Singapore-MIT Alliance for Research and Technology

On July 1, 2007, in partnership with the National Research Foundation of Singapore (NRF), 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
- Develop robust partnerships with local universities and institutions in Singapore, and, in particular, integrate research with graduate and postgraduate education through co-supervision
- Attract and anchor global research talent to Singapore
- Help instill a culture of translational research, entrepreneurship, and technology transfer
- Be a platform for Singapore and MIT to develop global interactions within and beyond Singapore

The SMART Centre currently encompasses five interdisciplinary research groups (IRGs) and an Innovation Centre. Over 100 researchers from MIT and Singapore participate in each IRG. Each IRG has an initial five-year term and, after review and approval, may receive an additional five-year term.

The SMART Centre is MIT's largest international endeavor. It enables MIT faculty members and students to engage in research that cannot be carried out in Massachusetts, e.g., in infectious diseases such as malaria, dengue, and tuberculosis; on environmental phenomena such as the ocean-air coupling unique to equatorial regions, and the resulting weather patterns; and in 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, which includes many who migrate to Singapore from all over Asia, and it also provides MIT researchers with access to certain dedicated facilities not available on the Cambridge campus (such as biosafety level three laboratories) and 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 percent 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 on a leave of absence from MIT. Moreover,

at least one PI from each IRG is in long-term residency in Singapore at all times. Some faculty members have chosen to stay longer because they found the environment so conducive to their research; one PI stayed for two years. In addition to the PIs, there is a steady circulation of MIT faculty, postdoctoral, and doctoral and undergraduate student researchers via shorter-term visits of a week to several weeks. As a result, the atmosphere at the SMART Centre is dynamic.

The SMART Centre is located at the Campus for Research Excellence and Technological Enterprise (CREATE), a complex of state-of-the-art research laboratories developed in Singapore by NRF and occupied by world-class research universities and corporations. A number of other universities have set up research laboratories at CREATE, including Berkeley, Ben-Gurion University, Cambridge University, ETH Zurich, Hebrew University, Peking University, Technical University of Munich, and Shanghai Jiao Tong University. SMART is the largest research entity at CREATE in terms of participants and space.

The SMART Centre's co-location of several research teams from several research organizations will strengthen collaboration among the IRGs and among the various international research entities, as well as their collaborations with Singapore-based universities and research institutions. Construction was completed in the fall of 2012, and all of the five IRGs, the innovation centre, and headquarters are located at CREATE.

Interdisciplinary Research Groups

Research at SMART is carried out in IRGs. As of July 1, 2014, SMART's five IRGs are focused on infectious diseases, environmental sensing and modeling, biosystems and micromechanics, future urban mobility, and low-energy electronic systems.

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. Progress is periodically evaluated by IRG-specific scientific advisory boards (SABs) comprised 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 NUS.

The topic and team for each IRG are selected through an annual MIT-wide competition that begins with an open call for whitepapers to all MIT faculty members. Teams of faculty self-organize and submit whitepapers for review by the SMART Centre's advisory committee, composed of department heads from MIT's School of Engineering and School of Science. The advisory committee requests full proposals from shortlisted teams, which typically amount to five, and selects a single proposal for submission to the NRF Board. 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 at MIT.

The research in each IRG is multidisciplinary in nature, drawing on faculty from several departments at MIT and at National University of Singapore (NUS) and Nanyang Technological University (NTU), research institutes, and governmental agencies in Singapore. Participants in a single IRG number roughly 145, including about 15 MIT faculty members, faculty from Singapore universities, senior researchers from Singapore research institutes and agencies, postdoctoral researchers (from MIT, Singapore, and the SMART Centre), doctoral students (from MIT and 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.

Infectious Diseases

The Infectious Diseases IRG seeks 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 was renewed for an additional five years beginning January 1, 2013.

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 can transition seamlessly between different scales, ranging from as small as a single building to as large as the entire state and the surrounding ocean. Integrating a variety of data sources, many from novel sensors, the model will help users understand how changes at any scale impact the overall system. Examples include how a rise in sea level would impact mesoscale facilities like Marina Bay as well as small-scale facilities like waste outflows; how buildings contribute to a heat-island effect that in turn impacts the atmospheric state; and how contaminant discharges affect mesoscale water bodies and ultimately the ocean. The CENSAM IRG was renewed for an additional five years beginning January 1, 2013.

BioSystems and Micromechanics

By merging diverse engineering and bioscience areas such as microfluidics, nanomechanics, imaging, computational modeling, materials science, and biology, the BioSystems and Micromechanics IRG aims to develop disruptive technologies to diagnose, treat, and mitigate diseases while educating the next generation of biological engineers. The BioSystems and Micromechanics IRG was renewed for an additional five-year term effective January 2014.

Future Urban Mobility

The Future Urban Mobility 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. The IRG has submitted a renewal proposal for an additional five-year term effective January 2016.

Low Energy Electronic Systems

The Low Energy Electronic Systems IRG aims to identify new integrated circuit technologies that reduce energy per function, reduce power consumption, and increase performance. These integrated circuits of the future are expected to impact applications in wireless communication, power electronics, LED lighting, printing, displays, and computing. Initial technology goals are in the areas of power electronic systems, efficient communications, and multifunctional displays and lighting systems.

Innovation Centre

In addition to the IRGs that carry out research, SMART has also established an Innovation Centre 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 and students to develop their ideas with an eye toward the marketplace. A condition for receiving this funding is that the researchers must agree to team 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 grant 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 receive an invaluable education on the process of commercialization. In addition to drawing together a strong team of catalysts, the Innovation Centre is developing a network of venture capitalists from both Boston and Singapore.

The Innovation Centre also conducts educational programs that team students from NUS and NTU with students from INSEAD, a leading graduate business school in Singapore, and Singapore Management University.

Thanks to SMART funding, 120 invention disclosures have been filed and 13 companies established.

Outreach

Through generous gifts, the SMART Centre established a summer research internship program, the Singapore-MIT Undergraduate Research Fellows (SMURFs) program, to excite student interest in research and encourage students to consider research careers.

Undergraduates from NTU, NUS, and MIT engage in research at the SMART Centre, work in their faculty supervisors' labs, actively participate in research projects, and engage with postdocs, graduate students, and other researchers. Academic experiences are supplemented with numerous arranged social activities. Participants have indicated that they greatly value their experiences at SMART and the community ties that formed out of the experience.

SMART also engages the wider research, technology, and entrepreneurial communities in Singapore through special symposia, short courses, and seminars given by eminent members of the MIT community. Open to the public and free of charge, these events are extremely well attended.

To encourage an open and interactive culture and foster informal social and technical conversations among different IRGs, SMART organizes career development and social activities for its researchers. In addition, SMART holds monthly Friday afternoon socials to which all SMART participants are invited. These are well attended, and they have helped build a sense of community.

SMART has been fortunate to secure funding from the Singapore Ministry of Education (MOE) for 100 MOE-funded doctoral students to work at SMART. The funding provides a four-year grant to cover full tuition/stipend/supplement/travel to each of 100 incoming doctoral students. The students must be admitted to NUS or NTU, perform 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 recruit postdocs from around the world who are employed and based permanently at the SMART Centre. SMART has also set up the SMART Fellows program (modeled after the Humboldt Fellows program) to recruit a few extremely talented postdocs each year to work on their own research projects. These projects must connect in some way to an IRG theme. In addition to research funding, SMART Fellows receive an attractive stipend and mentoring from an MIT SMART faculty member.

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