Singapore-MIT Alliance for Research and Technology

On July 1, 2007, in partnership with the National Research Foundation (NRF) of Singapore, MIT launched a new research center with a bold and unique vision. The Singapore-MIT Alliance for Research and Technology Centre, (SMART Centre) was founded on the premise that several of the major challenges facing society are interdisciplinary in nature, and that solving them requires global collaboration in strategically located centers of research excellence.

The mission and vision of the SMART Centre is to:

- Be a world-class interdisciplinary research center that maintains the same standards of excellence as at MIT
- Identify and conduct research on critical problems of societal significance and of interest to Singapore
- Develop robust collaborations with researchers from local universities and institutions in Singapore to co-advise local doctoral students and postdoctoral researchers
- Help instill a culture of translational research, entrepreneurship, and technology transfer
- Be a magnet for attracting and anchoring global research talent to Singapore and MIT
- Be a platform for Singapore and MIT to develop global interactions within and beyond Singapore

The SMART Centre currently has seven interdisciplinary research groups (IRGs) and an innovation center. Over 685 researchers and staff from MIT and Singapore participate in SMART. Each IRG has an initial five-year term, and subject to review and approval may receive an additional five-year term. Three IRGs are in their second five-year term, two IRGs are winding down, and two new IRGs commenced on January 1, 2018.

The SMART Centre is MIT's largest international endeavor and it is the only such research center outside Cambridge, Massachusetts. It enables MIT faculty members and students to engage in certain types of research that cannot be carried out in Massachusetts. Examples of this research include infectious diseases, such as malaria, dengue, and tuberculosis; environmental phenomena, such as the unique equatorial ocean-air coupling and the resulting weather patterns; and the development of microfluidic stem cell technologies in therapeutics for diseases that are most prevalent in the Singapore region (e.g., certain liver diseases). The SMART Centre gives MIT access to the deep pool of research talent in Singapore, as well as those who are attracted to Singapore from the rest of Asia. It also provides MIT researchers with access to certain dedicated facilities not available on the Cambridge campus (such as the biosafety level three laboratories) as well as to clinical and field work essential to these research problems.

One measure of MIT's strong commitment to SMART is the amount of time that MIT researchers spend in Singapore. Each principal investigator (PI) spends at least 20% of his or her time at the SMART Centre during the life of the IRG, and this must include at least one continuous stay of six months. During this six-month stay, the faculty member is not on sabbatical leave or a leave of absence from MIT. Moreover, at least one PI from each IRG is in long-term residency in Singapore at all times (except for professional trips that she or he might normally make). Some faculty members have chosen to stay longer because they found the environment so conducive to their research (more than one PI stayed for two continuous years). In addition to the PIs, there is a steady circulation of MIT faculty, postdoctoral, doctoral, and undergraduate student researchers via shorter-term visits of a week to up to two months. As a result, the atmosphere at the SMART Centre is most certainly dynamic.

The SMART Centre is located at the Campus for Research Excellence and Technological Enterprise (CREATE) in Singapore. CREATE—a complex of state-of-the-art research laboratories developed in Singapore by NRF—is occupied by world-class research universities and corporations. A number of such universities (e.g., UC Berkeley, Cambridge University, ETH Zurich, Hebrew University, Technical University of Munich, and Shanghai Jiao Tong University) like SMART, have set up research laboratories at CREATE. SMART is the largest research entity at CREATE in terms of participants and space. This co-location of several research teams from several research organizations will lead to stronger collaboration among the IRGs, as well as collaboration among the various international research entities, in addition to their collaboration with Singapore-based universities and research institutions. All of the five active IRGs, the innovation center, and headquarters are located at CREATE.

Interdisciplinary Research Groups

Research at SMART is carried out in IRGs. As of July 1, 2018, SMART has five IRGs focused on the following five topics: antimicrobial resistance; biosystems and micromechanics; disruptive and sustainable technology for agricultural precision; future urban mobility; and low-energy electronic systems. Two additional IRGs, one focused on infectious diseases and the other focused on environmental sensing and modeling will wind down on December 31, 2018.

The SMART Centre maintains quality through its careful selection and subsequent nurturing of each IRG. Once chosen, the IRG receives substantial funding and other resources needed to carry out its work. Its progress is periodically evaluated by IRG-specific scientific advisory boards (SABs) composed of non-MIT experts in the field of the IRG. The feedback from the IRG SABs is meant to nurture the IRGs, especially through their constructive criticisms, which help the IRGs to grow stronger. In addition, the SMART Centre presents semiannual reports to its governing board, which is co-chaired by the provost of MIT and the former president of National University of Singapore (NUS).

The topic and team for each IRG is selected through an annual MIT-wide competition that begins with an open call to all MIT faculty members. Teams of faculty self-organize and submit white papers. The SMART Centre's Advisory Committee (composed of department heads from MIT's School of Engineering and School of Science) reviews

these white papers and then asks for full proposals from the shortlisted teams, which typically amount to five. After reviewing the full proposals, the advisory committee then picks a single proposal, and this is submitted to the NRF board for consideration. The process is very competitive with several high-quality proposals making it to the final pool. The faculty members on the participating teams are among the most research-active tenured faculty at MIT. The key selection criteria include the importance of the problem proposed for study, the interdisciplinary character of the problem, the innovativeness of the proposed approach, and the strength of the faculty team. Other considerations include the importance of the problem to Singapore, and the reasons why the MIT faculty would choose to go to Singapore to work on this problem rather than working on it in Cambridge, Massachusetts.

The research in each IRG is multidisciplinary in nature and consequently draws on faculty from several departments at MIT, and from faculty at NUS and Nanyang Technological University (NTU), Singapore University of Technology and Design (SUTD), research institutes, and governmental agencies in Singapore. The total number of participants in a single IRG varies from a low of 50 to a high of 120. This includes between four and 15 MIT faculty members participating in an IRG. The other IRG participants are faculty from the universities in Singapore, senior researchers from Singapore research institutes and agencies, postdoctoral researchers (from MIT, Singapore, and the SMART Centre), doctoral students (from MIT and the universities in Singapore), and even undergraduate researchers (from both MIT and Singapore) during the summers.

We summarize below the research problems identified by each IRG.

Antimicrobial Resistance

The Antimicrobial Resistance Interdisciplinary Research Group (AMR) is a unique translational research and entrepreneurship program aimed at solving the growing threat of resistance to antimicrobial drugs. AMR leverages the scientific and clinical strengths of MIT and Singapore to develop transformative technologies to identify, respond to, and treat drug-resistant microbes. AMR projects address the threat of drug-resistant microbes by developing diagnostics and drugs based on synthetic biology; defining new resistance mechanisms in biofilms and dormant infections; developing anti-resistance drugs and drug delivery strategies; and exploiting host immunity to combat resistant microbes. AMR will also accelerate the pace of drug development by streamlining clinical trials and regulatory practice. The AMR group began its five-year term on January 1, 2018.

Biosystems and Micromechanics

By merging diverse engineering and bioscience areas, such as microfluidics, nanomechanics, imaging, computational modeling, materials science, and biology, the IRG aims to develop disruptive technologies, and with them become better able to diagnose, treat, and mitigate diseases, while simultaneously educating the next generation of biological engineers. The IRG's vision is that it, and Singapore, will become the focal point for translating cutting-edge science into novel technology for human health care. The IRG will end its second five-year term on December 31, 2018, and will receive a no-cost extension until December 31, 2019 to wind down the research.

Disruptive and Sustainable Technology for Agricultural Precision

The Disruptive and Sustainable Technology for Agricultural Precision (DiSTAP) IRG aims to revolutionize how food is produced to meet the demands of a growing population in an increasingly resource-constrained world. While this technology and science facilitates Singapore's agricultural independence and ensures access to high-quality foods for the future, this technology can also be applied around the world—making Singapore a leader in precision agriculture and urban farming. The DiSTAP IRG began its five-year term on January 1, 2018.

Future Urban Mobility

This IRG intends to develop a modeling and simulation platform with an integrated model of human and commercial activities, land use, transportation, environmental impacts, and energy use. This modeling engine will be linked with a range of networked computing and control technology-enabled mobility innovations, and with operations research-based decision models, to analyze the impacts of various novel concepts, including real-time information and management systems, and innovative mobility services such as mobility-on-demand and green logistics. This will yield a new paradigm for the planning, design, and operation of future urban mobility systems in and beyond Singapore. The IRG has been renewed for an additional five-year term and will end phase two on December 31, 2020.

Low-Energy Electronic Systems

The IRG aims to identify new integrated circuit technologies that will become the new added value for reduced energy per function, lower power consumption, and increase performance in our electronics infrastructure. These integrated circuits of the future are expected to impact applications in wireless communication, power electronics, LED lighting, printing, displays, and computing. The research is performed by teams that have expertise in materials, devices, and circuits, invoking new advances at all levels to produce electronic systems that perform new functions while decreasing system energy use. The initial technology goals are in the areas of power electronic systems, efficient communications, and multifunctional displays and lighting systems. The IRG was renewed for a second phase in January 2017.

Infectious Diseases

The major goals of this IRG are to advance basic understanding of pathogen-host interactions at the cellular and molecular levels; develop technology platforms that will be useful for studying infectious diseases; use this basic knowledge to develop diagnostics, prophylactics, and therapeutics for specific infectious diseases; and train a new generation of leaders for academia and the pharmaceutical and biotechnology industries. The infectious diseases IRG will wind down on December 31, 2018.

Center for Environmental Sensing and Modeling

The ultimate goal of the Center for Environmental Sensing and Modeling (CENSAM) IRG is to develop an accurate and predictive model of the natural and built environment of Singapore that would seamlessly transition between different scales, from the level of a single building or facility to the level of the state, including the surrounding ocean.

This model will integrate a variety of data sources (many from novel sensors) and allow users to understand how changes at any scale impact the overall system. For example, how a rise in sea level would impact mesoscale facilities, like Marina Bay, and small-scale facilities, like waste outflows. Conversely, buildings contribute to a heat-island effect that reflects itself in the atmospheric state, or contaminant discharges reflect themselves in mesoscale water bodies and ultimately in the ocean. The CENSAM IRG will wind down on December 31, 2018.

Innovation Centre

In addition to the IRGs that carry out research, SMART has also established an innovation center modeled after MIT's Deshpande Center for Technological Innovation but adapted to the culture and practices of Singapore. Its mission is to instill a culture of translational research, entrepreneurship, and technology transfer.

The SMART Innovation Centre provides funding for faculty, as well as to students, to further develop their ideas with an eye toward the marketplace. A condition for receiving this funding is that the researchers must agree to team up with so-called catalysts—entrepreneurs, or venture capitalists with experience starting companies, or both. The Innovation Centre has identified and trained a strong group of catalysts in Singapore. Three types of awards are given: Ignition Grants (for very early proof-of-principle development), Innovation Grants (for further proof-of-concept development), and Explorer Grants (for student teams).

This approach, borrowed from the Deshpande Center, increases the chances of product commercialization. Even when an idea does not reach the marketplace the inventors have had an invaluable education on the process of commercialization. The Innovation Centre has drawn together a strong team of catalysts and is developing a network of venture capitalists from both Boston and Singapore.

The Innovation Centre also conducts educational programs with the Singapore Management University (SMU), a leading graduate business school in Singapore.

Through SMART funding over 209 invention disclosures have been filed and 30 companies established.

Outreach

SMART Centre has established a summer research internship program: the Singapore-MIT Undergraduate Research Fellows (SMURFs) program. It is open to all undergraduates at NTU, NUS, SUTD, and MIT, and gives students in those schools the opportunity to engage in research at the SMART Centre over the summer. The SMURFs work in their faculty supervisors' labs, actively participate in the research projects, and engage with postdocs, graduate students, and other researchers. SMART hopes these opportunities excite student interest in research and encourage students to consider a career in research. Their academic experiences are supplemented with numerous arranged social activities. Based on feedback from the students, we know that the SMURFs greatly value their experiences at SMART, the community ties that form out of the experience, and the ability to explore Southeast Asia.

Another way in which SMART has engaged the wider research, technology, and entrepreneurial communities in Singapore is through outreach in the form of special symposia, short courses, and seminars given by eminent members of the MIT community. These are open to the public, free of charge, and are extremely well attended.

In order to encourage an open and interactive culture as at MIT, SMART organizes career development and social activities for its researchers. The intent is for researchers from different IRGs to interact, leading to social or technical conversations. In addition, SMART holds monthly afternoon socials to which all SMART participants are invited. These are well attended and they have helped build a SMART sense of community.

SMART has been fortunate to fund a doctoral students' fellowship program to help students conduct their graduate studies at SMART. The funding provides a four-year grant to cover full tuition, stipend, travel, and to supplement costs. The students must be admitted to NUS, NTU, SUTD or SMU, must do a significant part of their research at the SMART Centre, have co-advisors from their home university and MIT, and have the opportunity to spend six months in residence at MIT.

In addition to the postdocs from MIT, NUS, and NTU who conduct research at SMART, the IRGs also advertise and recruit postdocs from around the world who are employed and based permanently at the SMART Centre.

SMART has set up the SMART Postdoctoral Scholars program (modeled after the Humboldt Fellows program) to recruit a few extremely talented postdocs each year to work on their own research projects, provided the project connects in some way to an IRG theme. The SMART fellows receive a particularly attractive stipend and research funding of their own. An MIT SMART faculty member serves as a mentor, so that the SMART fellow has access to mentoring as and when needed.

Looking Forward

SMART is currently renegotiating a new agreement with the Singapore National Research Foundation. The new agreement would commence in either summer 2019 or the beginning of 2020, and would apply to any IRG commenced after January 2019.

There is one proposal under review by NRF and if approved would commence on January 1, 2020 or possibly in July 2019. In October 2018, SMART intends to issue a call for white papers to the MIT community for new IRGs. Successful white papers would be asked to submit full proposals for an effective start date of January 2020.

Daniel Hastings
Director
Chief Executive Officer