques cannot reproduce the sequentially triggered mutations of concatenated genes. NLAC has developed the genome integrating technique whereby three genes are modified in sequence in the intestinal tract to create an orthotopic mouse model of colorectal cancer accompanied with metastasis. Preliminary results are promising, and the model's verification is expected to be completed in 2019.



Construct designed for mouse model of metastatic colorectal cancer using genome integrating technique.



[NLAC]

Developing Advanced Severe Immunodeficiency Nude Mice

Assisting Patient-Derived Xenograft Transplantation and Drug Testing and a Valuable Aid to Precision Medicine

Laboratory mice serve as an essential platform for tumor drug testing, but traditional laboratory mouse models are less than ideal for transplantation of patient-derived xenograft. To optimize the test platform, NLAC has successfully developed advanced severe immunodeficiency (ASID) mice in 2017. The ASID mice have had most of their immune cells removed, enabling human tumors to grow more easily. NLAC further developed hairless ASID mice in 2018, allowing observation and more accurate measurement of tumors. This nude ASID mice are expected to be available to all researchers in 2019.



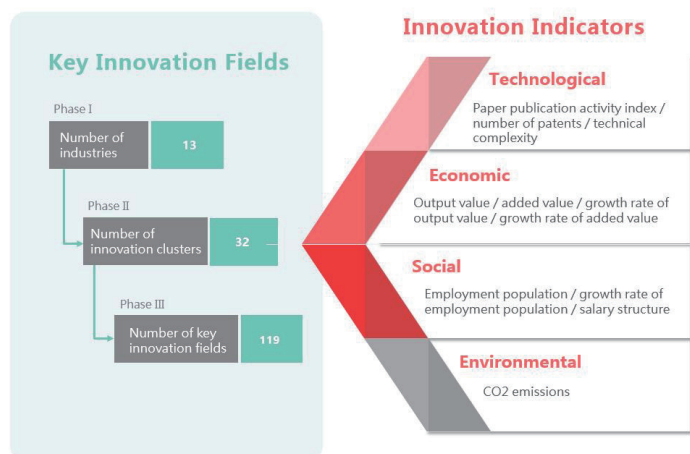
ASID nude mice

[STPI]

Constructing a Multi-Perspective Decision-Making Model for Evaluation and Analysis

Developing Strategic Tool for Sci-Tech Policy Making

STPI has summarized and analyzed 119 key innovation fields from 13 different industries by adopting a self-constructed multi-perspective (including technological, economic, social and environmental) decision-making model for evaluation and analysis to carry out more comprehensive assessment of technologies. This decision-making model is beneficial to evaluate Taiwan's potential technologies from the perspective of national policies. The results of evaluation can serve as a reference for the policy makers when they make strategic selections in appropriate innovation fields in the future.



Evaluation framework for Taiwan's potential innovation fields

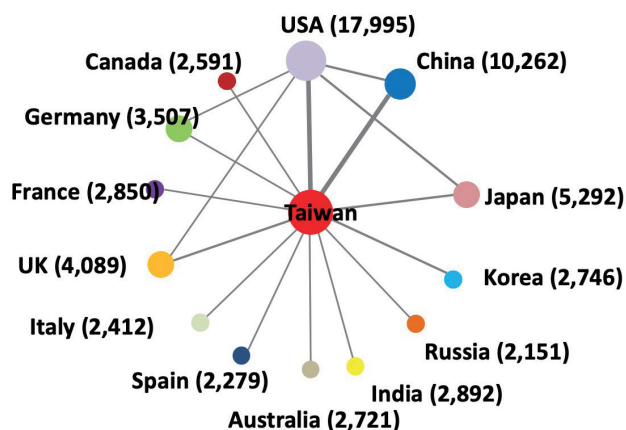
Taiwan's international partners for collaborative research

[STPI]

Taiwan's Research Performance from a Global Perspective

Demonstrating Taiwan's Research Capabilities

Academic research is the foundation for national innovation; therefore, STPI commits to observing the long-term performance of Taiwan's research capabilities. In April 2018, STPI organized a press conference to demonstrate the performance of Taiwan's research papers in both quantity and quality and compared with such innovative countries as the US, Switzerland, the Netherlands, Sweden, and Israel. In addition, STPI co-hosted a research conference entitled "Taiwan as a Hub of Research and Learning: Present & Future" with John Wiley & Sons, during which STPI shared Taiwan's achievements in academic publication. The conference facilitated research communications among local and international research leaders, striving to enhance Taiwan's strength in scientific research.



KEY DEVELOPMENT PLANS

- National Applied Research Laboratories -



As the largest interdisciplinary research organization under MOST, NARLabs is dedicated to supporting academic research, building R&D platforms, fostering highly-skilled talents and developing pioneering technologies while supporting the advancement of key programs in Taiwan and acting in concert with government policies.

As a strong backbone of R&D staff, NARLabs assists in perfecting testing environments, building science towns, setting up overseas offices and so on to elevate Taiwan's R&D capability and promote international cooperation.

[TAIWAN CAR Lab]

TAIWAN CAR Lab

In order to promote the simultaneous development of Taiwan's autonomous technology with the rest of the world, the Ministry of Science and Technology (MOST) and National Applied Research Laboratories (NARLabs) have planned to build the first proving ground "TAIWAN CAR Lab" for autonomous vehicle and component system development in Tainan Shalun Green Energy Science City since 2017. TAIWAN CAR Lab covering an area of about 1.75 hectares can simulate the low-speed driving of domestic roads with a speed under 30 km/h, and provide small or medium-sized buses for the real-time test of mixed traffic in a closed field. For the main key procedures of autonomous driving: "perception", "decision" and "control" to conduct comprehensive evaluation to promote the development of industrial technology and innovative services, and lay a solid foundation for the next generation of intelligent transportation in Taiwan. TAIWAN CAR Lab is expected to be officially launched in 25, Feb. 2019. It can provide a full range of R&D services, and help speed up the development and implementation of related technologies through the virtual and road-test platforms.



Autonomous car field



Autonomous car, developed by National Cheng Kung University (NCKU)



NARLabs signed a MoU with Thai-Taiwan Business Association

[NARLabs]

Prospect of Setting up an Overseas Office in Thailand

NARLabs dedicates itself to the S&T development in Asia by supporting the New Southbound policy of the Government and promoting S&T cooperation with Europe through the "National Contact Point for EU Framework Programmes". In response to the New Southbound policy, NARLabs set up its first overseas office at Thailand Science Park in March 2019, extending the scientific cooperative results of Taiwan and Thailand to neighboring countries. The aim of setting up an overseas office is to connect Taiwan with the world while carrying out NARLabs' role in offering platforms to university-academia-industry linkage. In the future, NARLabs will join hands with universities in Taiwan to bridge innovative industries, using cutting-edge technology to create local values and sharing security and prosperity with friendly countries. Preliminarily, advanced technology of NARLabs will be integrated. Founded on the partnership with National Science and Technology Development Agency (NSTDA) of Thailand, NARLabs will strive to expand and deepen the collaboration between the two countries in high-performance computing, artificial intelligence, biotechnology medicine, information and communications technology, disaster prevention and rescuing, etc.

SMART GREEN ENERGY SCIENCE CITY

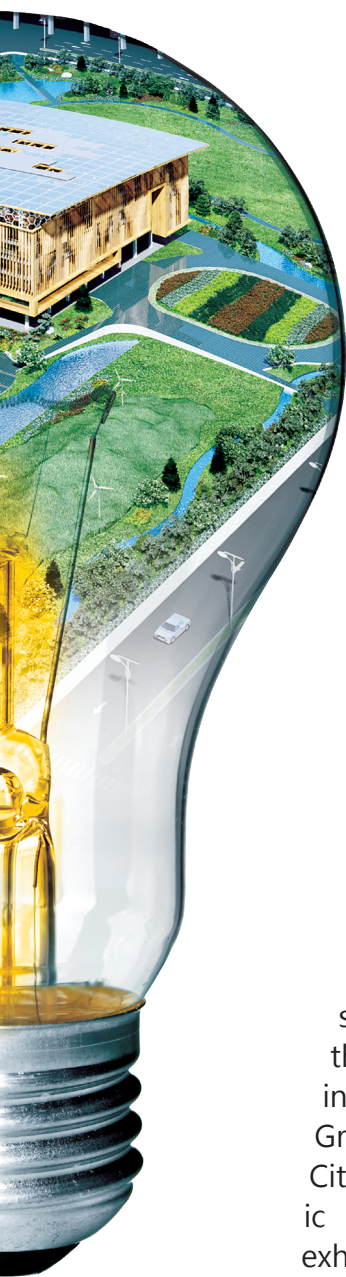


GREEN

[Tainan Shalun Smart Green Energy Science City]

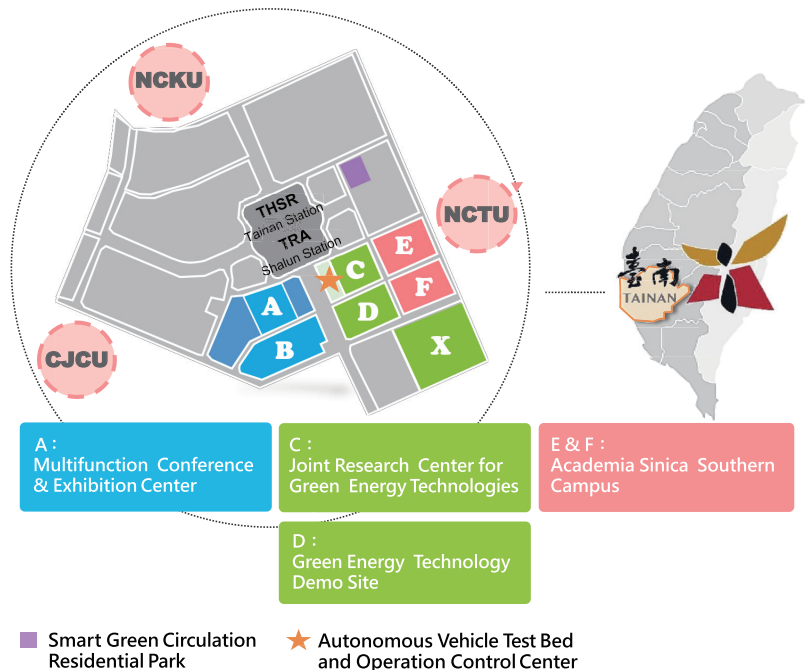
Tainan Shalun Smart Green Energy Science City

In line with energy policy implementation, the government has planned to establish the Shalun Smart Green Energy Science City in Tainan, Taiwan. The construction and project management of Zone C (see below figure) in Shalun Smart Green Energy Science City are entrusted to NARLabs and Southern Taiwan Science Park Bureau. Currently, the projects including (1) Smart City Infrastructure, (2) Smart City Low-carbon Environment Establishment, and (3) Green Energy Science Innovative Service Platform, are underway within the Zone C. The first project aims to accomplish the infrastructure of The Joint Research Center for Green Energy Technologies, which is expected to be launched in 2020. The second project aims to complete the accompanying facilities such as smart grids, smart environment-monitoring devices, and 3-dimensional virtual model system by 2020.



The third project is carried out by the research centers of NARLabs, the Central Weather Bureau, and the Ministry of Science and Technology. The project aims to conduct prospective and critical green energy related research, develop relevant guidelines, establish test platforms and international cooperation. More specifically, the sub-projects under the third project include "Domestic Design Guidelines for the Support Structure of Offshore Wind Turbines," "Establishment of Key Component Testing Platform of Offshore Wind Turbines," "Low Startup Voltage Transistor Technology," "GaN Green Power Device," "Green Chip," "Meteorological-Information Based Green Energy Operations Center," "Studies on the key issues for developing high-energy and safe batteries," "Taiwan-Germany Joint Research on High-performance and High-safety Batteries," and "Battery

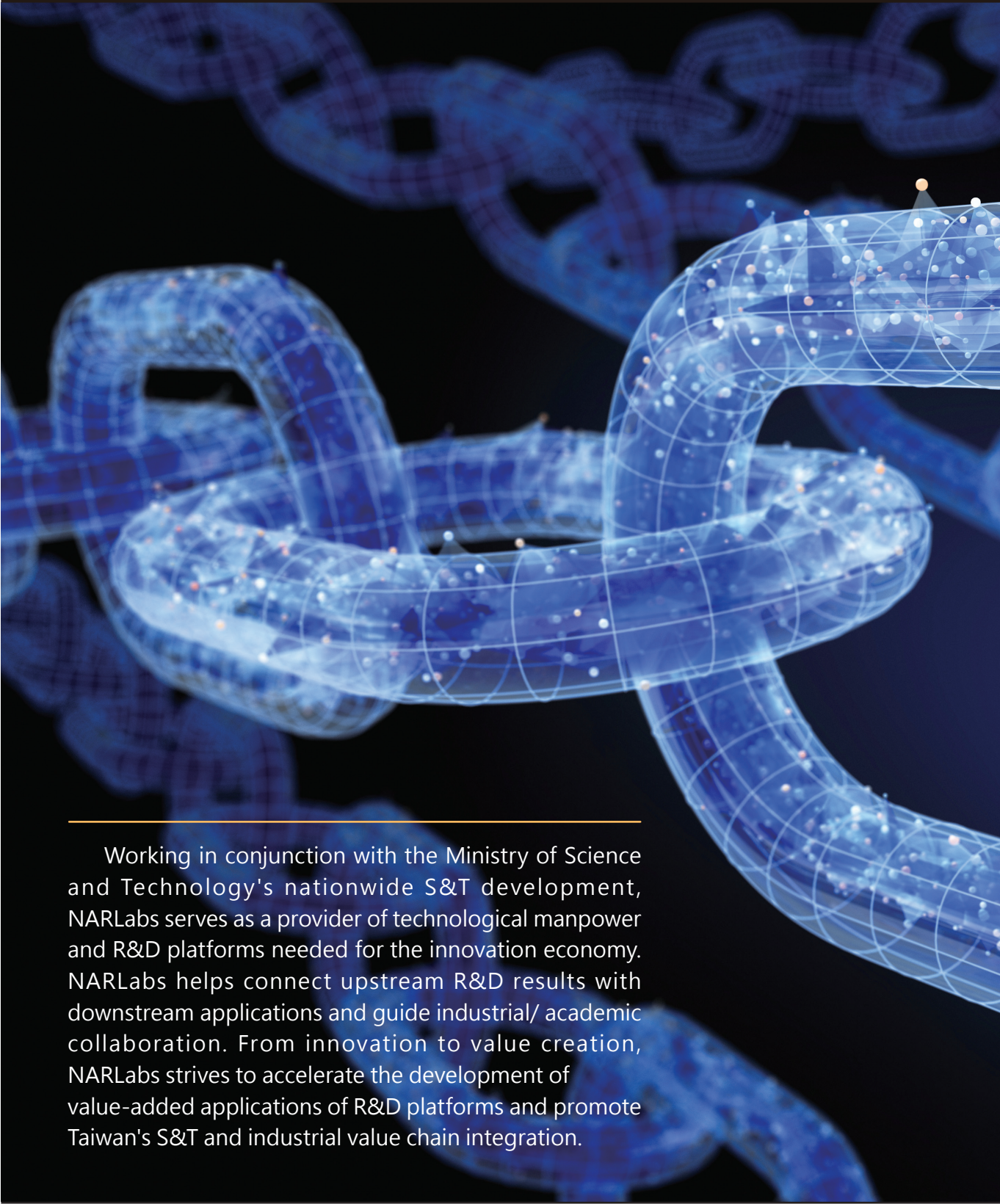
Materials Manufacturers Consortium." The ultimate goal is to build a network for TAIWAN CAR Lab, Zone C and D (demo site of NARLabs and the ITRT respectively) in the Shalun Smart Green Energy Science City as well as academic research institutes, exhibition and business areas. This network is expected to advance the growth of green energy industries.



Tainan Shalun Smart Green Energy Science City

INDUSTRY-ACADEMIA COLLABORATION

- National Applied Research Laboratories -



Working in conjunction with the Ministry of Science and Technology's nationwide S&T development, NARLabs serves as a provider of technological manpower and R&D platforms needed for the innovation economy. NARLabs helps connect upstream R&D results with downstream applications and guide industrial/ academic collaboration. From innovation to value creation, NARLabs strives to accelerate the development of value-added applications of R&D platforms and promote Taiwan's S&T and industrial value chain integration.

[TAIWAN CAR Lab]

Signing MoUs of Autonomous Vehicles Marked a Major Milestone for the Industry

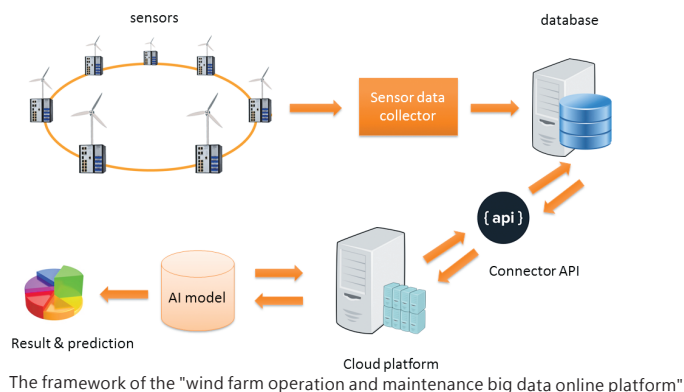
The development of autonomous vehicles is a world trend. The Ministry of Science and Technology (MOST) and NARLabs have planned to start the first autonomous proving ground "TAIWAN CAR Lab" in Taiwan since 2017, and scheduled to officially open the ground on Feb. 25, 2019. In order to strengthen the cooperation between the industry and TAIWAN CAR Lab, NARLabs collaborated with Acer, ARTC, NCKU, 7 starlake, CECI, CHT to develop autonomous vehicles, intelligent transportation, and 5G application technology. In the future, TAIWAN CAR Lab will focus on virtual simulation system, autonomous database and evaluation standards to make Taiwan more competitive in the industry and academia.

[NCHC]

An Online Platform of Meteorological and Oceanographic Mast Data from Changhua Offshore Wind Farm

Fueling Taiwan's Energy Transition with Big Data Analysis

NCHC collaborated with Taiwan Power Company and National Cheng Kung University to establish the "wind farm operation and maintenance big data online platform" to fully utilize the observation data collected by the meteorological mast in offshore Changhua.



[NCREE]

Design Guidelines for the Support Structure of Taiwan Offshore Wind Turbines



NARLabs signed a Letter of Intent (LOI) with Acer Inc.

Since site conditions in Taiwan Strait and extreme environmental conditions (earthquakes and typhoons, for instance) are different from European experiences, the design of offshore wind turbines and the establishment of wind farms require domestic guidelines to ensure safe operations of the wind farms. According to the DNV GL standard adopted by the international certification system, NCREE formulated and complied with the "Design Guidelines for the Support Structures of Taiwan Offshore Wind Turbines" as a basis for the domestic wind power industry. In addition, NCREE cooperated with the Bureau of Standards, Metrology and Inspection to make the contents of the seismic force and geotechnical surveys developed in the guidelines meet national standards.

NCHC is able to make valuable use of the collected data by following the European standards and quality control guidelines, as well as harnessing its strength in data management and analysis. Ultimately, the platform is expected to help eliminate general public's doubt for the development of offshore wind power. Moreover, with such platform and database, Taiwan can better assess and develop wind power on its own and help national energy transition.

[NSPO]

The FORMOSAT-7 Constellation Sheds Light on the Results of University-Institute Cooperation

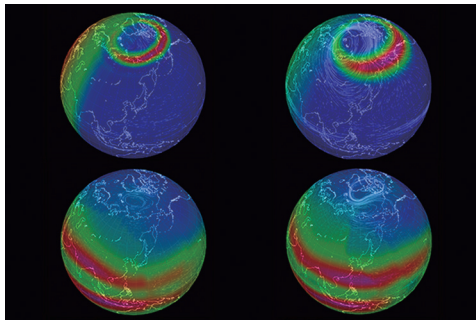


Figure / Space weather forecast model

On October 16, 2018, NSPO, National Central University and Cheng Kung University collectively held a seminar, titled "Improving Severe Weather Forecast and Optimizing the Accuracy of Positioning and Navigation," with the aim of explaining the importance of the FORMOSAT-7 in weather forecast and space weather. The FORMOSAT-7 is going to team up with ICON and GOLD, two missions of NASA launched in 2018 (led by US Berkeley and CU-Boulder respectively), to explore the space weather as well as the Earth's atmosphere. The Journal of Aeronautics (Astronautics and Aviation, JOAAA) published a special issue on the FORMOSAT-7 in December 2018.

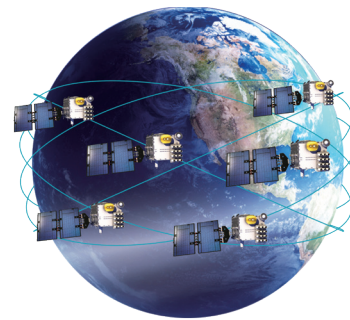


Figure / FORMOSAT-7 1st batch six satellites constellation

[TORI]

TORI Developed High Efficiency Drifting Buoys

Predicting Large-Area Drift Trajectories for In-Time Marine Rescue Operation



Two types of drifting buoys

Drifting buoys are often used in maritime search and rescue operations to narrow down the search area. Taiwan Ocean Research Institute (TORI) has independently developed a low-cost, miniature drifting buoy, which is suitable for large-scale deployment to obtain the drift trajectories within a radius of 8 km. These trajectories can serve as a reference for the rescue team about possible drift direction, thereby improving rescue efficiency.

Single day occultation observation position

FORMOSAT 3 / COSMIC-I FORMOSAT 7 / COSMIC-II

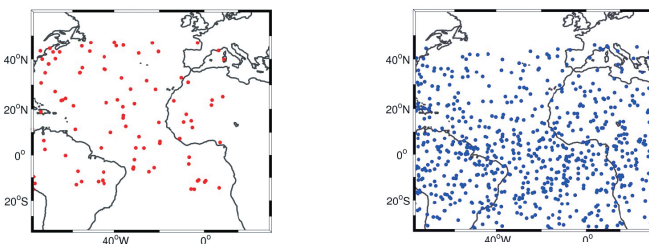
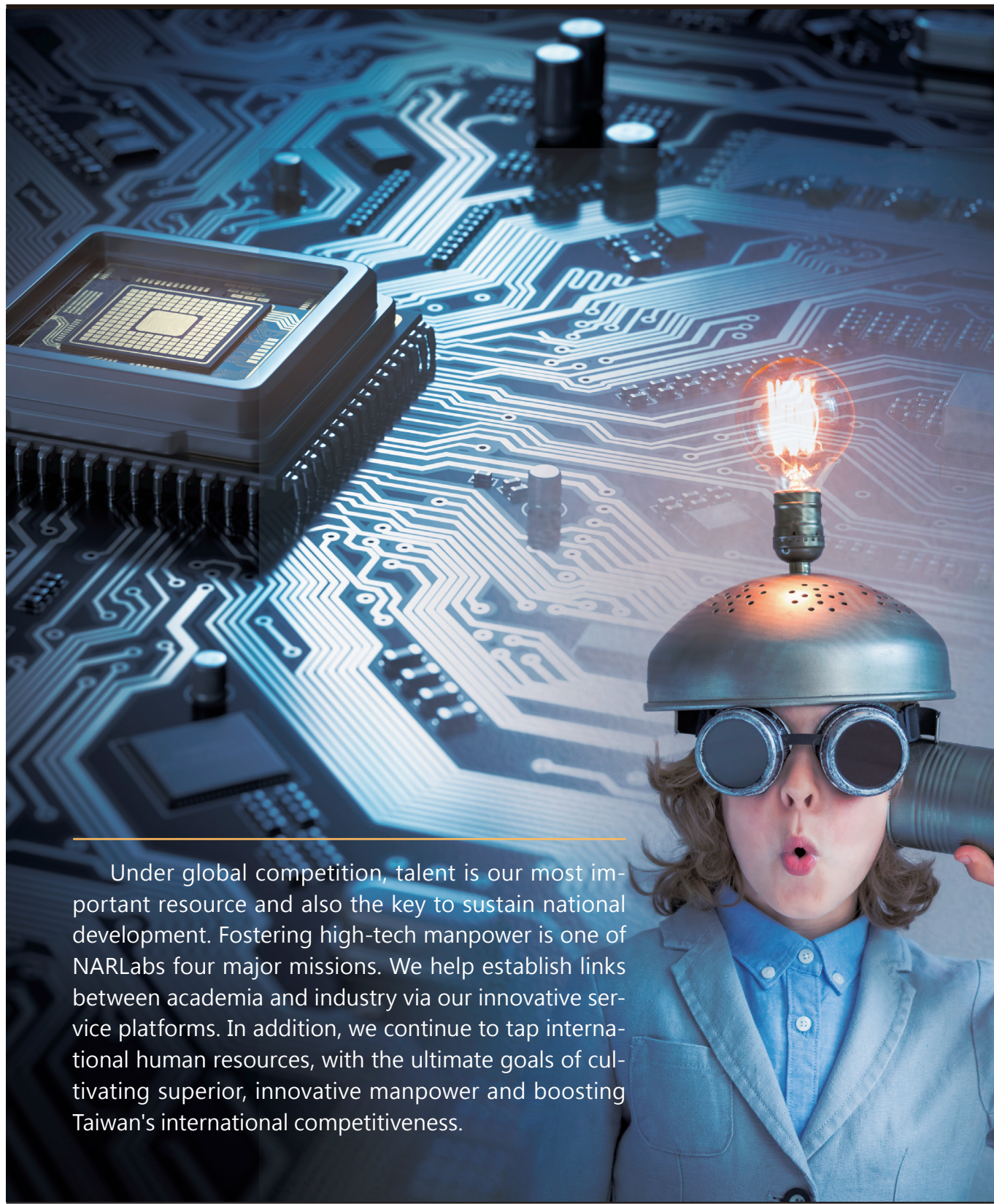


Figure / New observation method of FORMOSAT greatly increases the amount of tropical and subtropical data. (In corporation with University of California, Davis)

In space weather forecasting, FORMOSAT-3 is by far the world's most important provider of ionospheric observation data. There are currently about 5 million radio occultation data to observe the ionosphere, 4.5 million of which are from FORMOSAT-3. In the future, FORMOSAT-7 will provide new observation data for mid- and low-latitude ionospheric once every 30 minutes, and can greatly improve the feasibility of space weather forecasts.

S&T TALENT CULTIVATION

- National Applied Research Laboratories -



Under global competition, talent is our most important resource and also the key to sustain national development. Fostering high-tech manpower is one of NARLabs four major missions. We help establish links between academia and industry via our innovative service platforms. In addition, we continue to tap international human resources, with the ultimate goals of cultivating superior, innovative manpower and boosting Taiwan's international competitiveness.

Watch the Award-winning Video to Learn Interesting Science Facts



Still: Fly to the Outer Space



Still: NLAC-Small Lives, Big Contribution

[NARLabs]

MOST Sent the Popular Science Video "Trailblazers - Stories from the Laboratory" to Elementary Schools, Junior and Senior High schools in Taiwan

The popular science video "Trailblazers - Stories from the Laboratory" subsidized by the MOST, and produced by Dong Tai Communication Co. and NARLabs, was the winner of "Natural Science Best Documentary Television Series" in the 2017 Golden Bell Awards. NARLabs funded and made a public release version of the video, sending it to all elementary schools, junior and senior high schools and five-year junior colleges in Taiwan. Students can watch this

wonderful video for free. Teachers can also use this video to make teaching materials and teaching lessons. By doing so, the educational effect of this extraordinary popular science video could be maximized. NARLabs hopes that the scientific literacy of junior and senior high school students could be elevated and more students will get interested in scientific research, putting an effort into fostering future technology manpower.

[CIC]

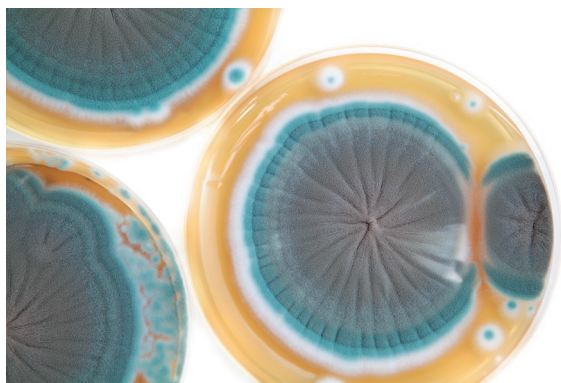
MorSensor Wireless Sensing Bricks Creative Application Design Contest

Exploring Infinite Possibilities of Science and Technology



Group photo of chief competition judge Prof. Yi-Bing Lin, who was also the vice president of National Chiao Tung University, and the gold-medal-winning team

National Chip Implementation Center hosted the 4th MorSensor Wireless Sensing Bricks Creative Application Design Contest in 2018. The champion team won with an Intelligent Respiratory Sensor which aims at enhancing respiratory care of asthma patients. The cross-analysis result of the data gathered by the nitric oxide and airflow sensors in the respiratory sensor could help medical practitioners to identify the levels of inflammation and obstruction in the lungs of the asthma patients. It can also serve as a reference while medical practitioners decide on the administration and withdrawal timing, dosage, and frequency of steroid medications. The respiratory sensor has fulfilled the vision of the contest as it has a high degree of completeness and a highly applicable function targeting the homecare health monitoring and self-care portable device industries.



[STPI]

Cultivating Biomedical Talents and Linking with Innovative Industries

2018 International Drug and Medical Device Development Symposium & SPARK Taiwan DEMO DAY

Executed by STPI, the SPARK Program was launched in 2013 in accordance with the biotechnology industry development planning. This program aims to provide assistance to those that are in the pharmaceutical industry or the medical device industry with potential products but are lacking in initial commercial planning for entrance into the market. On May 7, STPI hosted the "2018 International Drug and Medical Device Development Symposium: Cruising through the Valley of Death" and discussed the challenges the biomedical research teams face during the commercialization process and how to respond. During "Bio Taiwan 2018," STPI also organized the "2018 SPARK Taiwan DEMO DAY" which invited 13 outstanding SPARK teams from National Taiwan University, National Cheng Kung University, National Yang-Ming University, Taipei Medical University, and China Medical University to demonstrate the features of their products and innovation. The DEMO DAY successfully attracted many investors and leaders in industry to approach SPARK teams and seek business opportunities.



2018 International Drug and Medical Device Development Symposium

[TIRI]

The 10th NARLabs *i*-ONE Instrument Technology Innovation Competition

Realizing Ideas, Nurturing Makers



Participants presented their creations to the reviewing committee.

To encourage students to turn imagination into reality with their own hands, TIRI started holding the NARLabs *i*-ONE Instrument Technology Innovation Competition in 2009. It has been ten years since its inauguration, and the quality of proposal submissions continues to set the bar higher. After a decade, the seeds of innovation have bloomed, fulfilling NARLabs' commitment to cultivate scientific research talents.

INTERNATIONAL COOPERATION

- National Applied Research Laboratories -



For international cooperation, NARLabs aims to establish global partnerships and online platforms with its core vision, embracing the pursuit of "Global Excellence, Local Impact". NARLabs strives to promote innovative R&D efforts and a range of international collaborative undertakings to establish exchange channels for leading researchers in Taiwan and abroad.

[NARLabs]

2018 Taiwan International Conference on Green Energy Technology

Focusing on Green Energy Technology Pioneering Development

In order to focus on the research direction of national green energy technology, Taiwan International Conference on Green Energy Technology was held in Tainan on Oct. 8, 2018 with "Renewable, Smart, Happiness" as its major theme. Experts from Belgium, Finland, Germany, Netherland, Japan and Singapore were invited to exchange experience and views toward to the pioneering development of green energy technology with scholars in Taiwan. Over 200 scholars and experts attended this conference. Apart from the science research topics related to the application of green energy, the conference was also centered on the trend of technology development. NARLabs' Vice President Kuang-Chong Wu discussed the worldwide trend and the potential development of green energy technology with Fukushima Renewable Energy Institute (FREA)'s Director-General Masaru Nakaiwa, Dr. Hirohide Furutani and Taiwan Institute of Economic Research (TIER)'s Deputy Director Yen-haw Chen. By exchanging valuable information, NARLabs hopes to inspire some brilliant research ideas and create further collaborative opportunities with international green energy technology R&D organizations through this conference.



[CIC]

CIC Participated in the Development of a Global Photonic Integrated-circuit-Development Roadmap

Helping Taiwan Take Initiative in the Development of Silicon Photonic Integrated Circuits Worldwide

Hann-Huei Tsai, the deputy division director of the Heterogeneous Integration Technology Division of CIC, visited the Netherlands in June 2018 to participate in the World Technology Mapping Forum, where he discussed with United States and European experts on the global development of photonic integrated circuits. This ensured Taiwan's participation in the worldwide development of silicon photonics. The first version of the development roadmap was expected to be announced in the first quarter of 2019.



CIC represents the National Applied Research Laboratories at the World Technology Mapping Forum



WORLD TECHNOLOGY MAPPING FORUM
BUILDING THE FIRST GLOBAL INTEGRATED PHOTONICS SYSTEMS ROADMAP

INTERNATIONAL STRATEGIES AND COLLABORATORS

● UNITED STATES

- Argonne National Laboratory
- BROAD Institute
- International Center for Advanced Internet Research, Northwestern University
- National Oceanic and Atmospheric Administration
- Stanford University
- University of California at Los Angeles
- University of Houston
- University of Washington

● CANADA

- University of Toronto

● GERMANY

- Helmholtz Centre for Ocean Research Kiel
- R/V *SONNE*

● FRANCE

- CEA-Leti
- National Centre for Space Studies
- R/V *Marion Dufresne*

● CZECH REPUBLIC

- Institute of Physics, Academy of Sciences of the Czech Republic

● ENGLAND

- Medical Research Council

● BELGIUM

- imec

● AUSTRALIA

- Australian National Fabrication Facility
- Commonwealth Scientific and Industrial Research Organisation

● NEW ZEALAND

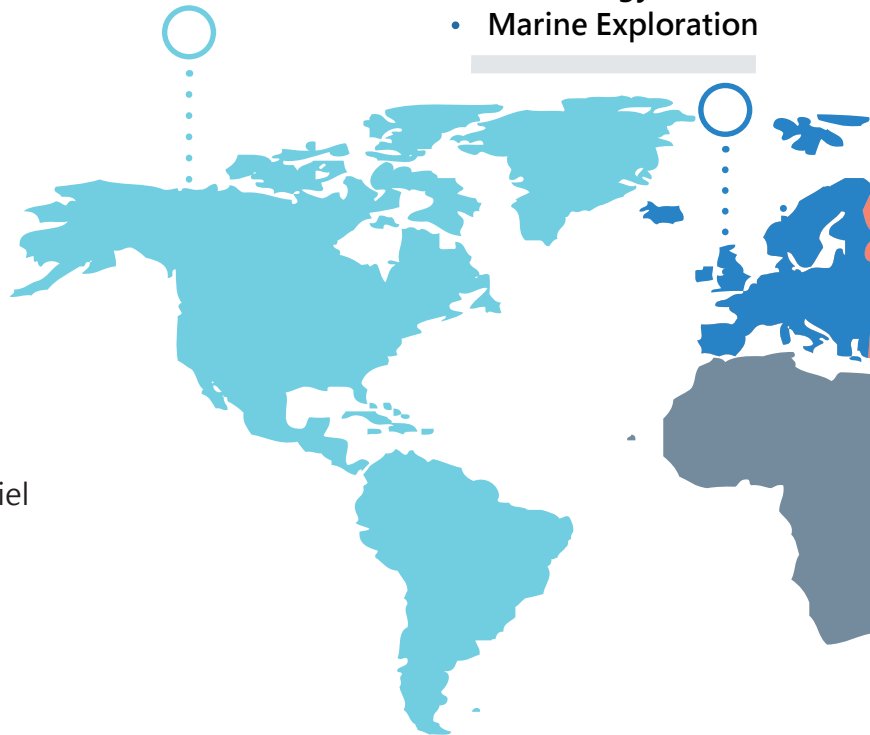
- QuakeCoRE

AMERICA

- Smart City
- Aerospace Technology

EUROPE

- Information & Communication Technology
- Marine Exploration



GLOBAL LAYOUT, TECHNOLOGY DIPLOMACY

NARLabs strives to boost international partnership and academia participation to become an international scientific research organization with "global excellence, local impact".

- Apply multiple international affairs mechanisms
- Dedicated to multilateral academic research
- Support global sustainable development

SOUTHEAST ASIA

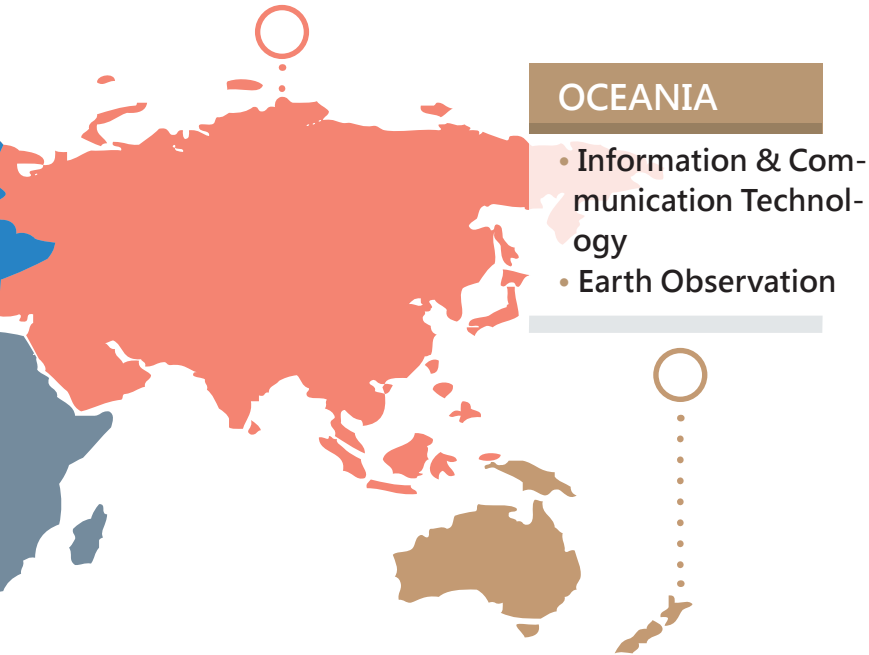
- Disaster Prevention Techniques
- Biomedical Technology

NORTHEAST ASIA

- Artificial Intelligence
- Technology Policies

OCEANIA

- Information & Communication Technology
- Earth Observation

**2018 KEY NUMBERS**

- 75** International collaborative agreements
- 28** International collaborative projects
- 55** International papers and patents
- 4** International collaborative derivative products
- 8** Derivative services

JAPAN

- Earthquake Research Institute, University of Tokyo
- Japan Agency for Marine-Earth Science and Technology
- National Institute of Advanced Industrial Science and Technology
- The Japan Aerospace Exploration Agency
- The RIKEN Center for Computational Science

SOUTH KOREA

- Korea Institute of S&T Evaluation and Planning
- Korea Institute of Science and Technology Information
- National Research Council of Science & Technology
- Seismic Simulation Test Center

HONG KONG

- University of Hong Kong

PHILIPPINES

- Department of Science and Technology

SINGAPORE

- National Additive Manufacturing Innovation Cluster

INDIA

- Indian Institute of Technology, Roorkee
- Institute of Seismological Research

THAILAND

- Geo-Informatics and Space Technology Development Agency
- NARLabs Bangkok Office
- National Science and Technology Development Agency

VIETNAM

- Ministry of Natural Resources and Environment

SOCIAL ENGAGEMENT

- National Applied Research Laboratories -



For social engagement, NARLabs is commissioned to serve as the guardian of Taiwan by developing innovative science and technology for reducing damages from natural disasters and enhancing the quality of living for people in Taiwan. NARLabs' employees devote themselves to fostering Taiwan's technological innovation as S&T volunteers. As climate change causes a growing number of natural disasters, NARLabs researchers have made significant impacts through monitoring and early warning technologies.



Children took part in NARLabs' Open House activity, getting to know national scientific instruments.

[NARLabs]

NARLabs "Scientists Secret Base" Exhibition Opened

Science is Fun! Let's DIY Together!

To enable people to get a feel of difficult science and cultivate more small scientists, NARLabs' ten research centers and scientists arranged four major themes for exhibition: "Space Base," "Fantasy base" and "Secret Database." FORMOSAT-7, unmanned aircraft models and elaborate interactive designs such as aurora, 3D projection, photoelectric games, undersea exploration, aseismic building construction, observation on mice' behaviors and Pride database were displayed. The centers also held various interesting DIY activities, hoping that people can experience the fun of science and take more interest in it.



Scientists went out of laboratories, ushering children into scientific knowledge in our everyday life.

[NARLabs]

More than 2,300 People Took Part in NARLabs' Open House Activities

Enhance People's Scientific Literacy, Spur Their Interests in Science

National Nano Device Laboratories (NDL), National Chip Implementation Center (CIC), National Space Organization (NSPO), National Center for High-performance Computing (NCHC) and Taiwan Instrument Research Institute (TIRI) of NARLabs are located in Hsinchu. To let people have a better understanding of the role NARLabs playing in scientific development and talent cultivation, NARLabs cohosted an Open House activities with the five research centers in Hsinchu on Sept. 1, 2018. The activity attracted more than 2,300 people. A lot of families joined the event to have a glimpse of the research essence in these national scientific research centers. Children lingered at the activities and imperceptibly learned fundamental scientific knowledge and spirit.



Parents and children had fun together, experiencing science in daily lives.



Adults and children experienced science by operating air rockets.

[CIC, NDL]

IC60 – I See The Future Series Event: The Master Forum and Special Exhibition at Huashan 1949 Creative Park

Enabling the Public to Experience the Influence of Integrated Circuits (ICs), Inspiring more Students to Enter the Field of ICs



Opening ceremony of the IC60 Master Forum; from left to right are the president and CEO of SEMI, Ajit Manocha; the founder of the Taiwan Semiconductor Manufacturing Company, Morris Chang; the previous Premier of the Republic of China, William Lai; and the Minister of the Ministry of Science and Technology, Liang-Gee Chen



Cleanroom suit experiential event during the IC60 Huashan Special Exhibition

Taiwan is a primary global supplier and producer of ICs. IC manufacturing is also a crucial driver of Taiwan's economy. The National Chip Implementation Center collaborated with SEMICON Taiwan to host the IC60 Master Forum on September 5, 2018. During this event, the founder of the Taiwan Semiconductor Manufacturing Company, Morris Chang, the father of flash memory, Dr. Simon Min Sze, and the founder of Cadence Design System Inc., Dr. Paul Huang, were invited to give keynote speeches. Moreover, other experts who were the first to be sent to the United States in 1974 to learn about semiconductor technology were invited to share their training experience. Also in 2018, a special IC60 exhibition was hosted at Huashan 1949 Creative Park from September 8 to 18. Individuals from various sectors were invited to attend to understand the importance of ICs, thereby increasing students' interest in researching related topics and demonstrating the limitless possibilities of creating the future using IC technology.

[NLAC]

Executive Office of Mentor Program for Women in Science

The National Laboratory Animal Center implemented the "Mentor Program for Women in Science (WiSE Program)" and invited academic and research mentors to share their life and professional experiences with young female researchers. With the core spirit of "Inheritance", the mentors worked with participants to think about and solve potential problems



The opening ceremony of the WiSE Program Office

encountered in their careers and assisted them stay motivated to keep moving forward. In 2018, a total of 19 mentor-mentee interaction activities were organized with 437 participants. Twelve workshops and 7 online courses were conducted with 1,182 visitors altogether. The Program Office also provided a wide variety of information and event notices to increase the opportunities for female scientists to interact and communicate.

[NARLabs]

Pingtung Technology Pilot Month Officially Launched

Enhance People's Scientific Literacy, Spur Their Interest in Science



Sprinkle scientific seeds to Pingtung, lead students to enjoy the fun of science.



How to live safely in Taiwan, where many earthquakes occur? Through model making, this activity has helped children get a notion of structural safety in buildings.

To shorten rural-urban difference and enable Taiwanese students to know the scientific development of our country, NARLabs held a rural scientific education activity. It was hoped that through scientific model tour and science discovery experience camp, participants including young students could have a better understanding of the status quo of Taiwan technology development, become interested in science and technology and enhance their own scientific literacy. Besides exhibiting the SpaceX Falcon 9 model of FORMOSAT-5, FORMOSAT-7 and model of research vessel *LEGEND*, Remotely Operated Vehicle (ROV) model and simulation models, the activities of "Pingtung Technology Pilot Month" included the discovery experience camp elaborately-designed by National Space Organization (NSPO), Taiwan Ocean Research Institute (TORI), National Center for Research on Earthquake Engineering (NCREE), and National Laboratory Animal Center (NLAC).

[TORI]

Oceanographic Research Vessel *LEGEND* Unveiled for Public Tours

Missions Include Bringing Citizens Closer to the Ocean

The ocean, known as planet Earth's inner space, is a mysterious place full of unknowns. Harsh weather conditions on the seas, complex underwater terrains, and our inherent limitations have made it extremely challenging to work in this area. The TORI-commissioned oceanographic research vessel *LEGEND* was officially inaugurated at the Port of Kaohsiung on May 23, 2018. In August 2018, R/V *LEGEND* departed southern Taiwan and sailed along the east coast of Taiwan to explore the Kuroshio current and to conduct science outreach programs. We made stops at the ports of Hual-



Visitors boarding the *LEGEND* to visit the bridge

ien, Keelung, and Kaohsiung and welcomed the arrival of visitors coming aboard the vessel. By joining the guided tours provided by oceanographic instrumentation professionals and the open-floor information sessions with senior survey specialists, the visitors were able to become familiar with the country's largest oceanographic research vessel and its most advanced oceanographic research equipment, as well as to appreciate the importance of ocean research missions. The open on-board tours at the three ports attracted more than 3,000 visitors.

HISTORY TIMELINE

- National Applied Research Laboratories -

JANUARY

CIC hosted "Amateur Musician System" press conference. This technology was awarded 2016 International Trade Fair "Ideas-Inventions-New Products" (IENA) Special Prize and has obtained a ROC patent.



MARCH



STPI hosted the first "Formosa Grand Challenge" competition to encourage innovators to use their creativity and technology to solve the challenge of speech AI applications.

0123

0223

0301

0305

HIGHLIGHT

President Tsai Ing-wen Received the FORMOSAT-5 Team



FEBRUARY

TAIWAN CAR Lab began field construction.



With the help of "TIRI (formerly known as ITRC), NARLabs" signed a MOU with China Medical University Hospital and National Additive Manufacturing Innovation Cluster (NAMIC) for collaboration on forming the first 3D printing medical team in Asia.

CIC and NDL held the "IC 60- I See the Future!" award ceremony for national writing competition.

The Launch of Research Vessel *LEGEND* Opened a Marine Science New Era

TORI research vessel *LEGEND* launching ceremony



HIGHLIGHT



NCREE announced "Life-Cycle Based Bridge Management System for Disaster Prevention".

JULY

NCREE co-established an AI center with Department of Civil Engineering, National Taiwan University.

0327

0413

0421

0508

0523

0601

0605

0627

0706

APRIL

STPI hosted the "Taiwan Scientific Research Performance from Global Perspectives" press conference, analyzing the quality and performance of paper publication in Taiwan.

MAY

NCHC's Peta-scale supercomputer "TAIWANIA 1" officially launched



JUNE

CIC and Synopsys, Inc. signed a letter of intent for AI technology cooperation.

"New Contribution of Taiwan-France Marine Cooperated Investigation to Taiwan Energy Development" press conference

SEPTEMBER



More than 2,300 people joined NARLabs Open House activities.

TIRI hosted the "Semiconductor Advanced Fabrication and Equipment R&D Alliance" exchange meeting, exhibiting self-made essential equipment and inviting nearly 150 experts from the industry and academia for exchange.



"The Tainan Base of the Nano Chip Center," co-established by NDL, CIC and NCKU, broke ground.

AI Supercomputer "TAIWANIA 2" Beat a New Record

NCHC's self-developed and self-made AI supercomputer "TAIWANIA 2" named 20th-most powerful computer, and 10th-most energy-saving mainframe computer in the world.

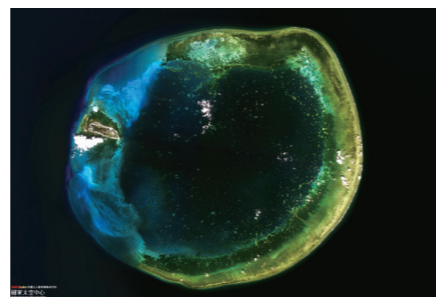
HIGHLIGHT

AUGUST

NLAC provided safety testing services for animal pharmaceuticals, serving the industry while ensuring human and animal health.



FORMOSAT-5 began official imaging operation.



HIGHLIGHT

NLAC New Building Relocation

NLAC launched an initial acceptance inspection of Building G construction in National Biotechnology Research Park, acting in concert with the lump sum contract work of Academia Sinica to carry out joint inspection.

NOVEMBER



NARLabs' "Scientists' Secret Base" Exhibition opened.

0820

0901

0921

0927

1113

1116

OVERVIEW

- National Applied Research Laboratories -



OUR LABORATORIES

- National Laboratory Animal Center
- National Center for Research on Earthquake Engineering
- National Space Organization
- National Center for High-performance Computing
- Taiwan Semiconductor Research Institute
- Taiwan Instrument Research Institute
- Science & Technology Policy Research and Information Center
- Taiwan Ocean Research Institute

The Driving Force behind Prospective Medicine

National Laboratory Animal Center

Being the largest laboratory animal resource center in Taiwan, NLAC also acts as the foundation and key platform for the development of biotechnology industry and biomedical research. In accordance with Taiwan's national development policy in biotechnology, NLAC serves as an animal breeding and testing environment that meets international standards. To uphold its core values of "Quality First, Welfare Foremost", the Center provides diversified animal resources and testing services based on a dual-track approach of advancing scientific application and animal welfare. In supporting pre-clinical evaluation of new drugs, medical devices, and biotechnology products, NLAC aims to fulfill the needs of biomedical product development and medical research and ultimately to accelerate the internationalization of Taiwan's biotechnology industry.

Integration Transcends Limitation

Taiwan Semiconductor Research Institute

National policies have played a crucial role in the success of Taiwan's world-renowned semiconductor industry. The Taiwan Semiconductor Research Institute (TSRI) is the new title given to the Institute that was established through the merging of the National Chip Implementation Center (CIC) and the National Nano Device Laboratories (NDL) in 2019. The CIC and NDL have played an active role in the development of the domestic semiconductor industry, and in the future, the TSRI will continue to provide one-stop services related to device assembly, manufacturing, design, tape-out, testing, and system integration, thereby serving as the strong backbone of industry and academia.



Local Guardian, Global Vision

National Space Organization

NSPO is an institution that integrates space technology development in Taiwan. Through the implementation of various satellite programs, NSPO supports national space missions, promotes scientific research, and drives industrial development. NSPO has completed FORMOSAT-1 scientific, FORMOSAT-2 remote sensing and FORMOSAT-3 meteorological constellation programs. NSPO is currently conducting FORMOSAT-5 and FORMOSAT-7 programs with missions related to remote sensing and meteorology respectively.

Policy Navigation, Technology Innovation

Science & Technology Policy Research and Information Center

With the position and vision as a national S&T policy think tank, STPI grasps the global science & technology trends and performs systematic research in S&T policy to make timely, professional, and objective recommendations in the national policy formulation process. STPI's missions include supporting the government, cultivating innovative and entrepreneurship talents, establishing national and international S&T information systems, and providing integrated services.

Aseismic Homeland, Sustainable Future

National Center for Research on Earthquake Engineering

To meet the need for pre-earthquake preparedness, emergency response and post-earthquake restoration, NCREE develops the three major core techniques: "Earthquake Resistant Structural Test and Numerical Simulation," "Seismic Design and Retrofit Evaluation" and "Rapid Evaluation of Structural Damage Status." NCREE uses the advantages of giant experimental facilities, experimental technology and earthquake database to connect with domestic industries and academia, reinforcing international cooperation for building a sustainable and aseismic homeland in Taiwan.



Ocean Technology, Exploration Pioneer

Taiwan Ocean Research Institute

TORI integrates the R&D of physical oceanography, marine biogeochemistry, marine geologic hazard, and ocean exploration technology, hoping to progressively strengthen the core detection technology, store energy for operating major equipment, and integrate marine environmental information to serve as references for the industry, academia and research community. The acquisition of the research vessel *LEGEND* will accelerate the development of marine-related research topics that are not only extraordinarily valuable to the local community, but also involve forward-looking technology.



Frontier Technology, Dream Incubator

Taiwan Instrument Research Institute

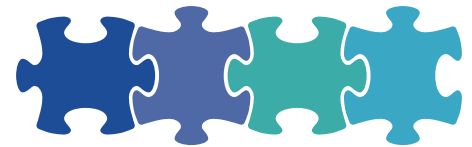
TIRI is the only organization that provides advanced instrumentation research and related instrument system innovations for the fields, including science, engineering, biomedical and agricultural science, etc. By holding the principle of "Drive Technology Innovation to Promote Academic Research," TIRI continues to provide instrument technology solutions and innovative application services for the industry, academia and research organizations. Furthermore, TIRI is also the first organization to offer the one-stop services, including medical devices development, consultation, test and verification. Serving as a national dream team, TIRI is dedicated to assisting the academia in commercializing their creative ideas.

AI Pilot, Future Innovation

National Center for High-performance Computing

NCHC effectively integrates high-performance computing, 100G-bandwidth research and education network, and national-level AI research resources and cloud-based facilities to provide the industry, government, academia and research institutes with a high-performance computing environment for large-scale sharing. NCHC thus lays the foundation for Taiwan's scientific and technological development and promotes AI applications. In the future, NCHC will utilize government database and AI technologies developed by the industry, academia and research institutes to help the industry create high-value AI applications. NCHC's ultimate goals are to upgrade industries and promote innovation, and thereby creating a better future.

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NLAC	National Laboratory Animal Center
NCREE	National Center for Research on Earthquake Engineering
NSPO	National Space Organization
NCHC	National Center for High-performance Computing
TSRI	Taiwan Semiconductor Research Institute
TIRI	Taiwan Instrument Research Institute
STPI	Science & Technology Policy Research and Information Center
TORI	Taiwan Ocean Research Institute

* The list above is arranged in alphabetical order by surname.

LOCATION

TAIPEI

- | NARLabs Headquarters
- | National Laboratory Animal Center
- | National Center for Research on Earthquake Engineering
- | Science & Technology Policy Research and Information Center

HSINCHU

- | National Laboratory Animal Center*
- | National Space Organization
- | National Center for High-performance Computing
- | Taiwan Semiconductor Research Institute
- | Taiwan Instrument Research Institute

TAICHUNG

- | National Center for High-performance Computing*

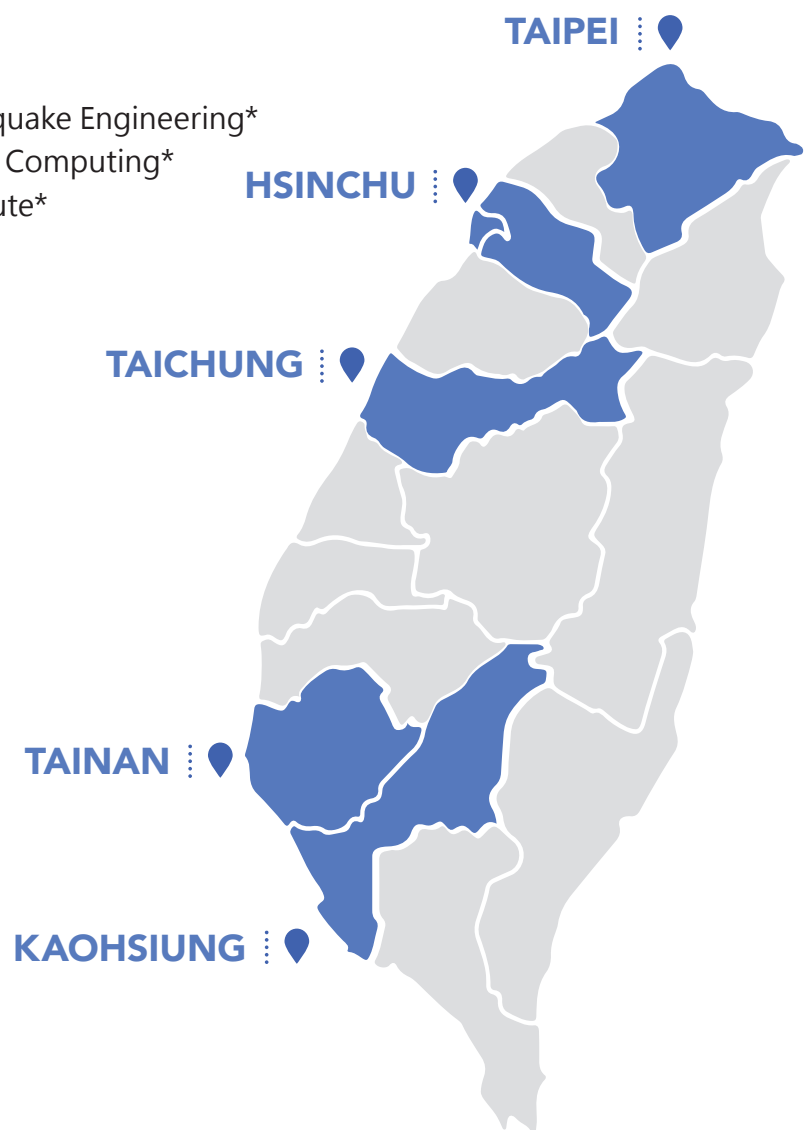
TAINAN

- | National Laboratory Animal Center*
- | National Center for Research on Earthquake Engineering*
- | National Center for High-performance Computing*
- | Taiwan Semiconductor Research Institute*

KAOHSIUNG

- | Taiwan Ocean Research Institute

* Branch Office

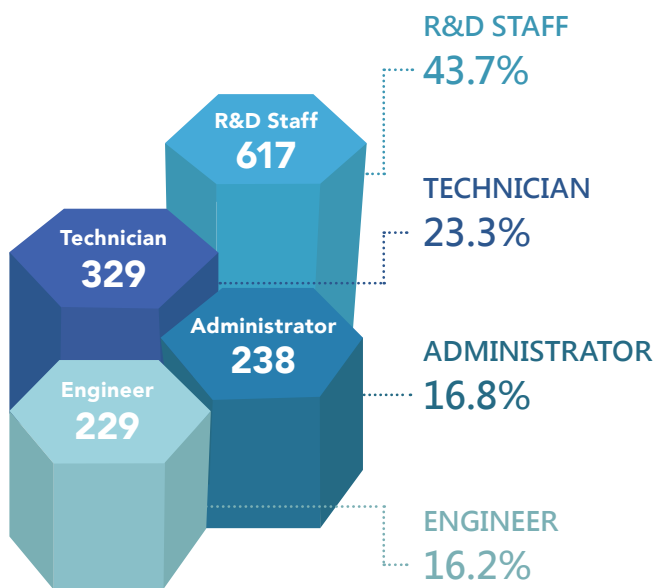


2018 HUMAN RESOURCES

1,413
EMPLOYEES

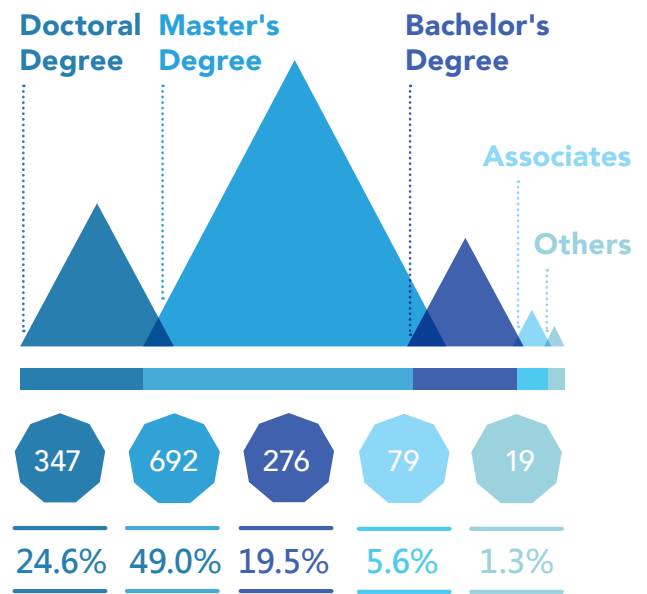
HUMAN RESOURCES PROFILE

Number of Employees

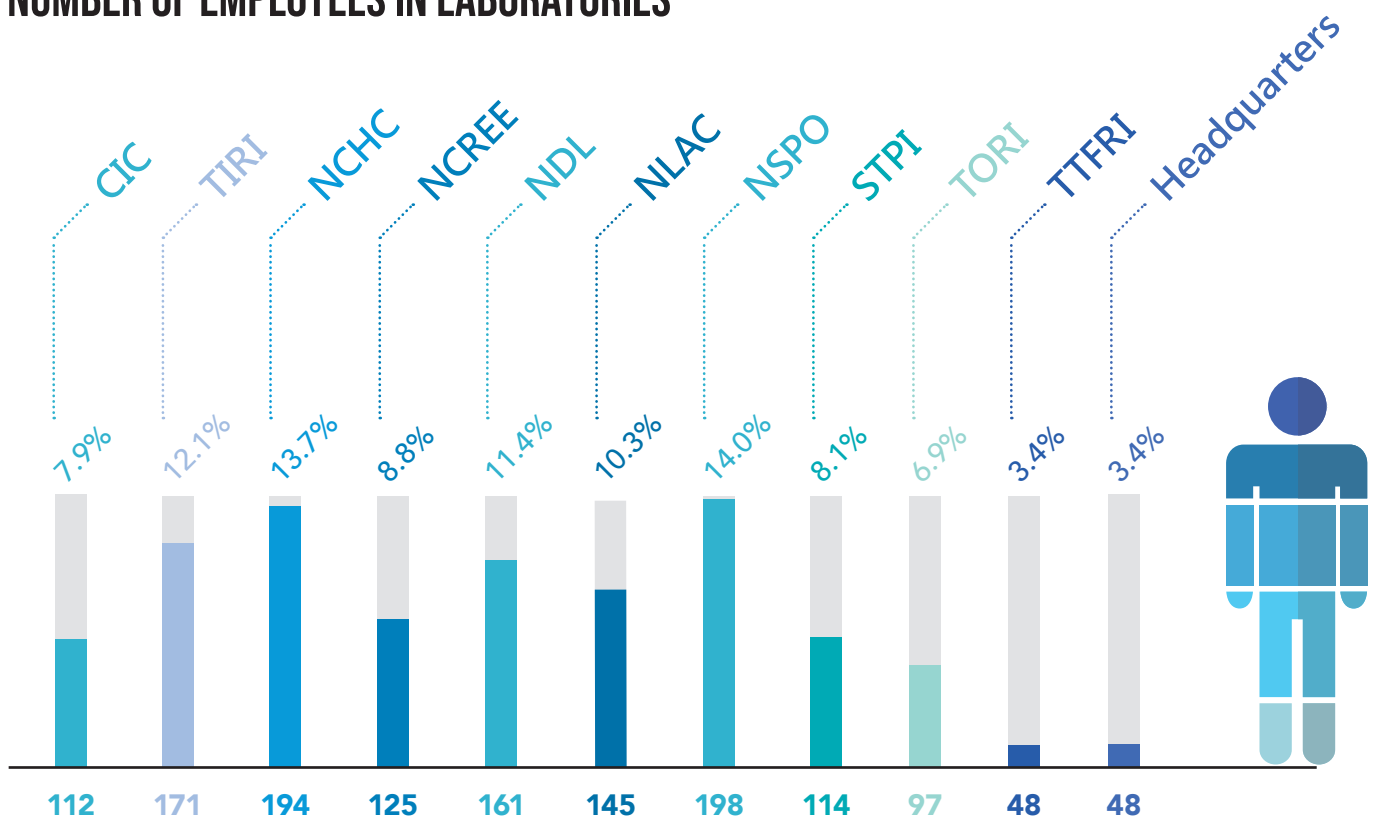


EDUCATION LEVEL

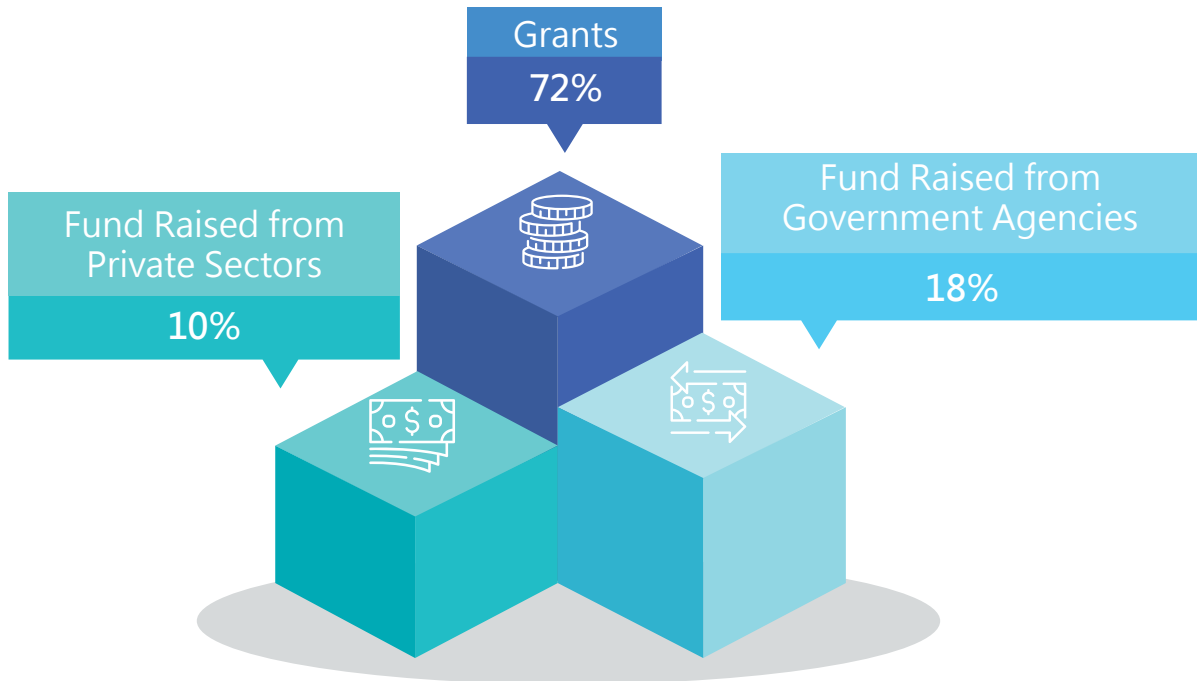
Number of Employees



NUMBER OF EMPLOYEES IN LABORATORIES

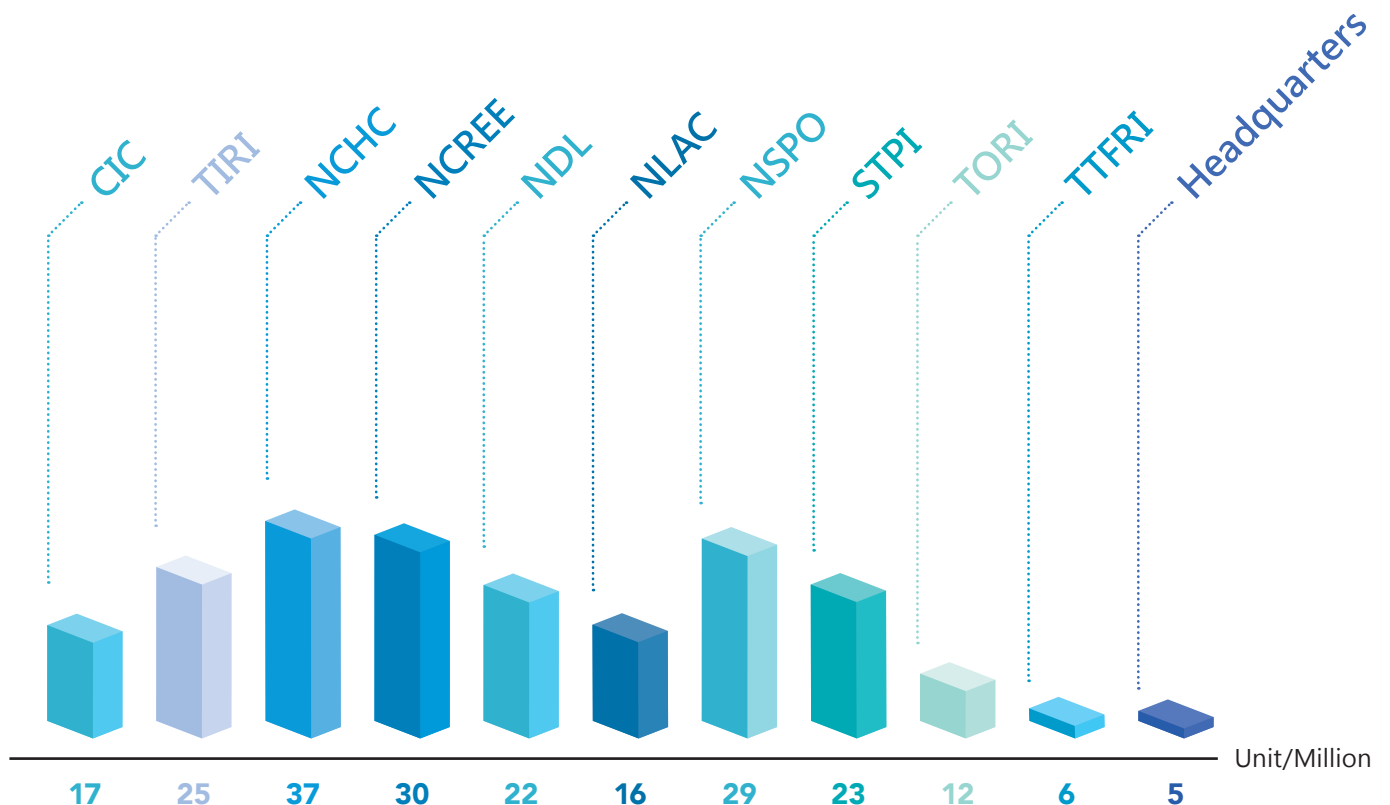


FINANCIAL INFORMATION



Revenue (FY 2018)
(Rate: 1 USD = 30.765 NTD)

Total USD\$ **222**
MILLION



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