The Avro Arrow with test pilot Jan Zurakowskim in 1958.
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The rousing lessons of the Avro Arrow

Ottawa hasn't been a reliable supporter of science and technology. Quantum computing gives the country a chance to reverse course

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As Canada marks its 150th anniversary, Prime Minister Justin Trudeau has been working hard to signal a new determination in Ottawa to put Canada on the world's technological map. Mr. Trudeau dubbed his most recent federal budget an "innovation budget" and has been promoting his government's agenda through visits to promising startups and tech companies. He even gave media reporters a brief lesson in quantum computing at a highly publicized press conference last year.

In choosing quantum computing as his theme, Mr. Trudeau was selecting a hot topic, one very much in the news these days. Moreover, he had in mind a technology that was actually pioneered in Canada, by the company D-Wave Systems, currently based in Burnaby, B.C. So, does this herald a new golden age for Canadian R&D?

There is precedent here for some skepticism. When it comes to science and technology, Ottawa has a long history of talking the talk but not walking the walk. The controversial story of MacDonald Dettwiler and Associates provides a case in point. The iconic space-technology firm, based in Richmond, B.C., managed to corner much of the world market in sophisticated satellite surveillance during the period from 1990 to 2005, as well as design and build the famous Canadarm for the American space shuttle. And yet the company has now shifted its focus to the U.S., a move that became almost inevitable once the government of Stephen Harper decided to pull back from investing in aerospace. Canada's future in space has been uncertain for years, even according to reviews prepared by the Canadian government.

Such hesitance from Ottawa is not new. Those with long memories, or an interest in Canadian history, will recall the infamous Avro Arrow story, one of the most remarkable betrayals of a Canadian industry by a Canadian government. Immortalized in the media, books, and the 1996 CBC film, *The Arrow*, starring Dan Aykroyd, the Avro story has acquired mythical proportions in the Canadian consciousness, and is still worth relating.

In October, 1957, Avro was the third-largest company in Canada, employing 50,000 people, and it had just rolled out the world's most advanced fighter aircraft, the CF-105 Avro Arrow. The Arrow was entirely designed and built in Canada by an extraordinary team spearheaded by Crawford Gordon Jr. How Canada came to take the lead from the world's superpowers, and how it could have gone on to become a big high-tech player, has provided material for historians and journalists for many years. But the reality turned out to be very different.

In February, 1959, the government of John Diefenbaker cancelled the Arrow project and ordered all the Arrow aircraft – as well as the blueprints, models, and designs – to be destroyed. The government tried to argue that cash was short and that the future of defence was in missiles. They accordingly bought from the U.S. a collection of Boeing Bomarc missiles, which turned out to be useless. Later on, when the political dust had settled, the government bought 64 second-hand Voodoo fighters (capable of less than half the speed of the Arrow), also from the U.S. The total value of these purchases amounted to more than the cost of the entire Arrow program.

Mr. Diefenbaker's actions destroyed far more than just the Arrow project. Before long, almost all the talent responsible for the company's success had left Canada, with many former employees going on to play key roles in the design of the supersonic Concorde civil airliner and the hardware for the American Apollo and Gemini space programs. The damage to Canadian aerospace, to national self-esteem, and to other innovative technological efforts was colossal and far-reaching.

This history echoes into the current day. In 2017, Canadian aerospace policy is dominated in the news by the attempt to buy, at fantastic cost, a set of 65 unproven F-35 fighter planes from Lockheed Martin. Apparently, Canada remains dependent on foreign suppliers for military aircraft; what will happen in the civil-aviation sphere now seems to rest largely on the fate of the Quebec-based company Bombardier.

Given this 50-year history, we can certainly ask: What hope is there for Canadian high tech on the world stage? And what of quantum computing?

The advent of quantum computation (and, more generally, of quantum information processing or QIP, for short) will likely have as great an impact on the 21st century as aerospace did on the 20th century. As one might expect of anything with the word "quantum" in it, QIP is a little harder to understand than is flight, but we think the effort is worthwhile. QIP depends on quantum mechanics, the game-changing theory discovered in 1925 by Werner Heisenberg, Erwin Schrödinger, and others.

Until 1925, it was universally assumed that all objects in the universe, from the smallest elementary particles to the largest cosmic structures, could exist in only one physical state at a given time – what we now call a "classical state." The idea that a molecule could be in several different places at once, or that an electronic circuit could carry two different electric currents at the same time, would have been ridiculed before 1925.

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However, the nonsensical has now become fundamental. In spite of enormous efforts to show that quantum mechanics must fail, it has withstood all tests and has, along with Einstein's theory of space-time and gravity, extended our understanding of the physical world from sub-nuclear scales up to the entire universe. The idea that physical systems can be in "superpositions of states" – in several states at once – is here to stay.

Around 1980, the renowned American physicist Richard Feynman noted that such superpositions must also apply to any kind of information, and hence to any information-processing system. Thus, a computer could be in a superposition of different computations, a database in a superposition of different searches, a data transmission in a superposition of different coded messages, and so on. The ability to run many computations simultaneously meant that quantum computers would be almost unimaginably powerful. Early ideas included quantum decryption (allowing the decryption of any classical message – past, present, or future – with ease) and quantum encryption (encoding messages beyond the reach of any conceivable classical computer).

Other ideas included ultrafast data searches, computations, and optimization (the search among many different scenarios or outcomes for the one best satisfying certain predefined criteria). All these relied on the possibility of having exponentially many operations going on at once –s uperposed – in a single physical system.

However, what really counts in a game like this is to actually make a quantum computer – and this is what D-Wave did. Its "quantum optimizer" has now attracted enormous attention, with a cover article in Time magazine and the purchase of D-Wave computers in the U.S. by Lockheed, NASA, and Google, as well as by several universities, the Los Alamos National Laboratory, and a data-security company.

In response to this success, there have been major investments by a number of large corporations and governments. Within the space of 2016 alone, the European community announced a $1.5-billion research initiative in quantum computing; the Chinese government, in collaboration with Austria, launched a $500-million satellite intended to accomplish global quantum communication; and in an announcement of enormous hubris, Google published a plan for world domination of the new field. It is nevertheless amusing to observers that all the Google and European Union publicity so far has featured photos of D-Wave processors.

Obviously, when the stakes are this high, these are merely gambits – there are still many moves left to play. The D-Wave quantum optimizer is not a full-blooded "gated" quantum computer, which will require solving the difficult problem of eliminating what is called "decoherence," the process by which even tiny interactions of the computer with its surroundings disrupt the very delicate correlations between the different parts of a superposition. Suppressing decoherence requires extraordinary control over these minute interactions, and thus remains a significant challenge. More radical designs – such as the "topological quantum computer" advocated by Microsoft – are even further in the future. But this simply means that fortune will favour not only the brave but also the persistent, those in for the long haul.

So, will Canada stay in the game? A complaint often directed at Ottawa over the years has been about its inability to engage in ambitious long-term planning, both domestically and in foreign affairs. So far, the federal interest in quantum computing has concentrated on style over substance – the majority of D-Wave's funding has come from the U.S., and there has been little effort to bring together researchers from the Canadian university community and the R&D effort in Canadian industry (a mistake not being made in other countries).

But there is still time for both Ottawa and the provincial governments to focus, to maintain the momentum already gained, and to make sure that an Avro-style hemorrhage of talent does not occur again. For Canada's 150th anniversary, it would be refreshing to see a daring and ambitious effort in this direction, with a clear desire in Ottawa to stay the course.

But herein lies the root of the problem. For great enterprises of this kind to succeed – whether it is an Avro Arrow, an Apollo moon shot, or even an agenda for social change such as that advocated by the Truth and Reconciliation Commission of – the participants must feel inspired by what appears to be a lofty goal, and they must believe they can succeed in attaining it. Canadians, however, are not used to the idea of taking on the world and winning (except perhaps in winter sports). To get past this, we clearly need a commitment by the federal and/or provincial governments to give real backing to such enterprises.

But, perhaps even more than this, what is required is a change of mindset in the country as a whole. And this is where strong and visionary political leadership can make a big difference: first, by inspiring the country to believe that we really can succeed; and then, by making sure that small groups of dedicated people get the support they need. It will not be enough to say "Yes, we can," or to have photo ops about quantum computation.

Nearly a dozen other countries are now seriously investing in quantum computation, with a mixture of private and government capital. If we really believe that Canada is capable of playing in such a high-stakes game, then we should also get serious and get on with it – now, before the Canadian advantage is lost and the enthusiasm (and the people) drain away.

Perhaps by the time of Canada's 200th anniversary, in 2067, Canadians will be able to proudly say that their country has finally succeeded in playing (and winning) at the big table. This would befit a country that already has four times the population of both Switzerland and Sweden (two big international high-tech players) and that is projected to have a larger population by 2067 than any European country except Germany.

The Trudeau government has promised change – now, as we look to the future, is the time for Canada to deliver.

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