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 (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 solve critical problems of societal significance and of interest to Singapore
- Develop robust collaborations with researchers from local universities and institutions in Singapore
- 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 five active interdisciplinary research groups (IRGs) and an Innovation Centre. Approximately 600 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 first term, and two are in their second. One other IRG has concluded its first term.

The SMART Centre is MIT's largest international endeavor and is the only such research center outside Cambridge, MA. It enables MIT faculty members and students to engage in research that is challenging to carry out in Massachusetts, such as solving the growing threat of resistance to antimicrobial drugs, revolutionizing food production for an urban environment, developing world-leading integrated circuits using the industry's global supply chain, and developing 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 and the rest of Asia. It also provides MIT researchers with access to dedicated facilities not available on the Cambridge campus (such as Biosafety Level 3 laboratories), data, and clinical and field work. The IRG funding level allows for scaled long-term collaborative research that can be combined with infrastructure investment, something difficult to replicate in Cambridge. SMART's ecosystem is particularly valuable for moving from early research through translation to market impact within a five- to 10-year time frame. Combined with the Innovation Centre, the SMART Centre offers teams of faculty a unique environment for advancing their ideas for impact.

One measure of MIT's strong commitment to SMART is the amount of time MIT researchers spend in Singapore. Each principal investigator spends at least 20% of his or her time at the SMART Centre during the life of the IRG. This may include one continuous stay of six months, during which the faculty member is not on sabbatical leave and does not require a leave of absence from MIT. There is a steady circulation of MIT faculty as well as postdoctoral, doctoral, and undergraduate student researchers via shorter-term visits ranging from one week to up to two months. As a result, the atmosphere at the SMART Centre is extremely dynamic.

The SMART Centre is located at the Campus for Research Excellence and Technological Enterprise (CREATE) in Singapore. CREATE is a complex of state-of-the-art research laboratories developed in Singapore by the National Research Foundation and is occupied by world-class research universities and corporations. A number of such universities (University of California, Berkeley, University of Cambridge, ETH Zurich, the Hebrew University of Jerusalem, Technical University of Munich, University of Illinois, and Shanghai Jiao Tong University) also have set up research laboratories at CREATE. The SMART Centre is the largest research entity at CREATE in terms of participants and space. This co-location of several research teams from multiple research organizations has led to stronger collaboration among the IRGs, as well as collaboration among the research entities, as shown by the number of multi-organization research grants awarded to SMART.

Interdisciplinary Research Groups

Research at SMART is carried out in IRGs. As of July 1, 2020, SMART has five active IRGs, which are focused on antimicrobial resistance, critical analytics for manufacturing of personalized medicine, future urban mobility, low-energy electronic systems, and sustainable technologies for agricultural precision. One IRG, focused on developing tools to understand cell and tissue diseases biosystems, ended on December 31, 2019.

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 comprised of non-MIT experts in the field of the IRG. The advisory board feedback is meant to nurture the IRGs, especially through constructive criticism. In addition, the SMART Centre presents semi-annual reports to its governing board, which is co-chaired by the provost of MIT and the provost/deputy president of National University of Singapore (NUS).

The topic and team for each IRG is selected through an annual competition that begins with an open call for white papers to all MIT faculty members. Teams of faculty self-organize to submit white papers, and SMART management also encourages and helps organize the formation of teams. The SMART Centre's Advisory Committee (comprised of department heads from MIT's School of Engineering and School of Science) reviews the white papers and asks for full proposals from the shortlisted teams. After reviewing them, the advisory committee selects proposals to be submitted to the NRF Board for consideration. The faculty members on the participating teams are among MIT's most research-active tenured faculty. Key selection criteria include the importance of the

problem proposed for study, its interdisciplinary character, the innovativeness of the proposed approach, and the strength of the faculty team. Other considerations include the importance of the problem to Singapore, and why MIT faculty would choose to go to Singapore to work on this problem rather than working on it in Cambridge.

The research in each IRG is multidisciplinary and consequently draws on MIT faculty from several departments, as well as faculty at the National University of Singapore, Nanyang Technological University (NTU), the 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 30 to as many as 150, which includes four to 15 MIT faculty members. Other participants are faculty from the universities in Singapore, senior researchers from Singapore research institutes and agencies, postdoctoral researchers, doctoral students, and even undergraduate researchers (from both MIT and Singapore) during the summers.

Below is a summary of the research problems identified by each current 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. This IRG 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. This IRG began its five-year term on January 1, 2018.

Critical Analytics for Manufacturing of Personalized Medicine

Critical Analytics for Manufacturing Personalized Medicine (CAMP) focuses on ways to utilize living cells as medicine delivered to humans instead of today's approach of powdered pharmaceuticals, leading to improved health outcomes and reduced time/costs so more patients will have access to promising, approved therapies. This IRG's vision is that CAMP, and Singapore, will become the focal point for translating cutting-edge science into novel drug discovery for human health care. CAMP began its first five-year term on June 1, 2019.

Disruptive and Sustainable Technology for Agricultural Precision

Disruptive and Sustainable Technology for Agricultural Precision (DiSTAP) 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, it can also be applied around the world, making Singapore a leader in precision agriculture and urban farming. DiSTAP began its five-year term on January 1, 2018.

Future Urban Mobility

The Future Urban Mobility (FM) IRG intends to develop a modeling/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. FM has been renewed for an additional five-year term and will end phase 2 on December 31, 2020.

Low Energy Electronic Systems

The Low Energy Electronic Systems (LEES) IRG aims to identify new integrated circuit technologies that will become the new added value for reduced energy per function, lower power consumption, and higher 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. Teams that have expertise in materials, devices, and circuits invoke new advances at all levels to produce electronic systems that perform new functions while decreasing system energy. The initial technology goals are in the areas of power electronic systems, efficient communications, and multi-functional displays and lighting systems. LEES was renewed for a second phase and will end on December 31, 2021.

Innovation Centre

SMART's Innovation Centre was initially modeled after MIT's Deshpande Center for Technological Innovation. Over time it has adapted to the culture and practices of Singapore and has advanced into a unique translational enterprise. Its mission is to instill a culture of translational research, entrepreneurship, and technology transfer.

The SMART Innovation Centre provides funding for teams of faculty, students, and researchers to further develop their ideas with an eye toward the marketplace. A condition for receiving funding is that the researchers must agree to team up with "catalysts"—entrepreneurs and/or venture capitalists with experience starting companies. 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).

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.

Through SMART Centre funding, over 260 invention disclosures have been filed, and 45 companies have been formed.

Outreach

The SMART Centre has established a summer research internship program: the Singapore-MIT Undergraduate Research Fellows (SMURF) program. Unfortunately, due to COVID-19, the SMURF Program was postponed. SMART had made the commitment that any 2020 SMURF can automatically participate in the 2021 SMURF Program without having to resubmit an application.

SMURF is open to all undergraduates at NTU, NUS, SUTD, and MIT, and gives students the opportunity to engage in research at the SMART Centre over the summer. The SMURFs work in their faculty supervisors' laboratories, actively participate in research projects, and engage with postdoctoral researchers, graduate students, and other researchers. Academic experiences are supplemented with numerous arranged social activities. According to feedback from the students, 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 the SMART Centre 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 and free of charge.

In order to encourage an open and interactive culture, SMART organizes career development and social activities for its constituents, enabling researchers from different IRGs to meet and have social or technical conversations. In addition, SMART holds monthly afternoon socials to which all SMART participants are invited. These are well attended and have helped build a sense of community.

SMART has set up the SMART Postdoctoral Scholars program (modeled after the Humboldt Research Fellowship) 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 an 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 when needed.

Because communication is an important aspect of successful outreach, the SMART Centre has engaged a local publication relations firm to communicate more effectively to Singapore, MIT, the United States, and relevant communities throughout the world. This year, through their assistance, SMART has generated 852 stories globally, 23 broadcast interviews, 13 press releases, 13 thought leadership articles, and 22 online interviews.

COVID-19

At the outset of the COVID-19 restrictions, most MIT research labs were shut down. However, SMART Singapore labs were able to remain open, but only for research projects related to COVID-19.

SMART has four promising projects in this field:

- Cheap and rapid paper-based tests for diagnosis of COVID-19. The test aims at detection of the virus-specific proteins from bodily fluids. Test result are known within five minutes using very simple procedures. The researchers anticipate the test can be performed by the general public at a scale of approximately 200,000 tests/day.
- Sewage-based surveillance of COVID-19. Wastewater surveillance can offer a real-time, cost-effective view of a community's health and security that is independent of biases associated with case reporting.
- CRISPR technology and sample partitioning for rapid, sensitive, and accurate quantification of SARS-CoV-2 nucleic acids. The research teams' assay integrates multiple technologies to collectively result in a novel chip-based assay of detection limit of one copy per reaction within one hour. This assay has the potential to reduce false negatives and false positives while providing the absolute copy number of the virus.
- Development of a nanosensor for the SARS-CoV-2 virus. State-of-the-art SARS-CoV-2 testing requires clinical laboratories to run RT-PCR tests after several steps of sample processing and signal amplification. The nanosensor technology developed at SMART for plant hormones is based on corona phase molecular recognition, which comprises synthetic recognition sites adsorbed on nanoparticles that bind selectively to the virus particles. This technology can be leveraged to diagnose COVID-19 patients in real time without the need for sample processing at point of care or point of entry.

Leadership Change

In January 2019, Eugene Fitzgerald, the Merton C. Flemings-SMA Professor of Materials Engineering in the Department for Materials Science and Engineering, replaced Professor Daniel Hastings as the SMART Centre director and chief executive officer. Professor Fitzgerald has a three-year term subject to renewal for an additional three years.

Looking Forward

The SMART Centre renegotiated an agreement with the Singapore National Research Foundation in May 2019. The new agreement applies to any IRG commenced after May 2019, and will expire in the fifth year of the last approved IRG.

Eugene Fitzgerald
Director and Chief Executive Officer