UNIVERSITY’S VISION & MISSION

A great global university founded on science and technology, nurturing leaders through research and a broad education in diverse disciplines.
As we stand on the brink of the 21st century’s second
decade, it is clear that the move towards the Fourth
Industrial Revolution is well under way. Industry 4.0
will see immense changes in how humans incorporate
machines in everyday work and play, both as tools, and
perhaps, even as AI “colleagues”.

It is therefore imperative that NTU’s College of
Engineering (CoE) stays focused on how our research
programmes and educational curricula are brought in line
with this metamorphosis. After all, we are responsible for
the next generation of engineers, thinkers and innovators.

IN (RE)SEARCH OF INNOVATION
The field of research remains a key area where CoE can
find a strong foothold on the path to Industry 4.0. It is
important for us to continue collaborating with leading
industry partners to jointly develop technologically
advanced solutions for a sustainable future.

One such collaboration is our partnership with Fraser &
Neave (F&N) to set up a joint lab in Singapore with the
aim of developing innovative products and recipes for F&N’s
range of beverages. Named F&N-NTU F&B Innovation Lab,
this four-year cooperative initiative will see about 30
researchers and students from NTU working with F&N’s
own R&D team to innovate technologies that can be
applied to the fast-moving consumer goods category (FMCG).

Apart from food sustainability and security, FinTech is
another avenue of research. Together with WeBank,
China’s first digital-only bank, NTU CoE set up a FinTech
research centre to support Banking 4.0, where banking
can be personalised and done anytime, anywhere. The
team will also look into how blockchain technology can
enhance banking services, and developing new digital
platforms for financial services using the Internet-of-Things (IoT) and machine learning applications.
In addition to new collaborations, we have also cemented our existing partnership with Rolls Royce, which was renewed with an $88 million joint investment to develop novel technologies for powering the future of aircraft propulsion. In line with the Fourth Industrial Revolution, the Rolls-Royce@NTU Corporate Laboratory will leverage on Industry 4.0 technologies that will connect computers with machines and engines, thus generating valuable data for further enhancements.

INSPIRED TO EDUCATE

We are, first and foremost, an institute of education. To this end, we are continuously enhancing our curricula to reflect changes in the real world. This translates to courses and programmes that not only support our Industry 4.0 vision, but also prepare our students when they leave our honoured halls. This is our promise to them: that they will receive their education through a high value-added, experiential learning journey.

The new SkillsFuture Work-Study Degree Programmes that were launched this year are the perfect example of this. Conjointed in partnership with industry leaders, the four programmes integrate institution-based learning with structured on-the-job training (OJT). Students will be exposed to the professional work environment, allowing them to develop valuable soft skills and cultivate an understanding of real-world practices.

Not forgetting the imminent challenges of Industry 4.0, our other tie-ups with major industry partners will prepare our students for the digital economy and future workplace. Currently, our partnerships with Alibaba, AMD, Delta, Dyson, HP, Rolls-Royce, Singtel, etc. offer our students the opportunity to be exposed to real-world challenges in these corporate laboratory environments under the mentorship of industry leaders and academic mentors. They stand to hone their technical competencies through real-world experience, access to advanced equipment, up-to-date knowledge, and insights on trends, while developing their communication, problem solving skills and creativity.

Through collaborations like these, where our students will have first-hand experiences of real-world working environments, problems and scenarios, I have no doubt that they will graduate with a much higher degree of confidence.

PASSING ON THE WISDOM

I wish to acknowledge our incredible faculty, without whom no amount of strategising and planning can be successfully implemented. They are our mentors and guides, whom we rely on to ignite the sparks of inspiration in our students.

In 2019, CoE recruited 17 full-time faculty members, including one who was appointed Distinguished University Professor in recognition of his academic talents and extraordinary scholarly achievements.

We also appointed six new Visiting Professors from various overseas tertiary institutions, and eight new adjunct faculty members from research institutions and private companies. To further encourage interdisciplinary research, we embarked on inter-school hires and joint appointments. This allows for a more diversified knowledge base for our students.

In addition, the University has created 50 named faculty chair professorships to recognise outstanding achievement at early, mid-career and senior faculty levels. A total of 24 CoE faculty members were appointed named chair professorships in 2019.

To further retain our faculty, the College and our six schools constantly work together to create new opportunities for faculty development, interactions and inter-disciplinary collaborations. With such a strong pool of faculty members, supported by a team of enthusiastic and dedicated researchers and administrative professionals, CoE is in an excellent position to reinforce our standing as one of the top engineering colleges in the world.

THE FUTURE STARTS HERE

2019 has delivered admirably by adding to our strengths and expanding our reach. I would like to express my deepest appreciation to our inimitable faculty, our intrepid researchers, our untiring support staff and administration team, and our enthusiastic cohort of students. While 2020 may have started on an uneven path, I am certain that together, we can engineer a bright year ahead.
College LEADERSHIP

Professor Louis Phee
Dean, College of Engineering

Professor Wang Xin
Chair, School of Chemical and Biomedical Engineering

Professor Wang Rong
Chair, School of Civil and Environmental Engineering

Professor Miao Chun Yan
Chair, School of Computer Science and Engineering

Professor Tan Yap Peng
Chair, School of Electrical and Electronic Engineering

Professor Lam Yeng Ming
Chair, School of Materials Science and Engineering

Professor Ooi Kim Tiow
Chair, School of Mechanical and Aerospace Engineering
Professor Lee Pooi See was the Associate Dean (Faculty Recruitment and Development) from 1 January 2019 to 31 December 2019. Professor Lim Teik Thye is currently the Associate Dean (Faculty Recruitment and Development).
Global Standings

1st in Asia
Quacquarelli Symonds (QS) World University Rankings for Engineering and Technology Faculty 2020

8th in the world
Quacquarelli Symonds (QS) World University Rankings for Engineering and Technology Faculty 2020

8th Most Cited University In The World
Essential Science Indicators 2020 by Clarivate Analytics

15th in the world
Times Higher Education (THE) World University Rankings in Engineering and Technology 2020

Top 15 Universities Globally For Engineering Research Output
Essential Science Indicators 2020 by Clarivate Analytics

FUTURE-READY, BY ALL STANDARDS

The standards to which we hold ourselves are necessarily high. After all, we have a reputation to maintain, being the ones responsible for inspiring and nurturing the next generation of engineers. It is therefore heartening to know that our standards are also held in high esteem on the global stage, which can only propel us to work even harder to do even better.
ALL FOR ONE, ONE FOR ALL

Individually, each of our six schools is exemplary in their respective fields. But together, they shine with the brilliance that can only come from faculty and staff who have put in years of dedication to engineer a sterling education for our students.

Source: Quacquarelli Symonds (QS) World University Rankings by Subject 2020

College of Engineering

School of Materials Science and Engineering
3rd in Materials Science

School of Electrical and Electronic Engineering
6th in Electrical and Electronic Engineering

School of Chemical and Biomedical Engineering
11th in Chemical Engineering

School of Mechanical and Aerospace Engineering
11th in Mechanical, Aeronautical and Manufacturing Engineering

School of Civil and Environmental Engineering
12th in Civil and Structural Engineering

School of Computer Science and Engineering
16th in Computer Science and Information Systems
Our achievements are a reflection of the commitment and dedication that CoE faculty, students, researchers and support personnel inject into all that we do. Our goal is to always deliver excellence in engineering education and research, laying the foundations to reach our maximum potentials at the dawn of Industry 4.0.
Faculty, Staff and Student POPULATION

UNDERGRADUATE AND GRADUATE STUDENT POPULATION

Undergraduate Students
- Full-time: 9,820
- Part-time: 828
Total: 10,648

Graduate Students
- Full-time: 1,771
- Part-time: 811
Total: 2,582

BREAKDOWN OF GRADUATE STUDENT POPULATION BY PROGRAMME TYPE

- Coursework Programme (M.Sc.): 1,036
- Research Programme (Ph.D.): 1,418
- Research Programme (M.Eng.): 128
Total: 2,582

BREAKDOWN OF UNDERGRADUATE STUDENT POPULATION BY PROGRAMME TYPE

- Aerospace Engineering: 489
- Bioengineering: 371
- Chemical and Biomolecular Engineering: 580
- Civil Engineering: 405
- Computer Engineering: 312
- Computer Science: 1,723
- Data Science and Artificial Intelligence: 76
- Electrical and Electronic Engineering: 2,213
- Engineering: 650
- Environmental Engineering: 137
- Information Engineering and Media: 328
- Maritime Studies: 340
- Materials Engineering: 765
- Mechanical Engineering: 1,967
- Renaissance Engineering Programme: 292
Total: 10,648

FACULTY AND STAFF POPULATION

- Faculty*: 540
- Research Staff: 1,191
- Professional, Administrative, Technical and Support Staff: 444
Total: 2,175

*Includes adjunct & visiting professors
FACULTY RECRUITMENT and RESEARCH

FACULTY RECRUITMENT

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<td>2015</td>
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RESEARCH FUNDING (As at 31 December 2019)

TOTAL
S$124.48M

- Ministry of Education (MOE) 20%
- A*Star 39%
- National Research Foundation (NRF) 19%
- Defence 4%
- Other Local Government Agency 9%
- Industry & Foundation 6%
- Others 3%

ENGINEERING CITATIONS

Number of Citations in All Fields (5-year intervals)

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<td>2014-2018</td>
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<td>2015-2019</td>
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Average Citations Per Paper (5-year intervals)

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<td>2013-2017</td>
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<td>2014-2018</td>
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<tr>
<td>2015-2019</td>
<td>14.28</td>
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</table>
OPTIMISATION
Preparation our Engineers for Industry 4.0

Our students carry within them the seeds of innovation to meet the novel needs of tomorrow’s world. It is our responsibility to nurture their passions and prepare them to achieve their finest results, both within the classroom and in the workforce.
Undergraduate STUDIES
ENGINEERING
OUR FUTURE

To nurture young minds on their journey in Engineering, that is CoE’s main goal. Our programmes empower students to take charge of their own learning process, and to pursue their ambitions, on a foundation that grows organically from their strengths, abilities and interests.

The innovative and industry-relevant programmes offered by our six schools cater to more than 10,000 undergraduates from diverse backgrounds. In addition to 11 single-degree Bachelor of Engineering programmes and 2 Bachelor of Science programmes, students have the choice of taking up a minor from over 35 disciplines, a second major or pursuing a double degree.

There is also our flagship programme - the Renaissance Engineering Programme (REP) which is an integrated programme that awards a Bachelor of Engineering Science and Master of Science in Technology Management at the end of four-and-a-half years. The REP is conducted in collaboration with leading institutions such as London’s Imperial College, University of California, Berkeley and Canada’s University of British Columbia, University of Toronto and University of Waterloo, as well as with public agencies and industry.

To further prepare our students for the Fourth Industrial Revolution through enhanced digital literacy, the college has also introduced courses on Computational Thinking, and Data Science and Artificial Intelligence.

We are fortunate to have been able to offer valuable professional internship programmes to our students, thanks to our strong working relationships with industry partners. These internships are essential to expose our students to real-life environments in preparation for their careers. We have also launched four SkillsFuture Work-Study Degree Programmes (WSDPs) in partnership with companies. Under the SkillsFuture WSDPs, institution-based learning is integrated with structured on-the-job training to better prepare students for the workforce after graduation.
With increasing globalisation, our immersion programmes are more essential than ever, giving our participating students a multifaceted experience in foreign environments, broadening their horizons, and helping them initiate networks that will be beneficial to their future. Through our holistic approach, our students will be well-equipped with both technical and soft skills, an important balance that will see them through future challenges.
As research is an important area for CoE, outstanding second and third year students are invited to take part in NTU’s prestigious Undergraduate Research Experience on CAmpus (URECA) programme. Over a period of 11 months, students will pursue an independent research project under the supervision of a professor. In addition to experiencing an exceptional research environment, they will also be conferred NTU President Research Scholar (NTU PRS) status.

11
Bachelor of Engineering Programmes

2
Bachelor of Science Programmes

5
Second Majors

OUR REPETOIRE
Here is the list of degree programmes offered in 2019:

**Bachelor of Engineering (B.Eng.) Programmes**
- Aerospace Engineering
- Bioengineering
- Chemical and Biomolecular Engineering
- Civil Engineering
- Computer Engineering
- Computer Science
- Electrical and Electronic Engineering
- Environmental Engineering
- Information Engineering and Media
- Materials Engineering
- Mechanical Engineering

**Bachelor of Science (B.Sc.) Programmes**
- Data Science and Artificial Intelligence
- Maritime Studies

**Double Degree Programmes**
- Computer Engineering/Computer Science and Business (with specialisation in Business Analytics)
- Engineering* and Economics
**Second Majors**
- Bachelor of Engineering in a chosen major with a Second Major in Business
- Bachelor of Engineering in Bioengineering/Chemical and Biomolecular Engineering with a Second Major in Food Science and Technology
- Bachelor of Engineering in Materials Engineering with a Second Major in Medical Biology
- Bachelor of Engineering in Bioengineering/Materials Engineering with a Second Major in Pharmaceutical Engineering
- Bachelor of Engineering in Civil Engineering/Electrical and Electronic Engineering/Environmental Engineering/Mechanical Engineering with a Second Major in Society and Urban Systems
- Bachelor of Science in Maritime Studies with a Second Major in Business

**Integrated Programme**
- Renaissance Engineering Programme

* In a chosen major
* All Bachelor of Engineering programmes are accredited by The Institution of Engineers Singapore, the Singapore signatory of the Washington Accord, through its Engineering Accreditation Board. The Washington Accord is an international agreement for mutual recognition of the substantial equivalence of engineering academic programmes in satisfying the academic requirements for the practice of engineering at the professional level.
WORK FORCE - READY
INTEGRATED ON-THE-JOB EXPERIENCE

To enhance students’ readiness for the workplace after graduation, NTU’s College of Engineering has launched four SkillsFuture Work-Study Degree Programmes (WSDPs) by integrating institution-based learning with structured on-the-job training (OJT) in partnership with companies.

The four CoE’s WSDPs were introduced to the following programmes:

1) Bachelor of Engineering in Materials Engineering
2) Bachelor of Engineering in Mechanical Engineering (Design Stream)
3) Bachelor of Science in Data Science and Artificial Intelligence
4) Bachelor of Science in Maritime Studies

CoE’s WSDPs comprise approximately 80 weeks of OJT integrated into the four-year undergraduate curriculum. Students will benefit from exposure to professional work environments, allowing them to learn on the job, develop soft skills and cultivate an understanding of real-world practices through multiple internships that culminate in an industry-sponsored final year project (ISFYP).

Some of the industry partners on board these WSDPs include multinational engineering and electronics company Bosch, pharmaceutical giant GSK, semiconductor industry heavyweight Global Foundries, and German automotive manufacturing company Continental Corporation.

For more information on the CoE’s WSDPs, please scan the QR code or visit the URL:

Graduate STUDIES

A CONVERGENCE OF IDEAS

Forming a substantial portion of our student body, the number of our graduate students spans close to 2,600, and hail from all over the world. Within this melting pot of diversity is a dynamic cohort who are seeking to expand their knowledge base and gain a richer education experience. This learning-centric community comprises 60% research students, and 40% graduate coursework degree students.

COLLABORATIONS WITH THE WORLD

In line with the rapid globalisation of the world, CoE offers dual or joint degree programmes with global partners, providing students the ideal multi-disciplinary, collaborative learning environment. Students in these programmes will be able to grow their knowledge under the mentorship of faculty members from both universities, as well as attend classes at both campuses. Not only do these programmes expand our students’ experiences, they also allow them to gain insights from a wider pool of faculty and researchers.
LIST OF GRADUATE PROGRAMMES OFFERED IN 2019

COURSEWORK
Programmes by coursework lead to Master of Science (M.Sc.) degrees. The list of M.Sc. programmes offered in 2019 is as follows:

School of Civil and Environmental Engineering
- M.Sc. (Civil Engineering)
- M.Sc. (International Construction Management)
- M.Sc. (Maritime Studies)

School of Computer Science and Engineering
- M.Sc. (Artificial Intelligence)

School of Electrical and Electronic Engineering
- M.Sc. (Communications Engineering)
- M.Sc. (Computer Control and Automation)
- M.Sc. (Electronics)
- M.Sc. (Power Engineering)
- M.Sc. (Signal Processing)
- M.Sc. (Green Electronics)
  - Joint Degree with Technical University of Munich (TUM), Germany. Admits only full time students.
- M.Sc. (Integrated Circuit Design)
  - Joint Degree with Technical University of Munich (TUM), Germany. Admits only full time students.

School of Materials Science and Engineering
- M.Sc. (Materials Science and Engineering)

School of Mechanical and Aerospace Engineering
- M.Sc. (Manufacturing Systems and Engineering)
- M.Sc. (Mechanical Engineering)
- M.Sc. (Project Management)
- M.Sc. (Smart Product Design)
- M.Sc. (Supply Chain and Logistics)
- M.Sc. (Systems and Project Management)

RESEARCH PROGRAMMES
All our engineering schools offer research degree programmes that lead to Master of Engineering (M.Eng.) or Doctor of Philosophy (Ph.D.) degrees.
NURTURING TALENTS IN OUR MIDST

SENSE TIME-N TU TALENT PROGRAMME LAUNCH CEREMONY
30 January 2019

SENSE TIME, the world’s leading artificial intelligence (AI) startup, and Nanyang Technological University, Singapore (NTU Singapore) have partnered to launch the Sense Time-NTU Talent Programme to nurture researchers working at the forefront of AI related fields such as deep learning and computer vision.

This is Sense Time’s first university talent programme in Singapore and is part of the Singapore Economic Development Board’s (EDB) Industrial Postgraduate Programme, an initiative to train postgraduate students in R&D through working on projects with companies in Singapore. The research projects will address areas related to deep learning, an aspect of AI that is concerned with emulating the learning approach that humans use to gain certain types of knowledge, and computer vision, which involves computers identifying and processing images like human vision does. The results will provide the appropriate output, action or analysis.

This four-year programme welcomes all Singapore citizens and Singapore permanent residents.

Candidates will have to meet the university’s admission and academic requirements and would have obtained a Bachelor’s or Master’s degree in Computer Science, Electrical and Electronic Engineering, Mathematics, Physics, or other related areas. Successful candidates will join Sense Time as full-time employees while pursuing full-time Ph.D. studies at NTU.

The programme will support each candidate’s tuition fees for four years, as well as provide a monthly stipend of S$5,000. The candidate may also have the opportunity to work on Sense Time’s projects in other cities, in addition to financial support for conferences and other benefits.

Did You Know?
This is Sense Time’s first university talent programme in Singapore and is part of the Singapore Economic Development Board’s (EDB) Industrial Postgraduate Programme that trains postgraduate students in R&D through working on projects with companies in Singapore.
BREAKING NEW GROUND

A BETTER WORLD THROUGH AI

The Master of Science in Artificial Intelligence (AI) programme is created for students who wish to develop, design and implement AI systems and at the same time cultivate a deep understanding of AI for project management and policy making. The programme emphasises on AI theory, techniques and tools to solve real-world problems with multiple types of constraints, e.g. problems with limited training data and big data problems.

Equipped with both theoretical and activity-based learning, this will allow graduates to upgrade their competencies and skills. The core courses focus on the foundations of AI knowledge, such as machine learning and deep learning, while a wide range of elective courses in different domains, such as image, video, text and Internet-of-Things (IoT) data are available to deepen understanding and knowledge in this specialisation.

The programme is run mainly by faculty from the School of Computer Science and Engineering (SCSE). SCSE also engages faculty members and research scientists from other schools and research institutions, such as School of Humanities, School of Physical and Mathematical Sciences and A*STAR to teach the programme.

THE POWER OF TWO

The School of Materials Science and Engineering from NTU Singapore and Sungkyunkwan University (SKKU), South Korea, have partnered to establish a dual doctoral programme with the goal of enhancing the academic relations and collaboration in scientific research. This dual doctoral programme allows Ph.D. level candidates at NTU and SKKU to earn two Ph.D. degrees, one from each university. The programme also aims to attract outstanding students, nurture future leaders for Singapore and South Korea, and advance knowledge and learning at the highest level.
Our vision of new discovery and growth lies in Research. At CoE, with the support of government, industry, and peers, we encourage the spirit of innovation through rigorous research and investigation. Through our efforts, we will forge the path to reach a better world for all.
Collaborative research continues to be one of our strengths.
The College of Engineering (CoE) research programmes initiated in 2019 showcased our growing capabilities in artificial intelligence (AI), machine learning, construction, healthcare diagnostics, and robotics.

Collaborative research continues to be one of our strengths, and the setting up of the following programmes have helped to further widen our network.

Rolls Royce-NTU Partnership – Following the successful completion of its first phase, this project entered Phase 2 in 2019, focusing on applying Industry 4.0 technologies to the future of aircraft propulsion.

Joint NTU-WeBank Research Centre on Fintech – In line with Singapore’s move towards a cashless society, this collaboration will support Banking 4.0, which allows for personalised banking to be conducted in any setting.

SenseTime-NTU Talent Programme – This collaboration will enhance our AI capabilities through nurturing researchers at the forefront of the AI technologies.

Polymer Matrix Composite Program (PMCP) and Structural Metals Alloys Programme (SMAP) – These are partnerships with other local universities and various research institutes under the Agency for Science, Technology and Research (A*STAR) that will focus on the manufacturing of high performance polymers and alloys respectively.

Construction research initiatives in 2019 embraced Industry 4.0 through the application of robotics and AI to address the challenges associated with this labour-intensive industry. Solutions include cyber-physical systems for construction automation, autonomous monitoring of construction project progress, and robotic transportation and hoisting of heavy materials.

AI and machine learning have also been applied to diverse uses in construction, from geological modelling in urban planning and underground construction to the management of a maintenance programme to reduce cases of spalling in Housing & Development Board flats in Singapore.

Other breakthroughs in construction research for 2019 include the time-saving 3D-printed bathrooms, and ready-to-stick polymer wraps that can increase the lifespan of existing concrete pillars.

Furthering our successes in healthcare and biomedical research in recent years, 2019 saw the development of healthcare-related diagnostics, such as a proof-of-concept chip that can analyse the health of a patient’s white blood cells, and an imaging probe that can detect the early onset of acute kidney failure.

These early detection tools will greatly enhance clinical outcomes, improve treatment choices and promote better disease management. In addition, a team working jointly with the National University Health System (NUHS) has developed a self-inflating weight management capsule as a potential non-invasive treatment option for obese patients.

The past year has also seen successes in translating natural systems to engineered solutions. The team that introduced the “IKEA Bot” in 2018 has developed a robot with human-like dexterity, capable of handling fragile items. Another team is working on mimicking the principles of marine bio-adhesive systems in mussels to help improve the longevity of synthetic glues in the presence of moisture, with applications in marine and offshore coatings, flexible electronics and tissue glue. The launch of the Max Planck-NTU Joint Laboratory for Artificial Senses also places NTU in a key position for research into artificial senses for the development of innovative robotics and healthcare solutions.

▲ A team is working on mimicking the principles of marine bio-adhesive systems in mussels and sandcastle worms to help improve the longevity of synthetic glues in the presence of moisture with applications in marine and offshore coatings, flexible electronics and tissue glue.
Inspiring Breakthroughs

Inspired by the human body, the secret lies in an organic substance that circulates in the human bloodstream, called a chelating agent, which can detect and bind to heavy metal ions. After binding, it prevents the heavy metal ions from interacting with other molecules and enzymes in the body, and marks it for excretion.

By combining a chelating agent with an optical measurement system, Associate Professor Yong Ken-Tye and Professor Tjin Swee Chuan from NTU’s School of Electrical and Electronic Engineering developed a handheld device that generates test results quickly and accurately.

The device consists of an optical fibre sensor modified with a chelating agent, and a laser that shines through it. In a water sample contaminated by heavy metals, the metal ions will bind to the chelating agent on the optical fibre sensor. This induces a shift in the output light spectrum, from which the device’s processing unit then calculates the concentration of heavy metals in the sample. The process takes approximately five minutes.

The NTU invention is able to detect heavy metal contamination at parts-per-billion precision. This level of sensitivity is in line with the safety limit requirements in Singapore that falls within the World Health Organisation’s standards. For instance, the device can detect lead levels of 5 parts per billion, which is lower than the 10 parts per billion limit stipulated by the Environmental Public Health Act in Singapore. The sensitivity of the sensor in the NTU handheld device is also not limited by exposure to air, and remains effective up to a temperature of 40°C.

After filing two patents, the NTU team has now successfully incorporated a spin-off, Waterply. It is now working with other local companies to collect more data through their invention to improve the accuracy of the device.

Waterply is also collaborating with a state-owned company in China to develop next-generation water...
sensors that can tackle water pollution. It could also be integrated into appliances for domestic use, such as water filtration systems.

The research project was supported by NTU’s Nanyang Environment and Water Research Institute (NEWRI), and NTUitve, NTU’s innovation and enterprise company.

Did You Know?

The NTU invention is able to detect heavy metal contamination at parts-per-billion precision. The sensitivity of the sensor in the NTU handheld device is also not limited by exposure to air, and remains effective up to a temperature of 40°C.

▲ (from left) Professor Liu Ai Qun and Associate Professor Kwek Leong Chuan showing the tiny 3mm quantum communication chip embedded on the bottom right of the green circuit board, which is 1,000 times smaller than current setups and provides almost unhackable levels of encryption. (Photo credit: NTU Singapore)

QUANTUM LEAP

NTU Singapore researchers develop quantum communication chip 1,000 times smaller than current setups

In the race to develop better cybersecurity, the gold standard is quantum technology. By using quantum algorithms and quantum keys, security data and information can be securely delivered without risk of interception or unauthorised decryption.

Led by NTU Professor Liu Ai Qun from NTU’s School of Electrical and Electronic Engineering, and Associate Professor Kwek Leong Chuan from Quantum Science and Engineering Centre (QSec) NTU, the team of researchers has developed a quantum communication chip that is 1,000 times smaller than current quantum setups, but offers the same superior security for which quantum technology is known.
Roughly 3mm in size, the chip uses quantum technology to provide enhanced security compared to existing standards. It does this by integrating passwords within the information that is being delivered, forming a secure ‘quantum key’. After the information is received, it is destroyed along with the key, making it an extremely secure form of communication.

It also needs 1,000 times less space than current quantum communication setups that can be as big as a refrigerator or even take up the space of an entire room or office floor. This opens doors for more secure communication technologies that can be deployed in compact devices such as smartphones, tablets and smart watches. It also lays the foundation for better encryption methods for online transactions and electronic communication. Furthermore, as the new chip uses standard industry materials such as silicon, it will be cost effective and easy to manufacture.

The team’s findings were published in a leading peer-reviewed journal, Nature Photonics.

The QSec NTU team is now looking to develop a hybrid network of traditional optical communication systems and quantum communication systems. This will improve the compatibility of quantum technologies that can be used in a wider range of applications such as internet connectivity.

Did You Know?

At about 3mm in size, the tiny chip is 1,000X smaller than current setups.
GETTING A FIRM GRIP ON ROBOTICS

NTU Singapore start-up unveils robot with human-like dexterous grip

Eureka Robotics, a robotics technology start-up from NTU, has unveiled a new robot that can pick up delicate optical lenses and mirrors with care and precision, just like a human hand. Named Archimedes, this built-in-NTU innovation was supported by SMART (Singapore MIT Alliance for Research and Technology).

Led by Associate Professor Pham Quang Cuong from NTU’s School of Mechanical and Aerospace Engineering, Archimedes has a 6-axis robot arm controlled by algorithms that use Artificial Intelligence (AI) to plan its motion and determine how much force to exert in its grip. The system can mimic the dexterity of human fingers and the visual acuity of human eyes.

With its finely-tuned mechanics, Archimedes can slot lenses and mirrors of different sizes into a custom loading tray, to get them ready for coating. This will be a boon to manufacturers of optical products such as cameras, medical imaging and eyewear, as it eliminates defects in production and improves productivity.

The accuracy of Archimedes in placing objects is within a tenth of a millimetre, yet it does so with the gentleness of a human touch, made possible by its control algorithms. While the robot also takes a few hours to slot delicate optics into a designated tray just like a human operator, the operator can now focus on higher-level tasks after taking three minutes to start the robot on its job. Using AI-powered robots will also enable manufacturers to collect real-time data, which can be analysed to improve their production processes.

Did You Know?

The Archimedes tri-prong gripper can pick up sensitive lenses easily and accurately.

(From left) Associate Professor Pham Quang Cuong and lead engineer Dr Pham Tien Hung, with the new robot that has human-like dexterous grip.
BLOOD TEST ON A CHIP

NTU Singapore scientists build chip to analyse health of white blood cells

A team of NTU scientists has developed a lab-on-a-chip system that can identify the health aspects of a person’s immune system from a drop of their blood within minutes.

Using a combination of microfluidics – tiny microscopic channels that can isolate white blood cells from blood – and electrical sensors, the new chip detects differences in the electrical properties of white blood cells taken from healthy and diabetic patients.

The chip first physically separates the various blood cells by size into the different outlets, like a coin-sorting machine. The isolated white blood cells are then run through a special channel where electrical impedance is measured for each cell at a very high speed (hundreds of cells per second).

The electrical impedance of an abnormal cell is usually higher than the impedance of a healthy cell, so a higher reading could indicate that there might be a health issue that needs further investigation.

The proof of concept device may one day help doctors to quickly gain insight into a person’s immune system, and spot early signs of inflammation and infection that could signal the need for further in-depth tests.

Designed and built by Assistant Professor Hou Han Wei and Assistant Professor Holden Li, both from NTU’s School of Mechanical and Aerospace Engineering, their invention, if successful in further laboratory and clinical assessments, could be turned into a portable device suitable for family clinics and polyclinics.

As immune health is often implicated in cardiovascular diseases, the device can potentially be an additional screening tool for doctors to use for early detection of heart diseases. In Singapore, cardiovascular diseases accounted for 30.1 per cent of all deaths in 2017 while diabetes is a serious health problem which affects about 10 per cent of the world’s population.

A prototype device and the engineering principles behind it were reported in two peer-reviewed journals: Lab on a Chip and Biosensors and Bioelectronics.

The material used to make the new lab-on-a-chip is a common medical-grade polymer and is easily manufactured using existing machinery, and can be made into a desktop-sized machine for use in clinics.

The scientists are doing more research on what different electrical impedance readings signify, so as to build a sort of reference library for an automated analysis, and will be working with doctors to test their prototype in a clinical setting.

Did You Know?

The chip works by:

1. Physically separating the various blood cells into different outlets.
2. Measuring the electrical impedance of isolated white blood cells at very high speed.
PROBING THE DEPTHS OF KIDNEY HEALTH

NTU Singapore engineers develop probes to detect acute kidney failure early

Engineers from Nanyang Technological University, Singapore (NTU Singapore) have developed a type of imaging probe that allows for earlier detection of acute kidney failure, a rapidly-developing condition that can be fatal.

Acute kidney failure usually occurs in a few hours or a few days, and is most common among patients who are critically ill and need intensive care. Current diagnostic platforms are unable to detect early stage, premorbid changes that underlie acute renal failure.

The new molecular imaging probe developed by the NTU team led by Associate Professor Pu Kanyi from the School of Chemical and Biomedical Engineering, in contrast, is sensitive enough to track changes in the biological processes triggered by the onset of the condition. The new renal probes, which have been tested in mice, are injected into the blood-stream. They ‘light up’ upon detection of molecular changes caused by the onset of acute kidney failure.

The NTU-developed molecular renal probes were capable of detecting the onset of the condition 1.5 days earlier than current molecular imaging procedures.

Associate Professor Pu envisions the use of these probes in an intensive care unit setting, where early detection of acute renal failure is paramount to a patient’s survival.

Aside from testing the probe’s ability to detect signs of acute kidney failure, the NTU team found that the probe has high renal clearance – more than 97 per cent of the probes injected into mice flowed through the kidneys, and were excreted as part of urine.

The probe’s high renal clearance efficiency means these probes could potentially be used in test strips for urine samples, making it a non-invasive method of detecting acute kidney failure.

The findings were published in Nature Materials in May 2019 and the team has filed a Singapore patent on this technology.

Did You Know?

The NTU-developed molecular renal probes were capable of detecting the onset of the condition 1.5 days earlier than current molecular imaging procedures.

Associate Professor Pu Kanyi (on the left) holding up the luminescent imaging probes that could allow for early detection of acute kidney failure.

(Photo credit: NTU Singapore)
SWALLOW THIS
MANAGING OBESITY WITH A PILL

NTU Singapore and NUHS scientists develop swallowable self-inflating capsule to help tackle obesity

A team from Nanyang Technological University, Singapore (NTU Singapore) and the National University Health System (NUHS) has developed a self-inflating weight management capsule that could be used to treat obese patients.

Called the EndoPil, the prototype capsule contains a balloon that is self-inflated with a handheld magnet once it is in the stomach, thus inducing a sense of fullness. Its magnetically-activated inflation mechanism causes a reaction between a harmless acid and a salt stored in the capsule, which produces carbon dioxide to fill up the balloon. The concept behind the capsule is for it to be ingested orally, though trials using this route for administration have not yet begun.

Designed by a team led by Professor Louis Phee, NTU Dean of Engineering, and Professor Lawrence Ho, a clinician-innovator at NUHS, such an orally-administered self-inflating weight loss capsule could represent a non-invasive alternative to tackle the growing global obesity epidemic.

Currently, moderately obese patients and those who are too ill to undergo surgery can opt for the intragastric balloon, which is inserted into the stomach via endoscopy under sedation. It is removed six months later via the same method. However, because it is a surgical procedure, not all patients are open to this option.

It is also common for patients who opt for the intragastric balloon to experience nausea and vomiting, with up to 20 per cent requiring early balloon removal due to intolerance. The stomach may also get used to the prolonged placement of the balloon within, causing the balloon to be less effective for weight loss.

The novel made-in-Singapore weight loss capsule, designed to be taken with a glass of water, could overcome these limitations.

Each capsule should be removed within a month, allowing for shorter treatment cycles to ensure that the stomach does not grow used to the balloon’s presence. As the space-occupying effect in the stomach is achieved gradually, side effects such as vomiting and discomfort can be avoided.

The team is now working on programming the capsule to biodegrade and deflate after a stipulated time frame, before being expelled by the body’s digestive system.

A US patent has been granted in 2016 for the balloon inflating mechanism, which was published in scientific journal PLoS ONE. A new US patent has been filed for the latest innovation.

After improving the prototype, the team hopes to conduct another round of human trials in a year’s time – first to ensure that the prototype can be naturally decompressed and expelled by the body, before testing the capsule for its treatment efficacy.

Professor Phee and Professor Ho will also spin off the technology into a start-up company called EndoPil. The two professors previously co-founded EndoMaster, one of Singapore’s most prominent deep tech startups in the field of medical robotics.

▲ (from left) Professor Lawrence Ho and Professor Louis Phee developed EndoPil, an orally-administered self-inflating weight loss capsule to treat obese patients. (Photo credit: NTU Singapore)
WRAP IT UP
STRUCTURAL PROTECTION MADE EASY

▲ (from left) Research Associate Choong Jun Jie and Associate Professor Ng Kee Woei, who is holding a structure that is reinforced with FasRaP. (Photo credit: NTU Singapore)

New quick-fix wrap by NTU and JTC can repair and reinforce existing structures

A new ready-to-stick wrap developed by Nanyang Technological University, Singapore (NTU Singapore) and JTC, allows existing structures to be easily repaired and reinforced to extend their lifespan.

Called FasRaP — short for Fast Wrapping Fibre Reinforced Polymer (FRP) — the innovative material is jointly developed by scientists and engineers from NTU, JTC and Prostruct Consulting Pte Ltd.

The joint research team, led by Associate Professor Ng Kee Woei, from NTU’s School of Materials Science and Engineering, created FasRaP using commercially available glass fibres, with the addition of a proprietary glue-like resin developed by NTU materials scientists that acts as an adhesive for the wrap.

The resin will only cure when exposed to light, making it possible for it to be pre-applied in the factory and packaged into a ready roll of sticky wrap, similar to double-sided adhesive tape.

When brought to the work site, FasRaP is ready to be applied directly on the structure, such as a wall or pillar.

Apart from halving the time and effort needed for installation, the use of FasRaP also ensures consistency in quality since conditions can be better controlled and monitored compared to manual application of resin onsite, and a reduction in reliance on skilled workers.

Comparing a bare concrete pillar without reinforcement and a pillar wrapped with FasRaP, static load tests show that the latter can withstand an additional 80 per cent load. In industry-standard blast load tests, FasRaP was proven to be just as strong as conventional FRP.

This new technology is especially useful for urban cities to rehabilitate ageing infrastructure including buildings and bridges that may have developed issues such as cracks and delamination of concrete. It is also suitable for reinforcing critical and sensitive infrastructure against potential blast threats.

The team has since spun-off FasRaP Pte Ltd and is in talks with both manufacturers of FRPs and potential clients. To accelerate the adoption and commercialisation of this new technology, JTC will identify suitable infrastructure projects to deploy FasRaP.

This invention highlights the capability of the tripartite research partnership between a government agency, industry and academia, to generate new solutions to tackle challenges in the building and construction sector.

Did You Know?

FasRap is especially useful for urban cities to rehabilitate ageing infrastructure and for reinforcing critical and sensitive infrastructure against potential blast threats.
ENGAGING WITH SPECIAL NEEDS CHILDREN

New interactive technology to help children with special needs learn better

With funding from Temasek Foundation through its Singapore Millennium Foundation (SMF) Research Programme, Associate Professor Goh Wooi Boon from NTU’s School of Computer Science and Engineering and his team have developed an interactive educational tool called the i-Tile, which makes learning more engaging for children with special needs.

Working with teachers from the Movement for the Intellectually Disabled of Singapore (MINDS) Fernvale Gardens School, NTU researchers developed inclusive lessons based on the i-Tile technology for use in classes with diverse learning needs. Since 2018, the i-Tile learning activities were trialled at the MINDS Fernvale Gardens School – a school for children and youths with moderate to severe intellectual disability and Autism Spectrum Disorder (ASD).

Research findings from the trials suggest that the design of the i-Tile learning activities, which incorporate purposeful movement, game-like elements and responsive audio-visual feedback, is effective in increasing and sustaining student engagement. The i-Tile lessons were also observed to help students learn life lessons, such as the need to take turns and the value of teamwork.

The reconfigurable nature of the i-Tile system also allows teachers to adapt and design new learning activities to meet their students’ diverse learning needs. Teachers are keen on using the i-Tile to help students remember their personal information, such as their telephone numbers and their home address, or to teach students money skills and how to shop for items in a supermarket.

The i-Tile system consists of two tablet computers and a custom-designed card-reader (the i-Tile) that can detect objects with Radio-Frequency Identification (RFID) such as a picture or alphabet card. The teacher facilitates the lesson using one tablet computer, whilst the other tablet computer acts as a coordinated remote display and is connected to the classroom’s projection display.

For instance, an image of an apple would appear on the screen and the student will have to move up to the front to select the corresponding word card and tap it against the i-Tile, which would then respond with the appropriate light and sound, indicating whether the choice is correct.

A variety of cards can be programmed by teachers allowing them to conduct inclusive lessons in a class of students with differing levels of competencies. While one student might visually match using picture cards, another could spell using the correct sequence of alphabet cards. It is observed that each student feels a sense of accomplishment at his or her respective level of ability.
Did You Know?

Benefits of i-Tile system:

1. Motivates students
2. Increases and sustains student engagement
3. Helps students learn life lessons

Teachers involved in the trial unanimously agreed that the i-Tile lessons generated higher motivation in their students, with some looking forward to the next lesson, wanting to excel and get the right answers. This positive attitude in learning gave the students a sense of pride in their achievement and sustained their engagement.

Moving forward, Associate Professor Goh will continue to work with MINDS Fernvale Gardens School to scale up the lessons, training more teachers in the use of the i-Tile system, and customising learning resources to meet future learning needs.

If successful, the i-Tile learning system and pedagogy could be rolled out to the other MINDS schools and will also be available for licensing from NTU.

(from left) Mr Gerard Vaz, Principal of Fernvale Gardens School, Associate Professor Goh Woon Boon, Principal Investigator of the i-Tile project and Professor Leo Tan, Chairman of Temasek Foundation Innovates.
Enlightening Collaborations

▲ (from left) Professor Lam Khin Yong, NTU Senior Vice President (Research), Ms Chan Lai Fung, Permanent Secretary (National Research and Development) and Chairman of A*STAR, Deputy Prime Minister and Minister for Finance Mr Heng Swee Keat, NTU President Professor Subra Suresh, Dr Bicky Bhangu, President for South East Asia, Pacific and South Korea, Rolls-Royce, and Dr Dave Smith, Director of Central Technology, at the Rolls-Royce@NTU Corp Lab Phase 2 launch ceremony.
MOVING AHEAD WITH RENEWED DRIVE

Rolls-Royce and NTU extend research partnership with new S$88 million investment

Singapore’s first corporate laboratory in a university, the Rolls-Royce@NTU Corporate Laboratory (The Corp Lab) was jointly set up by NTU, Rolls-Royce and the National Research Foundation (NRF) in 2013. It has successfully completed its first five years of research partnership and is now moving into its next phase with a joint investment of S$88 million.

The Corp Lab was the first to be supported under the Singapore public-private research and development (R&D) partnership between universities and companies. In Phase 1, it managed 53 research projects in areas such as power electronics, data analytics, and repair and manufacturing technologies.

The research outcomes from these projects are now being used to help design and develop future power and propulsion systems and improve manufacturing operations in Singapore and in other global sites of Rolls-Royce.

The Corp Lab also developed digital solutions using artificial intelligence (AI). This has led to a new virtual engine emulator that uses AI to analyse decades of engine design data to harvest new insights. This greatly reduces the design cycle time as the system can automatically generate design options based on desired features, allowing engine designers to select promising candidates that can be further optimised to create future aircraft engines.

With the partnership renewed, the lab will enter Phase 2 with 29 ambitious projects focused on developing novel technologies that will power the future of aircraft propulsion.

The 29 new projects will make use of Industry 4.0 technologies – connecting computers, machines and engines, generating valuable data that will enhance design, manufacturing, maintenance, services, and operations.

A key objective of the projects is to develop technologies that are eco-friendly, efficient, and sustainable. For example, the team will look at developing innovative energy storage solutions to enable hybrid-electric aircraft. This will accelerate the adoption of alternative energy systems in the aerospace industry.

The lab will also address challenges associated with 3D printing and additive manufacturing technologies, such as finishing and polishing processes for internal 3D-printed components. It aims to enhance and streamline manufacturing involving 3D printing in order to open up more room for creativity and innovation.

Did You Know?

Rolls-Royce@NTU Corporate Laboratory is Singapore’s 1st corporate laboratory in a university.

Into its second phase with a joint investment of S$88 million, there will be 29 projects focused on developing novel technologies that will power the future of aircraft propulsion.

Scan the QR code or visit the URL below to find out more about the projects in Phase 2.

GETTING A REAL SENSE OF THINGS

Max Planck-NTU Joint Laboratory for Artificial Senses

Nanyang Technological University, Singapore (NTU Singapore) and Germany’s Max Planck Institute of Colloids and Interfaces (MPICI) have launched a joint lab to conduct research in artificial senses and develop innovative robotics and healthcare solutions.

Professor Chen Xiaodong from NTU’s School of Materials Science and Engineering is the director of the new Max-Planck-NTU Joint Laboratory for Artificial senses. Together with Professor Markus Antonietti from Max Planck Institute for Colloids and Interfaces, Professor Ong Yew Soon from NTU’s School of Computer Science and Engineering, Associate Professor Sierin Lim from NTU’s School of Chemical and Biomedical Engineering, and Associate Professor Ling Xing Yi from NTU’s School of Physical and Mathematical Sciences, the interdisciplinary research team will leverage on advanced materials, ‘skin’ electronics, biomedical engineering, and artificial intelligence (AI) to develop robotic technologies with sensory capabilities.

These include skin-like wearable devices that monitor health and environmental conditions through smart sensors, robots equipped with sensing feedback that provide customised care by adjusting their interaction and engagement to suit the patient, and enhanced prosthetic devices with ‘artificial sensing’ capabilities that could restore rudimentary sensory functions for patients who have lost them.

The partnership will also conduct research to extend human senses beyond their natural capabilities. This includes developing new sensory technologies that will allow users to see or hear radar frequencies or microwaves, smell infections or genetic patterns, or even sense earthquakes.

Located at NTU, the joint lab is MPICI’s first venture in Southeast Asia and will house 30 NTU and MPICI researchers and staff who will explore mechanical sensing such as pressure and strain, and chemical sensing like smell and taste, physiological sensing that usually involves electrocardiograms (ECG), as well as the development of ‘exteroceptors’ – sensors that pick up external stimuli such as touch, sound, pressure, light, and temperature.

The joint lab will be equipped with advanced materials processing instruments, high-end signals analysers, and human-machine interface and machine learning algorithm-based setups.

It will also serve as a platform and launch pad for scientists, engineers and students to take their ideas from the lab, to working prototypes that can be commercialised.
**BANKING ON FINTECH**

**NTU Singapore and WeBank set up a joint research centre on Fintech**

Nanyang Technological University, Singapore (NTU Singapore) and WeBank, China’s 1st digital-only bank, officially launched Singapore’s 1st joint research centre on Fintech on 31st January 2019. Housed at NTU Yunnan Campus, the new S$25 million research centre will support 35 research scientists and engineers over the next 5 years, Professor Miao Chunyan from NTU’s School of Computer Science and Engineering and Mr Yao Jun from WeBank are the co-directors of this joint research centre.

By employing “state-of-the-art” research, such as Artificial Intelligence (AI), data science and analytics, Artificial Intelligence of Things (AIoT) and blockchain technologies, the centre aims to enable and realise Banking 4.0, where banking can be personalised and done anytime, anywhere; and fundamentally transform how we borrow, save, pay, invest and insure.

The research centre will develop technologies that integrate behavioural science with advanced analytics to give users personalised wealth management advice on the go. This will help to make wealth management advice accessible not just to wealthy individuals, but to the general public at large.

The team will also examine ways to enhance digital services 4.0 through the adoption of AIoT and blockchain technology and develop new means of digital marketing using the Internet-of-Things (IoT) and machine learning technology. Blockchain enhances the customer experience by making banking more accountable and secure in every business and customer interaction. Potential applications for AIoT-based digital marketing include boosting the digital banking’s social presence, and targeting genuine customers.

In the past year, the Centre has initiated translational research projects in emerging Fintech areas, ranging from federated learning AI, behavioural finance, smart contracts, to user experience optimisation. The projects have received recognition from both academia and industry, including the Innovation Award and the Most Educational Video Award from UCAI’19 and the Innovative Applications of AI Award from AAAI 2020. The user experience optimisation platform, which is currently being test-bedded by WeBank, will help financial institutions to improve their customer service experience.

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**Did You Know?**

The Joint NTU-WeBank Research Centre on Fintech aims to **enable** and **realise** Banking 4.0, where banking can be **personalised** and done **anytime, anywhere**.
A BREATH OF FRESH AI.R

Artificial Intelligence Research Institute (AI.R)

The Artificial Intelligence Research Institute (AI.R) was initiated in 2019 as one of three strategic working groups whose aim is to foster interdisciplinary research within the university.

Combining research in Artificial Intelligence (AI), Machine Learning (ML) and Internet-of-Things (IoT), AI.R will facilitate AI research both within the NTU community, as well as in collaboration with external parties (government bodies, industries, research entities, and Institutes of Higher Learning), create the AI+X education programme, and help secure external research funding, especially by tapping on Singapore’s Research, Innovation and Enterprise 2025 (RIE2025) funding.

NTU President Professor Subra Suresh has approved a seed funding of S$200K for AI.R to organise symposiums in AI, ML & IoT. With the funds, AI.R will organise two symposiums with a focus on topics like AI for education, AI for environments, AI for food, etc. The outcome of the symposiums will be new programme proposals and new collaborations (local and international).

Professor Guan Cuntai from NTU’s School of Computer Science and Engineering is the director, while Associate Professor Bo An from NTU’s School of Computer Science and Engineering and Associate Professor Hallam Stevens from NTU’s School of Humanity are the co-directors of AI.R.

To date, AI.R has secured a total of S$2.355M research grant to fund various AI research activities in the institute.

Did You Know?

AI.R. will:

1. Facilitate AI research both within the NTU community, as well as collaboration with external parties
2. Create AI+X education programme
3. Secure external research funding
F&N and NTU Singapore set up joint lab to develop new ingredients and greener packaging

Nanyang Technological University, Singapore (NTU Singapore) and Fraser and Neave, Limited (F&N) have jointly opened a laboratory in Singapore to develop innovative products and recipes for F&N’s range of beverage products.

The four-year partnership will see about 30 researchers and students from NTU and F&N working together to translate food technology innovations into industry applications for fast-moving consumer goods (FMCG).

Research projects range from enhancing food products and processes to developing biodegradable packaging solutions for the food and beverage (F&B) industry.

The F&N-NTU F&B Innovation Lab was launched by Singapore’s Minister for Education, Mr Ong Ye Kung, together with NTU President Professor Subra Suresh and Mr Lee Meng Tat, CEO, Non-Alcoholic Beverages of F&N.

Located at NTU’s School of Chemical and Biomedical Engineering, the F&N-NTU F&B Innovation Lab is spearheaded by NTU’s Food Science and Technology (FST) Programme and F&N’s Research & Development (R&D) department. Professor William Chen, Director of NTU’s FST Programme, and Dr Yap Peng Kang, Head of Corporate R&D of F&N serve as co-directors of this lab.

To date, the partnership has identified several joint research projects. Besides developing new beverages with additional health benefits, other research projects will also look into maintaining the freshness of products as well as developing new solutions for environmentally friendly packaging.

This is F&N’s first long-term joint research partnership with an academic institution.
Our alumni, faculty and students are the heart and soul of CoE, constantly acquiring new knowledge, seizing new opportunities, and accomplishing new goals. Their achievements make us proud and we celebrate their talent, passion and creativity each and every day.
Nothing makes us prouder than to know that our graduates have gone on to succeed in the real world. Such stories are not only a testament to the determination and passion they possess, but also an assurance that the College has done well to impart skills and knowledge graduates need to achieve their successes. With the holistic education that CoE has provided them, our graduates are more than prepared to play important parts in Industry 4.0, and even to lead in various fields. Presented here are two such exemplary members of our alumni, who share their stories of inspiration and hard work, so that more may aspire to reach further.
ALEX CHEN XIANYONG

REDEFINING INSURANCE

Alex was the valedictorian of CoE’s pioneer batch of Renaissance Engineering Programme (REP) graduates in 2016, majoring in Civil Engineering.

He is the founding CEO and current Chairman of Asia Risk Transfer Solutions (ARTS), a Singapore InsurTech company founded with the mission of advancing inclusive insurance in developing Asia. ARTS helps insurance companies design and underwrite new digital products in the speciality areas of Natural Catastrophe and Agriculture Risk.

The origin of ARTS came about when he and his co-founder, Professor Haresh Shah of Stanford University, were working on studies related to insurance accessibility and affordability issues in developing communities during his undergraduate days in NTU.

“We developed a technology-based approach that enables the operation of cost-efficient natural disaster and agriculture insurance in Asia. Seeing this as both an important societal need and a significant market opportunity, we decided to establish ARTS to bring the idea to fruition.”

Since founding ARTS in 2016, the same year he graduated, the company has made significant progress and achieved major milestones. Their flagship product, CRES, was a finalist at the Singapore FinTech Awards 2017 and received the top innovation prize at the 7th Asia Insurance Technology Awards.

Our vision is a world where communities are well insured against adverse events that impact their health, assets and livelihoods.

Alex received the Nanyang Outstanding Young Alumni Award in 2019.
Our core technology is focused on the design, pricing, and operation of index-based insurance, which estimates losses and administers claims on the basis of a predetermined index (e.g. rainfall level) for loss of assets and production resulting from weather and catastrophe events. This allows insurance companies to significantly reduce their operating costs and enables greater access to insurance for developing communities," he says.

CRES is currently used by insurance companies in India to provide agriculture insurance to millions of farmers across the country.

On the role that the College of Engineering played in his success, he says, "The dynamic nature of the curriculum, and the added bonus of being the pioneer batch of the Renaissance Engineering Programme, made me attuned to new experiences and being comfortable with the unknown."

He further adds, "I saw REP as an exciting new programme with a vigorous curriculum and unique opportunities to learn and develop myself. I enjoyed the many opportunities to collaborate with my classmates in real-world projects, where I had the opportunity to pick up valuable project management, product development, business planning and communication skills."

Alex has big plans for ARTS. "Our vision is a world where communities are well insured against adverse events that impact their health, assets and livelihoods. The loomimg threats of pandemics and climate disruption only makes such efforts ever more important and fulfilling."

He continues to be involved in the REP, sitting as a member of the Advisory Committee, providing active feedback on the efficacy of the REP, relevance of courses, new industry trends, and the evolving roles of engineers in the industry.

**JASON LAW YI PING**

**AN ENERGETIC APPROACH TO BUSINESS**

Jason Law is an entrepreneur in the clean energy industry and a start-up supporter.

After graduating in 2009 with a degree in Materials Engineering, he spent five years in Far East Organization, where he was in charge of real estate project launches.

In 2014, he founded his first start-up, SunPro Energies, a solar design and integration company enabling people to generate solar energy from their own roof tops. SunPro Energies has since built up an excellent track record in residential, commercial, schools, government and large-scale projects.

"We need not always wait for everything to be in place before we start. While it is important to plan ahead, it is equally important to execute once you have reached the activation point. Beyond that, we learn and adjust on the ground as we go along."
Not one to rest on his laurels, in 2016, Jason co-founded Pylon City, an Internet of Energy (IoE) start-up. Their smart energy products are used by clients to monitor energy generation and consumption, track the maintenance of their assets and trade energy in a decentralised energy network.

From 2017 to 2019, Jason was the President of the School of Materials Science and Engineering Alumni Association (MSE AA). Under his leadership, MSE AA has initiated and organised many events that have benefited MSE, NTU and the society at large. More importantly, his team took time to mentor and advise young graduates.

Jason was awarded the Nanyang Alumni Service Award in 2019.

When asked about the motivations behind his start-ups, Jason says, “SunPro was able to combine my engineering training and my experience in dealing with buildings. When I thought about doing a business, I wanted to fulfill two criteria: it has to be something that positively impacts a large number of people, and it has to be a new and upcoming technology. The solar business is capable of achieving both in a direct and measurable way.”

“Pylon City originated from a climate change tech hackathon that I took part in with an ex-classmate, also an NTU alumni, Vincent, back in 2016. Our entry won first place in the Zero Carbon District category, and we thought, why don’t we bring this solution to real life and start a company that specialises in monitoring, managing and trading clean energy? That was how Pylon City was born.”

Jason credits the environment of CoE and the encouragement that his professors gave him for laying the foundations of his success. “The best thing about CoE are the professors I interacted with. Besides being academic mentors, they taught me the philosophy of value engineering, where a product or engineering design must have a use case, be marketable and able to make economic sense. They also assured me that it’s okay if I do not work in the field of materials science after I graduate. Pursue what you are excited and passionate about, they would say.”

“However, whether it is designing a solar PV system or creating a new product for smart energy management, I find myself appreciating the engineering concepts that I learnt back in school, even though that was many years ago.”

And what is Jason’s recipe for success?

He shares, “We need not always wait for everything to be in place before we start. While it is important to plan ahead, it is equally important to execute once you have reached the activation point. Beyond that, we learn and adjust on the ground as we go along.”

Jason has big plans ahead for his businesses. He is currently working on projects that develop communities from the ground up, where individual buildings will be able to produce, consume and share energy through a microgrid or electric vehicles.

“That is a pretty exciting vision for us to turn into reality.”
Our Faculty
Leading the Field

They are the backbone of CoE. With their wealth of experience, knowledge and wisdom, they support, guide and nurture the engineers of tomorrow. These are our distinguished faculty members, our professors, mentors and advisors. Respectable leaders in their own right, their dedication to our students is the key to opening the world for a new generation of leaders.
ASSOCIATE PROFESSOR
YEONG WAI YEE

An innovator in 3D Printing Research who hopes to attract more women into engineering

At the 3rd Annual TCT Awards Ceremony held at the National Conference Centre in Birmingham, England, one of the highest accolades went to our very own.

Associate Professor Yeong Wai Yee was awarded the TCT Women in 3D Printing Innovator Award – an international award that aims to shine a spotlight on the female innovators who are leading the charge in the world of design-to-manufacturing – and it is easy to see why.

Active in 3D printing research since 2004, Associate Professor Yeong has created multiple frontiers in 3D printing, taking the research/education/service leads in 3D Bioprinting, electronics printing and metal printing research.

“I have always been fascinated by 3D Printing,” she says. “I am geared towards researching 3D printing in high value and high risk areas such as the biomedical and aerospace industries. The potential to innovate is very high in these areas, and I want to change the status quo, create a new pathway for design and manufacturing, and finally a better solution for the industry.”

Currently serving as Programme Director at the Singapore Centre in 3D Printing (SC3DP) and NTU-HP Digital Manufacturing Corporate Lab, she has contributed more than 150 technical papers, generating more than 3,000 citations, and co-authored 2 textbooks.

On her work, she believes that to be a good researcher, one must first be a good engineer. “A top researcher is always curious, and is always seizing opportunities. We should also help one another and be open to collaboration,” she says.

As an educator, Associate Professor Yeong continues to improve the care of students as the Associate Chair (Students) at NTU’s School of Mechanical and Aerospace Engineering (MAE).

“We focus on communication and have created multiple channels for students to engage with faculty directly,” she says. “This is enabled by programmes such as a formalised student-faculty mentorship programme, new initiatives such as the MAE student town hall meeting, and a pop-up virtual reality activity corner in the MAE lobby where students and faculty can interact. Through this multi-pronged approach, we hope to ensure bonding and well-rounded development for students.”

Associate Professor Yeong also has a hand in strategising the MAE admissions programme. “Our approach creates a learning journey and experience for students to understand the core meaning of engineering, specifically mechanical and/or aerospace engineering at NTU. We look into the needs of various levels of students and develop relevant initiatives to reach them.”

Despite her own accomplishments, Associate Professor Yeong finds greater joy in helping others succeed. “My greatest achievement is seeing the growth of my staff and students because it is a privilege to be able to walk with them as they grow into capable engineers/researchers/faculty,” she says.

“For me, success is not defined by a single event, but by how much we can help others to be successful.”

Truly, an inspirational woman in every way.
“Living life on your own terms and making the best out of it.”

This motto certainly has done Professor Madhavi Srinivasan well, having been named one of 2019 Asia’s Top Sustainability Superwomen, the only professor to be included in the list.

“I felt so honoured when I found out that I was the only academic professor among other elite women leaders like CEOs, Presidents/Vice-Presidents, and executive board members of multinational companies across Asia,” she says.

Professor Srinivasan was recognised for her work in sustainable energy storage and e-waste recycling, especially in lithium-ion batteries and the extraction of reusable precious earth metals. She envisions a future where more than 70% of consumer devices are produced from recycled e-waste materials, supporting a more sustainable society.

“I am the Co-Director of a joint lab set up at NTU called SCARCE (Singapore CEA Alliance for Research in Circular Economy) in partnership with French Alternative Energies and Atomic Energy Commission (CEA). My team in SCARCE lab is championing an important initiative of finding sustainable, green environmental friendly ways to recycle, recover and reuse e-waste.”

She adds, “I am also working on next-generation water-based safe zinc and aluminium rechargeable batteries that are potentially safer than lithium-ion batteries as they don’t contain flammable electrolyte.”

One of the few female leaders in this field, Professor Srinivasan, a recipient of the Nanyang Research Award (2014) – the highest recognition conferred by NTU to faculty members in research; and L’Oreal Singapore for Women in Science National Fellowships (2010), wants to address the myths and stereotypes by reaching out to young girls early on in their education and correcting misconceptions associated with engineering. “I hope that will help attract more females to engineering,” she says.

A recipient of the Nanyang Education Award – the highest honour conferred by NTU to faculty members in the field of teaching – in 2012 and 2016, Professor Srinivasan is proud to have mentored, inspired, helped and made positive impacts on the lives of her students.

“To me, touching human lives and making a difference in society is probably the greatest accomplishment.”

Power-packed and fully-charged, a Superwoman in our midst.
TWO NEW IEEE FELLOWS

The IEEE Fellowship recognises individuals with extraordinary records of accomplishments in any IEEE field of interest. It is the highest grade of IEEE membership and is regarded by the international engineering community as a prestigious honour. The following two faculty members from NTU College of Engineering were recently elected as IEEE Fellows:

Associate Professor Li Mo
School of Computer Science and Engineering
For his contributions to development of wireless and networked sensing systems

Professor Wen Yonggang
School of Computer Science and Engineering
For his contributions to cloud systems for multimedia signal processing and communications

NEW NATIONAL RESEARCH FOUNDATION (NRF) FELLOWS

Nanyang Assistant Professor Christopher Lee Ho Tin
School of Electrical and Electronic Engineering

Assistant Professor Hortense Le Ferrand
School of Mechanical and Aerospace Engineering

Congratulations to Assistant Professor Christopher Lee Ho Tin from the School of Electrical and Electronic Engineering, and Assistant Professor Hortense Le Ferrand from the School of Mechanical and Aerospace Engineering for being conferred NRF Fellows in the NRF Fellowship Scheme.

The competitive programme seeks to attract, recruit and root outstanding young scientists from around the world to conduct independent research in all areas of science and technology in Singapore over a five-year period. The programme provides a research grant to support projects that have a high likelihood of making a breakthrough.

NATIONAL RESEARCH FOUNDATION (NRF) INVESTIGATORSHIP AWARD

Professor Liu Yang
School of Computer Science and Engineering

The College of Engineering would like to congratulate Professor Liu Yang from the School of Computer Science and Engineering for winning the NRF Investigatorship award.

The NRF Investigatorship provides opportunities for established, innovative and active researchers in their mid-career to pursue groundbreaking, high-risk research. It is intended to support a small number of Principal Investigators who have an excellent track record of research achievements and are recognised as leaders in their respective fields of research. Each recipient will receive up to S$3 million over 5 years to pursue groundbreaking research.
INSTALLATION OF FULL PROFESSORS IN 2019

The College of Engineering congratulates the following colleagues who were installed as full professors in 2019.

- **Professor Ivan Au Siu-Kui**
  School of Civil and Environmental Engineering

- **Professor Cho Nam-Joon**
  School of Materials Science and Engineering

- **Professor Vanessa Evers**
  School of Computer Science and Engineering

- **Professor Gao Huajian**
  School of Mechanical and Aerospace Engineering

- **Professor Jay T Groves**
  School of Materials Science and Engineering

- **Professor Lim Teik Thye**
  School of Civil and Environmental Engineering

- **Professor Liu Yang**
  School of Computer Science and Engineering

- **Professor Josep Pou**
  School of Electrical and Electronic Engineering

- **Professor Raju V. Ramanujan**
  School of Materials Science and Engineering
Professor Tan Chuan Seng  
School of Electrical and Electronic Engineering

Professor Tan Ming Jen  
School of Mechanical and Aerospace Engineering

Professor Tang Dingyuan  
School of Electrical and Electronic Engineering

Professor James Ming Wang  
School of Mechanical and Aerospace Engineering

Professor Wen Yonggang  
School of Computer Science and Engineering
NEWLY HIRED FACULTY IN 2019

A warm welcome to the following faculty members who joined us in 2019.

Legend:
CEE: School of Civil and Environmental Engineering
EE: School of Electrical and Electronic Engineering
MAE: School of Mechanical and Aerospace Engineering
MSE: School of Materials Science and Engineering
SCBE: School of Chemical and Biomedical Engineering
SCSE: School of Computer Science and Engineering

Ivan Au Siu Kui
Professor, CEE
Ph.D., California Institute of Technology, USA, 2001
Professor, Chair of Uncertainty, Reliability and Risk,
University of Liverpool, United Kingdom, 2013 – 2018

Chen Ming-Hsu
Assistant Professor, SCBE
Ph.D., University of Illinois at Urbana-Champaign,
USA, 2015
Postdoctoral Research Associate, Purdue
University, USA, 2017 – 2019

Tej Salil Choksi
Assistant Professor, SCBE
Ph.D., Purdue University, USA, 2017
Postdoctoral Scholar, Stanford University, USA,
2017 – 2019

Vanessa Evers
Professor, SCSE
Ph.D., The Open University, United Kingdom, 2001
Full Professor and Chair, University of Twente, The
Netherlands, 2011 – 2019

Mir Feroskhan
Assistant Professor, MAE
Ph.D., Florida Institute of Technology, USA, 2016
Postdoctoral Researcher, École Polytechnique
Fédérale de Lausanne, Switzerland, 2018 – 2019

Gao Huajian
Distinguished University Professor, MAE
Ph.D., Harvard University, USA, 1988
Walter H. Annenberg Professor of Engineering,
Brown University, USA, 2006 – 2019
Jay T Groves  
Professor, MSE  
Ph.D., Stanford University, USA, 1998  
Professor, University of California, Berkeley, USA, 2010 – 2019

Kedar Hippalgaonkar  
Assistant Professor, MSE  
Ph.D., University of California, Berkeley, USA, 2013  

Hortense Le Ferrand  
Assistant Professor, MAE  
Ph.D., ETH Zurich, Switzerland, 2017  
Postdoctoral Fellow, Nanyang Technological University, Singapore, 2017 – 2018

She Qianhong  
Assistant Professor, CEE  
Ph.D., Nanyang Technological University, Singapore, 2014  
Lecturer, The University of Sydney, Australia, 2017 – 2019

Shen Zhiqi  
Senior Lecturer, SCSE  
Ph.D., Nanyang Technological University, Singapore, 2005  
Senior Research Scientist, Nanyang Technological University, Singapore, 2011 – 2019

Tay Kian Boon  
Senior Lecturer, SCSE  
Ph.D., Massachusetts Institute of Technology, USA, 1994  
Senior Scientist, Crypto Lab® MINDEF – CSIT, Singapore, 2000 – 2017
Teoh Bak Koon  
**Senior Lecturer, CEE**  
Ph.D., National University of Singapore, Singapore, 2003  
Deputy General Manager (Engineering), Sembcorp Marine Ltd, 2011 – 2019

James Wang Ming  
**Professor, MAE**  
Ph.D., University of Maryland, USA, 1991  
Senior Vice President, Leonardo Helicopters, Italy, 2015 – 2017

Wen Bihan  
**Nanyang Assistant Professor, EEE**  
Ph.D., University of Illinois at Urbana-Champaign, USA, 2018  
Research Scientist, Dolby Laboratories, USA, 2018 – 2019

Wong Liang Jie  
**Nanyang Assistant Professor, EEE**  
Ph.D., Massachusetts Institute of Technology, USA, 2013  
Scientist, Singapore Institute of Manufacturing Technology, Singapore, 2014 – 2019

Zhang Tianwei  
**Assistant Professor, SCSE**  
Ph.D., Princeton University, USA, 2017  
Software Engineer, Amazon, USA, 2017 – 2019
Our Students
Engaging the Future

Above and beyond our rigorous curricula and conducive environment, it is the students of CoE who bring honour to our reputation. With their overflowing talent, sparkling innovativeness and pure enthusiasm, they have proven themselves over and over by leading the competition in international arenas. They are our brightest and most gratifying achievements, and their own successes will arm them well to take on even bigger challenges to come.
UNSHAKEABLE EXCELLENCE

CEE Students Clinch Top Prize for Safer, Earthquake-proof Structures

Can a team of engineering students who don’t hail from an earthquake zone prove their ingenuity in earthquake engineering? That’s what four third-year students from NTU’s School of Civil and Environmental Engineering (CEE) managed to achieve through sheer hardwork and resourcefulness. Kong Kok Khuen, Low Khai Jer, Foo Tun How Nicholas, Hew Gong Qi, and supervisor Associate Professor Li Bing, beat 48 other teams to clinch the top prize in the IDEERS competition (Introducing and Demonstrating Earthquake Engineering Research in Schools) 2019.

Now in its 19th year, the competition was held at the National Centre for Research on Earthquake Engineering in Taipei (Taiwan) in September 2019. Over the course of two days, participating teams had to design and build structures that would address common construction issues faced in earthquake prone areas. Teams were judged on prototype and architectural design, and a presentation to a group of judges on how their models functioned in minimising the impact of earthquakes.

In preparation for the competition, the NTU team utilised computer analysis to simulate structural behaviours in their proposed models. They also procured customised building materials and construction tools to practice their modelling work.

Their efforts paid off, and the results spoke for themselves. Our champions delivered an innovative solution in spite of the numerous resource constraints, proving their resourcefulness, creativity and problem-solving skills.

“4 students from NTU’s School of Civil and Environmental Engineering beat 48 other teams to clinch the top prize in the IDEERS competition 2019.”

▲ Cheers to our winning team! (second from left) Third-year Civil Engineering students Kong Kok Khuen, Foo Tun How Nicholas, Hew Gong Qi and Low Khai Jer, with their supervisor, Associate Professor Li Bing.

▲ The team in action.
**DRIVEN WITH A PURPOSE**

**Building Chemical-Powered Cars at the Chem-E-Car Competition in Sydney, Australia**

While it wasn’t exactly Formula One, this competition definitely had a few formulas in the engine. The Chem-E-Car Competition, organised by Engineers Australia was held in Sydney, Australia. It required participants to build a working car, powered by chemical reactions, and that could cover a specific distance.

Team CARNOT – comprising students Sarvesh Tusnial from NTU’s School of Mechanical and Aerospace Engineering (MAE), as well as Venkatesh Abhyankar, Daniel Chuah and Siddharth Dangi from NTU’s School of Chemical and Biomedical Engineering (SCBE) – had already clinched first place in a similar qualifying competition organised by NTU SCBE Club.

They represented NTU at the actual competition in Sydney, coming in third against teams from around the world, including India, Indonesia, the United Kingdom, and Australia.

Their entry used a temperature difference mechanism coupled with Peltier circuits to convert thermal energy to electrical energy. This, in turn, was used to power the motors that drove the car’s wheels. As microcontrollers like Arduino were not permitted, the team devised an innovative braking mechanism which utilised the reaction of Vitamin C in water, connected to an electrical brush to complete the circuit. Once the reaction reached a certain point, the circuit broke off and the car came to a halt. Truly, this was simple engineering at its best!

**SUPERCOMPUTER WHIZZES**

**Acing the Student Cluster Competition**

The Student Cluster Competition 2019 was held in Denver, Colorado, USA. It is a High-Performance Computing (HPC) multi-disciplinary experience integrated within the HPC community's biggest gathering, the Supercomputing Conference. The competition is a microcosm of a modern HPC centre that teaches and inspires students to pursue careers in the field. It demonstrates the breadth of skills, technologies and science that it takes to build, maintain and utilise supercomputers.

In this real-time, non-stop, 48-hour challenge, teams had to assemble small clusters on the exhibit floor, and race to complete real-world workloads across a series of applications and impress HPC-industry judges.

For the third year in a row, NTU’s School of Computer Science and Engineering (SCSE) has successfully produced teams that have consistently performed well in the SCC, taking home the overall Winner, Highest Linpack and HPCG awards in 2017; Highest Linpack award in 2018 and the most recent victories, Highest Linpack and HPCG awards in 2019.
RENAISSANCE
WOMAN

▲ Tan Jie Hui (middle) was named the winner of the Global EY Corporate Finance Woman of the Year 2020.

Student from Renaissance Engineering Programme Wins the Global EY Corporate Finance Woman of the Year Case Competition 2020

She came, she saw, she conquered! Tan Jie Hui, a second-year student from NTU’s Renaissance Engineering Programme, won the Global EY Corporate Finance Woman of the Year 2020 case competition held in Rome in February 2020.

The competition, now in its third year, is part of an EY Transaction Advisory Services (TAS) initiative to attract the next generation of female talents from across the globe to embark on career in corporate finance, and to make an impact in this field.

Finalists had to focus not only on gaining technical insights, but also on developing broader skills, such as business acumen, inclusive leadership and teaming, communication and influence, problem solving and entrepreneurship. In addition, they undertook a real-life M&A challenge in collaboration with Snam, one of the world’s leading energy infrastructure companies. The challenge provided them with exposure to the world of corporate finance.

The first phase of the competition took place in local countries where finalists undertook both group and individual challenges to demonstrate how they could contribute to a high-performing team. Jie Hui won the Singapore edition of the competition in November 2019 and represented Singapore in the global competition.

In Rome, thanks to her strong leadership skills, initiative, and creative ideas, she out-performed 21 other finalists from China, Finland, France, Germany, India, Ireland, Italy, Japan, Norway, Oceania, Switzerland, United Arab Emirates, United Kingdom and the United States of America.

As the global winner, Jie Hui will next embark on an all-expenses-paid, once-in-a-lifetime EY internship. The month-long experience will take her across the globe to work with EY TAS teams in multiple locations as they help clients build a better working world.
Credits and Thank You

COLLEGE EDITORIAL COMMITTEE

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Tan Tri Cia
Mok Shi Lin

SPECIAL THANKS GO TO

All featured faculty, staff, alumni and students from the six engineering schools for their contributions, patience, time and efforts, without which this annual report would not be possible.

Also, thanks to all other faculty and staff from Dean’s Office, the six engineering schools, Renaissance Engineering Programme Office and Corporate Communications Office, who at one point or another, have contributed to this annual report.

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