
Civil Space

Health in the Arms of a Space Robot

by Elizabeth Howell

IF THERE'S ANY DOUBT ABOUT HOW seriously the Canadian Space Agency treats space medicine, consider that nearly half of Canada's small group of 12 astronauts, past and present, has medical degrees.

Ken Money, Bob Thirsk and Roberta Bondar were selected as astronauts in 1983. Dr. Bondar flew in 1992. Then Bob Thirsk and Dave Williams (Class of '92) each made two flights in the ensuing two decades, with Dr. Thirsk's experience culminating in six months on the International Space Station.

Today, we have David Saint-Jacques (selected in 2009), who has not yet flown in space, but has already spent time in the NASA Extreme Environment Mission Operations (NEEMO) program, a NASA underwater space lab intended to simulate long-duration missions. Dr. Thirsk and Dr. Williams went before him.

The CSA is careful to say it did not specifically recruit doctors. "They had

the skills we were looking for, and they happened to be physicians," said the CSA's Dr. Jean-Marc Comtois, in an interview with *Space Quarterly*. Dr. Comtois is the CSA's Director - Astronauts, Life Science and Space Medicine and a former flight surgeon.

Still, the astronaut corps is just one illustration of the importance the CSA places on space medicine. Today, the agency is looking to take the lessons it has learned in space to apply them to problems here on Earth.

The primary problem for Canadians living in the north and seeking medical care is distance. There are tens of thousands of people living in remote communities, far from the specialists and physicians that many southern Canadians take for granted. A patient requiring surgery for a tumour or other complex medical condition usually has no choice but to be flown to a major centre. This takes a lot of time and money.

Dr. Anvari operates a telerobotic suite while the patient is in a hospital in another location.
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Deploying doctors up north is a partial solution, but an expensive and difficult one due to the distance to cover between small communities.

Enter a solution straight from the space program. Canada's robotic arm technology, first used to grapple satellites and hoist astronauts in 1982, is now being finessed to slice skin and cut out tumours. When coupled with telesurgery (performing surgery with a doctor in one place and patient in the other), it's a powerful tool indeed.

Telesurgery is made possible by the advent of high-speed fibre Internet cables. In 2001, the first transatlantic surgery was performed. The doctors (Michel Gagner and Jacques Marescaux) were in New York City. The gall bladder patient, 68, resided in Strasbourg. Every move the surgeons made was repeated by a robotic arm on the other end of the line, while the teams communicated by videoconferencing.

Today, McMaster University's Mehran Anvari is at the leading edge of telesurgery. He led a simulated gall bladder surgery on NEEMO 7 by both advising the astronauts on board and also performing the procedure robotically. He also worked on later missions.

Dr. Anvari's experience comes through years of innovation; as of April, he has performed 23 proof-of-concept surgeries between St. Joseph's Hospital in Hamilton and North Bay General Hospital, some 400 kilometres away.

In 2009, he became CEO of the Centre for Surgical Invention and Innovation, a federally funded research accelerator that includes staff from McMaster and St. Joseph's. Its strategic industry partner is MacDonald, Dettwiler and Associates (MDA) - the same company that operates and maintains the Canadarm and the Canadarm2.

MDA's target is not the traditional pieces of space equipment the company is used to working with. In this case, it's attacking breast cancer with robotic surgery. In August 2011, the British Columbia-based company (which also has a large presence in nearby Brampton, Ont.) signed a \$5.6 million contract with the centre. The agreement provides for a collaboration to develop an Image Guided Autonomous Robot set of products. Breast cancer biopsies are the first goal.

Although this type of procedure will not be done by telemedicine, using robotic technology is intended to "provide increased access, precision and dexterity, resulting in more accurate and less invasive procedures," stated a release at the time.

For MDA, space medicine is a way forward out of a very difficult economic situation with the Canadian Space Agency and other government space partners, its traditional client base. With space

Dr. Anvari guides a surgeon and his team via telemonitoring.
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programs in most nations cut back due to financial circumstances, companies need to turn to other fields to keep generating revenues.

As an example of space difficulties, MDA announced this spring it will need to restructure staff working in the RADARSAT Constellation mission due to budget uncertainty. So among the company's stated goals is to find ways to commercialize technology it already has available. Space medicine is one of those ways.

A large problem with robotic surgery is "latency", or the amount of time it takes a command from the doctor to reach the robotic arm. The greater the distance, the more latency occurs. This latency would become more of a factor in space if performing surgery, say, to a moon base (a distance of 1.2 seconds at the speed of light) and more extremely, a place such as Mars (an average of 20 light minutes away)

"Latency does affect your ability," Dr. Anvari said in an interview with *Space Quarterly*. "In the first 150 milliseconds to 200 milliseconds, there's a very unconscious slowing down. Your brain can slow down a little bit. Once it goes beyond that, you have to make some conscious decisions on how to deal with that latency."

According to Dr. Anvari, at 300 milliseconds and above it becomes difficult for many surgeons to operate. Above 500 milliseconds (0.5 seconds), complex surgeries are nearly impossible, something that became painfully obvious when working on NEEMO 7, Dr. Anvari said.

The solution to this problem is automation. A simple automation tool was used on NEEMO 12 in 2007, and Dr. Anvari and his associates are working on a successor project that they hope will appear in a future NEEMO mission.

In 2009, the centre received \$14.8 million in federal funding

through the Centres of Excellence for Commercialization and Research program. The money extends through 2014. "We're very fortunate that the federal government has provided the initial funding (for the centre), and hope that they will continue to help us," Dr. Anvari said.

For its part, the CSA maintains that space medicine is a priority even in the face of budget cuts that (as of press time) have removed at least 30 personnel positions from the payroll.

"As government departments, we all have to contribute to the fiscal realities, but our basic mandate has not changed," the CSA's Dr. Comtois said. "The fact the government has extended the (International Space Station) commitment to 2020 speaks volumes about the commitments of Canada to space, and towards space exploration, and increasing knowledge of space-based research."

One way Canada hopes to demonstrate this is through MicroFlow, a technology that was officially launched in February in partnership with Quebec's National Optics Institute (INO). The shoe-box sized instrument package, which can diagnose infectious diseases at the site, will travel to the International Space Station and will be first used by astronaut Chris Hadfield as he takes command of the station in 2013.

The aim in space is to make sure that the crew remains healthy for long-duration voyages. On Earth, its goals are no less lofty. "Its portability makes it possible to affordably monitor the immune status of HIV-positive patients in developing countries," INO stated in a February press release.

"It will also be a boon in Canada's remote northern communities, where it isn't uncommon to travel 200 km or more to have access to regional hospitals and diagnostic tests. And in more densely populated parts of Canada, MicroFlow could substantially reduce wait times for diagnosing infectious diseases, since

analysis can be carried out immediately and on site."

Canada's next frontier is to better understand the effects of weightlessness on the body, because bone loss, eye problems and other conditions endemic to astronauts are also functions of aging, Dr. Comtois said.

There will be a national workshop on aging in Toronto this spring, and in November, an international workshop on aging in space that the CSA plans to attend, he added. The CSA is right to focus on issues with relevance in an aging population, as that will be the fiscal reality of most of the developed world in the coming decades.

Space medicine has direct applicability since, as pointed out earlier, weightlessness induces many of the same attributes of aging. For healthy astronauts, these conditions are reversible. We need to understand why they can't be reversed in older people living their entire lives on the planet.

There is a danger, though. The CSA says the government is committed to funding its research on space medicine. But we can't know that for sure right now. No strategic plan has yet been released detailing where cuts will occur. This means that for all programs, we need to assume there is equal risk of reduction or elimination.

The best method to ensure the viability of Canada's space research is to share the cost with private industry partners, similar to what is being done at Dr. Anvari's centre. Our government must hold to its agreements with them so they are not twisting in the wind as MDA is finding now with RADARSAT Constellation.

But administered correctly, and funded wisely, private-public partnerships in medicine will ease the burden on the taxpayer and stimulate innovation in the private sector. Most importantly, they will result in more opportunities to improve the health of Canadians.



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