The Future of Canada in Space

An open letter to Canada's space community about opportunities for renewal and revitalization within the Canadian Space Agency.

November 20, 2008

Introduction

This is a paper about the future of the Canadian Space Agency and our nation's future in space. The authors of this paper are seven young Canadians who share a passion for space and the belief that there is a need for a renewed sense of purpose within the CSA. While studying with space professionals from around the world at the International Space University, the authors were impressed by the pioneering work being done in space by other nations, and inspired to contribute the results of our experiences to the current debate on the future of Canada's role in exploring and developing the final frontier

In order for Canada to continue to be a leading space-faring nation, our government must adopt bold new measures and methods. This is not merely a matter of redistributing the space agency's funding, or identifying new niche technologies. Instead, the agency must be prepared to create new goals that are clear, achievable, and visionary, re-imagine what space agencies are for and how they work, and embrace the unique opportunities that are available to our nation. The opportunity currently exists for a transformation that can dramatically increase the effectiveness of the CSA, provide new opportunities for Canadian industry, and allow our country to continue to play a truly pioneering role in space.

This document will outline several key concepts and strategies that can measurably improve the performance of the CSA. The key concepts upon which this paper is based are simple, but critical to any transformation within the agency. They include the following:

1. We Can Increase Innovation within a Limited Budget
2. We Need Clear Goals and a Coherent Vision
3. We Have Opportunities Right Now

Based on these concepts, there are specific measures the CSA can adopt in the near future to increase its effectiveness and relevance within Canada. Key among these are the use of innovative program management and funding structures, including the introduction of prizes, adopting a new vision that clearly establishes the role of the CSA in enabling humanity's future in space, creation of policies and programs that promote new entrepreneurial space ventures and increase the number of space firms in Canada, proactive and high-profile interaction with researchers and students at universities across the nation, and a coordinated effort to improve the efficiency of cross-border space business with our largest trading partner, the United States.

While this paper was written by young members of the space industry, we believe that the recommendations made within this paper, if adopted, will benefit the entire Canadian space community, and help to enable a renewed sense of vision within the CSA. After reading this paper, we hope you will feel open-minded and indeed positive about the future of the Canadian Space Agency, as we do.

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We Can Increase Innovation within a Limited Budget

The only limits to Canada's capabilities in space are self-imposed. As a nation, we don't talk a lot about space; when we do, a lot of talk is devoted to defining the "limits" of what Canada can do in space, or listing all the things we lack. This is self-defeating. Our nation has the potential to become a real leader in space, and if we restructure our activities to utilize this potential in new ways and for exciting ends, we can dramatically increase the effectiveness of the government's space expenditures.

It's true that, in comparison to some space agencies, the Canadian Space Agency is small. NASA employs thousands of people; CSA employs hundreds. The European Space Agency (ESA) spends around 3 billion Euros; CSA spends about 300 million dollars (actually, CSA was authorized to spend $385 million last year, but actually only spent about $314 million). Are we smaller? Yes. But being small is, in fact, a strength.

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Maintaining a small, lean space agency means that we aren't burdened with the bureaucratic inefficiencies of much larger organizations, allowing us to be more flexible and adopt changes faster. It is easier to be innovative in a small group. History is replete with examples of innovative breakthroughs that came from small groups of people working with limited budgets.

It's clear that staying small and agile provides significant advantages compared to growing into a large and ponderous organization. Small is good.

Being small, however, doesn't mean being limited. Canada has typically followed a strategy of using large portions of the CSA's budget to support the development of one or two "niche" technologies. Part of the reason we focused on niches was the belief that we couldn't afford to do anything else: if NASA can only manage so many projects with $17 billion per year, surely we can't do very much with $300 million?

This argument makes a false comparison. The value of money for accomplishing a goal depends on what methods are employed to achieve it. The "cost is no object", cold war-era methods established by space agencies during the previous century might be entrenched in other nations, but as a small, forward-thinking space agency, the CSA doesn't need to continue using the same model. If we are going to pursue innovation in space, the first place we need to practice that innovation is in how our space agency does business.

Government and non-profit organizations can do amazing things on small budgets when they use the right mix of budgetary discipline, innovative project management processes, and other creative methods. Consider the following:

- The MOST space telescope mission (Canada's first space telescope) - which cost $10 million and is enabling cutting-edge scientific study of planets circling other stars. This was developed through strong collaboration between several Canadian universities, leveraging their existing capabilities and the "old college spirit" to enable a high-tech but low-cost program that included government, researchers, and students.
- The NASA Lunar Prospector Mission – a $62.8 million program to develop a lunar orbiter that mapped the moon for potentially useful resources, including water. This probe made extensive use of components that had already been developed for other space

missions, which massively lowered development costs. A lesson in flexibility, it demonstrated that standardized hardware (which can be flown on various spacecraft) is a key to lowering costs.

- The NASA Commercial Orbital Transportation Services (COTS) program - a $500 million program that has stimulated US industry to develop not one, but two new competing launch vehicles to send crew and cargo to the International Space Station. $500 million (the equivalent cost of one Space Shuttle launch) may sound like a lot, but spread out over four years it's really only $125 million per year. By only handing out money when the COTS contractors meet scheduled milestones, NASA reduces its risk and ensures no budget overruns. By providing the "hurdle funding" that will enable the two COTS companies to develop new low-cost launch vehicles, NASA is helping to open new markets and commercial opportunities in space. While this may initially seem like "corporate welfare", the companies are both required to put their own "skin in the game" and NASA believes that in the long run it will actually save the agency money due to lower overall launch costs for its missions, making it a win all-round. Administration costs here are also low: the COTS office at NASA is run with only a couple of people.
- The Ansari X Prize - A $10 million dollar prize that led to the development of the first private piloted space vehicle, and the first private FAA-granted astronaut wings. Not only that, but it also led to the development of an entirely new industry: space tourism. The X PRIZE Foundation estimates that while they had to raise the $10 million for the prize, private industry invested over ten times that amount trying to win it. Prizes are a way of encouraging the development of new capabilities in high-risk areas without having to spend money on failed attempts, and of using relatively small incentives to kick-start large-scale research and development. There are still administration costs associated with these programs, but since they are usually limited to communicating with teams and doing outreach, they are relatively minor. The other major benefit to prizes is inspiration: the Ansari X PRIZE inspired countless students around the world by showing them that cool space projects don't always have to mean billion-dollar budgets and government subsidies. The flight of SpaceShipOne, which won the prize, became the second most popular news story of 2004. This level of excitement for engineering and science is exactly what our nation needs to promote if it hopes to entice future generations to pursue careers in science, mathematics, and engineering.

Clearly, the potential of CSA's budget depends on the way in which the programs are structured, as much as it depends on which projects are pursued. Rather than resigning ourselves to spend what other, more bloated space agencies would spend to accomplish a mission using traditional methods, we should be comparing ourselves to the most specific, innovative and successful programs around the world – such as those mentioned above – and building on their successes.

The examples above show that there are ways to provide incentives for new space technologies and capabilities while simultaneously incorporating assurances against budget overruns and keeping overhead costs low. For high-risk development of new systems, prizes are an excellent way to make the most of a limited budget, since no money is paid until results are achieved and overhead costs are kept low. Rather than picking the best technological approach ahead of time, CSA should clearly define the capabilities required and let private

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organizations compete in a “battle of ideas” for the best solution.

When prizes aren’t the answer, other options still exist: for technology development, fixed price, milestone-based development contracts can help overcome the financial hurdles faced by industry while controlling government costs. For space missions, the development and use of standardized systems provides a powerful way to bring economies of scale into the space industry. While some work in this area is currently underway, further development of standardized systems for commercial satellites, space science missions, and other types of space hardware is worthy of attention.

However, our nation’s success in space and preparation of the next generation of space professionals require more than just sound program management: they require a vision and a set of objectives that can inspire a generation, rather than merely provide a purpose for agency spending.

We Need Clear Goals and a Coherent Vision

Merely having a vision for the Canadian Space Agency is not enough – the vision must be one that can inspire a nation, provide leadership for industry, and create a clear basis for making decisions about which space projects to pursue.

What is the current purpose of the Canadian Space Agency? According to the law that created it, the Canadian Space Agency has the following mandate:

> *“To promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians.”*
> *Canadian Space Agency Act, SC. 1990, c. 13*

This is a broad and ambiguous statement. What implications does it have for daily decision making?

The use of space science and technology to provide social and economic benefits to Canadians is the part of the CSA mandate with the most immediate implications for Canadian citizens. It covers things like the creation of space jobs in Canada, the use of space technologies to provide things like remote sensing for disaster planning and environmental research, satellite communications technologies, and the development of new capabilities like tele-medicine.

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So, the first part of the mandate means that part of CSA’s goals must include the delivery of near-term, concrete space applications. These types of space applications don’t always seem that exciting. In the era of Google Maps and HDTV, few people take a moment to consider how space technologies improve their lives by providing improved weather predictions, global imagery for disaster relief, environmental monitoring, or

satellite TV. However, these things are critical for the current prosperity and future development of our society.

The CSA, to date, has provided support to industry for projects such as these by subsidizing technological development and helping to commercialize space-related technologies. An example of this would be Radarsat-2, a satellite developed by a Canadian company (MacDonald Dettwiler & Associates, or MDA) with money provided by the government. The government is granted ownership of some of the imagery produced when Radarsat-2 is operational for civil and military purposes; in return, the company is able to retain ownership of the satellite and sell the rest of the imagery to customers around the globe. In this role, CSA helps to provide the initial funding necessary to get the project started in the first place.

Many other examples of space industry participating in the market exist. In addition to providing satellite imagery, Canadian companies are involved in the development of communications satellites, payloads for satellites, and various other satellite components, as well as providing services for the international space industry. However, we believe that the government's vision for developing Canada's industrial potential can go further. For instance, companies in the United States are now developing vehicles to provide suborbital tourism flights, launch cargo to the International Space Station, and even developing inflatable space station modules that could be used to create new space stations to complement the ISS, or perhaps one day be used as space hotels.

The suborbital tourism industry, exemplified by Virgin Galactic's purchase of the technology used to win the Ansari X PRIZE, is being fostered in the US through the support of federal and state governments. The construction of spaceports in New Mexico and elsewhere, partially funded by government (similarly to how airports are financed) is expected to bring significant tourism revenue and new jobs to the communities from which the suborbital flights are conducted. NASA's commitment to purchase ISS cargo delivery services from private US contractors has resulted in the creation of hundreds of new high-tech jobs and a resurgence of a rocket development culture reminiscent of the "right stuff" era of the 1960s. The inflatable space hotel modules under development by Robert Bigelow, who has already established a hotel empire on terra firma, is based on technology originally developed by NASA researchers.

These visionary projects are aimed at the development of not just current markets, but future ones; in doing so, the entrepreneurs and government agencies that collaborate with each other help to ensure the creation of new jobs, increased wealth, and continued preeminence of their nation in space.

The conclusion to be drawn is not that Canada should build space hotels; rather, it is that as a friendly neighbor of the US, with a skilled high-tech workforce, and plenty of open space, we have the ability to foster, attract, or create many of the same types of exciting ventures currently under development in the US and elsewhere. For instance, Canada would make an excellent location for a suborbital tourist spaceport.

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The other two aspects of the Canadian Space Agency's mandate, advancing the knowledge of space and promoting the peaceful use and development of space, are summed up as "space exploration and development". Often, this part of the agency's mandate is justified by "science" – leading to painful and tiresome debates about whether robots or astronauts are better for doing space science. It's time, however, to recognize the importance of space exploration, space development, and human spaceflight for what it truly is. The following statements provide a concise description of what the long-term potential for space exploration truly is:

> *"For me the single overarching goal of human space flight is the human settlement of the solar system, and eventually beyond… the proper goal of a publicly-funded space program is to enable the human settlement of the solar system."*
> *NASA Administrator Dr. Michael Griffin*

> *"Robotic missions are much cheaper and may provide more scientific information, but they don't catch the public imagination in the same way, and they don't spread the human race into space, which I'm arguing should be our long-term strategy…If the human race is to continue for another million years, we will have to boldly go where no one has gone before."*
> *Dr. Stephen Hawking*

Does all this sound like science fiction? Absolutely. Then again, so did the Internet, or video phones, or so many other things that ordinary citizens take for granted today.

Most predictions about our long-term future go one of two ways. The first possible future typically involves the total annihilation of our species, whether by war, disease, or environmental disaster. The second possible future inevitably involves space travel. People know it's coming – someday – and this is why things that get regular people closer to living in space, like robotic missions to Mars and astronauts going to the Moon, grab their attention. People have an innate but rarely-expressed expectation that we will someday spread out into the cosmos, and it is the role of a space agency to help fulfill this expectation.

It is therefore critical that the Canadian Space Agency fulfill the second part of its mandate by being clearly establishing that it will be an enabler of the development and settlement of space, and pursuing programs that measurably contribute to this goal.

To put it another way, let's look at the role of space exploration by comparing it to something that most Canadians are already somewhat familiar with: global climate change. Global climate change isn't about what is going to happen to the weather in your city tomorrow, next week, or even next year. Its premise, rather, is based on our knowledge that what we do now will have an enormous impact on the opportunities and prosperity available to future generations. In this respect, controlling global climate change and developing space are two sides of the same coin – making small investments now to ensure that future generations enjoy continued prosperity and opportunity. Like any good investment, the sooner we start, the bigger the future rewards – which is why we need to seize the opportunities that exist now.

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-Dr. Michael Griffin

We Have Opportunities Right Now

Many opportunities already exist to effect positive and widespread change throughout our agency and industry. This section aims to outline the biggest opportunities and how to seize them.

The most immediate and most important opportunity we have is to use the current period of transition at our space agency to develop a truly visionary role for it, and to adopt innovative new ways of enabling that vision, as described above.

The second opportunity is to foster a renewed diversity and growth within the space industry to ensure that the failure, loss, or sale of any single company does not critically impact our national capabilities. This issue was recently highlighted when an American missile and space products company attempted to buy Canada's largest space company. This event highlighted several issues:

1. The Canadian company in question is an owner of a significant proportion of Canada's space expertise, and considered the "crown jewel" of our space industry;
2. The company is reliant upon contracts from the Canadian government for continued space business, as export and arms control issues with the US (due to ITAR regulations) pose a significant barrier to cross-border business;
3. The sale would have represented a US takeover of a large portion of Canada's space industry, including physical assets (satellites) that are critical to national defence.

We believe there should be no single "crown jewel" of Canadian space industry, both because of the danger of monopolistic practices and the inherent risk that national capabilities will be jeopardized should the company fail. The potential sale highlighted the opportunity to rectify the current situation by implementing strategies to encourage the development of multiple new entrepreneurial space companies across the nation.

As part of those innovative new strategies, we believe there is an opportunity for the CSA to help create an increased level of space entrepreneurialism in Canada by establishing technology incubators and small-business incentive programs for space companies. These could include start-up incubators located in geographically diverse regions, proactive measures on the part of the CSA to collaborate with small space businesses, and the creation of a venture capital-like technology development fund similar to the "In-Q-Tel" fund used by the US intelligence community. This will not only ensure increased competition in the market and improved national capabilities; it will allow Canada to increase its role in the creation of enabling new space technologies and the creation of new commercial markets in the space sector.

Another opportunity was highlighted by the example above: the opportunity for Canada to lobby the incoming US administration for ITAR reform. Currently, the US State Department classifies anything related to space as weapons technology – even if it's just a weather satellite – and effectively classifies it under ITAR. As a result, the amount of paperwork and red tape necessary to get even small parts transferred between

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Canada and the US is staggering, and can be considered the biggest single impediment to cross-border trade in space. Our partnerships in NAFTA, NATO and NORAD aside, Canadians face the same difficulties when attempting to work with or for US space companies, even on contracts of limited duration and scope.

Our government has the opportunity to fix these problems, potentially bringing millions or billions of dollars worth of new business into Canada, by beginning a long, dedicated and high-profile effort to convince the US government to reduce the ITAR barriers between our two countries. This will not be easy: issues related to arms control, national security, and big business are always difficult to negotiate. But the effort will be worth it, for both countries, as we would each gain access to the specialized technologies and talent available in our respective nations. ITAR reform must be a foreign policy priority for our government.

However, the pursuit of ITAR reform in the United States is ultimately an issue that our own nation has limited power to pursue. In light of this, a greater emphasis should be placed on the development of technologies and business practices that have limited exposure to ITAR and other regulatory issues in the US. Other industrial players, including major entities in Europe, are now pursuing "ITAR-free" strategies that allow them to market their products and services globally without the expensive and sometimes unreasonable restrictions placed upon ITAR-controlled goods. In the end, this strategy means more business and a broader global customer base, which are both desirable outcomes for the Canadian space industry.

A third opportunity exists within our nation's universities. As the MOST telescope and other current space projects demonstrate, there is enormous potential within our educational institutions to create top-quality space missions and develop our future space workforce by giving students the chance to develop relevant skills through working on real space missions. Furthermore, universities are the perfect place to conduct inexpensive space missions, since the use of university resources and enthusiastic students (who often work for pizza) can help reduce costs to the agency.

We believe that the CSA should embark upon a national space university program, including both engineering and scientific projects, in partnership with universities in every province and territory. These could include micro-satellites, "cansats" weighing only 1 kilogram each, scientific experiments to be run on the ISS and other space missions, student-run telescope tracking of Near Earth Objects (NEOs), sounding rocket and payload development, and many other activities. National CSA-sponsored student competitions in fields like rocketry would be another way to stimulate interest among students and garner positive publicity for the agency.

In addition to the student projects and competitions, the establishment of new university chair positions dedicated to space research would be a cost-effective way to reach out to universities nationwide. We believe that the implementation of a new "Space Chairs" program would complement the establishment of student-based university projects, and the two programs could even be tied by requiring funded chairs to be actively involved as mentors to students working on CSA-supported activities. More funded chair positions would also make Canada a more competitive nation for space

Develop our future space workforce by giving students the chance to develop relevant skills through working on real space missions.

experts who live abroad by providing incentives for them to pursue their research in Canada.
The opportunity to attract space expertise from abroad is not limited to university researchers. There are huge numbers of talented young professionals and students around the world that want to participate in the development of space. For most of them, "space" equates to the United States (as it does for many of us). However, the current climate in the US makes it difficult, if not impossible, for most of them to pursue their goals there. The authors of this paper know this first-hand: as students at the International Space University, we've worked with students from dozens of other countries and watched these talented young people become jaded by the immense difficulties they face in pursuing their careers, due primarily to matters of nationality.

Canada is in a prime position to snap up these dynamic and enterprising people, adding their talents and abilities to our economic base. If we provide space-related programs that welcome qualified people from around the world and provide a supportive setting for them to pursue their dreams, our nation will reap massive benefits resulting from their creative stimulus, from their value to Canadian employers, and from the new business opportunities they will create. Bringing highly-skilled, passionate people into our nation has always resulted in net benefits for Canadians.

To Sum Up

We currently stand on the precipice of a global effort to expand humanity's reach into space. The International Space Station is nearing completion; a plethora of nations are sending swarms of robotic missions to the Moon and Mars, to be followed shortly thereafter by human explorers. A small, daring space agency, such as the one that CSA could be, can play an important global role.

Setting visionary goals now will allow us to lead international cooperation in space – not piggyback on it. We can decide to play the role of the risk-taker, the role of the pioneer; this is perfectly in keeping with Canada's proud tradition of exploration. This will fire the engines of creativity throughout our nation's space industry and the young people who may someday join it. The first and most important opportunity we have is to become an international pioneer in space.

In short, now is the time for change. We hope you'll remember the following points:

1. Canada has the resources and skills to perform groundbreaking work in any number of areas, provided that we use our resources creatively
2. Innovation in how we run programs and spend money is as important as innovation in the technologies the money is used to develop
3. We need to think bigger and bolder than before, and grow beyond our current niches
4. We need "visionary" – not just vision. The space agency must provide for near-term benefits for all Canadians while actively supporting the long-term, sustainable, *human* development of space
5. Many opportunities currently exist to dramatically improve our space sector, including:
    a. Increased diversification and entrepreneurialism in the Canadian space industry through the establishment of space business and technology incubators, proactive government policy, and venture capital-like funds
    b. Active, high-profile lobbying for ITAR reform in the US with the new President
    c. A national program to establish space-related engineering and science projects in universities in each province and territory
    d. A new set of funded university chair positions for space research
    e. Legislation and programs to attract foreign space professionals

We have nearly limitless potential – now is our time to realize it.