Vision

• Provide quality engineering education
• Exert strong leadership in research and development
• Facilitate the entrepreneurial application of technology for the advancement and well-being of the nation and society in an increasingly globalised world

Mission

• To nurture engineers with a global outlook and passion for innovation, who can lead teams and apply knowledge creatively across functional boundaries
• To be a leading source of innovative technologies, products and processes by advancing frontiers of engineering knowledge
• To be an engineering school of choice for talented students, capable researchers, outstanding faculty and high quality staff
Introduction

It gives me great pleasure to present to you the NUS Faculty of Engineering Annual Report for the Financial Year 2003-2004. This inaugural report is aimed at updating our stakeholders of recent achievements and developments within the Faculty. We deeply appreciate the role that we have with our stakeholders and reaffirm our commitment to them as co-partners to help us realise our vision of becoming a cutting-edge school of engineering and NUS’ vision of developing into a global knowledge enterprise.

The past year was a particularly exciting one for us. It was a year marked by tangible progress in the areas of research, education and entrepreneurial activity. This report documents some of our achievements over the past year and provides an idea of where we are going in the coming years. Looking back, there is one event that we mark with great sadness: the sudden demise of Assoc Prof Lee Kwok Hong, formerly Vice-Dean of Research. Prof Lee will be remembered for his dedicated service and contributions to the University.

The external environment in which the University and nation are operating in has become more globalised and economic competition more intense. In line with Singapore's development into a knowledge-based economy to compete and thrive in this more volatile and uncertain environment, the Faculty has made fundamental and bold changes by shifting from a more centrally managed, one-size-fits-all educational system to one which is more diverse and dynamic. This new system provides greater flexibility and options for a diversified student population. Another fundamental shift was from knowledge transmission to the cultivation of a spirit of enquiry, critical thinking, life-skills and adaptability, as well as greater emphasis on research, innovation and enterprise.

Education – Imparting of Knowledge

Several key initiatives have been implemented to enhance the Faculty’s educational framework in order to match the strengths and passions of our students with appropriate syllabi and programmes and equip them to meet the challenges of the new economy. Starting from 2004, the Faculty will for the first time introduce direct entry to all undergraduate disciplines. This new admissions system aims to give students more choices and flexibility, and attract exceptional talents and outstanding undergraduate disciplines. This new admissions system aims to give students more choices and flexibility, and attract exceptional talents and outstanding students.

In anticipating the new Life Sciences emphasis in the global arena, the Division of Bioengineering inaugurated in August 2003 the BEng (Bioengineering) degree programme for its first batch of undergraduates. In the past year, research and learning at the Faculty have become increasingly multidisciplinary. The new synergies imply a redefinition of roles for existing and new departments. For instance, the Department of Chemical & Biomolecular Engineering (ChBE) has become more multidisciplinary. The new synergies imply a redefinition of roles for existing and new departments. For instance, the Department of Chemical & Biomolecular Engineering (ChBE) has become more multidisciplinary.

The Faculty is committed to creating an environment and infrastructure that supports high quality research and the recruitment, nurturing and retention of excellent researchers. Already in place is a vibrant research environment and culture conducive to R&D developments that supports high quality research and the recruitment, nurturing and retention of excellent researchers. Already in place is a vibrant research environment and culture conducive to R&D developments. The Faculty is committed to creating an environment and infrastructure that supports high quality research and the recruitment, nurturing and retention of excellent researchers. Already in place is a vibrant research environment and culture conducive to R&D developments that supports high quality research and the recruitment, nurturing and retention of excellent researchers. Already in place is a vibrant research environment and culture conducive to R&D developments.

Research – Creation of Knowledge

Achieving environmental sustainability is a key priority for Singapore and the world. In recognition of this, the Faculty also formed the Environmental Science and Engineering Programme by bringing together expertise in the area from ChBE Department and the Department of Civil Engineering (CE). The formation of the new Department of Materials Science & Engineering (MSE) in 2005 will create a strong and coherent undergraduate and graduate programme for itself and be a catalyst for faculty to work synergistically in different areas related to engineering materials.

We are committed to providing outstanding programmes in engineering education leading to a broad spectrum of degrees and employment and have made relevant changes to curricula, accompanied by reviews in teaching and assessment methods that tap talent and groom our graduates to think creatively.

Innovative research is usually rooted in strategic partnerships where ideas of different sorts coalesce to produce new and radical solutions. Our inter-disciplinary research environment – which serves as a focal point for the confluence of new ideas, solutions and opportunities – has become not only a strong draw for other talented faculty but has also become a strong selling point in faculty recruitment. For instance, last year, we recruited 19 faculty who have helped build up expertise ranging from bioengineering to nanotechnology. Connecting different ideas and approaches to solving problems has already resulted in developments ranging from bioimaging to tissue engineering. Increasing the propinquity of a mixed pool of talent generates momentum for creative solutions which add value to cutting-edge research.

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An example of such an alliance was the tie-up between ChBE Department and the Bioprocessing Technology Institute (BTI) for research collaborations, as well as to offer bio/pharmaceutical engineering specialisation options for our students. The Division of Bioengineering has a very close research collaboration with the Defence Medical and Environmental Research Institute (DMERI) on musculo-skeletal biomechanics. To help Singapore sharpen its edge in the field of nanotechnology, the Faculty set up the NUS Nanoscience and Nanotechnology Initiative (NUSNNI) in 2002 to unlock a new generation of materials and micro devices with revolutionary properties and functionalities. In parallel with this development, a new MEng programme in nanotechnology will be initiated in August 2004 to provide students and researchers with the opportunity to work on multidisciplinary projects with industrial collaborators.

The past year is one which saw several of our faculty and students making their mark in NUS’ quest for global excellence. Prof Colin Sheppard of the Division of Bioengineering was conferred the Humboldt Research Award in recognition of lifetime achievements in science. The Department of Electrical and Computer Engineering (ECE) won first place in the Humanoid Robot Competition at the Federation of International Robot-soccer Association’s (FIRA) Robot World Cup 2003 in Austria. The Department was also presented the Best Paper award by the Institution of Electrical & Electronics Engineers (IEEE) Transactions on Industrial Electronics and the Best Paper award by the IEEE Transactions on Semiconductor Manufacturing. Bioengineering graduate student Ryui Imai won the Far Eastern Economic Review Young Inventors Awards (Gold Medal) for his project on the development of 2D and 3D structures with aligned polymer nanofibres.

Funding – Aiding Developments

Over the past year, the Faculty successfully attracted almost $27 million in research grants excluding scholarship money, 56% of which came from the Academic Research Fund. This represents a 16% increase in funding over the previous financial year. The Faculty continued to attract external funds. For instance, the Silicon Nano-Devices Lab received an additional $3.8 million from A*STAR for nanotechnology research. The Centre for Offshore Research & Engineering (CORE) was set up with funding support from the Economic Development Board (EDB), Maritime and Port Authority of Singapore (MPA) and Keppel Corporation to promote and coordinate R&D and manpower developments in support of Singapore’s rapidly growing offshore engineering industry. The fund will provide support of up to $1 million per year for maritime and port research that will contribute to the growth of Singapore as a leading maritime hub. Many big-hearted and well-meaning corporations and individuals have also, over the years, generously contributed to our continued progress with financial support ranging from endowed professorships to research grants to book prizes. The Faculty acknowledges with deep appreciation and gratitude the unstinting support of all donors to the cause of engineering excellence at NUS. Developing stronger relations with our alumni and securing the future with sustainable endowments would also be accorded the highest priority.

Strategic Partnerships – Creating Synergies

In tandem with NUS’ aim to become a global knowledge enterprise, the Faculty hopes to forge impactful collaborations and partnerships with top overseas universities and organisations. Our efforts to gain greater synergy with the best in research and education were boosted by several collaborations with leading overseas institutions. An MOU was inked in April 2004 between NUS and Supelec (Ecole Superieure d’Electrique), one of France’s prestigious Grandes Ecoles, to establish a new joint PhD programme for infocomm, microwaves and control. New ground was broken when the Faculty became a partner in the Supelec, ONERA, NUS, DSTA Research Alliance (SONDRA) joint research laboratory located at Supelec’s campus near Paris. NUS took another leap forward with the official launch of a joint PhD programme in chemical engineering between University of Illinois at Urbana-Champaign (UIUC) and ChBE Department. This premier partnership scores two firsts — the first doctoral programme offered jointly by UIUC and NUS and UIUC’s first joint doctoral programme in chemical engineering with an Asian university. Activities have also intensified closer to home — with the establishment of formal links with top institutions in India and China. MOUs were signed with four Indian Institutes of Technology (IIT) in Bombay, Kanpur, Kharagpur and Roorkee to cover academic collaboration and student exchange. In China, an MOU was signed between Shanghai Jiao Tong University’s School of Naval Architecture, Ocean and Civil Engineering and our CE Department. The efforts complement visits to Chinese cities with significant concentrations of alumni, and hosting of dialogue evenings to inform alumni of developments in the Faculty.

Entrepreneurial Activity – Student Education & Staff Opportunities

The Faculty actively promotes entrepreneurial activities and initiatives to create value from knowledge. A full spectrum of entrepreneurial support services to foster industry collaboration and facilitate greater commercialisation of ideas will be provided to our students, faculty and alumni in order to infuse a spirit of enterprise amongst them. An example is our Techopreneurship and Incubation Programme (TIP), with a registration of approximately 600 students, offered as a credit earning part of the curriculum. Besides students’ participation in workshops and projects, some concentrated on incubation as a result of which there are now 11 start-up teams in our incubation centre. One start-up has recently moved off-site, i.e. as a “spin-off”, to further develop its computer hardware business.

TIP staff, assisted by the student society Business Incubators Networking Organisations (BINGO), organised the recent NUS-Motorola Technopreneurship Challenge, open to all NUS students and won by the start-up Laser which is based on the commercialisation of technology from our CE Department. Also, two of our Mechanical Engineering students were members of the team which took the runner-up spot in the prestigious Lee Kuan Yew Global Business Plan Competition held recently.

A couple of the above start-up projects were initiated by the research and drive of our staff — and we intend to further promote such student and staff entrepreneurial interaction in the coming years. Siemens (Germany) has injected 1.5 million euros of capital into Purple Ace Pte Ltd, an ECE staff/student spin-off venture.

Administration – Leading & Setting Benchmarks

To facilitate the promotion and tenure (P&T) process, the Faculty has initiated an on-line progress-tracking system, where faculty can track the progress of their P&T applications. Departments will continue to work towards a lower student-staff ratio by continuing to recruit new faculty, employ more teaching assistants and adjunct faculty, and increase the number of joint appointments. The Faculty has also developed meaningful key performance indicators (KPIs) to drive a sound performance-based, market-driven philosophy for the allocation of its limited resources.

In the following pages, we have highlighted some initiatives and achievements by departments, centres, staff and students in the core competencies of education, research, entrepreneurship and service. Also provided are some financial information and facts & figures about the Faculty which will give a better idea of the activities and progress expressed by our theme Education, Enquiry & Enterprise...Engineering Tomorrow Today in sharing our vision towards becoming an outstanding 21st-century engineering school.

FROM THE DEAN

Professor Seeram Ramakrishna
Dean
NUS Faculty of Engineering
International Advisory Panel (IAP)

Terms of Reference
- Assist the Faculty in identifying suitable focus areas of research
- Review the Faculty’s strategic plan to achieve international excellence in the selected areas of focus
- Assist the Faculty in developing international research collaborations to accelerate progress
- Assess and make recommendations for the Faculty’s general development
Dean’s Advisory Board

Mr Inderjit Singh
CEO, Infiniti Solutions Pte Ltd, and
Executive Chairman, Tri Star Electronics Pte Ltd
Member of Parliament, Singapore

Prof Thomas L Magnanti
Institute Professor
Dean of School of Engineering
Massachusetts Institute of Technology, USA

Prof Don P Giddens
Dean of College of Engineering,
Lawrence L Gellerstedt, Jr Chair in Bioengineering
Georgia Research Alliance Eminent Scholar
Georgia Institute of Technology, USA

Prof Venkatesh Narayanamurti
John A and Elizabeth S Armstrong Professor of Engineering and
Applied Sciences
Dean of the Division of Engineering and Applied Sciences and
Dean of Physical Sciences
Harvard University, USA

Terms of Reference

• Advise on the Faculty’s strategic plans
• Help forge strategic partnerships with industry, research organisations and institutions of higher learning

The process of appointing more members to the Dean’s Advisory Board is in progress.
Faculty Board

Chairman
1. Prof Seeram Ramakrishna, Dean

Members
2. Prof Chow Yean Khow, Vice-Dean, Academic Affairs & Graduate Studies
3. Assoc Prof Tan Thiam Soon, Vice-Dean, Undergraduate Programmes
4. Assoc Prof Chua Kee Chaihong, Vice-Dean, Research
5. Prof Yeo Tat Soon, Vice-Dean, Administration
6. Prof Chou Siaw Kiang, Vice-Dean, External & Industry Relations
7. Prof Colin Sheppard, Head, Division of Bioengineering
8. Prof Raj Rajagopalan, Head, Department of Chemical & Biomolecular Engineering
9. Prof Fwa Tien Fang, Head, Department of Civil Engineering
10. Prof Yeo Swee Ping, Head, Department of Electrical & Computer Engineering
11. Prof Ang Beng Wah, Head, Department of Industrial & Systems Engineering
12. Prof Lim Seh Chun, Head, Department of Mechanical Engineering
13. Prof Poo Aun Neow, Director, Bachelor of Technology Programme
The NUS Faculty of Engineering comprises seven departments/division/programmes, with a total enrolment of more than 6,000 undergraduates. In designing the undergraduate programmes, the Faculty has to address present and future challenges such as stakeholder expectations and the concomitant manpower needs of industry as well as student interests which widen in parallel with the changing needs of industry. The rapid expansion of the engineering knowledge base in our current climate of information explosion has created a trend toward breaking down boundaries between disciplines. Accordingly, we have adapted undergraduate curricula to adopt a multidisciplinary approach with the flexibility for students to discover their interests in specific core programmes and also in areas outside of engineering.

Students enrolled in the Faculty read a Bachelor of Engineering in one of the following programmes:
1. Bioengineering
2. Chemical Engineering
3. Civil Engineering
4. Computer Engineering
5. Electrical Engineering
6. Environmental Engineering
7. Industrial & Systems Engineering
8. Mechanical Engineering

With effect from Academic Year 2004-2005, applicants to the Faculty will be able to select, at the point of admission, a specific engineering programme of their choice. Alternatively, they can opt for admission to a common engineering programme first and then select a specific engineering programme after completion of their first year. In all cases, admission and allocation is merit-based.

The curriculum in the Faculty is broadly organised as follows:

<table>
<thead>
<tr>
<th>Engineering Undergraduate Curriculum Structure</th>
<th>Programme Requirements</th>
<th>Major Requirements</th>
<th>Unrestricted Elective Modules</th>
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<tbody>
<tr>
<td><strong>University Requirements</strong></td>
<td><strong>Faculty Requirements</strong></td>
<td><strong>Common Science Modules (26 MCs): Physics I &amp; II, Mathematics I &amp; II, Programming Methodology, Statics &amp; Mechanics of Materials, Electrical Engineering</strong></td>
<td>12 MCs of Unrestricted Elective Modules (UEMs) – entirely up to student to decide</td>
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<tr>
<td>At least 2 and up to a maximum of 4 General Education Modules (GEMs) = 8-16 Modular Credits (MCs)</td>
<td>Common Year 1 Modules: Critical Thinking &amp; Writing = 4 MCs</td>
<td>84 MCs for discipline-specific Majors, i.e. Bioeng, ChE, CE, EE, CPE, EVE, ISE &amp; ME</td>
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</tr>
<tr>
<td>1 Singapore Studies (SS) Module = 4 MCs</td>
<td>Common Non-Year 1 Modules: HRM &amp; Engineering Professionalism = 6 MCs</td>
<td>Major Requirements</td>
<td></td>
</tr>
<tr>
<td>At least 2 and up to a maximum of 4 Breadth Modules (outside student’s Faculty) = 8-16 MCs</td>
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<td>110 MCs (68.75%)</td>
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<tr>
<td><strong>Total MCs = 28 (17.5%)</strong></td>
<td><strong>Total MCs = 10 (6.25%)</strong></td>
<td><strong>Total MCs = 110 (68.75%)</strong></td>
<td><strong>Total MCs = 12 (7.5%)</strong></td>
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<td><strong>Total MCs = 160</strong></td>
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An extensive array of enhancement programmes has also been developed to add diversity to the student’s experience at the Faculty. This includes:
1. Student Exchange Programme
2. NUS Overseas Colleges
3. Local and Overseas Industrial Attachment
4. Vacation Internship Programmes
5. Technopreneurship & Incubation Programme
6. Innovation Programme
7. Undergraduate Research Opportunities Programme
8. Independent Work Programme (student proposed)

In keeping with the times, current admission requirements for undergraduate enrolment are:
‘A’ level students – Passes in Physics and Mathematics, and for Chemical Engineering and Environmental Engineering, an additional requirement of ‘A’ level Chemistry.
Polytechnic students: Good grades from accredited courses.

Students enrolling for Bioengineering do not need an ‘A’ Level qualification in Biology, but will be required to read LSM1301 General Biology. The Faculty is also moving towards enrolling exceptional students, looking beyond an applicant’s academic abilities, and this includes leadership qualities, entrepreneurial spirit and other special talents that the applicant has passion for. This will allow diversity in our student population and serve the nation’s needs to produce a constant supply of well-qualified and thinking engineers who will drive the economy to a higher level of growth and development. As we offer a professional degree which is recognised and accredited by Singapore Engineering Accreditation Board (EAB) and UK accreditation bodies and agencies, students whom we accept into our programme must also meet the necessary requirements to practise as professional engineers when they graduate.
We are committed to the pursuit of academic excellence in a vibrant research community actively engaged at the forefront of ideas and as a powerhouse of innovation. The graduate experience helps students realise their full potential and prepare them for an increasingly borderless and innovation-driven global economy.

The Faculty has built strong international partnerships with universities. Their names are synonymous with some of the best in their field including University of Illinois at Urbana-Champaign (UIUC); Massachusetts Institute of Technology; US Naval Postgraduate School, Monterey; French Grandes Ecoles; Technische Universiteit Eindhoven (TU/e) and Tsinghua University.

Graduate Programmes

Research-based degrees
- Doctor of Philosophy (PhD)
- Joint PhD with UIUC
- Joint PhD with TU/e
- Joint PhD with Supelec
- Master of Engineering (MEng)

Coursework-based programmes
- Master of Science in
  - Chemical Engineering
  - Civil Engineering
  - Electrical Engineering
  - Environmental Engineering
  - Industrial & Systems Engineering
  - Materials Science & Engineering
  - Mechanical Engineering
  - Mechatronics
  - Safety, Health & Environmental Technology
  - Transportation Systems & Management
- NUS-UIUC Joint Master of Science in Chemical Engineering
- Dual Master’s Degree Programme with Tsinghua University
- Graduate Diploma in
  - Aviation Management
  - Maritime & Port Management

Our Faculty is also actively involved in other engineering programmes which are offered at university level and by university-affiliated institutes:
- Singapore-MIT Alliance (SMA)
- Design Technology Institute (DTI)
- Temasek Defence Systems Institute (TDSI)
- The Logistics Institute-Asia Pacific (TLI-Asia Pacific)

Research remains the primary focus of the Faculty in its pursuit of excellence. Exciting research opportunities for graduate studies are available in Bioengineering, Chemical & Biomolecular Engineering, Civil Engineering, Electrical & Computer Engineering, Industrial & Systems Engineering and Mechanical Engineering. The University’s reputation as a research hub has accounted for a significant number of international students in the graduate population. Attracting students from the US, France, China, India, New Zealand, ASEAN and Japan, among others, we emphasise the close association of research and graduate training.

Enrolment of Graduate Students

Graduate students are an important and valued part of the Faculty. Our graduate programmes are sought after by candidates from Singapore as well as in the region and beyond. For the year 2003, we have 2,859 graduate engineering students of which over half (1,689) are pursuing their research degree programmes.

The doctoral programme is the prime focus of our research degree programmes. An increasing number of applicants are being admitted into the PhD programme. For the year 2003, over 40% (739) of research engineering students are pursuing their doctoral degrees.

With new merging technologies and in an innovation-seeking global arena, we strive to invest and attract the brightest graduate candidates and provide ample opportunities to students to realise their full potential and prepare them for a future in a globalised economy.

New Joint Programmes

Joining forces with one of North America’s top five engineering schools, UIUC, NUS has taken a big step towards the forefront of doctoral education in chemical engineering. This leap forward is the result of an agreement signed on 3 February 2004, officially launching a joint PhD Programme in Chemical Engineering between UIUC and the Department of Chemical and Biomolecular Engineering in NUS. The first batch of students will be admitted in August 2004.

The Memorandum of Understanding for a Joint PhD Programme with Ecole Superieure d’Electrique (Supelec) in France was signed on 28 April 2004. Another collaboration in the works is a joint Master of Science in Intelligent Transport Systems to be offered with the Department of Transportation of Technische Universität München (TUM), Germany.
The Office of Vice-Dean, Research, is responsible for coordinating research planning, setting and implementing relevant research policies, and managing research resources and information in the Faculty.

Our primary objectives are three-fold: (1) To cultivate within the Faculty a vibrant research setting where cutting-edge and interdisciplinary research activities abound and research findings are constantly disseminated through seminars, public lectures and research publications; (2) To position the Faculty as a leading source of innovative technologies, products and processes through our research activities; and (3) To develop the Faculty into an engineering school of choice for research students, staff and visitors.

In line with these objectives, one of our key strategies is to use our limited internal research funding to seed-fund and support targeted initiatives which have the greatest potential to produce cutting-edge results. The intent is for these to, in turn, spawn projects that will give rise to outcomes of high impact and which are capable of attracting significant external funding. Another goal is to foster greater inter-departmental research collaboration amongst faculty. Towards this end, a new funding initiative for group projects has been formulated and this will be implemented in Financial Year (FY) 2004.

Another key strategy is for us to work more closely with national research institutes and other key funding agencies in Singapore. Research collaborations and co-funding arising from these linkages not only help to further stretch our limited research funding but also ensure that our research activities are industry-relevant since these research institutes and agencies have very clearly defined missions to carry out economically relevant research. In FY2003, we have strengthened our linkages with a number of A*STAR-funded research institutes and developed strong links with the Maritime and Port Authority of Singapore and the Singapore Economic Development Board.

To do good research, it is important that faculty be supported by an efficient research management infrastructure, policies and procedures that will allow faculty to take full ownership and accountability for their research projects. An efficient research management infrastructure helps faculty to plan ahead and to reduce paper work required in such tasks like preparing research proposals, progress reports and reporting achievements. Our third key strategy is to provide such a research management infrastructure which will comprise relevant databases and online (pre-completed) forms as well as a calendar of events with automated calls and reminders. The results of some of this Office’s activities in this area will be deployed in FY2004.

Finally, our fourth strategy is to ensure that our research results and achievements are properly and appropriately disseminated to the right target audience. This is necessary for the Faculty to be known internationally in order to be attractive to high quality researchers and students. Equally important is the need to inform our own faculty, researchers and students where we stand, amongst the major institutions we wish to benchmark against. Knowing where our strengths and weaknesses are, we can then take appropriate measures to address these in order to achieve our objectives. Towards this end, we have started to comprehensively revamp the Faculty’s research website to make it an attractive one-stop portal for faculty, students and visitors to gather information and follow the progress of our research efforts. We have also started a fortnightly public lunchtime lecture series during which our faculty present their latest research work and achievements. We are gratified that these lectures have so far attracted good response in terms of attendance.

Looking forward to FY2004, we will continue with our efforts to implement our strategies outlined above in order to realise our three primary objectives. In particular, we look forward to excelling in our role as facilitators to great research.
Office of Vice-Dean, Administration

The aim of the Vice-Dean of Administration is to create a conducive environment and to provide the support needed by the Faculty in fulfilling its vision of becoming a premier school of engineering.

Currently, there are seven administrative centres under the charge of Vice-Dean of Administration, namely human resource, finance, safety, space, information technology, professional activities and audio visual aids.

Faculty resources include tangible (finance and budget, space and utilities, IT and AVA support) and intangible resources (human, safety). For the distribution of tangible resources, several long-term measures have been taken based on a fair and transparent distribution process, and on an optimum distribution of limited resources based on performance and the judicious adherence to the Faculty’s goals.

In 2003, our efforts were focused on waste reduction as well as assisting departments to establish budgeting processes in preparation for the performance-based one-line budget to be implemented in Financial Year (FY) 2004. We are proud to have achieved significant improvements within the year: our utilities bill was $165,000 less than the projected value of $4.6 million, or a respectable savings of 3.7%. With careful planning, the commitments carried forward year-to-year was reduced from about $3.5 million in FY2002 to approximately $1.7 million in 2003. The Expenditure on Manpower (EOM) and Other Operating Expenditure (OOE) surpluses were also capped at $170,000 (0.26%) and $70,000 (0.75%) respectively. The overall surplus of $92,000 (0.12%) out of a total expenditure of about $80 million is a reflection of prudent financial management by all departments.

In the management of human resources, considerable effort was exerted to create a friendly, safe and conducive environment for students, staff and researchers. For academic staff, a fair and transparent assessment system had already been implemented by the University. On the Faculty’s part, we enhanced the transparency of the process by implementing an on-line "progress-tracking" system for faculty to track the progress of their promotion and tenure applications. This new system was popular enough to be adopted university-wide. At the same time we set up a website dedicated to the welfare and promotion of activities for non-academic staff. We actively heightened safety standards, by implementing various measures to enhance laboratory and personal safety to ensure the Faculty remains a safe place for students and staff.

In line with corporate trends, we aim to improve job satisfaction by empowering Administrative Officers in the decision-making process and to facilitate a widening of their scope and exposure to a wider job spectrum through a system of rotations. Structured training plans have also been put in place to equip them with new skills to meet new challenges. Management Support Officers are now involved in the decision-making process, set their own targets on which their appraisals will be based, and given structured training programmes for personal development. A Faculty Review Committee, comprising all Vice-Deans and Deputy Heads, was constituted to ensure fair assessments of non-academic staff across the different departments and units in the Faculty.

It has indeed been an exciting year for all on board. The year also marked the beginning of a new era in which resources cannot be taken for granted, and are to be given on the basis of competition and performance. On the other hand, our approach has become enlightened, with increased social consciousness as we expend energy and resources on staff welfare and well-being, to create a conducive work environment and become not just an institution to study, but also an ideal place to work in.
In the last year, we organised and participated in a series of public events and activities, established links with select overseas institutions, and strengthened our relationship with industry and alumni.

Despite the slower flow of visitors arising from the SARS outbreak in March 2003 and the chicken flu threat in February 2004, the Faculty received visitors from 25 institutions, comprising mainly academics and officials from government agencies from 16 countries across the globe.

In the area of collaboration, Memoranda of Understanding (MOU) were signed with four IITs (Institutes of Technology) in India; Bombay, Kanpur, Kharagpur and Roorkee. The MOUs cover academic collaboration and student exchange with a view to engaging talented students for graduate studies in NUS. The first IIT exchange student from Bombay spent a semester with the Department of Electrical and Computer Engineering in January 2004.

In China, an MOU was signed between Shanghai Jiao Tong University’s School of Naval Architecture, Ocean and Civil Engineering and our Department of Civil Engineering during a visit by a nine-member delegation headed by Dean Seeram in March 2004. Contact was concurrently established with Xi’an Jiaotong, Zhejiang and Fudan Universities for possible collaboration in research, staff exchange and student talent recruitment. The efforts complement ongoing research collaboration with Tsinghua and Beijing Universities.

The Faculty welcomed a visit from Mr Chan Soo Sen, Minister of State for Education and Community Development & Sports, and LG (NS) Lim Chuan Poh, Second Permanent Secretary, Ministry of Education, in August 2003; and Mr Chiang Chie Foo, Permanent Secretary, Ministry of Education, in a separate visit in the same month.

The Faculty also participated in the EDB Choice Engineering Career Fair in March 2004 and, in conjunction with the NUS Open House in March 2004, opened our doors to prospective students, parents and alumni. Besides visiting laboratories and viewing research exhibits, visitors were able to participate in a special “Quiz-the-Engineering-Professors” where they picked the brains of our teaching staff.

In support of the Science .03 event organised by A*STAR and the Singapore Science Centre, the Faculty’s professors gave a series of talks to students and the public throughout four weekends in September 2003, to generate greater awareness of the impact of science, technology and biomedicine in modern living.

On a regional level, 84 overseas ASEAN scholars from the Sunburst Youth Camp organised by the Singapore Technologies Group, were treated to a tour of our engineering laboratories.

We successfully organised our first overseas engineering alumni gathering in Shanghai on 5 March 2004. Hosted by Dean Seeram, the occasion was well attended by 30 alumni working in various parts of China. In the same year, we were proud to honour Mr Lau Joo Ming, Director of Building Technology Department at the Housing and Development Board, as the Faculty’s latest Distinguished Engineering Alumnus at the Faculty’s Annual Lunch.

Our industry relations gained momentum when the Inaugural Keppel Offshore & Marine Lecture was delivered to some 500 people by the first recipient of the Keppel Chair, Prof Torgeir Moan from Norway. This is the first public event resulting from the NUS-Keppel collaboration to establish Singapore as a centre for offshore and maritime engineering.

Publicity was generated for the Faculty’s research achievements in engineering and technopreneurship in the print and broadcast media. Among the highlights are our Gold award winners in 3D scaffold using nanotechnology for tissue growth and replacement; and a multi-million dollar project for conversion of incineration ash into landfill. Other groundbreaking projects, including our 3D mixed reality movies, a medical breakthrough research in bone scaffold for bone regeneration, student-focused projects such as the first made-in-Singapore race car, built from scratch by our undergraduates, attracted local and international media coverage.

In the year ahead, we hope to establish closer links with our students, prospects, partners in industry and academia, and alumni across the globe. For starters, our newest engineering alumni in Class 2003 and 2004 will be receiving the first batch of free lifelong e-mail addresses to be given to graduates of NUS and the NUS Faculty of Engineering. To create an environment for synergistic engagement, we have begun re-construction of the Faculty web portal which will be a one-stop on-line centre servicing the needs of our community groups and “Friends of the Faculty”.

Prof Chou Siaw Kiang
Vice-Dean, External & Industry Relations
Milestones

1956 Professional engineering education commenced in the then University of Malaya (UM) at Bukit Timah campus.

1958 The Department of Engineering was elevated to full faculty status when it was transferred to Kuala Lumpur, Malaya. The Singapore Polytechnic (SP), a constituent college of UM, first offered a four-year professional engineering diploma.

1968 First batch of SP graduates received the BEng degree from the University of Singapore.

1969 Faculty of Engineering was constituted under the University of Singapore with three departments: Civil, Electrical and Mechanical. It was initially located in the same buildings as the Singapore Polytechnic at Prince Edward Road.

1972 The Department of Industrial and Systems Engineering was established.

1977 The Faculty of Engineering was shifted to the new Kent Ridge campus.

1978 Establishment of joint campus between University of Singapore and Nanyang University.

1979 The Department of Chemical Engineering was transferred from the Faculty of Science. Part-time MSc courses in Construction Engineering and Industrial & Systems Engineering, and MEng and PhD research degrees were offered.

1990 The Postgraduate School of Engineering was set up.

1994 The modular system was adopted by the Faculty of Engineering.

1995 A part-time BTech programme was introduced.

1997 An undergraduate course in Computer Engineering was introduced. The Environmental Engineering programme was formed.

1998 Department of Chemical Engineering renamed Department of Chemical & Environmental Engineering.

2000 Department of Mechanical and Production Engineering was renamed Department of Mechanical Engineering. Department of Electrical Engineering was renamed Department of Electrical and Computer Engineering.

2002 Division of Bioengineering was set up.

2004 The Department of Chemical and Environmental Engineering was renamed Department of Chemical and Biomolecular Engineering. Environmental Science and Engineering Programme was formed.
Facts & Figures

Distribution of Staff (as at March 2004)

- Faculty Members, 28% (281)
- Adjunct, 7% (70)
- Research, 24% (240)
- Other Teaching Staff, 4% (35)
- Administrative, 5% (46)
- Non-Academic, 32% (318)

* includes Visiting Staff, Fellows, Senior Fellows, Associate Professorial Fellows, Professorial Fellows, Professors (Joint)

Distribution of Faculty members (as at March 2004)

- Assistant Professors, 30% (84)
- Senior Lecturers, 2% (5)
- Teaching Assistants, 3% (8)
- Professors, 17% (47)
- Associate Professors, 48% (137)

* includes Senior Tutors and Instructors

Education

Undergraduate
The NUS Faculty of Engineering offers eight full-time programmes; each of four-year duration. The programmes lead to the degree of:
- BEng (Bioengineering)
- BEng (Chemical Engineering)
- BEng (Civil Engineering)
- BEng (Computer Engineering)
- BEng (Electrical Engineering)
- BEng (Environmental Engineering)
- BEng (Industrial and Systems Engineering)
- BEng (Mechanical Engineering)

In addition to full-time undergraduate programmes, the Faculty also conducts a part-time programme leading to the degree of:
- BTech (Chemical Engineering)
- BTech (Electronics Engineering)
- BTech (Manufacturing Engineering)
- BTech (Mechanical Engineering)

Postgraduate
The Faculty provides training leading to the award of the following postgraduate degrees:
- Doctor of Philosophy (PhD)
- Master of Engineering (MEng)
- Master of Science (MSc)
  - Chemical Engineering
  - Civil Engineering
  - Electrical Engineering
  - Environmental Engineering
  - Industrial & Systems Engineering
  - Materials Science & Engineering
  - Mechatronics
  - Mechanical Engineering
  - Safety, Health and Environmental Technology
  - Transportation Systems & Management
- Graduate Diploma
  - Aviation Management
  - Maritime & Port Management
  - Defence Technology and Systems
- Double Degree programmes with French Grandes Ecoles, France
- Joint PhD with Technische Universiteit Eindhoven (TU/e), the Netherlands
- Joint PhD with University of Illinois at Urbana-Champaign (UIUC), USA
- Joint PhD with Ecole Superieure d'Electricite (Supelec), France
- Joint MSc in Chemical Engineering with UIUC, USA
- Dual Master's Degree Programme with Georgia Institute of Technology (Georgia Tech), USA – MSc in Logistics & Supply Chain Management (NUS) and MSc in Industrial Engineering (Georgia Tech)
- Dual Master's Degree Programme with Naval Postgraduate School (NPS), Monterey, USA – MSc in Defence Technology and Systems (NUS) and MSc (NPS)
- Master of Technological Design (Embedded Systems)
- Master of Technological Design (Rapid Product Development)
- Master of Technological Design (Mechatronics)
- Dual Master's Degree Programme with Tsinghua University (TU), China – MSc in Transportation Systems & Management (NUS) and MSc (TU)
- Singapore-MIT Alliance programmes
  - Master of Science (S.M.) and PhD in Advanced Materials for Micro- and Nano-Systems
  - Master of Science (S.M.) and PhD in High Performance Computation for Engineered Systems
  - Master of Science (S.M.) and PhD in Molecular Engineering of Biological and Chemical Systems

* The BEng programme in chemical engineering includes specialisations in Biomolecular Engineering, Biopharmaceutical Engineering, Microelectronics and Process & Systems Engineering. Also included is the Chemical Sciences Programme (jointly with the Department of Chemistry and the Office of Life Sciences) intended to prepare students for postgraduate studies in the biomedical sciences.
### Undergraduate Student Intake as at Academic Year 2003-2004

<table>
<thead>
<tr>
<th>Engineering Programmes</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full-time BEng Programmes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>154</td>
<td>96</td>
<td>250</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>72</td>
<td>25</td>
<td>97</td>
</tr>
<tr>
<td>Engineering</td>
<td>721</td>
<td>295</td>
<td>1,016</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>14</td>
<td>31</td>
<td>45</td>
</tr>
<tr>
<td><strong>Part-time BTech Programmes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>171</td>
<td>59</td>
<td>230</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,132</td>
<td>506</td>
<td>1,638</td>
</tr>
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</table>

### Undergraduate Student Population by year and by programme

<table>
<thead>
<tr>
<th>Engineering Programmes</th>
<th>First Year</th>
<th>Second Year</th>
<th>Third Year</th>
<th>Final Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full-time Programmes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioengineering</td>
<td></td>
<td>41</td>
<td></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>250</td>
<td>240</td>
<td>206</td>
<td>194</td>
<td>889</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td></td>
<td>153</td>
<td>204</td>
<td>179</td>
<td>536</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>97</td>
<td>86</td>
<td>119</td>
<td>84</td>
<td>385</td>
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<tr>
<td>Electrical Engineering</td>
<td></td>
<td>472</td>
<td>496</td>
<td>522</td>
<td>1,490</td>
</tr>
<tr>
<td>Engineering</td>
<td>1,016</td>
<td></td>
<td></td>
<td></td>
<td>1,016</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>45</td>
<td>32</td>
<td>43</td>
<td>35</td>
<td>153</td>
</tr>
<tr>
<td>Industrial and Systems Engineering</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td></td>
<td>327</td>
<td>357</td>
<td>406</td>
<td>1,090</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,408</td>
<td>1,391</td>
<td>1,465</td>
<td>1,420</td>
<td>5,677</td>
</tr>
</tbody>
</table>

| **Part-time Programmes** |            |             |            |            |       |
| Chemical Engineering    | 61         | 40          | 34         | 28         | 163   |
| Electronics Engineering | 112        | 68          | 71         | 76         | 327   |
| Mechanical/Manufacturing Engineering | 57 | 66          | 63         | 41         | 227   |
| **Total**               | 230        | 174         | 168        | 145        | 717   |

### Undergraduate Student Population by gender

<table>
<thead>
<tr>
<th>Engineering Programmes</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full-time Programmes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,020</td>
<td>1,657</td>
<td>5,677</td>
</tr>
<tr>
<td><strong>Part-time Programmes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>556</td>
<td>161</td>
<td>717</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,576</td>
<td>1,818</td>
<td>6,394</td>
</tr>
</tbody>
</table>
### Postgraduate Student Population by programme as at September 2003

#### Enrolment by Coursework

<table>
<thead>
<tr>
<th>Programmes (By coursework)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grad.Dip.Aviation Mgt.</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Grad.Dip.Env.Eng.</td>
<td>16</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td>Grad.Dip.Maritime &amp; Port Mgt.</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>MSc (Chem. Eng.)</td>
<td>50</td>
<td>24</td>
<td>74</td>
</tr>
<tr>
<td>MSc (Civil Eng.)</td>
<td>98</td>
<td>22</td>
<td>120</td>
</tr>
<tr>
<td>MSc (Elect. Eng.)</td>
<td>198</td>
<td>39</td>
<td>237</td>
</tr>
<tr>
<td>MSc (Env. Eng.)</td>
<td>57</td>
<td>33</td>
<td>90</td>
</tr>
<tr>
<td>MSc (Ind. &amp; Sys. Eng.)</td>
<td>181</td>
<td>66</td>
<td>247</td>
</tr>
<tr>
<td>MSc (Mat’l Sc. &amp; Eng.)</td>
<td>55</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>MSc (Mech. Eng.)</td>
<td>113</td>
<td>4</td>
<td>117</td>
</tr>
<tr>
<td>MSc (Mechatronics)</td>
<td>41</td>
<td>7</td>
<td>48</td>
</tr>
<tr>
<td>MSc (SHE)</td>
<td>34</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>MSc (Transp.Sys. &amp; Mgt.)</td>
<td>32</td>
<td>13</td>
<td>45</td>
</tr>
<tr>
<td>NUS-UIUC MSc (Chem. Eng.)</td>
<td>14</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>901</td>
<td>269</td>
<td>1,170</td>
</tr>
</tbody>
</table>

#### Enrolment by Research

<table>
<thead>
<tr>
<th>Programmes by Research</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEng</td>
<td>702</td>
<td>248</td>
<td>950</td>
</tr>
<tr>
<td>NUS-TU/e Joint PhD</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>NUS-UIUC Joint PhD</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>PhD</td>
<td>546</td>
<td>183</td>
<td>729</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,255</td>
<td>434</td>
<td>1,689</td>
</tr>
</tbody>
</table>

#### Enrolment Summary

<table>
<thead>
<tr>
<th>Programmes (all)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>By Coursework</td>
<td>901</td>
<td>269</td>
<td>1,170</td>
</tr>
<tr>
<td>By Research</td>
<td>1,255</td>
<td>434</td>
<td>1,689</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,156</td>
<td>703</td>
<td>2,859</td>
</tr>
</tbody>
</table>

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### Class of 2003 – Degrees Conferred

- **MEng**: 12% (261)
- **MSc**: 24% (547)
- **BEng**: 61% (1,371)
- **PhD**: 3% (77)

### Student Profile (as at September 2003)

- **Graduate**: 31% (2,859)
- **Undergraduate (Full-time)**: 61% (5,677)
- **Undergraduate (Part-time)**: 8% (717)
Research

New Research Thrust
- Establishment of NUS-University of British Columbia (UBC) Applied Science Research Centre to support research collaborations with NUS Faculty of Science and UBC Faculty of Applied Science in Materials Engineering, NanoScience and NanoTechnology as well as InfoComm and InfoTech.
- Definite steps taken towards initiation of new inter-disciplinary research in information and communication technologies through the University's InfoComm and InfoTech Initiative and other relevant sources of research funding.

Research Reputation
- Close to 210 editorial positions held with international journals, representing an increase of about 42% from previous year.
- Best paper awards in Institution of Electrical & Electronics Engineers (IEEE) Transactions on Industrial Electronics, IEEE Transactions on Semiconductor Manufacturing, Computers & Chemical Engineering Journal and Institution of Civil Engineers’ Transport Journal.
- Prestigious Humboldt Research Award conferred by Alexander von Humboldt Foundation.
- Richard A Glenn Award by Fuel Chemistry Division of American Chemical Society.
- Far Eastern Economic Review 2003 Young Inventors Awards (Gold Medal).
- Singapore National Academy of Science’s Young Scientist Award.

Research Output
- About 990 research papers published in internationally refereed journals and approximately 500 papers presented at conferences.

Patents and Commercialisation
- Innovative research capability reflected in filing of 45 patents.
- 20 patents granted during same period.
- 5 technologies commercialised.

Research Funding
- Total of $26.96 million in research grants (excluding scholarship monies) attracted for financial year, 56% from Academic Research Fund and 44% from external sources.
- Research funding for all on-going projects amounted to $122.46 million, 65% due to external grants.

External Links

Links with Affiliated National Research Institutes
- Department of Chemical and Biomolecular Engineering (ChBE), Bioprocessing Technology Institute (BTI) [A*STAR RI] entered into an agreement to establish BTI-ChBE Joint Programme in March 2004 to carry out joint teaching and training activities as well as collaborative research and development projects in bioprocess engineering of microbial systems.
- Department of Electrical and Computer Engineering and Institute for InfoComm Research (I2R) [A*STAR RI] established a joint-laboratory to collaborate in various aspects of communication and information technology.

Links with Public Sector Organisations and Overseas Institutions
- Joint research laboratory focusing on electromagnetics, radar signal processing and other defence-related projects was established with Defence Science and Technology Agency, in collaboration with French Supelec and ONERA (defence-related research institute).
- NUS-UBC Applied Science Research Centre was established to support research collaborations together with NUS Faculty of Science and UBC Faculty of Applied Science.

Strategic Partnerships

Joint Degrees
- University of Illinois at Urbana-Champaign (UIUC), USA
- Technische Universiteit Eindhoven (TU/e), the Netherlands
- Ecole Superieure d’Electricite (Supelec), France

Double/Dual Degrees
- Georgia Institute of Technology (Georgia Tech), USA
- Naval Postgraduate School (NPS), Monterey, USA
- Tsinghua University, China
- French Grandes Ecoles, France
  - Ecole Polytechnique; Ecole Centrale Paris; Ecole Nationale des Ponts et Chaussees; Ecole Nationale Superieure des Mines de Paris; Group des Ecoles des Telecommunications, Ecole Superieure d’Electricite (Supelec)
Engineering Showcase
- highlights, accomplishments and achievements
Educational Philosophy and Teaching Highlights

The NUS Faculty of Engineering recognises that an engineering education provides a highly versatile route, offering a wide array of options for graduates to become professional engineers, as well as creators and innovators of new technologies. We are committed to producing future leaders of the engineering profession in Singapore and the region, who can meet the widely varying and changing engineering needs of the global economy.

On the most basic level, we seek to inculcate in students a strong ownership of learning as the only way to respond to the speed of technological changes, as formal teaching is no longer sufficient to prepare graduates for the knowledge-based economy in which we live. On a higher plane, we seek to imbue in our students the ability to generate new niche ideas based on a strong foundation in engineering and applied sciences, and cater to their diverse capabilities and wide-ranging interests.

To cater to these considerations, the hallmarks of our curriculum are rigour, flexibility and diversity. In comparison with the highly prescriptive curriculum of yesteryear, the new engineering curriculum is highly flexible without compromising technical prowess. With flexibility in the curriculum, diversity is actively encouraged in students to customise their study and participate in a wide range of enhancement programmes to match their varied interests and also develop a global perspective. A programme of particular importance is the Student Exchange Programme (SEP). In Academic Year (AY) 2003-2004, a total of 216 engineering students, representing 15% of the cohort went on student exchange, an increase of over 50% compared to AY2002-2003. These students went to 56 universities in 17 countries. In return, 210 students (double that of AY2002-2003) from 66 universities in 24 countries joined campus life at Kent Ridge and added a distinct global flavour.

Student Exchange Programme (SEP) student Miss Seah Shi Pei on a dog sled in Jokkmokk, University of Oulu, Sweden
An important change consistent with this mindset of flexibility and diversity is the introduction of a new admissions system whereby students are admitted directly to a specific programme or to a common first year programme, in response to their diverse interests and expectations.

To ensure that graduates remain relevant in a continually evolving technological landscape, we actively encourage students to take over ownership of learning by inculcating a habit of life-long learning. On our part, our philosophy is to rise to the challenge of ensuring that the curriculum is up-to-date with ever-changing technologies. Through systematic curriculum and assessment design, students are weaned from the habit of learning for the sake of exams. For example, there is a significant increase in the number of modules with a substantive continual assessment component. The curriculum also places a significant pedagogical emphasis on open-ended problems, projects and design, together with a substantive final-year dissertation so as to inculcate in students the ability to analyse a problem holistically, recognise the critical issues and then apply the theories learnt to develop specific solutions to the problem.

The Faculty also actively encourages the use of open-ended projects specially designed to encourage creativity and innovation even as they learn. New projects like Embedded Computer Systems Design and CMOS VLSI Systems Design introduced by the Department of Electrical and Computer Engineering bring into sharp focus the many complexities of modern systems. In the Division of Bioengineering, the module on Tissue Engineering adopts a problem-based learning approach, while ensuring students have hands-on sessions on cell tissue culture on scaffolds.

Likewise, Systems Design Projects in the Department of Industrial and Systems Engineering encourage students to apply systems thinking concepts and gain practical experience in solving complex real-world industrial problems. Since 2001, the Department of Mechanical Engineering has an on-going special project for selected students to design and build a race car to participate in the annual Formula Society of Automotive Engineers (FSAE) inter-university competition. Increasingly we have widened our scope beyond academic projects, such as Operation Orion 2003 where students from the Department of Civil Engineering applied their knowledge in the construction of a kindergarten for children in a commune in Vietnam.

In recognition of the trend towards e-Learning, the Faculty has developed several innovative e-Learning and teaching tools for use by faculty members for their teaching needs, including an innovative advanced web-based tutorial management system called IMPARO. IMPARO has helped the Faculty to build intelligent partnerships worldwide, especially AUN/SEED-Net, an engineering education consortium of 19 universities along the Pacific Rim.

In keeping with our thrust in e-Learning, faculty in the Department of Chemical and Biomolecular Engineering have developed an interactive simulation of chemical processes coupled with visualisation to enhance students’ understanding of interaction among various modules at an early stage of chemical engineering education.

In the Department of Civil Engineering, a similar holistic approach has been adopted with the introduction of a new pedagogical tool, known as the Virtual Island which emphasises the integration of knowledge learnt from various modules as well as to inculcate independent learning and lateral thinking.

Beyond e-Learning tools, the Faculty also houses a smart facility called the e-Smart Classroom, equipped with state-of-the-art video-conferencing as well as advanced information and communication technologies, to promote interactive distance education and enhance teaching, learning, research and industrial collaboration.
Accomplishments in Research

A hub pulsating with life and driven by a vibrant research culture – this continues to be the goal of the Faculty to establish itself as a leading source of innovative ideas, technologies, products and processes and as an engineering school of choice for research students, faculty and visitors. Novel, “no walls” research is the key thrust that provides the impetus to the fulfillment of this goal, along with constant dissemination of research findings through seminars, public lectures and research publications to cultivate a research-active environment.

Strategic initiatives taken by the Faculty include multidisciplinary research in the areas of Bioengineering, Chemical and BioMolecular Engineering, Materials Engineering, Microsystems Technologies and Information Communication (InfoComm) Technologies. The year saw definite steps taken towards the initiation of a new major area of inter-disciplinary research in InfoComm Technology. The Faculty is now ready to grow InfoComm and InfoTech (ICIT)-related research through the University’s ICIT Initiative as well as other relevant sources of research funding.

During the year, research activities within the Faculty resulted in a number of major achievements. For example, in coastal environmental research, destruction of some of the most recalcitrant hydrocarbons associated with oil spillage has been achieved with the use of indigenous microbial biomass. In the imaging of magnetic nanostructures, high-resolution magnetic force microscopy tips amenable to batch fabrication have been developed. In the fabrication of nanometer scale fibres, which have many applications in bioengineering, such as tissue regeneration, filtration of viruses and drug molecules, optimal fabrication of nylon/clay composite nanofibres has been achieved.

A number of major multidisciplinary research projects carried out within the Faculty have also led to significant achievements. These include the development of several water quality enhancement systems in joint work with the Ministry of the Environment, the Public Utilities Board, the Defence Medical & Environmental Research Institute and the Faculty of Medicine, as well as the development of an integrated Computer Aided Design – Finite Element Analysis – Rapid Manufacturing Machine System for the design of prosthetic sockets in joint work between the Division of Bioengineering and the Department of Mechanical Engineering.

Research accomplishments in the Faculty have also been affirmed by numerous international and national accolades in the form of best paper awards for publications in major international refereed journals as well as international/national research awards. Examples are best paper awards by the Institution of Electrical & Electronics Engineers (IEEE) Transactions on Industrial Electronics, IEEE Transactions on Semiconductor Manufacturing, the Computers & Chemical Engineering Journal and the Webb Prize by the Institution of Civil Engineers’ Transport Journal, a prestigious Humboldt Research Award, the American Chemical Society’s Richard A Glenn Award and the Far Eastern Economic Review 2002 and 2003 Young Inventors Awards (Bronze and Gold respectively); 1st place in the Humanoid Robot Competition at the Federation of International Robot-soccer Association’s (FIRA) Robot World Cup 2003, as well as a Singapore National Academy of Science's Young Scientist Award.
The Faculty continued to keep up its momentum of forging strategic alliances with public and private sector partners as well as major partner universities to amass talent transcending boundaries and disciplines to spearhead its research drive. The year’s initiatives were aimed at establishing closer synergistic ties, involving joint research projects, joint laboratories and adjunct research appointments, with Research Institutes (RIs) of the Agency for Science, Technology and Research (A*STAR), the Ministry of Defence and other relevant organisations or agencies. The Faculty’s endeavour resulted in new joint laboratories being set up with A*STAR RIs, including the Institute for InfoComm Research and the Bioprocessing Technology Institute, while negotiations to set up similar joint laboratories are on-going with the Institute for Chemical Engineering and Sciences and the Institute of Materials Research and Engineering. A research collaboration Memorandum of Understanding is also being prepared to foster a stronger partnership with the Maritime and Port Authority of Singapore. Negotiations with the InfoComm Development Authority to set up a Human Interface Technology laboratory, in collaboration with the University of Washington, are also under way. With the Defence Science and Technology Agency, a joint research laboratory focusing on electromagnetics, radar signal processing and other defence-related projects has been established, in collaboration with two French institutions – Supelec and research agency ONERA. The Faculty is also working closely with the Economic Development Board to set up a Centre for Offshore Research and Engineering, for which a $2.66 million training grant has been provided by the latter. An on-going project, with the University of Freiburg and Fibrosys (Wuppertal, Germany), focuses on the application of novel pharmacological agents to down regulate scar formation in eye tissue repair. As an example of applied Nanobiomechanics, the changes in the physical properties of malaria-infected red blood cells are studied using novel molecular and bioengineering approaches and computational modelling.

For the financial year, the Faculty successfully attracted a total of $26.96 million in research grants alone (excluding scholarship monies), 56% of which came from the Academic Research Fund and 44% from external sources. Research funding for all on-going projects amounted to $122.46 million, 65% of which were due to external grants.

Our research work translated into a total of about 990 research papers being published in international refereed journals and approximately 500 papers were presented at conferences. The impact of the work done was evident from the increase in the number of papers being published in premier international journals. The Faculty also made substantial leadership contributions to the academic community by holding close to 210 editorial positions with international journals. This represents an increase of about 42% from the previous year.

The year ahead sees the Faculty further leveraging on the momentum set in place for partnerships in research by increasing its collaborative efforts and working synergistically with national research institutes, industry and selected peer institutions overseas. In addition, to enable meaningful benchmarking with the major engineering colleges in good American and European universities, relevant key performance indicators will be identified.
The Technopreneurship & Incubation Programme (TIP) for undergraduate students, part funded by T21 funds from EDB, was launched in September 2000 as a major part of the Enhancement Programme in which all students need to participate in as part of their curriculum and in order to graduate. The TIP offers three-day Technopreneurship Orientation Workshops four times a year, frequent seminars by technopreneurs, guidance for the writing of business concept plans and full business plans, and incubation space and facilities for start-ups by student teams. The programme is administered by a TIP Committee consisting of representatives from all Departments in the Faculty, plus visiting and adjunct technopreneurs.

Students may join the TIP at any time. Currently there are around 600 students participating in the Programme. Every year around 250 students take part in the three-day TIP Workshops, 150 attend TIP Seminars, and 50 submit Concept or full Business Plans. Some of the latter go on into incubation. In the incubation centre, there are currently 11 start-ups, engaging some 60 students. Most of these are engineering students, with a few from other Faculties. One company has already moved off-site and is now successfully operational in Singapore in the business of building and selling customised PCs and related equipment. Other start-ups are in various technopreneurship areas including robotics, home automation, window panel technology, and IT service support.

The TIP staff also participate in NUS Enterprise activities like the Overseas Colleges Programmes at Silicon Valley, Bio Valley and Shanghai, as well as the annual Start-up@Singapore Business Plan Competitions organised by the NUS Entrepreneurship Centre (NEC). This all helps maintain seamless relationships between the technopreneurship programmes of the Faculty and NUS Enterprise. The recent NUS-Motorola Technopreneurship Challenge for NUS students was organised as a TIP activity and attracted an entry of some 40 teams of NUS students. TIP students notably do well in these competitions. Some of the competition winners have gone on to start up their companies. A good example is the competition winning company, Liaser, which is a start-up based on commercialising technology from the Department of Civil Engineering for the economic production of stable high grade backfilling material as needed for land reclamation. The raw materials here are the ash from incineration plants and the marine mud from dredging and excavation works. Both these materials would otherwise be waste, costly and difficult to dispose of.

Besides the linkages with NUS Enterprise, TIP benefits from strong linkages with both the student society and the independent Singapore society Business Incubators Networking Organisation (BINGO). These provide TIP students with easier networking access to like-minded potential and active technopreneurs.

Future plans include increasing the guidance to TIP students by more mentoring from staff, and more visibility to the students of the on-going work in the Faculty’s labs and of its available patented technologies.
Our Achievements

Our staff and students are committed to the quest for excellence in the core competencies of education, research, entrepreneurship and service. Numerous achievements in the past year have set new benchmarks in raising the standing of the Faculty.

Dr Adrian Cheok [Department of Electrical & Computer Engineering (ECE)] was appointed a Visiting Associate Professor and Visiting Foreign Scientist by Kyoto University, as well as Guest Professor at Universitat Paderborn in Germany on a fellowship grant sponsored by Heinz Nixdorf Institut. In addition, he was presented the Singapore National Academy of Science’s Young Scientist Award 2003 and the Hitachi Fellowship 2003 – awarded to only the top three researchers in the Asia-Pacific – for research on mixed reality. Dr Cheok has also set up exhibitions at the Ars Electronica Museum of the Future, launched the Ars Electronica Festival 2003, and operates a permanent exhibition at the Huereka Science Museum in Finland.

In recognition of outstanding services to the Institution of Engineers Singapore (IES), the engineering profession and the nation, Prof Chew Yong Tian [Department of Mechanical Engineering (ME)] was made an Honorary Fellow of the ASEAN Federation of Engineering Organisations.

Prof Jacob Phang from ECE was conferred the title of “Chevalier” in the order of Palmes Academiques by the French government in recognition of his sustained efforts towards the improvement of France-Singapore relations in the area of education and research. Prof Ng Wun Jern [Department of Civil Engineering (CE)] was given the same honour in February 2003.

Another staff who made the Faculty proud was Dr Ong Soh Khim from ME Department who became the first female in the ASEAN region to be honoured with the M Eugene Merchant Outstanding Young Manufacturing Engineer Award for her significant achievements and leadership in the field of manufacturing engineering.

Two staff members from the Division of Bioengineering received international recognition for their respective contributions and expertise. Prof Colin Sheppard was honoured with the Humboldt Research Award for his lifetime achievements in science, while Prof Nhan Phan-Thien was awarded the Australian Centenary Medal 2003 for his significant contributions to science in Australia.

Also flying the flag was Prof Raj Rajagopalan (Department of Chemical & Biomolecular Engineering) who was presented the IICT-Avon’s Padmashree Dr G S Sidhu Award by the Indian Institute of Chemical Engineers for distinguished contributions to chemical engineering and related areas, in particular colloid and interface science and to the interfaces between chemical engineering, chemistry and physics. The award is named after a distinguished Indian chemical engineer and sponsoring bodies, Indian Institute of Chemical Technology (IICT) and Avon.

A team called RoboSapiens, comprising Dr Prahlad Vadakkepat from ECE and his students Zhang Ruisiang and Tee Wei In, set new standards for humanoid robots in clinching the First Prize in the Humanoid Competition at the Federation of International Robot-soccer Association’s (FIRA) Robot World Cup 2003 held in Austria.

Another proud moment for the Faculty was the accomplishment of Bioengineering PhD student Ryuji Inai in winning the Gold at the 4th Young Inventors Awards organised by Far Eastern Economic Review in association with Hewlett-Packard. Mr Inai beat more than 90 contestants from premier tertiary institutions in the Asia-Pacific region with a breakthrough technique for building tiny 2D and 3D scaffolds from polymer nanofibres, which are many times smaller than a strand of hair, for applications in tissue engineering.
Demonstrating sound business acumen and planning, two NUS Faculty of Engineering teams, Geo-X Corporation and Elengen Incorporation, qualified for the finals of the Megabucks 2003 business plan competition organised by the Indian Institute of Technology Kanpur, India.

Assoc Prof Chen Benmei from ECE Department was presented the Temasek Young Investigator Award 2003 by the Defence Science & Technology Agency and NUS for his research proposal on developing advance nonlinear control methods for a radio-controlled helicopter. This award was jointly presented in recognition and support of outstanding researchers in areas relevant to defence and security.

Two CE colleagues, Assoc Prof Choo Yoo Sang and Dr Ju Feng, were conferred the Institution of Engineers Singapore Prestigious Engineering Achievement Award 2003 for their work in heavy lift software and the expertise developed from associated R&D.

Dr Mansoor Abdul Jalil of ECE Department was conferred the Singapore Youth Award for his research achievements in nanotechnology and excellent service to the community at large.

Final-year ECE student Heng Eu Jin was a member of QuantaGen, comprising students from NUS College in Silicon Valley, which beat 218 other teams to emerge victorious at the Start-up@Singapore national business plan competition.

Another team called Liaser, whose members include CE students Joshua Kumar, Desmond Leong and Andy Tan, won the Gold Award at the NUS-Motorola Technopreneurship Challenge with a technology that turns incineration ash from waste disposal plants and marine clay from dredging/excavation projects into non-toxic, reusable products suitable as a back-fill material.

Two staff members received NUS’ University Awards 2003 in recognition of their outstanding teaching and research – Assoc Prof Seah Kar Heng of ME Department was presented the Outstanding Educator Award while Assoc Prof Wu Yihong from ECE was given the Young Researcher Award. Prof Seah also helped supervise his team of undergraduate engineering students to build Singapore’s first racing car from scratch.
In the early months of 2003, as health workers and governments around the world dealt with the SARS pandemic, the NUS Faculty of Engineering worked closely with the University to contain the outbreak. The University Central SARS Action Team issued a Master Plan of actions which was followed by the Faculty as well as departments. Various precautionary measures were introduced to protect and boost confidence of staff, students and visitors. The Faculty set up a Crisis Management Team (CMT) to conceive, establish and implement day-to-day programmes. CMT members discharged specific duties with a chain of command in the Faculty, with key operations determined in the areas of communications and support, facilities, lab operations and IT.

Monitoring Measures
Vigilance, quick action, and good communication are critical factors in dealing with a global disease as deadly as the SARS virus. The Faculty’s quick response included arrangements for mandatory screening of temperature for all staff, students and visitors. These operations were extended to all offices, classrooms, labs and even canteens. The Faculty distributed lanyards to employees and graduate students for staff identification, as well as thermometers to all employees and sections of students for the monitoring and logging-in of temperatures twice a day. This stringent monitoring, in line with Government travel advisories, was also applied to the tracking of Faculty staff and students’ travel to and from Singapore.

e-Pathfinder
The Faculty responded to the crisis by developing a major intranet tool to handle major communication such as staff movement, visitor tracing, temperature logging, sourcing of data and collation of contact summary. Our innovative impetus rose to the challenge, and the Faculty came out with the e-Pathfinder system.

e-Pathfinder was best utilised for handling of a few suspect cases in the Faculty who were discovered with high temperatures. CMT was able to prepare contact collations and tracing summaries by using the e-Pathfinder system while the patients were rushed to the designated hospitals.

Other Measures
We triumphed in the battle against SARS by observing facilities protection, mobilising groups to screen temperatures, issuing tags and recording visitors’ health declarations as well as guiding visitors at prime locations, with conspicuous displays of signboards at entrances to various buildings.

Special labs, identified as high-risk hazards, were of particular concern to the Faculty. The CMT developed Standard Operating Procedures (SOPs) for all special labs, forming floor-level emergency response teams in all buildings to receive instructions, implement actions and transmit critical feedback. There were alternatives in every line of command should one fail.

Overcoming the Odds
As a campus, as a community and a country under siege, the Faculty was proud to have done its part in containing a vicious virus threatening to mutate if left unchecked. All the committees formed, at both Faculty and Department levels, made tremendous efforts to mitigate the SARS outbreak. The integrity shown by the entire Faculty and the camaraderie displayed by staff and colleagues during the crisis, turned a trying period in our history into a memorable and touching time, as we sought to put others before self.
Educational Excellence

- challenging the way we think
The convergence of engineering and the life sciences has paved the way for an exciting new field which has seen exponential growth in recent years. Bioengineering opens up endless opportunities for engineers to contribute to an understanding of how biology works, using the skills engineers are trained in – the use of mathematical models and quantitative approaches. The Division of Bioengineering, inaugurated in 2002, proudly enrolled its first batch of 41 Bioengineering undergraduates at the start of the Academic Year 2003-2004, in addition to 31 graduate students.

Overseeing our move towards acquiring the status of a full-fledged department, a Visiting Committee and a Departmental Consultative Committee were set up to monitor our progress and performance. The former comprises a panel of distinguished academics with many years of experience in chairing departments, namely, Prof David Gough, former Chair, Department of Bioengineering, University of California at San Diego; Prof Charles Cain, former Chair, Department of Bioengineering, University of Michigan, Ann Harbor; Prof Kam Leong, Johns Hopkins University and Johns Hopkins Singapore; Prof Wang Shih Chang, Head of Department of Diagnostic Radiology, NUS; and Prof Jackie Ying, MIT and Director, Institute of Bioengineering and Nanotechnology, Singapore.

Our Departmental Consultative Committee comprises internal and external members. Our four external members are prominent individuals from industry and the medical field, with valuable insights to assist us in curriculum development and outreach to industry – Dr Nicholas Ng, Regional Manager, Promega Corporation; Mr Alok Mishra, Business Development Manager, Johnson & Johnson Medical Singapore and Mr Wong Yew Sin, Director of the Centre for Medical Device Regulations, Health Sciences Authority; and Mr Abel Ang, Head, Medical Technology, Biomedical Sciences Group, Economic Development Board. Our two internal members are Dr Ivor Lim, Department of Surgery, NUS & Consultant, NUH; and Assoc Prof Peter Lee, Head, Bioengineering Programme, Defence Medical and Environmental Research Institute (DMERI), DSO National Laboratories.

Collaborations and Partnerships

Researchers worldwide have crossed multidisciplinary platforms in the race to make advances in this field. Likewise, Assoc Prof Lim Chwee Teck from the Division of Bioengineering has teamed up with the Departments of Microbiology and Physics at the National University of Singapore as well as Monash University, MIT, Ohio State University and the Institut Pasteur to investigate the nanomechanics of malaria-infected red blood cells (RBCs). New techniques involving the use of optical tweezers or laser traps are employed to extract information on changes in the physical and structural properties of human RBCs at both the cellular and molecular levels. Among the changes is the increase in rigidity of the parasite-infected RBC membrane. In the case of Plasmodium falciparum infections, the cells even become “sticky” for a number of other cells and vascular structures. One serious consequence of the rigid and sticky RBCs is the clogging of the microvasculatures in organs such as the brain. This impairs blood flow and may result in coma and even death. The team is now able to stretch RBCs with forces above and beyond that obtained by other researchers. Such “large deformation” studies provide more realistic information on the elastic properties of the highly deformable RBC. It is hoped that this will assist us to better understand the mechanisms resulting in the clogging of blood vessels, and lead to solutions in overcoming it.
Internship Programme
An internship programme was set up in partnership with the Indian Institute of Technology, Kharagpur (IIT-Kg) which established an inter-disciplinary School of Medical Science and Technology in 2001 to foster teaching as well as R&D activities in areas of Medical Science and Technology. This was followed by the introduction of an inter-disciplinary three-year Master’s Programme in Medical Science and Technology in July 2001 which is only open to medical graduates. Out of a total of about 700 applicants, only 10 medical graduates are offered placements in the programme. In the first two years of the course, students concentrate mainly on course work covering engineering-related modules while the third year is mainly project based. Having fulfilled the necessary prerequisites of a life science background, students receive technical training for two years to prepare them for projects related to bioengineering. In June 2003, three IIT-Kg students spent 10 months of internship in the Division of Bioengineering, returning to India in April 2004 to complete their theses. Plans are afoot for two of these students to return to the Division to do their PhD under NUS scholarships. It is anticipated that more IIT-Kg students will be coming to NUS for their internships.

NEW INITIATIVES IN RESEARCH
Bioimaging
A new research thrust for the Division of Bioengineering is in bioimaging. This is widely recognised as a core area of bioengineering by the international bioengineering community and has been identified by the Office of Life Sciences as an important platform technology. It has also been identified by BMRC (Biomedical Research Council) as a significant R&D platform to be developed in Singapore, as evidenced by their recent Bioimaging Workshop in April 2004. According to the BMRC, “The special attraction of this platform is its inherent interdisciplinary nature, bringing together surgeons, engineers and basic scientists. Our department sees a niche for Singapore to become a key player in the international Bioimaging arena.”

Bioimaging offers synergies and exciting new possibilities for collaboration with existing research thrusts in the Division, including those in biosensors and signal processing, nano-bioengineering, biomechanics, biomaterials and tissue engineering. This new research area is championed by Prof Colin Sheppard, well-known for his pioneering role in the development of the confocal microscope, the two-photon fluorescence microscope and the second harmonic generation microscope.
Together with Dr Huang Zhiwei, whose research interests are in the areas of Raman spectroscopic imaging and optical coherence tomography, a research group is planned to develop novel instruments and techniques of optical imaging for biomedical applications.

**The Promise and Potential of Tissue Engineering**

Tissue engineering uses a variety of methods to regenerate tissue. In seeking the use of new natural materials for ligament/tendon tissue engineering, faculty members from the Division of Bioengineering, Assoc Prof Toh Siew Lok and Assoc Prof James Goh Cho Hong have been exploring the use of silk fibres as scaffolds for application to tissue-engineered ligaments/tendons. We are currently working out a one-year Materials Transfer Agreement with the Silk Innovation Centre, Mahasarakham University, Khon Kaen, Thailand for the supply of silk fibres.

**Tissue Modulation**

This new research thrust complements the existing research in the areas of Biomaterials, Tissue Engineering and Tissue Repair. The Tissue Modulation Laboratory was founded in Jan 2004 by Assoc Prof Michael Raghunath using local therapeutic approaches to positively influence the development and composition of tissue in a wound undergoing healing and repair. All such approaches target effector cells that exert certain functions – or are prevented from doing so. Current approaches focus on gene delivery (with or without viral vectors), introduction of cells (with or without genetic transduction) and the delivery of growth factors or antibodies to scavenge them. In contrast, the Laboratory prefers the application and local delivery of pharmacological substances that are well defined. The current key issues are characterisation of biological effects in a tissue context and the mode of delivery.

- **Setting up a single cell testing apparatus at the Nano Biomechanics Laboratory**
- **Hybrid of micro- and nanofibers for tissue engineering**
- **Computational modelling on the stretching of a red blood cell (NUS-MIT collaboration)**
A New Name … and New Directions

The year marked exciting changes in the research and educational programmes of the Department and the new directions they augur. Symbolic of the changes is the new name of the Department – Chemical & Biomolecular Engineering – which became effective in January 2004, with the endorsement of the University Senate and NUS Council. The new name recognises the increasing role of biology as an enabling science in chemical engineering as well as the research and educational activities in the Department at the interface between chemical engineering and biology.

Today our unprecedented ability to manipulate biological cells at the genetic level has led to the emergence of what is often referred to as new biology and systems biology. These developments highlight biology at the molecular level as a chemical science and biological cells as cellular factories – perspectives that invite the Department to play a central role in developing a new breed of engineering scientists, with a solid background in biology and chemistry combined with the quantitative-integrative skills of an engineer. The Department has introduced an undergraduate specialisation in Biomolecular Engineering and is also planning additional research and educational initiatives to meet the challenge of producing the next generation of research scientists and graduates.

While consolidating and extending its scope in biological and life sciences, the Department continues to maintain and enhance its strengths in traditional core areas such as Process and Systems Engineering, Catalysis and Reaction Engineering, Advanced Separation Processes and Transport Phenomena through educational initiatives (e.g. specialisation in Process Systems Engineering) and research clusters (e.g. formation of the Chemical and BioSystems Engineering Group to spearhead growth areas such as chemical supply chains, microsystems control and systems biology). In addition, the Department supports innovative activities in Functionalised and Smart Materials for biosensors, molecular and polymer electronics, novel smart membranes for separation processes and novel optoelectronic and photonic materials and Nanostructured Materials for new catalysts and fuel cells.

New National and Global Joint Programmes

The Department signed a partnership with the Bioprocessing Technology Institute (BTI) in the Biopolis for research interactions as well as for offering Bio/pharmaceutical Engineering Specialisation Options to our undergraduate and graduate students [under EDB’s Specialist Manpower Programme (SMP) and Postgraduate Manpower Programme (PMP), respectively]. The agreement forms a road map for dynamic day-to-day interactions with BTI on research dealing with protein crystallisation and mammalian cell cultures and new educational initiatives that go beyond traditional chemical engineering. The joint facility with BTI will form the nucleus of the Biomolecular Cluster that is being set up in the Department for research in biomolecular engineering targeted to support Singapore’s drive to become a leading centre of biochemical and biomedical research in the world. The Department is also exploring research interactions on Systems Biology with the Bioinformatics Institute (BII), another national research institute in the Biopolis.
The year also marked the formal signing of an agreement with the University of Illinois at Urbana-Champaign (UIUC), ranked amongst the top five engineering colleges in the US, to establish a Joint PhD Programme in Chemical Engineering. Not only is this the first PhD programme offered jointly by NUS and UIUC, it is also UIUC’s first collaboration with an Asian university in the field of chemical engineering. The Joint PhD Programme is designed to attract talented students to engage in research at the frontiers of chemical engineering, to provide UIUC and NUS faculty with opportunities for research collaboration, and to enhance the visibility of both institutions as leaders in global education and research. This collaboration with UIUC is an important step towards globalisation of NUS’ education and research. One of the key research areas targeted for the Joint PhD Programme is biomedical sciences, but efforts are underway to expand the scope of the programme.

The Department is also reaching out to other major institutions in Asia. An example is the Memorandum of Understanding (MOU) signed with the Institute of Advanced Materials (IAM), a newly-founded research unit at Fudan University, whose activities include organic/polymeric flat panel displays, biomedical materials, and devices at molecular level for electronic, photonic and optoelectronic applications. With strong support from the Ministry of Science and Technology, the Government of Shanghai City, and industrial organisations, the Institute is fast becoming the Chinese centre for original research on advanced materials and technology and for the cultivation of people with skills in materials science and technology. The agreement covers exchange of research students and faculty members, collaborative research, and joint academic and scientific activities.
Awards

The following staff and students received international accolades for outstanding achievements:

Assoc Profs I A Karimi and R Srinivasan and Mr N Julka were recognised with the Best Paper Award for their work on chemical supply chain management reported in the December 2002 issue of Computers and Chemical Engineering. This paper was selected from a field which included works from universities such as Carnegie Mellon, Princeton, ETH Zurich, Switzerland, and Imperial College. This award, given each year since 1987, has been won by only two other non-US universities, ETH Zurich and Imperial College, with NUS joining their ranks to become the first Asian university to do so.

Assoc Prof Marc Garland and his students Dr Chen Li, Mr Chew Wee, Mr Effendi Widjaja, Dr Li Chuanzhao and Mr Zhang Huajun won the HPC Quest Gold Award for their project on Massively Parallel Entropy Based Pattern Recognition for System Identification in Noble Medicated Chemical Synthesis in the HPC Quest Competition. HPC Quest is jointly organised by Institute of High Performance Computing (IHPC) and IBM. It aims to encourage the use of high-performance computing to further R&D activities in Singapore.

Prof Raj Rajagopalan was awarded the IICT-Avon’s Padmashree Dr G S Sidhu Award by the Indian Institute of Chemical Engineers for distinguished contributions to chemical engineering and related areas. The award, named after a distinguished Indian chemical engineer and the sponsoring bodies, Indian Institute of Chemical Technology (IICT) and Avon, carries a citation, plaque and honorarium and was presented to Prof Rajagopalan particularly for his contributions to colloid and interface science and to the interfaces between chemical engineering, chemistry and physics.

Dr Mark Saens was awarded the Richard A Glenn Award by the Fuel Chemistry Division of the American Chemical Society (Washington, DC), for his work on New, Computer-Discovered Pathways for Methane and Ethane Pyrolysis with David Matheu (MIT, currently at National Institute of Standards & Technology, USA), Jeffrey Grenda (ExxonMobil) and Prof William Green (MIT) while at MIT.

Educational awards and accomplishments include the 2003-2004 Engineering Educator Award given to Prof Lee Jim Yang by the NUS Faculty of Engineering and the publication of Prof Ajay K Ray’s textbook on Mathematical Methods in Chemical and Environmental Engineering (with Prof Santosh K Gupta of the Indian Institute of Technology Kanpur, India) by Thomson Asia Pte Ltd. The book, in its preliminary version, was already used at NUS and in a few other universities in Asia as a textbook and its formal release is expected to increase adoption by more universities.
The Department of Civil Engineering aims to be the premier civil engineering institution providing quality education and leadership in research, development and application of technology for the advancement and well-being of Singapore.

The Department offers BEng (Civil), MEng, PhD programmes, MSc programmes in Civil Engineering and Transportation Systems and Management, as well as Graduate Diploma programmes in Aviation Management and Maritime & Port Management.

In addition to the above formal programmes, the Department has unique enrichment programmes such as the computer-based Virtual Island (VI) project, which fosters integration of knowledge across modules and subject domains and enhances the IT skills of students. Other enhancement programmes include Infrastructure and Society, Industrial Seminars, Technical Visits, Undergraduate Research Opportunities Programme (UROP) and Industrial Attachments.

We recently introduced 10 study plans for students’ selection:

- Offshore Engineering
- Engineering Project Management
- Geotechnical Engineering
- Hydraulic and Coastal Engineering
- Infrastructure Design and Development
- Infrastructure Systems and Management
- Intelligent Geoinformatics Systems
- Structural Protection and Rehabilitation Technology and Materials
- Transportation and Logistics
- Environmental Engineering

The department is structured into five groups:

i) Composites and Protective Engineering (CPE)
ii) Environmental Engineering (EnvE)
iii) Geotechnical Engineering (GE)
iv) Infrastructure Systems and Management (ISM)
v) Structural and Offshore Engineering (SOE)

The Composites and Protective Engineering (CPE) Group’s focus is on high performance protective materials, developed by optimising the microstructure of composites using micromechanical-based models. An ultimate goal of the developed technology is to monitor and enhance the health of Singapore’s key national infrastructures and to mitigate natural and man-made hazards. The areas of research can be broadly classified under (a) advanced composites, (b) protective technology and (c) smart materials and structural health monitoring. In recognition of the Group’s work, the American Concrete Institute (ACI) presented the ACI Award for outstanding contributions in Research and Development pertaining to concrete materials and design to the Centre for Construction Materials and Technology (CCMT) in September 2000. The Group also obtained a BCA grant for the Development of High Strength Lightweight Concrete with and without Lightweight Aggregates, and DSTA grant for the Development of Advanced Protective Materials and Systems against Close-in Blast and Penetration.

The Environmental Engineering (EnvE) Group is focusing on four key research areas – i) water quality enhancement and water reclamation, ii) membrane technology for water beneficiation, iii) disinfection processes and emerging contaminants detection/removal, and iv) nano- and molecular-biotechnology for water beneficiation. The Group has made considerable breakthroughs on water quality enhancement and water reclamation technologies as well as on state-of-the-art water safety assessment tools for rapid and sensitive detection of waterborne pathogens and emerging micro-pollutants.
The EnvE Group hosts the Centre for Water Research, which recently completed a $4.1 million collaborative project with Public Utilities Board (PUB) and A*STAR on Health Effect Study and Microbiological Analysis of Reclaimed Water in September 2003, making NEWater available for indirect potable reuse application in Singapore. The Group also spearheaded an A*STAR-Ontario Joint Research Programme with University of Toronto on Integrated Membrane Process for Water Reclamation & Microbial Control as well as an A*STAR-funded project on Nanoparticle Detection Scheme for Immuno and DNA Assay in Microfluidic Devices. In addition, group members are appointed to serve in the PUB Audit Panels for NEWater.

The Geotechnical Engineering (GE) Group’s research is focused on developing new ways to maximise the country’s useable space. Studies are being carried out on deep excavation and tunneling, alternative fill materials for land reclamation, and deep sea reclamation. Such research is underpinned by basic research in soil characterisation, numerical analysis, centrifuge testing probabilistic analysis and field studies. On-going research projects funded by BCA grants include (a) Development of a Geotechnical Information System (GEOINFOSYS) for Singapore, and (b) Optimisation of the Use of Waste Soils from Construction for Large Scale Land Reclamation.

Many projects are conducted in collaboration with local partners like the Housing & Development Board (HDB), ITC Corporation and the Maritime and Port Authority of Singapore (MPA); and overseas collaborators which include Kyoto University, Tokyo Institute of Technology, Port and Airport Research Institute, Japan, University of Western Australia and Universite Laval, Quebec, Canada.

The Infrastructure Systems and Management (ISM) Group’s research activities are centred on two major themes: Intelligent Transportation and Vehicle Systems (ITVS), and Construction Management and Informatics. ITVS research activities focus on the use of macro- and micro-traffic simulation, in combination with geoinformatics to address issues in real-time monitoring of traffic and vehicle performance, congestion management and incident detection, traveller information requirements and logistics planning. Research into transportation safety focuses on developing innovative methodologies including safety audits to identify traffic conflicts and to analyse traffic risks. Interactions between vehicles in the presence of control devices are investigated with the use of image processing technologies. Industry collaborators include the Land Transport Authority, Civil Aviation Authority of Singapore, Ministry of the Environment and Honda ICVS Singapore Pte Ltd. Members of the Group received the Webb Prize 2003 from the Institution of Civil Engineers, United Kingdom, and the TR100 Young Innovators award from Massachusetts Institute of Technology (MIT)’s Technology Review magazine in 2002.
The Structural and Offshore Engineering (SOE) Group conducts research on (a) offshore structures, (b) hydrodynamics, (c) assessment of structures under extreme loads, and (d) smart materials and structural health monitoring. Its collaborating research partners include Defence Science & Technology Agency (DSTA), HDB, Delft University of Technology, Norwegian University of Science and Technology, University of Melbourne and Texas A&M University, USA. Members have won numerous awards, including the Stanley Gray Award – Offshore Technology 2000 from the Institute of Marine Engineering, Science and Technology (IMarEST), and the Prestigious Engineering Achievement Award from the Institution of Engineers, Singapore in 2003. Of significance this year, staff in SOE Group played an instrumental role in setting up of the Centre for Offshore Research & Engineering (CORE) with funding support from EDB, MPA and Keppel Corporation to promote and coordinate R&D and manpower developments in support of Singapore’s rapidly growing offshore engineering industry. The Fund will provide support of up to $1 million per year for maritime and port research that will contribute to the growth of Singapore as a leading maritime hub.

Major Financial Grants

The major financial grants received by the Department in 2003 totalled $1.6 million including:

- Advanced Treatment of Industrial Wastewater with intermediate Organic Strength, Industrial Environmental Engineering Pte Ltd (ECO) ($35,018)
- Optimisation of Membrane Bioreactor System for Primary Sewage Reclamion, Centre for Advanced Water Technology (CAWT)/PUB ($300,000)
- Demand Forecasting Models for Intelligent Community Vehicle System (ICVS); Honda ($344,448)
- Pavement Management System for Changi International Airport; CAAS ($192,000)
- Effect of Water-Reducing and High-Range Water-Reducing Admixtures on the Microstructure of Cement Paste and Performance of Concrete; Borregaard Ligno Tech (BLT), Borregaard Ind Ltd, Norway ($201,250)
- NUS Academic Research Fund ($551,074)
Electrical and Computer Engineering (ECE) are among the most exciting and challenging areas of engineering. They are key disciplines in a rapidly evolving technological society. Electrical and computer engineers have been driving the evolution of technology by applying fundamental concepts and integrating knowledge from various disciplines while pursuing frontier research, creating new ideas and designing and developing new products.

The Department is made up of more than 150 academic and research staff who have distinguished themselves in their respective areas of research and education. Their research activities have a wide compass – Biomedical Engineering, Communications & Wireless Networks, Computer & Distributed Systems, Electrical Energy, Information Networking, Intelligent Control Systems, Parallel & Distributed Processing, Electronic Materials & Devices, Microwave Engineering, Mixed-Reality Systems, Multimedia Signal Processing, Nanotechnology, and VLSI IC Design.

Undergraduate Programmes
The Department offers two full-time undergraduate programmes – Bachelor of Engineering in Electrical Engineering and Bachelor of Engineering in Computer Engineering. ECE undergraduate programmes are designed to graduate versatile engineers for immediate employment and to prepare them for the challenges ahead. Both programmes have a strong emphasis on scientific and engineering fundamentals and a high degree of flexibility which provide a wide diversity of educational experiences. The diverse and rich mix of educational, business and research opportunities allow students to plan their individual learning experiences in accordance with their career aspirations. The current total enrolment of undergraduate students in the Department is 2,004. This is made up of 1,570 students in BEng (Electrical Engineering) and 434 students in BEng (Computer Engineering).

Graduate Programmes
Graduate programmes are built on undergraduate programmes with the aim of providing specialised training. The research-based Master of Engineering (MEng)/Doctor of Philosophy (PhD) programme aims to train human resource and future leaders in R&D, while the coursework-based Master of Science (MSc) programme provides excellent opportunities for practising engineers to upgrade their knowledge and core capabilities. Both programmes range across a wide spectrum, including Biomedical Systems, Communications & Networking, Computer/Multi-Media Systems, Electrical Energy Systems, Materials & Devices, Intelligent Control systems, Microwaves & Electromagnetics, and Integrated Circuits & Systems.
The Department also offers multidisciplinary MSc in Mechatronics and MTech in Software & Knowledge Engineering. The former is jointly run with the Department of Mechanical Engineering and the latter with the Institute of Systems Science and the School of Computing, NUS.

We actively collaborate with our NUS counterparts, industry, government bodies and other national research institutes such as the Data Storage Institute, the Institute for Infocomm Research, and the Institute of Microelectronics. On the international front, the Department has collaborative links with Stanford University, MIT, Cambridge University, Technische Universiteit Eindhoven, Tsinghua University etc.

As we continue to strengthen our infrastructure to nurture world-class research relevant to Singapore, re-align efforts and distribute resources towards high-impact research, we will enhance our international profile by expanding our collaborations with national research institutes and renowned overseas institutions.

**Major Research Areas**
- Biomedical Systems
- Communications & Networking
- Computer/Multimedia Systems
- Intelligent Control Systems
- Materials & Devices
- Microwaves & Electromagnetics
- Electrical Energy Systems
- Integrated Circuits & Systems
The following were initiated:

- **Joint laboratory with Institute for Infocomm Research (I2R):** A joint laboratory to collaborate in various aspects of information technology and communications in accordance with the respective needs and objectives of I2R and the Department.

- **SONDRA Laboratories:** a joint laboratory between NUS and Supelec [with support from both Defence Science & Technology Agency (DSTA) and ONERA] has been formed at Supelec. This joint research facility, SONDRA (Supelec-ONERA-NUS-DSTA Research Alliance) Laboratories will focus on electromagnetics, radar signal processing and other defence-related projects. The official launch was on 28 April 2004.

- **Joint PhD with Supelec:** Under this programme, NUS & Supelec students will spend at least two semesters of their PhD candidatures at each university either reading modules or working on their research projects, after which they will be awarded the PhD degree jointly by both universities. The MOU was signed on 28 April 2004.

**Research Funding**

Two major projects with funding of more than $1 million were initiated in 2003:

- Development of MOSFET gate stack technology for sub-50 nm CMOS ($2.5 million)
- Development of Flash Memory Devices Using Quantum Dots Embedded in High-K Dielectrics ($1.35 million)

Our total research funding for 2003 amounted to $9.39 million from external agencies and $2.76 million from internal sources (i.e. Academic Research Fund from both the University and the Ministry of Education). This brought the total funding for ongoing research projects to $39.08 million and $16.26 million, respectively from external and internal sources. External funding agencies include A*STAR, DSTA and Chartered Semiconductor Manufacturing Pte Ltd.

**Achievements and Awards**

In 2003, our accomplishments led to six US patents with another five filed. International and national accolades include:

1. **Best Paper award in the Institution of Electrical & Electronics Engineers (IEEE) Transactions on Industrial Electronics** (Dr A M Khambadkone)
2. **Best Paper award in the IEEE Transactions on Semiconductor Manufacturing** (Assoc Prof Ho Weng Khuen)
3. **First place in the Humanoid Robot Competition at the Federation of International Robot-soccer Association’s (FIRA) Robot World Cup 2003 held in Austria** (Dr Prahlad Vadakkepat)
4. **Singapore National Academy of Science’s Young Scientist Award** (Dr Adrian Cheok)
5. **IEEE Antennas and Propagation Society Undergraduate Scholarships** awarded to two undergraduate students for their final-year projects (Final-year students Liu Haibo and Liu Xin)

In addition, the Temasek Professor project on Front End Processes Related Research for Advanced CMOS Technology garnered notable achievements with five and seven conference presentations respectively at two of the most prestigious conferences in the area, Symposium on VLSI Technology and International Electron Devices Meeting (IEDM).

The year 2003 alone saw 405 international journal publications of which over 70% were in premier/leading journals. Last but not least, the Department also widened its linkages and networks through the hosting of two international conferences, Progress in Electromagnetics Research Symposium (PIERS 2003) and 2nd International Electron Devices Meeting (IEDM).
As the only degree-level ISE department in Singapore, the Department of Industrial & Systems Engineering (ISE) is positioning itself to make further contributions to the advancement of knowledge in the ISE domain and to Singapore's economy in key areas, such as manufacturing, defence, logistics, and healthcare, that are experiencing changes thrust upon them by the dynamic global business and technological environment.

The Department offers an undergraduate BEng (ISE) degree programme and graduate programmes leading to the MSc (ISE) degree by coursework, and MEng and PhD degrees by research.

The year 2003 saw the Department continuing its drive for excellence in research and teaching, undertaking externally-funded projects with a total value approximating $4 million. It signed a Memorandum of Understanding (MOU) on 10 January 2003 with Pohang University of Science and Technology, South Korea, to promote joint research and development activities, as well as academic exchanges. In February, another MOU was signed with Singapore Airport Terminal Services Ltd (SATS), together with The Logistics Institute-Asia Pacific. The Department works closely with SATS on research to discover new models and methodologies to improve SATS' operational efficiency, which in turn enhances Singapore's competitiveness in the air cargo logistics industry.

Another new research initiative in Advanced Planning and Decision System was started in the period under review. This three-year project is a major research collaboration between the Department and the Defence Science and Technology Agency under the Defence Innovative Research Programme, which funds innovative research with the potential to create significant value to the defence and security of Singapore.

In 2003, ISE faculty members served on the editorial boards of 22 international academic journals, while a number of faculty members served as Editors or Associate Editors.

The Department admitted its second batch of 40 BEng (ISE) students in July 2003. As the Singapore economy becomes increasingly knowledge-intensive and service-based, the demand for ISE graduates is expected to grow. The MSc (ISE) degree programme remains highly popular and the job opportunities for MEng/PhD degree graduates are good. There is a consistently strong demand for ISE service modules by undergraduate and graduate students in the NUS Faculty of Engineering.

The ISE modules offered by the Department support a number of degree programmes in the University, such as the NUS-Georgia Institute of Technology Dual MSc in Logistics and Supply Chain Management, the NUS-Technische Universiteit Eindhoven Joint Master of Technological Design Programme, and the NUS-Naval Postgraduate School Master of Defence Technology & Systems Programme.
The Department’s vision is to be a premier department providing quality education and leadership in research, development and application of technology and knowledge in the ISE domain for the advancement and well-being of Singapore.

Its mission

- To have rigorous education programmes that produce versatile and enterprising graduates
- To achieve excellent research, riding on the global scientific and technological trends in selected areas relevant to Singapore
- To be the choice ISE department for talented students, outstanding faculty and dedicated staff

In 2003, the Department achieved a historical milestone when it produced its 1,000th MSc graduate. It now looks forward to producing its first batch of 40 BEng (ISE) graduates in 2005. As at Academic Year 2003-2004, the enrolments for graduate coursework/research and undergraduate programmes are 350 and 80 respectively. It plans to steadily increase the annual undergraduate intake and actively publicise its programme to junior college students so as to ensure awareness and quality intake.

Achievements and Awards

The following staff in ISE were recognised for their achievements:

Prof Goh Thong Ngee – named as one of the first Honorary Members of the Singapore Quality Institute, the highest honour bestowed on an individual, for exemplary contributions to the quality profession.

Assoc Prof Tang Loon Ching – presented the Stan Ofsthun Award for the most outstanding technical paper at the 2004 Reliability and Maintainability Symposium.

Assoc Prof Poh Kim Leng – awarded the Engineering Educator Award by the Faculty for teaching excellence.

Community/Industry Partnerships

The ISE Departmental Consultative Committee, whose members meet on a regular basis, consists of six senior executives from industry and five faculty members from the Department. It serves to strengthen the Department’s links with public and private sector organisations and to provide a mechanism for regular consultation and exchange of views. On 29 August 2003, the members met to discuss ways of ensuring that the Department’s programmes remain relevant to Singapore and to the region.
Physiological Testing on an Ergocycle

In the same year, the Department conducted 13 seminars, many of these jointly organised with the Design Technology Institute (Singapore), IEEE Engineering Management Society (Singapore Chapter), IEEE Reliability Society (Singapore Section), The Logistics Institute-Asia Pacific or Operational Research Society of Singapore.

Management and Resources
The Department has 16 full-time and five adjunct/visiting faculty members. The Department Management comprises:

- Prof Ang Beng Wah, Head of Department
- Assoc Prof Poh Kim Leng, Deputy Head (Administration)
- Assoc Prof Chew Ek Peng, Deputy Head (Academic)
- Assoc Prof Tang Loon Ching, Deputy Head (Research)
- Assoc Prof Huang Huei Chuen
- Dr Yap Chee Meng

The ISE Visiting Committee comprising five distinguished academics has been appointed by the Faculty to meet the following objectives:

- Review the overall development of the Department, identifying its strengths and weaknesses in the context of its operating environment
- Benchmark the Department’s teaching, research and management performance against relevant norms
- Assist the Department in prioritising performance gaps to be bridged
- Make recommendations for the future directions in priority areas
Mechanical Engineering (ME) is broad-based, often viewed as the “unseen” foundation of the other engineering disciplines. Any system that involves motion of one form or another invariably requires the inputs of mechanical engineers. Hence, mechanical engineers are involved in the research, development, design and manufacturing of all kinds of products, ranging from small devices such as the ubiquitous mobile phone to the largest aircraft and ocean-going vessels. Mechanical engineers are also needed in the most sophisticated production facilities, especially in the oil industry as well as in wafer fabrication plants.

In 2003, the Department of Mechanical Engineering continued to grow in stature and reputation, with a number of significant changes, achievements and honours. The Department also witnessed a change in leadership in December 2003 when the helm was handed over from Prof Chou Siaw Kiang to Prof Lim Seh Chun. Under the latter's leadership, the Department looks forward to not only maintaining the high standards achieved during Prof Chou's tenure but to scaling greater heights in the coming year.

Quality Student Intake

In the year under review, the Department's success in maintaining student quality was quantified by the highest cut-off CAP (Cumulative Average Point) for Yr-1 students streamed to the major engineering departments. This may be attributed to the Department's consistent message to students on the:

- Importance of mechanical engineering as a fundamental branch of engineering that is required in the research, development, design and manufacturing of a wide range of products
- Broad-based nature of mechanical engineering training that we provide, which emphasises strong engineering fundamentals and competency in design
- Opportunities for specialisation in selected technology areas of current relevance
- Exciting new developments and directions in mechanical engineering and related research

The Minor in Materials Engineering was equally successful in attracting students from the Faculties of Engineering and Science in its second year of running. The quota of 30 was fully subscribed.

Research and Collaborations

In research, staff members sharpened their research focus and enhanced their involvement mainly as a result of the adopted departmental strategic research programme. The Department has applied rigorous efforts in forging collaborations with strategic partners. A Memorandum of Understanding (MOU) between the Department and the School of Aeronautic Science and Technology, Beijing University of Aeronautics and Astronautics (BUAA), was signed in November 2003 to explore bilateral exchanges and cooperation in areas of mutual interest.

Research collaborators include academics from MIT, Georgia Institute of Technology, University of Cambridge, Swiss Federal Institute of Technology, Huazhong University of Science & Technology, Tsinghua University, McGill University, Norwegian University of Science & Technology and Kurchatov Institute Russia.

The three multidisciplinary areas of strategic focus which the Department supports and conducts, in conjunction with local and international collaborators, are:

- Microsystems technology
- Advanced materials engineering
- Biomedical engineering
Study on how a simulated human head-neck unit responds to impact-induced acceleration

Partnerships and Funding

The Department’s vibrant research environment attracted and sustained funding from both the public and private sectors. In 2003, we were working on over 75 projects with total funding of some $24 million.

The Department also carried out fruitful joint research with various local and overseas companies and institutes, including:

- Yamatake Corporation Japan
- Hitachi Production Engineering Laboratory
- British Gas Asia Pacific Pte Ltd
- Kinergy Pte Ltd, Institute of Materials Research & Engineering (IMRE)
- Institute of High Performance Computing (IHPC)
- Singapore Institute of Manufacturing Technology (SIMTech)
- Nanyang Technological University (NTU)

In addition, the Department worked freely and successfully with staff from other NUS departments, namely Electrical & Computer Engineering, Chemical & Biomolecular Engineering, Bioengineering, Civil Engineering, Physics and Materials Science.

New Laboratories Commissioned

- Microsystems Technology Laboratory which focuses on development and characterisation of MEMS devices and systems
- Neurosensors Laboratory which is aimed at developing sensors, devices and software for monitoring human brain activity

Laser technique for deformation measurement
Achievements and Awards

In 2003 our Department successfully obtained 10 patents; with staff and students receiving both international and local recognition in their respective fields:

1. *M Eugene Merchant Outstanding Young Manufacturing Engineer Award* by the International Society of Manufacturing Engineers in recognition of significant achievements and leadership in the field of manufacturing engineering. The recipient, Dr Ong Soh Khim, is also ASEAN's first female recipient of this award.

2. Honorary Fellowship by the ASEAN Federation of Engineering Organisations awarded to Prof Chew Yong Tian in recognition of outstanding services rendered to the engineering profession, the Institution and/or the nation.

3. *Norman A Dudley Award* for a paper judged to have the most potential for making the greatest contribution to the advancement of manufacturing practice co-authored by Prof Andrew Nee and Dr Ong Soh Khim and co-author.

4. *ATR Research Prize* (awarded by ATR International, a Japanese research institute) for Dr Etienne Burdet in recognition of significant work unveiling how humans learn novel tasks.

5. *2003 NUS Outstanding Educator Award* to Assoc Prof Seah Kar Heng.

6. Special Awards (Open Category) won by a fourth-year student, Tan Shel Lin, for her entry on a *Directional Hopper* in the Singapore Robotics Games 2003.

7. Institution of Mechanical Engineers (UK) *Andrew Fraser Prize* (Runner-up) by three PhD students for best papers presented – Xu Chengyu, Mervyn Fathianathan, Mani Mahesh.

8. Institution of Mechanical Engineers (UK) prizes/certificates to four outstanding undergraduate students – Frederic Barnes Waldron Prize: Chua Wee Eng Institution Project Prize: Chew Keng Thiam Institution Best Project Certificate: Chew Keng Thiam Institution Best Student Certificate: Chen Ran
One of the goals of the NUS Faculty of Engineering’s strategic plan is to develop rigorous and differentiated programmes to cater to the diverse needs and capabilities of students in support of national goals. To achieve this, we have reorganised our undergraduate programmes into three clusters: the Engineering Cluster, the Engineering Science Cluster, and the Engineering Enhancement Programmes.

For the Engineering Science Cluster, the Faculties of Engineering and Science have developed the Engineering Science Programme (ESP), aimed at equipping students with a strong foundation in applied sciences and mathematics, to produce a new breed of research-oriented, technology-savvy engineers who will excel in strategically emerging inter-disciplinary areas.

Key features of the ESP education are:

- A thematic and integrated treatment of a broad range of foundation subjects including mathematics, applied physics, chemistry and biology during the foundation stage
- An in-depth and multidisciplinary treatment in carefully selected focus areas (options), particularly in emerging/cutting-edge technologies at the interfaces of disciplines
- Development of the ability to have a holistic perspective of the basic sciences and to use a multidisciplinary, fundamental approach in the design and integration of innovative engineering solutions

Even within the focused tracks in engineering, there is a strategic need to produce graduates who are equipped to go further in research, design and development, and to scale new heights at the frontiers of technology developments. These would require graduates with a strong grasp of the fundamentals.

Our analysis of the current profile of students entering engineering at NUS suggests that there are more than 500 students, out of the cohort of 1,500, with three As or better in their GCE ‘A’ levels or equivalent. It is desirable to develop a curriculum that is both multidisciplinary and in-depth to stretch the potential of these students to achieve a high value-addition.

Engineering education has to evolve for Singapore to remain competitive. Our faculty has a moral imperative to provide an additional engineering programme to position Singapore at the frontiers of design and technology development. Such a programme should emphasise strong grounding in the fundamentals and yet be multidisciplinary, by providing students a framework for integrating all aspects of their growing knowledge. Although the ESP will be challenging to the students, its goals are achievable as prospective students are expected to come from the pool of outstanding students admitted into the Faculty.

The overall objective of the ESP is to produce graduates who are prepared to solve new problems, develop innovative designs, value add technology developments, integrate systems, and work at the interfaces of disciplines. A majority of ESP graduates are expected to pursue research-oriented careers and graduate studies. Through affiliated modules and programmes, students are geared for wider career choices, including starting technology-based new ventures.

The Programme, planned for its first intake in 2005, will consist of two years of foundation studies with compulsory modules in a broad but integrated applied sciences and mathematics framework, followed by two years of focus on multidisciplinary options. The foundation courses are differentiated from the current foundation course in several ways. For the ESP, the focus is on a thematic approach so that students are able to connect potential applications across disciplines. At the individual subject level, more depth would be covered including a deeper understanding, a rigorous use of mathematics to convey ideas and computational methodologies to handle complex systems. In particular, emphasis would be placed on why problems are solved in a certain manner and not just how problems are solved. Throughout the programme, engineering design principles will be emphasised, both through customised projects and in each individual module.
Environmental Science & Engineering Programme

Environmental problems are some of the most complex, challenging, and pressing issues that are of concern to policy makers across the globe. Achieving environmental sustainability is a key priority for Singapore and the world. In response to this, the NUS Faculty of Engineering established the Environmental Science and Engineering Programme (ESEP) in October 2003 by bringing together the expertise from teaching staff of the Departments of Chemical & Biomolecular Engineering and Civil Engineering. Designed to equip graduates with knowledge and skills to generate solutions to modern environmental challenges, ESEP incorporates in its curriculum strong fundamentals in chemical and biological processes, an understanding of environmental issues and competence in engineering.

In addition, ESEP promotes and coordinates basic and applied multi-disciplinary research in environmental science and engineering through the Departments of Chemical & Biomolecular Engineering and Civil Engineering in the areas of water quality, treatment, and reclamation; wastewater treatment; air pollution assessment and treatment; aerosol science and technology; management of terrestrial and coastal resources; and the broader environmental sciences.

A key feature of the programme is that ESEP faculty, researchers and students work in teams, fostering group learning, cross-disciplinary interactions and dynamism in research activities. The research activities in environmental science and engineering are a reflection of the expertise of its faculty, who are multi-national, highly trained, and well regarded in both academia and the industrial sector. Since its inception, ESEP has been actively involved in facilitating interaction between researchers, students, and industry with a noteworthy record of successful technology transfers to the industry.

ESEP is committed to providing excellence in education and research and preparing young environmental scientists and engineers for leadership positions in academia and industrial research and development.

Educational Programmes

ESEP oversees the following degree programmes:

- Bachelor of Engineering (Environmental Engineering)
- Master of Science (Environmental Engineering) (by coursework)
- Master of Engineering (Environmental Engineering)
- Doctor of Philosophy (by research)

In addition to the above, ESEP works with the Departments of Chemical & Biomolecular Engineering and Civil Engineering in the following research-based degree programmes:

- Master of Engineering (by research)
- Doctor of Philosophy (by research)

Educational Philosophy and Objectives

The environmental engineering undergraduate curriculum is designed to provide students with a good foundation in the basics and different major aspects of environmental science and engineering. To encourage our graduates to become well-rounded and globally oriented, ESEP also encourages the students to participate in various enhancement programmes such as the University Scholars Programme, the Industrial Attachment Programme, Overseas Student Exchange Programme and the Undergraduate Research Opportunities Programme (UROP). In addition, ESEP students may embark on programmes leading to a Bachelor’s degree in Engineering with a minor in Management of Information Technology, Business, Bioengineering, Materials Science & Engineering, Technopreneurship and Urban Environmental Engineering.

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Major Funding

- Health Effect Study and Microbiology Analysis of Reclaimed Water; (PUB) $2,448,707, (A*STAR) $1,596,971 (1999-2003)
- Reclamation and Microbial Control; (A*STAR) $200,000 (2001-2004)
- Monitoring of Singapore Marine Environment; Maritime & Port Authority of Singapore (MPA) $165,000 (2002-2008)
- Bioremediation of Oil Contaminated Beach Sediments; (A*STAR) $25,000 (2003-2004)
- Regional Smoke Haze; United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) $17,000 (2003-2004)
- NUS Academic Research Fund; $1,943,674 (2000-2006)

Service to local industry and government bodies

Board of Directors, MWH Consultants
External Audit Panel for NEWater, Public Utilities Board (PUB)
Internal Audit Panel for NEWater, Public Utilities Board (PUB)

Service as editors/associate editors and editorial board members of journals in environmental science and engineering

- Advances in Asian Environmental Engineering, Kyoto University, Japan
- ASCE Practical Periodic of Toxic, Hazardous and Radioactive Wastes Management, American Society of Civil Engineers, USA
- Journal of the Chinese Institute of Environmental Engineering, National Taiwan University, Taiwan
- Environmental International, Elsevier Publishers, UK
- The International Journal of Environmental Studies, Taylor and Francis (part of the Taylor & Francis Group), UK
- Microbes and Environment, Japanese Society of Microbial Ecology & The Japanese Society of Soil Microbiology, Japan
- The Scientific World (Atmospheric Systems Domain), Infotrieve, USA
- Water Environment Research, Water Environment Federation, USA

Award

- Best Paper Award, North American Membrane Society 2003, for Numerical Simulation of the Effect of Spacer on Concentration Polarisation in Spiral Wound Reverse Osmosis Modules, by faculty: Assoc Prof Song Lianfa, Prof Ong Say Leong and Prof Ng Wun Jern (Department of Civil Engineering) and doctoral student Ma Shengwei.
The Bachelor of Technology (BTech) Programme is a self-funding, part-time evening programme. It was initiated in 1995 in response to the strong aspirations of the large number of polytechnic graduates working in the local industry to upgrade to an engineering degree. It provides an affordable avenue for these graduates to pursue a degree course without having to give up their full-time jobs or to go overseas. The modular structure of the course enables students to study at their own pace depending upon their family and work commitments.

The Programme provides a balance of theoretical grounding, engineering applications and project work. Students are granted the equivalent of a one-year exemption from a four-year full-time BEng degree. The BTech Programme is designed such that its academic standard is as rigorous as that of any full-time BEng course offered in NUS. With a concern for high standards and quality, the same grading system, degree classification, teaching staff, laboratory experiments and facilities are adopted for the BTech degree as are used for the BEng degree.

While based on the well-established and highly-respected full-time BEng course, the curriculum for the BTech course is specially oriented to suit the backgrounds and needs of polytechnic graduates working in the local industry. The Programme prepares these graduates for high-level positions in engineering design, management, development and research in a knowledge-based economy by strengthening their mathematical and engineering science foundations illustrated with engineering applications. Since its start in 1995, the Programme has produced close to 1,000 graduates.

Programme Structure
Currently, courses leading to four BTech degrees are offered, namely the BTech (Chemical), BTech (Electronics), BTech (Manufacturing) and BTech (Mechanical).

Admission to the BTech Programme requires a relevant diploma from a local polytechnic, or its equivalent. Students typically attend classes for three evenings a week and complete their degree in four years.

Accreditation
All BTech degree programmes are fully accredited by the Institution of Engineers Singapore (IES) and Professional Engineers Board Singapore (PEB). In addition, the BTech (Electronics) programme is accredited at the MEng level by the Institution of Electrical Engineers (UK) and the BTech (Manufacturing) and BTech (Mechanical) accredited at the MEng level by the Institution of Mechanical Engineers (UK).

Student Intakes and Graduation
The student intake for 2002 and 2003 totaled 572, while in the same period a total of 283 students graduated.

<table>
<thead>
<tr>
<th>PROGRAMME</th>
<th>2002-2003</th>
<th>2003-2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTech (Elect Eng)</td>
<td>331</td>
<td>341</td>
</tr>
<tr>
<td>BTech (Mech/Mfg Eng)</td>
<td>260</td>
<td>180</td>
</tr>
<tr>
<td>BTech (Chem Eng)</td>
<td>87</td>
<td>114</td>
</tr>
<tr>
<td>Total</td>
<td>678</td>
<td>635</td>
</tr>
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The number of students who graduated with a Bachelor of Technology in 2002 and 2003:

<table>
<thead>
<tr>
<th>PROGRAMME</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTech (Elect Eng)</td>
<td>78</td>
<td>50</td>
</tr>
<tr>
<td>BTech (Mech/Mfg Eng)</td>
<td>78</td>
<td>43</td>
</tr>
<tr>
<td>BTech (Chem Eng)</td>
<td>Nil</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>156</td>
<td>127</td>
</tr>
</tbody>
</table>

The BTech Programme continuously monitors and updates its curriculum contents to stay relevant to the local industry. The results of a survey done on final-year BTech classes have shown that 92% of the students received a promotional advancement in their jobs after enrolment in the BTech Programme and of these, more than 70% indicated that their studies in the Programme contributed significantly to their promotions. The survey also showed that as many as 86% of the students made use of the knowledge gained, with 38% using it to a large extent.

Awards
Outstanding students who received awards for achieving academic distinction during the year include:

- **Electronics Engineering**
  - Chong Chun Woo - TECH Semiconductor Prize
  - Khow Siang Thye - IES Gold Medal
  - Wong Ee Hoa - HP Asia-Pacific Prize

- **Mechanical & Manufacturing Engineering**
  - Soon Chee Yoong - IES Gold Medal

Advisory Committee
The BTech Programme has an Advisory Committee comprising prominent members of the local industry to ensure that its courses remain relevant and stay in close touch with local industry.

Members of the Advisory Committee
- Ms Lee Bee Wah, Vice President, Institution of Engineers Singapore
- Mr Peter Tan, Managing Director, Flextronics International Ltd
- Mr Chng Teo Hye, Executive Chairman & Co-CEO, Fujitsu Asia Pte Ltd
- Mr K Y Wong, Vice President/Managing Director, Berkley Industries (Asia) Pte Ltd
- Mr Ng Chong Khim, Deputy President, Corporate Services & Marketing, President, CSG, Singapore Technologies Electronics Ltd
The primary aim of the Professional Activities Centre (PAC) is to provide high quality continuing education programmes to upgrade the engineering profession. These include short courses, in-house training, public lectures/seminars, international conferences and non-examination BTech and MSc modules. Through these programmes, PAC plays an important role in keeping engineers and alumni abreast of developments relevant to their sectors.

PAC is managed by the PAC Board chaired by Prof Teoh Swee Hin (Department of Mechanical Engineering) and is represented by Assoc Prof Leung Chun Fai (Department of Civil Engineering), Assoc Prof Huang Huei Chuen (Department of Industrial & Systems Engineering), Assoc Prof Surendra Ranganath (Department of Electrical & Computer Engineering) and Assoc Prof Ting Yen Peng (Department of Chemical & Biomolecular Engineering).

Programmes at the PAC have evolved, as have relationships with sponsors and industry partners. In spite of a difficult 2003 due to SARS, the Gulf War and an economic downturn which saw many local companies cutting down on training commitments, PAC’s performance exceeded expectations. In that year, PAC collaborated with the Public Utilities Board (PUB) to offer selected Core Technology Programme modules to its staff on a monthly basis. There were also 26 short courses organised in 2003 compared to 18 in 2002. In July 2003, PAC and the Centre for Offshore Research & Engineering (CORE) successfully organised the inaugural Keppel Offshore and Marine Public Lecture which attracted a capacity crowd.

We continued to make great strides in the past year by enhancing our collaborations with industry which extended beyond research and development to include partnerships with business development professionals, and to build custom and in-house offerings. In November 2003, PAC jointly organised a well-attended public talk on The Simplicity of Organising a Successful Conference with the Singapore Exhibition and Convention Bureau and the Singapore Institute of Landscape Architects. The objective of the talk was to encourage staff to come forward and organise international conferences to bring greater visibility to the University and the NUS Faculty of Engineering. At the same time PAC also assisted in the organisation of the 7th Asian Symposium on Visualisation in November 2003 which attracted over 120 participants.

To address the ongoing needs of both domestic and international engineers, PAC has offerings from all fields of engineering with up to 40 courses in 2004. We believe our initiatives will set the foundation for sustainable growth as we increase awareness of our Centre’s value add in the new knowledge environment.

Courses/Conferences in the Upcoming Year

- 1st Nano-Engineering and Nano-Science Congress 2004
- 1st International Conference on Advanced Tribology 2004
- Part-Time Programmes for Non Exam Students (BTech) & (MSc)
- Computer Entertainment Technology
- Six Sigma Primer
- Fracture Mechanics and Fatigue Process
- Plasma Processing Technology for Semiconductor Applications
Research Innovation

- shaping the future with our discoveries
The Centre for Advanced Computations in Engineering Science (ACES) was established in November 1998 to conduct research in areas of advanced computational methods, including computational mechanics, computational fluid dynamics, computational inverse problems, and computational methods for micro-nano systems and bio-systems. There are currently 17 research staff including postdoctoral fellows, research fellows and research engineers, in addition to 13 research students, working on projects leading to a doctorate or masters degree.

Exciting ongoing projects carried out at ACES include 3D Smooth Particle Hydrodynamics (SPH) code developed to simulate penetration phenomena, the simulation of self-insertion of a protein into a nanotube, and the simulation of the evolution of quantum dots. The outcomes of ACES projects have been published in three monographs, 55 international journal papers and 20 international conference papers. In addition, the Centre graduated four PhD students and 25 masters students in 2003.

We have attracted funds and support from a wide range of organisations, and government agencies such as the Agency for Science, Technology and Research (A*STAR), Defence Science and Technology Agency (DSTA), Institute of High Performance Computing (IHPC), CAD-IT Consultants (Asia) Pte Ltd, NEI (S) Pte Ltd, and SunStar (S) Pte Ltd. We collaborate with researchers from institutions across the globe including MIT, Pennsylvania State University, Tohoku University, Tokyo University, Hong Kong University of Science & Technology, Tsinghua University, China Academy of Sciences, Jilin University and Xi’an Jiaotong University.

Some of ACES’ achievements in research and education in 2003 include:

- Publication of a paper titled A Generalised Differential Quadrature Rule for Bending Analysis of Cylindrical Barrel Shells in Computer Methods in Applied Mechanics and Engineering which was one of the top-10 most downloaded articles on Science Direct in 2003.

- The APACM Award for Computational Mechanics which was given by the Asian-Pacific Association for Computational Mechanics (APACM) 2004.
The Centre for Advanced Chemical Engineering (CAChE) offers a unique environment in bringing together researchers, Singapore’s vibrant and integrated chemical industry, as well as international partner institutions together to provide students with hands-on experience in both academia and industry.

We currently administer a Joint MSc and a Joint PhD Programme in Chemical Engineering with the University of Illinois at Urbana-Champaign (UIUC). NUS is UIUC’s first Asian university partner to establish a Joint PhD Programme in Chemical Engineering:

- The Joint MSc programme is fully funded by a grant from the Economic Development Board (EDB) and donations from the industry such as Schering-Plough, DuPont, CSM, Seraya, ExxonMobil, GSK, Pfizer and Tech Semiconductor. This programme involves coursework and industrial attachments in both Singapore and the US. Examples of successfully completed industrial projects include: Drug ‘N’ Doe Study and Cleanability Studies using Gravimetric Method, Study of Correlation Between Metrology Tools for Silicon Germanium Epilayer Stoichiometry (CSM), Crystallisation Studies of an Active Pharmaceutical Ingredient (Schering-Plough), Modelling of the Styrene Reactors (Seraya Chemicals), and PAC Fuels and Lubes (S3) Prediction and Optimisation Model (ExxonMobil).

- The Joint PhD Programme with UIUC receives grants from A*STAR. In this programme, research is focused on, but not limited to, biomedical science and engineering. Students spend two years each in NUS and UIUC for both coursework and research. Examples of research projects currently undertaken by students are: Numerical Modelling of Antisolvent Crystallisation, Industrial Biocatalysis for Bio/Pharmaceutical Manufacturing, Study of Protein and Pharmaceutical Crystallisation Using Microscale Platforms, and Multiscale Simulation of Surfaces and Interfaces in Biological Systems.

We offer both undergraduate and graduate student exchanges and industrial attachments. Our latest thrusts in this direction include student exchanges and research with prestigious European universities such as Technische Universiteit Delft (TU Delft), Technische Universiteit Eindhoven (TU/e), Technische Universität Berlin (TU Berlin) and Eidgenossische Technische Hochschule Zurich (ETH Zurich).
The Centre for Construction Materials & Technology (CCMT) functions as the research arm of the Structural Engineering Group at the Department of Civil Engineering. The objective of CCMT is to enhance the capabilities and competitiveness of Singapore's infrastructural industry by developing innovative methodology, products, systems and processes through research and development. The Centre's research teams comprise 13 academic staff, one professional officer, four research fellows, seven research engineers and 41 research scholars.

The research focus of CCMT is in the areas of marine and offshore structures, large-scale infrastructure, protective structures and innovative structural composites, high performance and smart materials technology and biomechanics. Most of our research and development work is supported by external funding but basic research work is supported by the University’s research programmes. Thus far, the Centre has completed projects valued at $863,700 out of $5.129 million of externally-funded projects. The total funding for on-going projects is valued at $6.205 million.

In 2003, a total of four monographs and 84 technical papers were published, of which 44 were international journal papers and seven were keynote papers presented at conferences. The Centre has since generated five patent applications. Our other achievements in 2003 included two awards – the Prestigious Engineering Achievement Award 2003, from the Institution of Engineers Singapore (IES), presented to Assoc Prof Choo Yoo Sang and Dr Ju Feng for Heavy Lift Engineering and Research. A Bronze Medal Award, also from IES, was presented to Assoc Prof Tan Kiang Hwee in recognition of his two years of service as an IES Council Member.
Centre for Intelligent Control

The Centre for Intelligent Control (CIC) was founded in 1993 with a mission to be a focus of research and development for intelligent control in Singapore and to develop human resources in advanced technologies for intelligent systems.

The strengths of the Centre lie in four broad areas: advanced process control, optimisation and tuning, computational intelligence with applications to autonomous systems, and precision servo systems.

The Centre, hosted by the Department of Electrical and Computer Engineering, comprises 20 staff from various departments in NUS, plus 32 research students pursuing doctorate degrees, and another 28 pursuing their masters degrees.

The Centre’s researchers work in collaboration with research institutes such as Temasek Laboratories, Data Storage Institute (DSI), Singapore Institute of Manufacturing Technology (SIMTech), Defence Science & Technology Agency (DSTA), DSO National Laboratories, and Institute for Chemical and Engineering Sciences (ICES). CIC routinely works with international collaborators such as Kogakuin University, St Petersburg State University, University of Tokyo, Georgia Institute of Technology, University of Sydney and Stanford University. Our total research funding for 2003 was $7.7 million.

Highlights of CIC’s achievements include:

- **Temasek Young Investigator Award**, DSTA 2003, awarded to Assoc Prof Chen Benmei
- **2002 Best Paper Award** – IEEE Transactions on Semiconductor Manufacturing, Institute of Electrical and Electronics Engineers, 2003, USA, awarded to Assoc Prof Ho Weng Khuen
- **Best Young Investigator Paper Award**, Adaptive Iterative Learning Control for Strict-Feedback Nonlinear Systems, IEEE Intelligent Automation Conference, 2003, Hong Kong, awarded to Assoc Prof Sam Ge Shuzhi
- First prize in the Humanoid robot championship, FIRA Robot World Cup Austria 2003, Federation of International Robot-soccer Association (FIRA), won by a team led by Dr Prahlad Vadakkepat
The Centre for Integrated Circuit Failure Analysis and Reliability (CICFAR) seeks to be an internationally recognised centre of excellence, providing specialised research and development services and manpower training to the microelectronics industry. CICFAR’s research focus is on the investigation and development of new techniques and instrumentation systems for physical and failure analysis of semiconductor materials, devices and circuits, and the application of these techniques and systems for studies in device reliability. Our Centre works closely with industrial partners such as Advanced Micro Devices (AMD) whose involvement is essential for the understanding of real issues and in anticipating the future needs of the integrated circuit (IC) industry. For a longer term perspective, new research projects have recently been initiated to develop and characterise novel nanoscale structures and devices.

The relentless shrinkage of device geometries and increasing IC complexity pose tremendous challenges to the failure analyst, and necessitates the development of new and novel solutions. At the same time, device reliability and degradation issues have to be discovered and studied for each new generation of devices.

In 2003, our Centre published 13 journal articles, 19 conference papers and one distinguished publication. We are also actively involved in the organisation of the annual International Symposium on the Physical and Failure Analysis of Integrated Circuits (IPFA) and other industry related events.

Some of our CICFAR research data are now widely recognised by the international reliability community. Two US patents were granted in 2003, making up a total of eight US patents to date, with five others pending. Our patent portfolio plays an important role in the commercialisation and acceptance of new techniques and instruments by the industry, with five technologies already commercialised to date. The current research funding is $2.2 million, making up a total of approximately $11.8 million in funding received since the inception of the Centre in July 1990.
The vision of the Centre for Intelligent Products & Manufacturing Systems (CIPMAS) is to develop devices, machines and manufacturing systems with built-in expertise or intelligence, enhanced user-friendliness and ease of integration for useful applications. To achieve this, CIPMAS focuses on research and development in the following key areas – intelligent manufacturing, automation technology, robotics, mechatronics and control engineering, and computational intelligence including neural networks, evolutionary methods, and fuzzy logic systems. Our work includes basic research in developing advanced technologies, as well as applied research, where working prototypes are realised for immediate industry applications.

More recently, applications have targeted on the biomedical area, micro-electro-mechanical systems and nano systems engineering. In all these technology groups, computational intelligence and other emerging technologies will be applied. These techniques include neural networks, fuzzy knowledge-based systems and evolutionary computing.

The Centre comprises four main technology groups:

1. **Intelligent Manufacturing** addresses the challenges of developing intelligent interfaces and decision support tools to facilitate, automate and integrate product design and manufacturing processes and systems. Research projects include the development of rapid tooling technology for injection moulded parts (with an industry partner, Kinergy, Singapore); advanced integrated analysis and synthesis techniques for matching fixture design (with Pennsylvania State University and Georgia Institute of Technology); and a virtual manufacturing system (with Huazhong University of Science & Technology, China).

2. **Automation Technology** addresses areas such as multi-axis NC machining, and machine intelligence in the form of multi-sensory fusion, knowledge-based systems, fault recovery and diagnosis. Research projects include an intelligent pipe measurement system for Jurong and Sembawang Shipyards; a PC-based CNC machine tool jointly developed with Excel Machine Tools, Singapore; and design, development and fabrication of a universal miniature-machine tool for micro-machining with MikroTools Pte Ltd.

3. **Robotics** research is aimed at the development of mobile manipulators working in human environments. Areas of focus include task-based force and motion control during constrained motion tasks, control of the dynamic behavior of manipulators, task primitives and sensing strategies for robotic tasks, machine vision, and intelligent robot-human interfaces including haptics and robotic telepresence, and coordinated control of multiple robots. Projects include the control of the dynamic behaviour of robotic manipulators through advanced sensing technology and applications to automation (with Stanford University and Singapore Institute of Manufacturing Technology); a ship welding robotic system that is walk-through programmable for Far East Levingston Shipbuilding (Singapore); vision-guided robotic motion; navigation with reactive motion planning; a computer aided surgical system and a haptic device for catheter simulation and training (with the former Kent Ridge Digital Labs); a robotic assistant for micro-vascular surgery (with National University Hospital); and an Internet-Integrated Home Control System [with the former National Computer Board (NCB)].

4. **Mechatronics and Control Engineering**’s research efforts are directed towards adaptive (or self-learning) and robust controllers via microprocessor or microcontroller-based implementations. Mechatronics and control engineering is the crux of automation systems wherein intelligence is embodied in the controller together with multi-sensory information to achieve intelligent decision making abilities resulting in robust applications. Members of the group are closely involved in most of the projects mentioned earlier. The group is also at the forefront in this field working with the Maritime and Port Authority of Singapore on projects such as the control of sway in crane operations.
The Centre for Microwaves & Radio Frequency (CMRF) is a leader in the research and development of Microwaves and Radio Frequency Systems. The Centre comprises four main groups:

The Electromagnetic Research (EMR) group concentrates on the fundamental aspects of electromagnetic wave propagation and the development of various numerical techniques and solvers for use by the other research groups.

The Circuits and Components Design and Development (CCDD) group concentrates on the development and design of device and microwave integrated circuits.

Outputs from EMR and CCDD groups are verified and calibrated by the Measurement, Instrumentation and Test (MIT) group, and are then used to support the activities of the Systems and Applications Realisation (SAR) group in developing systems which are useful to local telecommunications industries, RFIC and MMIC industries, as well as defence industries.

CMRF’s work is widely recognised, producing 40 international journal articles and 40 international conference papers in 2003, with many of its staff serving as Guest Editors, Associate Editors and Editorial Board Members. We have continued to attract significant research funding in recent years amounting to $3.2 million from external sources and $350,000 from the Academic Research Fund.
The Centre for Optoelectronics (COE) collaborates with the Institute of Materials Research and Engineering (IMRE), on materials growth of semiconductors for fabrication into devices such as semiconductor lasers, LEDs, photodetectors and optical waveguide components.

The Centre focuses on use of specific III-V compound semiconductors and growth by Metal Organic Chemical Vapour Deposition (MOCVD) and Molecular Beam Epitaxy (MBE). The materials and heterostructures are characterised for optical, electronic and microstructural properties. Other studies include simulation of optoelectronic radiative processes and the development of microelectronics unit processes.

Our recent achievements include a breakthrough in the growth of an InAs relaxed epilayer less than 0.1 µm thick, with the lowest dislocation density, on GaAs substrate using MBE. We have patented major discoveries and advanced techniques, such as blue electroluminescence in gallium nitride (GaN) LEDs on silicon, as well as GaN nano-ring successfully grown on sapphire, a first report worldwide. We also successfully developed the technology to fabricate the InAs quantum dots (QD) on GaAs emitting at 1.33 µm. IMRE, in a joint effort with COE, successfully grew multiple quantum wells capable of emitting white light from LEDs without the use of phosphors, another important milestone.

COE’s research thrusts in next-generation devices will focus on nanoscale tailoring of quantum structures using natural lithography, and the study of fundamental optoelectronics radiative processes in nanostructures.
The Centre for Power Electronics (CPE) was established for promoting advanced power electronics research and development efforts in Singapore. Power electronics is interdisciplinary and is at the confluence of three fundamental technical areas – power, electronics and control. Due to its pervasive and critical presence, power electronics plays a very important role in powering the new Infocomm economy and in improving the quality and efficiency of global energy usage.

The research activities in the Centre cover a wide area in power electronics. These include efficient switch-mode and soft-switched power supplies as well as next-generation power semiconductor devices and smart power IC’s for infocomm applications. Research is also in progress in the use of power electronics for motion control applications, such as micro-electro-mechanical systems, micro-actuators and high performance electromagnetic drives. Alternative energy systems based on fuel-cells is also being investigated.

The Centre's projects are funded internally by university-based research funding as well as from external sources, such as A*STAR, Defence Science Organisation, Land Transport Authority and Toshiba Corporation. CPE is staffed by a highly-qualified team including a core group of four faculty members, Assoc Prof Ramesh Oruganti, Assoc Prof Liang Yung Chii, Assoc Prof Sanjib K Panda and Dr Ashwin Khambadkone, with expertise in various advanced areas in power electronics. Periodical talks and seminars in power electronics are conducted by staff as well as distinguished visitors.

CPE researchers have distinguished themselves by winning the Best Paper award once from IEEE Transactions of Power Electronics for the year 1999 and a second time from IEEE Transactions of Industrial Electronics for the year 2002.
The Centre for Protective Technology (CPT) was set up in 1998 in a joint effort with the Ministry of Defence (MINDEF) as part of its efforts to synergise with the NUS Faculty of Engineering’s research expertise. The CPT spearheads efforts to develop protective technology, as well as provide scientific and engineering solutions to meet national needs in weapon and defence systems, and to address emerging national challenges for both government and industry.

Activities at CPT include:

1. Focused research and development work in protective technology, with emphasis in areas of national importance
2. Research and development collaboration with foreign institutions and industry through technology transfers
3. Acting as a resource centre in protective technology
4. Providing specialised advisory services to government bodies and industry

In the past, the focus of CPT was on protective technology against conventional modes of attack. After the terrorist strike of 11 September 2001, the CPT re-directed its research towards more emphasis on protecting civilian infrastructures against less conventional modes of attack. We are currently engaged in researching and developing conventional protective technology but our long-term aim is to achieve rapid improvements in building systems against such attacks, as well as to develop new blast-resistant and hardened materials that can cope with new threats. We are also entering into partnerships with local enterprises to design turn-key protective systems for infrastructures.

The Centre has received approximately $1 million of research grants and contracts annually.
Singapore's compactness and the close relationship among researchers, industry and policy-makers provide a unique opportunity for the island-state to serve as a large scale test-bed for the development of innovative infrastructures. This is a unique advantage the Centre for Soft Ground Engineering (CSGE) has over other leading research centres elsewhere, with an edge to be a leader in this field and the opportunity to showcase the significant impact we have made in our part of the world. What we face is exceptional as all new infrastructures have to be built in an already heavily built-up city state and especially, the usual scale of the problem, such as volume of material, imposes severe restrictions on the range of economically-feasible solutions. Our challenge is to develop innovative solutions to improve land productivity while maintaining a healthy eco-friendly environment.

CSGE was established in May 1991 as a research centre in the Department of Civil Engineering, in response to the critical need in our country and in the region, to carry out research and development work related to soft ground engineering. We have focused primarily on the development of hard and soft capabilities to provide the necessary basic building blocks for integration of large-scale systems, and have put in place the necessary conditions for research in geotechnical engineering:

a. Strong elemental testing and physical modelling capabilities  
b. Numerical and computing capabilities for very large-scale problems  
c. Large scale field testing and verification capabilities  
d. Information management for subterranean space

Our Centre has obtained significant fundings of about $1.5 million to embark on large scale research projects with industry partners including the mega scale Tekong land reclamation project in collaboration with the Housing and Development Board (HDB), as well as field testing in collaboration with Centre for Protective Technology (CPT), another centre hosted by the Department of Civil Engineering for the Defence Science & Technology Agency (DSTA) to develop blast resistant geosynthetics reinforced structures for civil defence and military applications, in response to the critical need for structures to withstand terrorist attacks. In 2003, we published 14 international journal papers and 32 international conference papers, including 13 geotechnical seminars. Our staff's active involvement in international bodies and associations such as the International Geomechanics Society and International Geosynthetics Society has led to invitations as keynote speakers at international conferences as well as participation on the editorial board of five international journals and three local/regional journals. Our Centre provides technical consultancy and advisory services to local industry and corporations, and has gained momentum as a major research centre in geotechnical engineering.
Cities all over the world are faced with increasing congestion on the roads, seas and air corridors. Singapore has come a long way in this area, from a backwater replete with rickshaws and bullock carts as the main means of transport, to using the newest technology to operate driverless trains and implement ERP (Electronic Road Pricing). Commuters can choose various means of reaching their destinations, whether travelling underground via the Mass Rapid Transit system, or by air-conditioned public buses. Singapore’s vast network of public and private transportation extends to the sea and sky.

Centre for Transportation Research (CTR) staff and researchers are proud to play a part in the development of Singapore’s advanced transport networks. We work with the Land Transport Authority (LTA), Maritime and Port Authority of Singapore, Civil Aviation Authority of Singapore, National Environment Agency, Ministry of Defence, Traffic Police Department, and major private organisations in the application of cutting-edge technology and research findings aimed at keeping Singapore’s world-renowned transport facilities safe, fast and efficient.

The Centre focuses on developing and applying advanced technologies in Transportation Engineering to manage transportation infrastructure and to achieve safe and efficient traffic.

Our main research activities fall in two broad areas:

- Intelligent Transportation Systems (ITS) which in turn consists of Intelligent Traffic Management Systems (ITMS) and Intelligent Highway Network Management Systems (IHMS)
- Transportation Logistics

The ITMS team has set up a campus testbed to provide real-time testbed-wide traffic and travel information, real-time vehicle performance monitoring, and online road network condition monitoring. Geographic Information System (GIS) and Global Positioning System (GPS) technologies are employed to demonstrate the impact of integrated operation of the different systems. We have also been awarded a research project by a leading Japanese car manufacturer to perform network level simulation for performance evaluation of a car-sharing scheme. Our team’s research thrusts have led to proposals on ways by which Singapore’s various road transport operation systems, such as taxi dispatching schemes and the ERP scheme, can be further enhanced in their operational efficiency.

IHMS focuses on expedient highway network performance data collection and applications of advanced IT techniques for efficient management of pavement networks. The IHMS research team’s pioneering work in nondestructive highway drainage measurement has led to a new device for drainage testing, patented in both Singapore and the US. Simulation software has also been developed to evaluate road traffic and aircraft operation safety on expressways and runways respectively. We are currently developing a state-of-the-art airport pavement evaluation and management system for Singapore’s Changi Airport, and are working with LTA to conduct an island-wide road network condition assessment using the latest technology.

Through the years, CTR has grown and developed its research base to include Transportation Logistics. The main research emphasis, in collaboration with The Logistics Institute-Asia Pacific is to apply ITMS and IHMS techniques and tools to increase the efficiency of freight transportation, and operations of transportation logistics terminals such as ports and airports. This necessarily involves research in Transportation Logistics Security. We are tapping into the global knowledge economy by signing a collaborative research agreement with the advanced logistics research group in Tsinghua University covering a double Masters degree in Transportation and Logistics launched in 2003. CTR has set in place all the necessary channels to be at the forefront of transport solutions, and even more exciting developments in the years ahead.
The world is fast running out of water. By 2015, according to estimates from the United Nations and the US government, at least 40% of the world’s population, or about 3 billion people, will live in countries where it is difficult or impossible to get enough water to satisfy basic needs. An inescapable fact about the world’s water supply is that it is finite. Especially for an island-state like Singapore, with its limited geography, it is critical to address R&D needs on water infrastructure development. For this purpose, the Centre for Water Research (CWR) was set up in the Department of Civil Engineering in 2002.

CWR has just completed a $4.1 million joint project with the Public Utilities Board (PUB), the Ministry of the Environment (ENV) and A*STAR on Health Effect Study and Microbiological Analysis of Reclaimed Water. This joint research project contributed towards a Government decision to implement NEWater for in-direct potable usage. We currently have two more on-going projects funded by A*STAR –

- Development of an Integrated Membrane Process for Water Reclamation & Microbial Control, an A*STAR-Ontario Joint Research Programme with University of Toronto; and
- Nanoparticle Detection Scheme for Immuno and DNA Assay in Microfluidic Devices project with funds amounting to $1 million.

CWR is also working with PUB to conduct joint research on water quality enhancement and other water-related infrastructure works. For example, a project between CWR and the Centre for Advanced Water Technology (CAWT), a subsidiary of Singapore Utilities International, on Pilot Scale MBR Study, amounting to $300,000, has been progressing well.

Our areas of focus are: membrane technology for water beneficitation, microbial diversity & genetics for water quality enhancement systems, micro-pollutants, bio-stability and health effects assessment, rapid detection of water pathogens and emerging contaminants, water reclamation, biofilm control and development and biotreatment technology.

CWR interacts frequently with industry through collaborative research projects, organising seminars, symposia and conferences, meetings with water industry professionals, serving as advisors and/or auditors to both Malaysia and Singapore water authorities, providing leadership in local, regional and international professional associations such as the Environmental Engineering Society of Singapore, Water Environment Federation, and International Water Association. CWR has organised 17 public seminars and given nine seminars at local and overseas institutions. In addition, 19 international publications and 28 conference papers have been published in 2003.
The Information Storage Materials Laboratory (ISML) is one of the NUS Faculty of Engineering’s joint laboratories with the Data Storage Institute. Established in 2001, ISML has built up its facilities through research grants provided mainly by A*STAR with a funding of about $9 million. It started first with metal-based spintronic materials and devices for ultra-high density data storage applications, and very recently, with the support of A*STAR again, a project on magnetic semiconductor based spintronics has been initiated. To further build up the state-of-art-facility and extend the scope of the research into the regime where bits meet atoms and charges interact with spins, the laboratory is currently in the process of establishing a major fabrication and characterisation tool for research on nanometer scale spintronic materials and devices. The major research topics include:

- Magnetic nanostructures
- Spin-dependent transport
- Modelling of spintronic devices
- Nanometer scale spintronic sensors
- Nano-memory devices
- Single spin detection techniques
- New materials

Presently, there are 25 students pursuing a graduate degree at ISML. In the last year, the group has published 32 papers in prestigious journals with 10 papers presented at international conferences such as 3M and Intermag. Researchers and staff at ISML were honoured with several distinguished awards including the NUS Young Researcher Awards for two years consecutively in 2003 and 2004, the Singapore Youth Award in 2004 for science and technology and the highest recognition in Singapore for achievers under the age of 35.

During the last few years, we have established extensive collaborations with both local and international research groups and organisations which include Hitachi Global Storage Technologies in San Jose, USA, the Department of Physics, NUS, and the Data Storage Institute. We are also a member of the Information Storage Industry Consortium (INSIC) which is the major international research partnership comprising industry and recognised university groups.
Laboratory for Concurrent Engineering & Logistics

The Laboratory for Concurrent Engineering & Logistics (LCEL) provides innovative engineering solutions to expedite design, manufacturing and product delivery by harnessing state-of-the-art information technology. We also develop advanced optimisation techniques to enhance the competitiveness of local manufacturing businesses. Our Laboratory provides cutting-edge integrated design, manufacturing and logistics solutions by collaborating with government agencies and industry.

LCEL is currently engaged in several research programmes. One is a four-year Infocomm Development Authority (IDA) programme which aims to achieve engineering collaboration over distributed environments on the Internet. Funded by partnerships comprising NUS, Sun Microsystems Asia-Pacific Science & Technology Centre (APSTC), SES Systems Pte Ltd and various manufacturing and construction companies, this programme addresses value chain issues in design, planning and management and realisation. For this particular programme, we received $1.9 million from the IDA InfoComm21 Fund.

Another programme is focused on developing and commercialising state-of-the-art laser-based rapid prototyping technology that can be applied to industry for functional prototypes and tooling. Two patents were successfully obtained in 2003 with commercialisation efforts underway. In collaboration with Kinergy we jointly developed and tested a rapid prototype (HTLRM) machine granting Kinergy the rights to market the machine worldwide.

In a separate programme, we have developed a novel micro-rapid prototyping machine fabricating 3D micro-structures based on micro-stereolithography and electroforming processes. In another process, using a drop-on-demand dispensing system at the scale of micron or sub-micron, 3D micro-scale functional metal parts and moulds for batch production can be fabricated.

Another key project in the pipeline is focused on developing a PC-based 4-axis robotic dispensing system with multiple dispensers to fabricate 3D scaffolds by layering techniques for tissue engineering applications.

Another collaborative effort with the Data Storage Institute (DSI) on e-Manufacturing involves the development of key technologies for Web-based intra- and inter-enterprise services for the hard disk drive (HDD) industry. Four major developments/deliverables include e-logistics for HDD manufacturing, remote maintenance of test equipment for HDD manufacturing, distributed visualisation tools for CAD, and dynamic workflow change management. Funding for the above research projects amounted to $2.49 million.
Large Scale Systems Laboratory

The Large Scale Systems Laboratory (LSSL) was established in May 1999 to spearhead research and development of large-scale infrastructure systems for maintaining sustainable economies and preserving quality of life in Singapore. The primary focus of LSSL is to engineer breakthroughs in the design, development, integration and use of infrastructures to overcome constraints posed by lack of natural resources, such as water, sea, land and energy. The scope aims to cover appropriate models for analysing large scale systems and strategies in the development, integration and usage of infrastructures to meet the demands of a growing population.

The LSSL currently functions as a virtual faculty laboratory to coordinate multidisciplinary research in three major areas: water infrastructure, coastal infrastructure and urban infrastructure.

Water Infrastructure
In a research project on organic matter characterisation, we have developed a fractionation system which can evaluate accurately the treatment of organics in wastewater reclamation systems. The feasibility and reliability of techniques of concentrating organic matter in reclaimed and reservoir waters have been verified, on a pilot-scale, in a separate project. A significant achievement by our research team working on virus removal by membrane filtration was the discovery of the protocol for virus detection and cultivation; optimal conditions for virus removal in the laboratory; and the process of viral movement through membranes.

Coastal Infrastructure
In the project on Optimisation of the Use of Waste Soils from Construction for Large-scale Land Reclamation, field investigations are being conducted at sites where large scale dumping of soils from land based construction activities are currently in progress.

Urban Infrastructure
We successfully completed a project on the modelling of land-use and transportation interactions in Singapore. In the construction of an analytical model for integrated, large-scale analysis of land-use and transportation, two new algorithms were developed (conjugate gradient projection and Frank-Wolfe acceleration) which enhance computationally efficient solutions. Static and time-dependent trip matrices estimations have been derived to furnish sound and reliable inputs to the model.
Collaborative Reach

- strengthening communities through our partnership
Design Technology Institute

Design Technology is of strategic importance in the transformation to a knowledge-driven economy, as industries move beyond manufacturing towards product design and development.

Design Technology Institute (DTI) was founded in Singapore in February 2002 to be the premier Asia-Pacific institute for rapid product development systems, methodologies, processes and design technology. With its focus on education and research, DTI is an important player supporting industries in capturing global market share and improving standards of living.

DTI serves as a critical link between industry and academia. In the current innovation-driven economy, DTI is well positioned to work with industry to enhance its design capabilities and create value. On 18 February 2004, the Design Technology Institute in Eindhoven was officially opened. The combined expertise of Technische Universiteit Eindhoven (TU/e) and NUS will enable DTI to make significant contributions to education and research in the specialised area of design technology and to benefit shared resources, ideas and knowledge. Students from the pioneer batch of Master of Technological Design (MTD) have completed their two-year programme (one year of academic coursework and one year of industrial attachment) and graduated in July 2004.

Academic
The three MTD programmes are:

- Rapid Product Development
- Embedded Systems
- Mechatronics

Plans for the coming year include a fourth MTD programme in Industrial Design in addition to the four new courses developed in 2003.

By rapidly translating original design concepts into commercial products, in an increasingly shorter product creation process, DTI’s graduates can create an impact on companies in the region and around the world. The Institute trained over 130 executives locally in the last year, offering at least six workshops and courses. We are engaged in eight industry consulting projects with four joint R&D projects with companies.

Industry

1. Number of executives trained in 2003: over 130
2. Number of programmes/workshops organised in 2003: 6
3. Number of joint R&D projects with companies in 2003: 4
4. Number of industry consulting projects in 2003: 8
5. Number of industry partners: 16

Executives from the following companies were trained in 2003

- Philips MTV, Siemens VDO Automotive, Philips Semiconductor and Philips CFT, Singapore Technologies Dynamics and Singapore Technologies Aerospace.

Joint R&D projects with

- Xerox Venray, SIMTech, Design Exchange and Philips POS.

Industry consulting projects in 2003

- Chinese Character Input project with PSB Corporation
- Spyware project with PSB Corporation
- ESEC Magazine Handler project with Philips ETD
- Design of LDM & Auto Door project with Advanced Solutions Engineering
- Design of Automatic Unwinder/Rewinder System project with Astech
- Verona HCCT project with Philips DAP
- DFSS Consultancy project with Siemens VDO Automotive
- SlimAir Consultancy project with Philips DAP

Industry Partners

Xerox Venray, VS Electronics, Venture Corporation, SMB United, Motorola Electronics, Delphi Automotive Systems, PSB Corporation, Pemstar Singapore, BBS Access, Nutek, Siemens VDO Automotive, Addvalue Technologies, Philips Electronics Singapore, DigiSAFE, Data Storage Institute, Biosensors International.
**Singapore-MIT Alliance**

Founded in 1998, the Singapore-MIT Alliance (SMA) is an engineering education and research collaboration between National University of Singapore (NUS), Nanyang Technological University (NTU), and the Massachusetts Institute of Technology (MIT). This partnership involves teaching staff from various NUS faculties and NTU schools, of whom 44% of SMA Fellows and 33% of SMA Associates are from NUS. The NUS Faculty of Engineering is represented by Prof Andrew Nee (Department of Mechanical Engineering), who is the Singapore Co-Director; Prof Chua Soo Jin (Department of Electrical & Computer Engineering), the Singapore Deputy Director; and Dean Seeram, a Joint Academic Committee member.

Leading academics from established universities in the region, namely Tsinghua, Beijing, Shanghai Jiao Tong and Xi’an Jiaotong Universities, all the Indian Institutes of Technology, University of Malaya and University of Technology Malaysia were invited to the Annual Symposium with the aim of building up a stronger network. NUS hosts four of the SMA programmes:

- **Advanced Materials for Micro- and Nano-Systems (AMM&NS)**
- **High Performance Computation for Engineered Systems (HPCES)**
- **Molecular Engineering of Biological and Chemical Systems (MEBCS)**
- **Computer Science (CS)**

In October 2003, SMA launched its very first electronic newsletter (http://web.sma.nus.edu.sg/smaconnect) to inform and promote awareness of SMA’s events and activities among counterparts, industry partners, funding bodies, students and staff. Other projects include outreach programmes and technical presentations. Between April 2003 and March 2004, three outreach programmes and 29 technical presentations were held. SMA held its 4th Annual Symposium on the theme **Global Linkages** in January 2004 at which both MIT and SMA’s research students presented papers and played an active part in the discussions.

SMA students have also gone on to achieve success beyond the classroom, receiving the following awards in the past year:

1. **Materials Research Society Graduate Student Award**; the recipient Meng Ying is a current AMM&NS doctoral candidate
2. **Best Paper Award** in the Annual Eurosensors Conference; the recipient Teh Weng Hong is an AMM&NS graduate
3. **Honourable Mention** in the George Nicholson Student Paper Competition at the INFORMS Annual Meeting; the recipient, Karthik Natarajan is one of the first PhD graduates in the HPCES programme

SMA students work in Singapore’s high-technology industries through collaborative projects and research, enriching the student experience while directly contributing to the knowledge base of the country’s international and regional economies. In 2003, a total of 41 projects were carried out with companies and research institutes.

**Organisations that participated in the S.M. Internship Programme (2003-2004)**

1. A & P Co-ordinator Pte Ltd
2. Accord Express Holdings Pte Ltd
3. Advanced Materials Technologies Pte Ltd
4. Agilent Technologies Singapore Pte Ltd
5. Bioinformatics Institute
6. BuzzCity Pte Ltd
7. Centre for Advanced Computations in Engineering Science
8. Centre for Microwave and Radio Frequency
9. Chartered Semiconductor Manufacturing Ltd
10. Crimsonlogic Pte Ltd
11. Data Storage Institute
12. Dow Chemical Pacific (S) Pte Ltd
13. DSO National Laboratories
14. elipva Ltd
15. Encephale Pte Ltd
16. Eudyna Devices Asia Pte Ltd
17. Hewlett-Packard Singapore (Pte) Ltd
18. Institute for Infocomm Research
19. Institute of Materials Research and Engineering
20. Institute of Microelectronics
21. Knowledge Touch Pte Ltd
22. Manico Technologies
23. Merck Sharp and Dohme (Singapore) Ltd.
24. Micron Semiconductor Asia Pte Ltd
25. MMI Holdings Ltd
26. Motorola Electronics Pte Ltd
27. Nanomaterials Technology Pte Ltd
28. NCS Pte Ltd
29. Philips Electronics Singapore Pte Ltd
30. ReasonEdge Technologies Pte Ltd
31. Seagate Technology International
32. SembCorp Logistics Ltd
33. Shell Eastern Petroleum (Pte) Ltd
34. Singapore Airlines Ltd (SIA)
35. Singapore Food Industries Limited
36. Singapore Institute of Manufacturing Technology
37. Sun Microsystems Pte Ltd
38. Superior Multi-Packaging Limited
39. Systems on Silicon Manufacturing Co Pte Ltd
40. Temasek Laboratories

Laser light scattering used for measuring the particle size and molecular weight of organic nano-particles – MEBCS programme

A live lecture being beamed from MIT to the NUS Centre for Instructional Technology Auditorium
The US Naval Postgraduate School (NPS) and the National University of Singapore (NUS) collaborated in July 2001 to establish the Temasek Defence Systems Institute (TDSI) for graduate education and research in the area of defence technology, systems engineering and analysis.

TDSI has the dual missions of providing postgraduate education in defence technology and systems, and conducting high-value research with NUS, NPS and Singapore’s defence community.

TDSI’s postgraduate programmes consist of:
- an 18-month full-time Masters degree in Defence Technology and Systems (MDTS) Programme; and
- a six-month full-time Graduate Diploma in Defence Technology and Systems (DDTS) Programme.

TDSI concluded a Collaborative Research and Development Agreement (CRADA) with the NPS in July 2003 and a Letter of Understanding (LOU) with its local sponsors in December 2003. With the successful conclusion of CRADA, five joint projects between NPS, NUS and Defence Science & Technology Agency (DSTA) were launched.

Three of the projects funded by these agreements are:
- Cooperative Weapons Systems at $213,000 (Assoc Prof Gerard Leng, Department of Mechanical Engineering)
- Antenna Design for UAV Application at $50,000 (Assoc Prof Li Le-Wei, Department of Electrical & Computer Engineering)
- Numerical Methods for Cavitating Flow Problems at $242,200 (Assoc Prof Khoo Boo Cheong, Department of Mechanical Engineering)

In 2003, TDSI successfully graduated its first cohort of 27 students from the new MDTS Programme. These students received their masters degree scrolls from NUS Chancellor, President S R Nathan, at the Commencement Ceremony on 6 July 2004. The second MDTS intake of 26 students completed the NUS phase in December 2003 and are currently in NPS for the second stage.

All 27 students from the fourth DDTS cohort completed their studies in December 2003 and were awarded the Graduate Diploma in Defence Technology and Systems at a ceremony held on 20 March 2004.
The Logistics Institute-Asia Pacific

The Logistics Institute-Asia Pacific (TLI-Asia Pacific) is a collaboration between the National University of Singapore (NUS) and the Georgia Institute of Technology (Georgia Tech) for research and education programmes in global logistics. TLI-Asia Pacific is modeled after The Logistics Institute (TLI) at Georgia Tech, which has wide industry recognition as one of the best institutes for education and research in logistics. This collaboration provides logistics expertise catering to industries in global logistics, information technology, industrial engineering and supply chain management.

TLI-Asia Pacific's principal aim is to deliver leading-edge research and development in logistics engineering, technology, and management as well as to provide high-quality postgraduate education in logistics at the MSc and PhD levels. The institute plays a pivotal role in helping the manufacturing industry and logistics service providers by providing training programmes for skills upgrading and by spearheading innovative logistics solutions using emerging technologies. Core programmes offered by the institute are:

- Global Logistics & Supply Chain Research Programmes funded by A*STAR and the Ministry of Defence (MINDEF)
- Degree education programmes such as Dual Masters Programme (DMP) and Double Degree Programme (DDP) with NUS Faculty of Engineering and Tsinghua University
- Professional Education (PE) programmes catering to the needs of industry executives and professionals

Underpinning this framework of programmes is the Industry Outreach arm of TLI-Asia Pacific, which seeks to develop and enhance a robust, mutually beneficial relationship with industry practitioners by means of an exclusive membership programme.

Staff of the Institute are drawn from the Department of Industrial & Systems Engineering at Georgia Tech and from the Faculties of Engineering, Business and Computing at NUS. NUS Faculty of Engineering staff in TLI-Asia Pacific are actively engaged in administration, teaching and research. We teach graduate modules under the DMP, act as Principal Investigators for research projects through internal funding by TLI-Asia Pacific or from external grants by A*STAR, MINDEF and other government agencies; supervise DMP students in their theses and participate in the Joint-Admissions Committee for DMP and DDP.

Results of Projects Funded by TLI-Asia Pacific

**Projects funded by TLI-Asia Pacific**

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Principal Investigator(s)</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Laboratory Platform for Container Security Route Planning and On-route Tracking (Total Project Value: $84,000)</td>
<td>Assoc Prof Cheu Ruey Long, Dr Lee Der-Horng, Dr Huang Bo, Dr K Kagaruman</td>
<td>Department of Civil Engineering (CE)</td>
</tr>
<tr>
<td>Integrated Logistics Planning for Assemble-to-stock Systems (Total Project Value: $50,000)</td>
<td>Assoc Prof Chew Ek Peng [Department of Industrial &amp; Systems Engineering (ISE)]</td>
<td></td>
</tr>
</tbody>
</table>

**Projects funded by External Agencies**

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Principal Investigator(s)</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Supply Chain Networks by A*STAR (Total Project Value: $1.69 million)</td>
<td>Prof Nukala Viswanadham [Department of Mechanical Engineering (ME)] Assoc Prof I A Karimi [Department of Chemical &amp; Biomolecular Engineering (ChBE)] Dr Rajagopalan Srinivasan (ChBE)</td>
<td></td>
</tr>
<tr>
<td>Temasek Research project - Air Cargo Logistics and Supply Chains by A*STAR (Total Project Value: $2.9 million)</td>
<td>Assoc Prof Chew Ek Peng (ISE) Assoc Prof Huang Huei Chuen (ISE - Programme Manager) Dr Jaruphongsa Wikrom (ISE) Dr Lee Chulung (ISE) Dr Lee Loo Hay (ISE) Dr Li Rongheng (ISE) Dr Alexander David Morton (ISE)</td>
<td></td>
</tr>
<tr>
<td>Joint Armed Forces/GT/NUS Applied Research (JAGUAR) by MINDEF (Total Project Value: $3.5 million)</td>
<td>Dr Ng Kien Ming (ISE)</td>
<td></td>
</tr>
</tbody>
</table>

TLI-Asia Pacific was voted the Best Education Provider in Asia at the Asian Freight & Supply Chain Awards for two consecutive years in 2003 and 2004.

The success of this symbiotic relationship between TLI-Asia Pacific, Georgia Tech and NUS is demonstrated by the award of Best Education Provider at the Asian Freight & Supply Chain Awards for two consecutive years in 2003 and 2004.
Research Frontier
- developing future technologies

Nanostructured Materials
Nanotechnology is the science of all things small. But for its small size, nanotechnology has great promise. Nanotechnology is essentially about exploiting the unique properties of materials, systems and devices at near atomistic length scale. The potential is in the breakthroughs associated with designing structures, which go right down to the fundamental building blocks of all matter—atoms and molecules. By rearranging the atoms that make up these materials, we can build new materials and devices with new functions. Among other fields, it also offers the prospect of higher-performance but lower-maintenance materials for manufacturing, defence, transportation, space, and environmental applications. Nanotechnology also heralds accelerated biotechnical applications in medicine, health care and agriculture, and the possibility of extending the limits of sustainable development. Its current applications, however, represent the fruition of only the tip of the iceberg!

Formation of NUSNNI
The NUS Nanoscience and Nanotechnology Initiative (NUSNNI) was formed in July 2001 when the then Vice-Dean of the NUS Faculty of Engineering, Prof Seeram Ramakrishna and Dr Vincent Tan, now Deputy Director of NUSNNI, commissioned a four-month study of the global and local nanotechnology scene. In keeping with the cross-disciplinary nature of nanotechnology, the compilation of the report and presentation materials were done in conjunction with the NUS Faculty of Science. At the end of that year in 2001, the report was presented to NUS President and the Office of Research, and in January 2002, NUSNNI was born. That same month, a Workshop on Nanoscience and Nanoengineering was held by the Science and Engineering Faculty to generate breakthroughs in applications related to Bioengineering and nanotechnology. Similar joint conferences between Singapore and China are also being initiated. Collaborative research work between research institutes and NUS has been impactful. For example, the Data Storage Institute (DSI) which was established by A*STAR and NUS, has achieved world-class standards in very high-density data storage. A DVD-sized magnetic disk which can hold 350 times more data than a conventional DVD has been developed. Its research achievement puts Singapore alongside the US and Japan in the technological-development roadmap of the information storage industry.

NUSNNI is committed to manpower training, and will continue to facilitate and initiate multidisciplinary research, and set research directions. The formation of an International Advisory Panel comprising world leaders in nanotechnology research and business will help NUSNNI to focus even more by identifying strong and high-impact niche areas. Efforts will also be made to strengthen partnerships with existing international collaborators, and to actively engage more university faculties and research institutes.

The Economic Development Board (EDB) has provided S$720,000 to set up industry-oriented programmes in the MEng in Nanoengineering. To support graduate education, more than 20 labs have been set up or supported. The Nanobioengineering Corridor, Silicon Nanodevices Lab and the Information Storage Materials Lab, among others, are but a few examples.

Collaborations
From the 19th to the 21st of April this year, a Singapore delegation visited the University of California, Santa Barbara (UCSB) for a joint workshop to exchange research ideas and results, and to explore collaborative opportunities. NUSNNI is currently organising a year-end nanotechnology workshop with researchers in Japan and there will be a joint Korea-Singapore Workshop on Nanobioengineering in Singapore in July 2005. The joint symposium will cover inter-disciplinary topics at the interface of bioengineering and nanotechnology. Similar joint conferences between Singapore and China are also being initiated.

The A*STAR-funded research project on Spintronics is looking into the harnessing of the spin of electrons in a new class of materials called magnetic semiconductors. The microbiology of biofilms technology for water reuse is also being researched which is an area with huge potential in water-scarce Singapore. And in the most recent of research-award achievements, a graduate student has won the Faculty’s first Gold Medal in the Far Eastern Economic Review/Hewlett Packard Young Inventors Award 2004 for his life saving work. A machine was designed, which can, for the first time, build 3D scaffolds and closely align the nanofibres in 2D and 3D scaffolds allowing scaffolds for tissue engineering to be controlled more precisely.

NUSNNI – A Propelling Force in R&D
These are only some of NUSNNI’s achievements of which it takes pride that new R&D areas have been developed to prime the Faculty to generate breakthroughs in applications related to Bioengineering and the Life Sciences, Infocomm Technology, and the Engineering Sciences. Hence, NUSNNI is fast becoming a dynamic driving force propelling innovative R&D and multidisciplinary research in signature areas of nanotechnology.
Materials Science & Engineering Initiative

The evolution and welfare of human’s defence capabilities, space exploration, electronics technology, and micro-electromechanical systems are some of the areas which are inherently dependent on advancements made in the science and engineering of materials. In order to be self-reliant at the national level in materials technology, the NUS Faculty of Engineering launched the Materials Science & Engineering Initiative (MSEI) with the following objectives:

(i) To create human resources trained in the area of materials to assist the existing and emerging materials-sensitive industrial sector;
(ii) To create a borderless undergraduate and graduate level education programme for both engineering and non-engineering students;
(iii) To develop world-class research infrastructure to facilitate research activities dealing with science and engineering of new and advanced materials and related technologies; and
(iv) To bridge the gap between university and industry through strategic research collaborations.

The first two objectives of MSEI to establish a network of educational programmes to address the needs of students with different degrees of interest in materials science have partially been met. Students who desire to enhance their knowledge in the area of engineering materials could opt to take the Specialisations and Minor programme currently available to them in the Faculty. These programmes have contributed to the creation of a small but much-needed pool of human resources specialised to different degrees in this important area of engineering materials. For students who want to make materials as their career option, programmes such as an undergraduate degree programme in Materials Science & Engineering as well as a double major are presently being considered. It is envisaged that when this network of programmes is fully established, it will further contribute towards the Faculty’s overall strategy to provide Singapore with the appropriate engineering human resources.

MSEI intends to encourage research in strategic areas that will have long-term impact on the needs of human society. Emphasis is placed on complementing and advancing the knowledge of materials rather than duplicating it.

Some of the research activities pursued under MSEI include:

- Development of novel materials for chemical, environmental, microelectronics, life sciences and pharmaceutical industries. These include the following: nanostructured and mesostructured catalysts, surface functionalisation, chemical separation using polymeric or ceramic membranes, biomaterials, electroactive polymers and coatings, ceramic absorbents, crystalline electronic materials, chemical and biochemical sensors, fuel cells, and electrochemical energy conversions.

- Exploitation of nanomaterials and nanostructures in microelectronics and photonic applications, semiconductor material systems, self-organised quantum heterostructures, magnetic material systems, spin electronic devices, nanowires, and carbon-and-related materials.

- Development, characterisation, and modelling of high-performance composite materials, with particular attention devoted to new and innovative materials such as smart materials, fiber-reinforced polymer and cementitious composites, and geo-synthetics, for improved performance and control of engineering structures, including blast and impact resistance, and durability.

- Development of novel monolithic and reinforced composite formulations with structural features ranging from micro- to nano-regime for possible use in electronic components, portable devices, microelectronics packaging, and the automotive, aerospace, space, sports and biomedical sectors.

Since the Initiative was launched, efforts have not been spared to build up research infrastructure in support of the various research activities. With the critical state-of-the-art facilities already in place within the Faculty, MSEI is well-positioned to make a significant impact in the area of materials science and engineering.
The NUS Faculty of Engineering is a key partner in the NUS InfoComm and InfoTech Initiative. Together with the School of Computing, we have defined the following five key technology areas of research to focus on meeting the Initiative’s goal of advancing the frontiers of Information, Communications and Perception technologies.

**Wireless Sensor Networks**

*Sensor Networks* is a new and exciting area of research that has tremendous potential in military and commercial applications. In military applications, sensors can be used to coordinate troop movements as well as track enemy movements. In commercial applications, a sensor network has a wide range of applications from inventory tracking to bio-hazard monitoring. Sensor networks are expected to have tremendous impact on almost every facet of human life. They will not only enhance the quality of life but also could potentially avert many life threatening disasters and tragedies such as earthquakes, bio-terrorism, etc. Research activities will investigate issues including energy efficient protocol design, sensor placement and coverage, cross-layer design issues such as joint data aggregation/fusion and routing, self-organisation, hybrid sensor networks (a combination of a few mobile nodes and a large number of static nodes), hierarchical clustering and data aggregation.

**Video Processing**

The goal of video processing is to develop methods of extracting robust descriptions of the scene depicted in a video. This description includes the scene’s spatial layout and its dynamic properties, i.e. the locations, movements and classifications of objects. Key research issues to be investigated are in understanding the geometry of deriving spatial layout from the video. This is especially so under the scenarios of uncalibrated camera, camera with non-conventional lenses, as well as multiple-camera configuration.

**Computational Intelligence and Autonomous Systems**

*Computational Intelligence* refers to computer systems that replicate the analytical, problem-solving and learning abilities of the human brain. These systems assimilate the benefits of knowledge and intelligence into the solutions of complex problems. Computational intelligence includes research areas such as evolutionary computing, artificial neural networks, fuzzy systems, machine learning, data mining and multi-agent systems. The importance of these methods and the reason for their huge potential in solving real world problems lie in their ability to learn from experience, to self-organise and to adapt their behaviour in response to a dynamically changing set of conditions and constraints.

*Autonomous Systems* are capable of acting independently in dynamic and unpredictable environments with minimal or no human intervention. Each of these systems usually comprises an agent or a group of agents coordinating to achieve a given task. The issues of autonomous agents and multi-agent systems are interesting and important directions of research and development in computer science these days. Agent technologies are being used in diverse fields and domains. In particular, the present research direction in building intelligent robotic systems requires an integrated approach to problem solving in computing, science and engineering, which warrants the need to combine the skills and knowledge from these disciplines.

The real-world operational issues, system evolution, cooperation, modelling of uncertainties, sensor fusion, sensor networks and intelligent control designs are a few of the interesting research directions.

**Mixed Reality**

*Mixed Reality* (the fusion of augmented and virtual reality) is a technology that allows the digital world to be extended into a user’s physical world. Unlike virtual reality in which the user is immersed in an artificial world, mixed reality operates in the user's real world. This is made possible through the use of (head-mounted) displays where the user’s real-world view can be overlaid with 3D computer graphics, text, video, audio and speech. Mixed reality can be used to develop an almost magical environment where the virtual world, such as 3D computer graphics images and animations are merged with the real world as seamlessly as possible in real time. This research will combine the enhanced bandwidth capabilities of broadband networking with mixed reality technology to prototype the next generation multimodal interface. New media and multimodal interfaces that support communication are of tremendous importance in ensuring efficient collaborative teamwork.

**System Support, Architectures and Algorithms for Stream Processing**

This research will develop network and operating system support, hardware architectures and algorithms for processing and managing large volumes of continuous data streams. Recently there has been a tremendous increase in applications which generate and process continuous and unbounded streams of data. Examples in the embedded systems domain are applications for playing streaming audio and video on networked handheld devices such as personal digital assistants and mobile phones. In the high-performance networking domain, such applications arise in mobile phone base stations and in intelligent routers for processing streams of network packets. Many applications belonging to this class also arise in the context of network monitoring and sensor networks which continuously capture some data that require online processing. All of these applications are centred on the notion of a stream, and it is increasingly being realised that conventional architectures, system support mechanisms and algorithms are inadequate for processing and analysing them. Instead, both the hardware and the software architectures for such applications should incorporate and be structured around the stream abstraction.
Service to the Nation, Public Sector and University

Prof Chan Eng Soon (Civil Engineering) - as Director, Tropical Marine Science Institute

Prof Cheong Hing Fatt (Civil Engineering) - as Dean, NUS School of Design and Environment

Prof Chew Yong Tian (Mechanical Engineering) - as Deputy Director, NUS Office of Research; Executive Secretary of Management Board, Institute of Engineering Science

Assoc Prof Cheu Ruey Long (Civil Engineering) - as Director of Degreed Education, The Logistics Institute-Asia Pacific

Prof Chong Tow Chong (Electrical & Computer Engineering) - as Executive Director, Science & Engineering Research Council (SERC), A*STAR; Executive Director, Data Storage Institute

Assoc Prof Chua Kee Chaing (Electrical & Computer Engineering) - as Co-Director, Institute of Engineering Science

Prof Chua Soo Jin (Electrical & Computer Engineering) - as Deputy Director (Industry), Institute of Materials Research & Engineering; Deputy Co-Director, Singapore-MIT Alliance

Prof Hang Chang Chieh (Electrical & Computer Engineering) - as Deputy Chairman, A*STAR; Chairman, Intellectual Property Office of Singapore; Chairman, Intellectual Property Academy

Assoc Prof Yaacob Ibrahim (Industrial & Systems Engineering) - as Minister for Community Development & Sports and Minister-In-Charge of Muslim Affairs

Assoc Prof Anjam Khursheed (Electrical & Computer Engineering) - as Associate Director, NUS Centre for Development of Teaching & Learning

Prof Lam Khin Yong (Mechanical Engineering) - as Executive Director, A*STAR Graduate Academy

Assoc Prof Lee Heow Pueh (Mechanical Engineering) - as Acting Executive Director, Institute of High Performance Computing

Prof Lee Tong Heng (Electrical & Computer Engineering) - as Vice-President (Physical Resources and Planning), NUS; Director, NUS Office of Research; Executive Director, A*STAR; Executive Director, Data Storage Institute

Prof Low Teck Seng (Electrical & Computer Engineering) - as Principal and CEO, Republic Polytechnic

Prof Lye Kin Mun (Electrical & Computer Engineering) - as Deputy Executive Director (Industry), Institute for Infocomm Research

Prof Andrew Nee Yeh Ching (Mechanical Engineering) - as Co-Director, Singapore-MIT Alliance; Chief Executive Officer, Design Technology Institute

Assoc Prof Jeff Obbard (Chemical & Biomolecular Engineering) - as Associate Director, Tropical Marine Science Institute

Prof Jacob Phang (Electrical & Computer Engineering) - as Chief Executive Officer, NUS Enterprise; Director, NUS Industry & Technology Relations Office; Director, NUS Venture Support

Assoc Prof Poh Kim Leng (Industrial & Systems Engineering) - as Deputy Director, NUS Graduate School for Integrative Sciences and Engineering

Assoc Prof Tan Kay Chuan (Industrial & Systems Engineering) - as Deputy Director, NUS Nanoscience & Nanotechnology Initiative

Assoc Prof Teo Chee Leong (Mechanical Engineering) - as Director, NUS Overseas Colleges

Prof Victor Shim Phyau Wui (Mechanical Engineering) - as Director, NUS Office of Corporate Relations

Prof N Viswanadham (Mechanical Engineering) - as Deputy Executive Director of Academic Affairs, The Logistics Institute-Asia Pacific

Prof Lawrence Wong Wai Choon (Electrical & Computer Engineering) - as Executive Director, Institute for Infocomm Research

Prof Miranda Yap Gek Sim (Chemical & Biomolecular Engineering) - as Executive Director, Bioprocessing Technology Institute

Prof Yeo Tat Soon (Electrical & Computer Engineering) - as Director, Temasek Defence Systems Institute

Prof Yong Kwet Yew (Civil Engineering) - as Member, Board of Directors, Land Transport Authority; Vice-President (Physical Resources and Planning), NUS; Director, NUS Office of Estate & Development
Income and Expenditure Statement for Financial Year (FY) Ending 31 March 2004

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Faculty's Operating Budget for FY03/04</td>
<td>$ 77,392,435</td>
</tr>
<tr>
<td>Commitments brought forward from FY02/03</td>
<td>$ 3,471,301</td>
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</tbody>
</table>

**Expenditure on Manpower**

<table>
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<th>Staff Type</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Teaching Staff</td>
<td>$ 44,893,650</td>
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<tr>
<td>Administrative Staff</td>
<td>$ 2,332,913</td>
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<tr>
<td>Non-academic Staff</td>
<td>$ 13,691,583</td>
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<tr>
<td>Research Staff</td>
<td>$ 4,042,710</td>
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<tr>
<td>Casual Staff</td>
<td>$ 109,983</td>
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<td></td>
<td><strong>$ 65,070,839</strong></td>
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**Other Operating Expenses**

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<tr>
<th>Description</th>
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<tbody>
<tr>
<td>Utilities</td>
<td>$ 4,418,255</td>
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<td>Teaching Materials</td>
<td>$ 1,760,044</td>
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<td>Maintenance of Equipment</td>
<td>$ 1,079,159</td>
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<td>Postage &amp; Telecommunication Charges</td>
<td>$ 285,897</td>
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<td>Computer Software - Maintenance</td>
<td>$ 257,639</td>
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<td>Consumables</td>
<td>$ 219,292</td>
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<td>Stationery &amp; Office Supplies</td>
<td>$ 169,962</td>
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<td>Allowance - Vacation Training Scheme</td>
<td>$ 161,255</td>
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<tr>
<td>Reports/Publications</td>
<td>$ 151,066</td>
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<td>Computer Hardware - Maintenance</td>
<td>$ 99,856</td>
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<td>Other Services</td>
<td>$ 78,785</td>
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<tr>
<td>Computer Software - Purchase</td>
<td>$ 68,304</td>
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<td>Student Assistant Allowance</td>
<td>$ 53,047</td>
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<td>Advertisement - Local</td>
<td>$ 46,095</td>
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<td>Computer Supplies</td>
<td>$ 45,261</td>
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<tr>
<td>Hospitality Expenses - External Visitors</td>
<td>$ 31,376</td>
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<tr>
<td>Airfare/Transport - Others</td>
<td>$ 29,586</td>
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<tr>
<td>Meals/Refreshments - Staff Meetings</td>
<td>$ 28,165</td>
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<td>Staff Travel - Overseas (Airfare/Transport)</td>
<td>$ 15,862</td>
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<td>Web Page Design</td>
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<td>Meals/Refreshments - Students</td>
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<td>Advertisement - Overseas</td>
<td>$ 16,906</td>
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<td>Others</td>
<td>$ 249,855</td>
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<td><strong>$ 9,299,702</strong></td>
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<table>
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<tbody>
<tr>
<td>Renovations &amp; Redecorations</td>
<td>$ 350,683</td>
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<td>Leave for Academic Purposes</td>
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<td>Academic Visitors/Advisors</td>
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<td>Staff Arrivals/Departures</td>
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<td>Academic Staff Conferences</td>
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<td>Staff Travel on Official Leave</td>
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<td>SARS-Related Expenses</td>
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<td>Academic Staff Recruitment</td>
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<td>Recruitment of Students</td>
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<td>Others</td>
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**Equipment/Fixed Asset**

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**Expenditure for FY03/04**

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<td><strong>$ (78,767,671)</strong></td>
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**Commitments brought forward to FY04/05**

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<tr>
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<td><strong>$ (1,690,112)</strong></td>
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**Operating Surplus for FY03/04**

<table>
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<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
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<td><strong>$ 405,953</strong></td>
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**Expenditure from reserves account (RSSRA)**

<table>
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<tbody>
<tr>
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<td><strong>$ (314,037)</strong></td>
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**Actual Operating Surplus for FY03/04**

<table>
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<th>Description</th>
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<td><strong>$ 91,916</strong></td>
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<tr>
<td>Maureen Lee-Kwee</td>
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<td>Assoc Prof Lim Chwee Teck</td>
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<td>Lin Xiao Wen</td>
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<td>Julie Liau</td>
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