

**Federal Government Investments in Scientific
Endeavours Are Critical to Enhancing a
Country's Competitive Position**

**Response to the Competition Policy Review
Panel's Consultation Paper: Sharpening
Canada's Competitive Edge**

By

The Coalition for Canadian Astronomy

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Introduction

The Coalition for Canadian Astronomy is pleased to make the following submission to the Competition Policy Review Panel. We will address head-on the question that will be automatically asked: what does astronomy have to do with enhancing Canadian competitiveness? We will argue that strategic Federal Government investments in scientific endeavours like ours are critical to enhancing a country's competitive position, while at the same time stimulating Canadian industry and growing the economy.

There are recurrent themes in the consultation paper that the Coalition feels are being achieved through our efforts to make Canada a world leader in astronomy:

- creating growth, opportunity and good jobs;
- creating conditions that will better enable Canadian firms to capture global opportunities and capitalize on economic opportunities that arise outside our national borders;
- enhancing Canada as an environment from which Canadian enterprises will emerge and prosper globally, with a particular focus on small and medium-sized enterprises; and,
- Making Canada a preferred location for the capital, talent and innovative activity that drive the modern economy.

Astronomy is a great Canadian success story. Canada continues to rank first in the world in this field. However, policy changes are needed if that success is to continue. Like most other facets of the economy, science is not immune to the aggressive moves being made in other countries.

Our response is divided into six main sections. First, we provide an overview of the Coalition and our achievements. Second, we examine the economic impact of astronomy research and why our success is relevant to this consultation. Third, we elaborate on how the Coalition is helping achieve each of the four goals listed above. Fourth, we respond to some of the specific questions raised in the discussion paper. Finally, we offer concluding remarks on the link between government scientific investments and Canada's competitive position and then summarize the policy recommendations made earlier in the document.

Section 1: Who We Are and Why We Are Relevant

The Coalition for Canadian Astronomy was formed in 2000 and is unprecedented in the Canadian science community. There are three sectoral partners in the Coalition: professional astronomers, academia and industry. The astronomers are represented by the Canadian Astronomical Society, which is made up of all professional astronomers and graduate students in the country.

On the academic side, 21 institutions are represented by the Association of Canadian Universities for Research in Astronomy (ACURA). ACURA was formed in 2003 and includes universities from across Canada with astronomy departments.

With over 200 companies now involved in astronomy projects, industry was also invited to be a Coalition partner. Astronomy projects today require highly specialized design and often have price tags into the hundreds of millions of dollars. Those projects need private sector expertise to be designed and built, and those industries that can provide it stand to reap considerable financial gain.

The Coalition was our response to the challenges posed by the globalization of Astronomy - not unlike the challenges facing other sectors of the economy. The engineering scale and technological sophistication of the next generation telescopes require the intellectual and financial resources of the international astronomy community to plan and construct them. Canadian astronomers had to make a conscious effort to be part of this new era. Opportunities were not going to fall in our lap.

Therefore, after lengthy debate and discussion within the astronomical community, a set of priorities was identified that would form the basis of the Long Range Plan for Astronomy and Astrophysics (LRP). The LRP vision document was created by a Blue Ribbon Panel to chart a course for Canadian astronomy over this decade and beyond. It calls for Canadian participation in the next generation of global astronomy projects, coupled with investments in technology development in Canada, the training of young Canadian scientists and engineers, and intellectual leadership in the planning and operation of facilities by Canadian astronomers.

The detailed science case for the projects in the LRP is a vast compendium of some of the most interesting and promising scientific investigations that are beyond the reach of existing telescopes. To put it in the simplest of terms, these new telescopes will give Canadian astronomers the tools required to answer previously unanswerable questions about the universe, offering important new information about possible extraterrestrial life, the origins of the universe and observations that test the fundamental laws of physics. However, it is the unexpected discoveries that these projects will make that will likely be the most exciting. The tremendous power of some of these telescopes will lead to discoveries of completely new types of objects and surprising aspects of the universe.

By developing the LRP, the community was forced to focus on a select few projects through which Canadian astronomers could make a global impact. The community's ability to come together and agree on these projects is essential to our success. We had to focus our efforts on specific projects and the support structures necessary to sustain them, rather than try to pursue every opportunity that arose. To ensure that the LRP was succeeding and the projects mentioned continued to be relevant, the community completed a Mid-Term Review in 2005 which validated our efforts to date.

In short, the LRP was the Canadian astronomy community's strategy to adapt to and thrive in an era of globalized astronomy. The Coalition was created to make the LRP operational. Once the astronomy community agreed upon its priorities, all stakeholders – astronomers, academia, and industry – needed to work together to achieve its goals.

We are aware of no other sector where a scientific community, academia, and industry work so well together to ensure the success of a plan. Canada consistently ranks among the top three nations in the world in astronomical research. Our success was even noted in the *New York Times*, which commented wryly on a citation study that showed Canada ranked first among 62 nations in a measure of research impact in astronomy. This is even more impressive when you consider that Canada's per capita investment in astronomy is eight times smaller than the United State and five times smaller than European countries with similar GDPs.

Our plan has worked. Canadian astronomers have achieved scientific excellence. The priorities we identified in the LRP are providing Canadian astronomers with the opportunity to work on world-leading projects or, in other words, to play an important role in the globalized field of astronomy.

We credit our success to our clearly defined plan and our Coalition relationship. We often state that the LRP and our Coalition approach are very similar to an industrial strategy, only rather than focused on more traditional industries such as automotive or aerospace, it was focused on what at first glance appears to be a purely scientific endeavour.

However, there is far more at stake here than simply discovering the origins of life in the universe (though the astronomers in the Coalition are most interested in that). The Coalition is equally proud of the economic benefits that we have delivered to Canadians. We believe astronomy is marketable scientific research, meaning we not only benefit from the scientific achievements and discoveries resulting from that research, but also generate economic opportunities through the knowledge gained in developing the tools and equipment needed for astronomy projects.

There is no doubt that astronomy has been a scientific success story in Canada. Of far more interest to the Panel, however, is our economic success and the impact we are having on Canada's competitiveness.

Section 2: Economic Impact of Astronomy Research

In the previous section we outlined briefly the scientific goals of the Long Range Plan, which, to summarize, focused on making Canada a world leader in this field. However, there are also economic goals in the LRP. The industry partners in the Coalition signed up because the LRP offers tremendous economic potential for Canadian companies.

Previous work in this field has generated hundreds of millions of dollars in business for Canadian companies. The projects identified in the LRP offer the potential for much more since they were selected to capitalize on the science and technology strengths of Canadian industry.

Past economic analysis (provided by KPMG) and experience has shown that Canada receives a two-to-one direct return for every dollar invested in astronomy. The indirect return is as high as ten-to-one, since the knowledge gained working on astronomy projects leads to new business opportunities in sectors far removed from astronomy.

Outlined below are three primary areas in which astronomical research is contributing to the Canadian economy, our productivity performance and our global competitiveness, through direct contracts awards, the development of spin-off technologies, and skills development. In other words, this is where we begin to directly address how astronomy is related to Canada's international competitiveness.

Contracts Awarded

The first economic impact consideration comes directly from the astronomy projects themselves, which today cost into the hundreds of millions of dollars. Canadian companies can only compete for these contracts if Canada participates in the project in question.

There are several examples of Canadian companies being awarded contracts for LRP-related projects. For several of these companies, it is the first time they have ever been involved in astronomical projects. These small and medium-sized companies are spread across the country and have become engaged at the best time to leverage longer-term industrial benefits: the upfront design and research phase. Canadian firms will then have the opportunity to pursue future contracts as they move into their next phase of development.

The best way to understand this impact is to look at three specific examples of Canadian companies benefiting from these projects.

Dynamic Structures – Coquitlam, British Columbia

The Thirty-Metre Telescope (TMT), which will be the world's largest, is currently in the design phase. The TMT is expected to cost \$1 billion, with \$80 million already invested in the design phase. Canada is one of the four international partners in this massive undertaking and a Canadian company, Dynamic Structures, is poised to win a \$100 million contract to design and build the enclosure for this telescope.

Designing and building telescopes is an area of expertise first developed by Dynamic Structures in the 1970s when Canada invested to become a partner in the Gemini Twin Eight-Metre telescopes. That initial investment led to a \$44 million contract for Dynamic Structures to build the domes for these telescopes. The structural design expertise generated by Dynamic Structures through their involvement with this project and the earlier Canada-France-Hawaii telescope has now grossed over \$300 million, not including the pending TMT contract.

Through its work on the development and construction of astronomical facilities, Dynamic Structures now supports a large cluster of small and medium-sized companies throughout Western Canada who are subcontracted to develop and maintain various elements of these projects. Thanks to that initial contract awarded to Dynamic Structures in the 1970s, the company has now designed, manufactured and constructed 12 of the largest telescope enclosures in the world, helping showcase Canada's scientific and industrial strengths internationally.

Breconridge – Kanata, Ontario

Breconridge is one of the world's top 50 electronics manufacturing services companies and a major contractor for the manufacturing of printed circuit boards for the Expanded Very Large Array (EVLA), a key component of Canada's commitment to the Atacama Large Millimetre Array (ALMA). These 29-layer state-of-the-art circuit boards put Breconridge on the cutting edge of technology development. This contract is worth about \$4 million.

Breconridge is also performing a \$300,000 study for the National Research Council for the CLAR RF-to Optical Transmission System, which aligns with Canada's efforts to be part of the Square Kilometre Array (SKA). The SKA will be the world's largest radio observatory and is expected to cost around \$1.5 billion. Even though Canada is seeking only about a 3 percent share of this observatory, this position will allow Breconridge to compete for over \$500 million worth of contracts once the SKA construction begins.

TeraXion – Sherbrooke, Québec

TeraXion has been involved in LRP projects since 2003, contributing the laser system in the antennas of the Atacama Large Millimetre Array and a high-end system that will be used to test the antenna front-end receiver system before final deployment. Upon completion of these contracts, TeraXion will have earned revenues of more than \$5 million from this LRP work. At peak times over 15 people were employed to serve on these contracts and 8 on average will be necessary to fulfill on-going contractual obligations in the next 18 months.

The development of the unique laser technologies required for the ALMA project has been instrumental in the technological and commercial growth of the company. TeraXion is now identifying other markets that may benefit from the products and technologies resulting from this LRP-related work in hopes of using it for novel applications. The company is expecting commercial success in this area in the defence and aerospace industries.

All the contracts described in the examples above translate into jobs and income for Canadians. This return on investment is even more impressive when you consider the businesses that are getting contracts to support our astronomical research. All are in the high tech field and many are small or medium-sized, providing Canadian companies a unique opportunity to distinguish themselves in this advanced sector.

However, these contracts will only continue to flow to Canadian companies if we continue to partner in international astronomy projects. **No participation = no contracts.** It is that simple. Canada's continued participation depends on continued financial support from the Federal Government. Without Federal Government investment in astronomy, these opportunities would not have presented themselves.

Recommendation 1: The Federal Government Should Continue To Fund The Projects Identified In The Long Range Plan For Astronomy.

Spin-off Technologies

While the two-to-one direct return on investment in astronomy is impressive, the return generated from the development of spin-off technologies (estimated to be as high as ten-to-one) is phenomenal. The contracts and work experience that have come from LRP projects have generated new knowledge and technological developments that produce a variety of spin-offs and market advantage for Canadian industry.

When working on projects, the Canadian Astronomical community uses a "smart procurement" model in which contractors are introduced to problems faced by the astronomical community and they in turn use their existing capabilities to find creative solutions. The knowledge gained in solving these problems leads to new business opportunities in sectors far removed from astronomy as technological developments are spun-off into other applications. Furthermore, this process routinely requires developing new machinery and equipment, which improves competitiveness.

Listed below are examples of spin-off technologies developed from astronomical research:

- the development of image reconstruction techniques and sensitive microwave receivers that are used for analysis of CAT scans, magnetic resonance imaging (MRI) and breast cancer scans;
- the precursors of the detectors that scan baggage at airports were developed for X-Ray astronomy satellites;
- the technology for the Netscape web program;
- digital cameras and computer imaging; and,
- synthetic aperture radar technology, employed by RADARSAT to map the earth in high detail.

Consider specific examples like the creation of Softimage, a software company which has now grown into an industry leader in computer visualization and video production. It was developed by two researchers from the Observatoire Mont Mégantic in Québec. Or look at aforementioned Dynamic Structures, which has parlayed its work experience with observatory enclosures and telescopes into becoming a world leader in the design and construction of theme park rides.

All this happened because the Federal Government made a modest investment in astronomy research. Not only is this research increasing our scientific knowledge and generating direct economic returns through contracts and jobs, but it is also delivering huge benefits as Canadian companies develop spin-off technical expertise that offers tremendous marketing and business development potential. This astronomy work has encouraged Canadian industry to invest in research and development.

Recommendation 2: The Federal Government Should Recognize And Encourage The Spin-off Potential That Exists When Making Investments In Scientific Research.

Skills Development

Canada currently enjoys a privileged position at the top of the global astronomy community. To stay there, we need to ensure we are developing the next generation of astronomers. The benefits currently being enjoyed by Canadian industry will only continue to flow if we have top-level astronomers in this country. Equally important, however, is the continued development of skilled labour to sustain Canada's emerging scientific and industrial strengths.

To that end, the Coalition's success has generated an explosion of interest in astronomy at the university level. The university sector has greatly expanded its astronomical strength, with an increase from 88 full-time-equivalent permanent teaching positions in 2000 to 110 in 2004 and 125 projected by 2009, *an increase of over 40 percent in a decade*. This has been accompanied by a *projected doubling of the number of graduate students in astronomy*, from 126 in 2000 to a projected 257 by 2009. There have been similar increases in the number of undergraduates participating in research projects and the involvement of adjunct faculty from other institutions. Furthermore, the field of astronomy has been awarded 23 Canada Research Chairs – twice the average share awarded to the NSERC-funded disciplines. Taken together, these achievements represent a significant increase in the overall capacity of Canada's universities to contribute to advanced education and research in astronomy and astrophysics.

This growth in interest at the university level is easy to explain. Canada's involvement in some of the world's leading astronomy projects is providing students and faculty with a chance to work on such projects. Because the LRP focuses Canada's attention on the next generation of astronomy facilities, academics and students are being trained on state-of-the-art equipment while working with the top scientists in their field. This not only stimulates interest in astronomy, it gives the next generation of Canadian astronomers the skills and experience needed to keep us at the forefront of this field.

Likewise, Canadian industry is becoming more advanced through its work on these projects. Highly skilled labour is being created as Canadian companies solve the problems presented to them by the astronomy community. As has been well-documented, highly skilled workers are extremely mobile and will go where the best opportunities exist. Fortunately, these opportunities are currently being created in Canada.

Recommendation 3: The Federal Government Should Recognize That Highly Skilled Labour Can Be Created In Canada Through Strategic Investments In Scientific Research.

Surprised?

Whenever we appear before a Government body to discuss the economic benefits of astronomy research, we feel like we have to pause to let people digest the fact that there are actually economic benefits from this research. Moreover, we usually find that most people are not even aware of the fact that Canada is a world leader in this highly advanced scientific field, or that Canadian companies are becoming world leaders in high technology businesses as a result of their work on astronomy projects.

Herein, we believe, lies part of the problem. The Coalition does not feel it should wade into the broader issues of globalization and the impression that Canadian companies are being bought up by foreign investors, or that Canada is losing its world-leading companies – especially when the evidence outlined in the consultation paper clearly shows this is not actually the case. However, that perception remains with the general public.

Therefore, we would politely suggest that the Canadian Government could do a better job of promoting its industrial successes. We have no illusions whatsoever that if a poll were to be conducted that it would find more than a handful of Canadians know anything about Canada's world-leading ranking in astronomy. That being the case, we devote 1.5 percent of our budget to public education and outreach. We want the general public to know about our success – both scientific and economic.

This accomplishes two goals. First, it shows taxpayers that their money is being well spent, especially when they see the economic returns for Canadian industry. Second, it creates excitement and interest in our field which helps us achieve our long-term goal of recruiting more young people to the sciences and the skilled professions. We can only remain number one if another generation of Canadian astronomers and engineers is getting interested in the field now.

Our budget for this education and outreach is very small and has limited potential. We believe the Federal Government can help. Canada should be celebrating its scientific and industrial successes, especially at a time when the perception exists that we are falling behind the rest of the world. In doing so, the Government can help build Canadian confidence and interest in the sciences and the success of our industry.

Recommendation 4: Canada Should Invest In Public Education Campaigns That Showcase Canada's Scientific And Industrial Success.

Role of Government

At this point, we would like to gratefully acknowledge the Federal Government's generous financial support for astronomy and to the LRP. The Coalition has received approximately \$85 million from the Federal Government, its various granting agencies and the Canada Foundation for Innovation (CFI) since the launch of the LRP in 2000. In many ways, the Federal Government can be considered the fourth partner in our Coalition.

The Coalition has been working closely with the National Research Council (NRC) and the NRC Herzberg Institute of Astrophysics (HIA) to secure the necessary funding for the remaining elements of the LRP. The HIA plays a unique role in the implementation of the LRP. In particular, the NRC which has the mandate to operate and administer any astronomical observatories established or maintained by the Government of Canada. Currently the NRC does not have enough funding in their A-Base funding to support the LRP. In fact, there is no single agency that can fund our projects. This has forced us to deal with a myriad of agencies with different mandates and reporting requirements. When the Coalition has received funding, it is often short-term and piecemeal. This is not conducive to long-term planning, especially with international partners.

The NRC-HIA provides critical services to the Canadian astronomy community that support access to and use of the telescopes for scientific research. Currently, the largest astronomical instrumentation laboratory in Canada is at HIA. In the past, the NRC has secured additional funds from the Government for capital costs for astronomy projects. Although other agencies such as the Natural Sciences and Engineering Research Council (NSERC) and the Canada Foundation for Innovation support the astronomy research and teaching program, it is the NRC that provides the leadership to ensure Canada's leadership in this discipline.

We want to highlight this financial support for one very simple reason: without it, the Coalition would not have enjoyed the successes previously elaborated here, nor would Canadian companies involved in our projects be developing world-leading technology in several niche areas that have commercial applications.

One point that we feel must be made here, and which will be echoed throughout this document, is the vital need for the Canadian Government to continue to make strategic investments in scientific research. We recognize that there are limited government dollars to go around. Therefore, we recommend that dollars ear-marked for scientific research be used to fund those disciplines that have a clear plan for success, like we developed with our Long Range Plan.

Recommendation 5: Federal Government Scientific Investments Should Be Strategically Targeted At Those Disciplines That Have A Clearly Defined Strategy For Achieving Excellence.

We would also like to confront another issue that is constantly raised: if the private sector benefits so much from these projects, why are they not making the initial investments? In other words, why does Government always have to foot the bill? The short answer is simple: there is no business plan that would support investing in an astronomy project. There is no commercial value *per se* in building a thirty-metre telescope, for example. The private sector is not in a position to make that investment (especially if it is a publicly traded company).

Therefore, scientific pursuits like ours need the Government as a financier. This is the only way we can continue to play a role in international astronomy. As noted earlier, this is not a lost investment. The Government makes a two-to-one direct return on every dollar invested in astronomy and a ten-to-one indirect return.

Finally, we would point out that the other countries involved in international astronomy also rely primarily on government for their funding, and likewise, companies in those countries benefit from those investments. Investments in scientific research help Canadian companies stay on the cutting edge of the global economy – particularly for small and medium-sized enterprises, which includes most of those involved in astronomy projects. Scientific research dollars are an excellent tool the Government can use to enhance the competitiveness of Canadian industry.

Recommendation 6: The Federal Government Must Recognize Its Role As The Primary Financier Of Major Scientific Pursuits.

Recommendation 7: The Federal Government Should Recognize That Scientific Research Dollars Can Be Used As An Industrial Stimulus.

Section 3: Astronomy and Competitiveness

Let us now return to the four themes we highlighted in the introduction and address each one specifically.

1. Creating Growth, Opportunity and Good Jobs

We have already touched on the economic benefits of astronomy research above, but let us again reiterate a couple of key points here. There is no doubt that astronomy research is creating growth, opportunity and good jobs in Canada. Consider again the earlier example of Dynamic Structures. Canada's initial investments in astronomy in the 1970s have helped that company generate hundreds of millions of dollars in telescope contracts and spin-offs. Hundreds of millions more are possible if Canada continues to be involved in the Thirty-Metre Telescope. Consider as well that Breconridge stands to win \$500 million in business from Canada's involvement in the Square Kilometre Array. These are just two examples, but the value of the past and future business clearly shows that astronomy research is contributing to Canada's economic growth.

Opportunity is more of a challenge to measure, though the example of TeraXion is useful. That relatively small company is using its experience derived from astronomy work to enter the international defence and aerospace market. Similar opportunities exist for other Canadian firms that have been involved in astronomy projects.

We would also add that opportunity should be considered from an academic point of view, not just an economic one. Canada should strive to attract the best researchers and students to our universities. This is happening in astronomy because the best opportunities are in Canada. Like any other academic discipline, professors and students want to work on projects that are at the cutting-edge of their field. If you want to be involved in cutting-edge astronomy, Canada is the place to be.

Finally, the type of jobs being created through Canada's astronomy investments are certainly good ones. The telescopes, enclosures and electronics needed for today's astronomy projects require highly skilled labour. These astronomy projects are creating high value, high paying jobs for small and medium-sized businesses across Canada. There is no need for Canada's best and brightest to leave the country to enjoy incredible work opportunities in these high technology fields. The good jobs are right here in Canada.

2. *Creating conditions that will better enable Canadian firms to capture global opportunities and capitalize on economic opportunities that arise outside our national borders*

Canada's investments in astronomy have both direct and indirect economic benefits. On the direct side, when Canada partners on international astronomy projects Canadian firms have the opportunity to bid on the contracts to build them. Since the 1970s, Canadian firms have developed expertise in this area, positioning them well for the massive projects currently in the design phase, such as the Thirty-Metre Telescope and the Square Kilometer Array.

Dynamic Structures that built the Canada-France-Hawaii and Gemini telescopes in the 1970s, was even picked by the Japanese Government to build their national observatory – beating Japanese firms in the process. Canadian companies are becoming the “go to” suppliers for astronomy projects.

The indirect benefits are also launching Canadian companies onto the world stage. To again use Dynamic Structures as an example, their experience working on astronomy projects has made them a world-leader in the manufacturing of amusement park rides. The company has built rides for Disney, Six Flags and Universal.

TeraXion is using its unique laser technology experience developed working on astronomy projects to market to international clients in the defence and aerospace industries. This is a classic example of a medium-sized business getting an opportunity to compete on the world stage thanks to astronomy investments.

Both directly and indirectly, Federal Government investments in astronomy are helping Canadian companies grow and compete on the world stage.

3. *Enhancing Canada as an environment from which Canadian enterprises will emerge and prosper globally, with a particular focus on small and medium-sized enterprises*

Much of the evidence here has already been captured above. We would only reiterate three factors that we consider critical to our success that could be applied to all scientific disciplines. The first was the development of a coherent plan for excellence. We analyzed the present state of the discipline and where it was headed in the future and identified the projects that would put us at the forefront of this field. The LRP was the result of that process and continues to guide us.

Second, the Coalition brought together all stakeholders involved in astronomy to implement this Plan. The LRP was the result of a lengthy process to focus our attention in a few specific areas. We knew Canada could not pursue every single astronomy project. We then needed to convince academia and industry to sign on to the Plan. The LRP would have been undermined if astronomers were pursuing one set of projects, universities a different set, and industry a third. The other partners quickly signed on because the LRP offered a course to excellence not just for astronomy, but also for our universities and industry.

Last, but certainly not least, that Plan needed the support of Government. As noted earlier, these projects require Federal Government financial support. By investing in science – especially a discipline that has charted a course for excellence in the way we have – the Government can create an environment that allows knowledge-based industries to thrive. Moreover, virtually all the companies benefiting from astronomy investments in this country are small or medium-sized enterprises.

Therefore, we believe our model, coupled with Government financial support, can certainly enhance Canada as an environment for enterprises to emerge and prosper globally. However, we cannot overstate the importance of Government financial participation. A nation must invest in science to maintain its economic competitiveness. Other countries are doing so and Canada risks getting left behind if these investments stop. Investments in science are an economic stimulus that does not distort the market in any way or lead to accusations of unfair trading practices. Past investments have clearly shown their value. We hope they continue.

4. Making Canada a preferred location for the capital, talent and innovative activity that drive the modern economy

We feel like we are getting repetitive, but here again, astronomy is meeting this goal. Because Canada is ranked in the top three in the world in astronomy by all measures, with some putting us first, this is where the top talent wants to be.

Likewise, Canadian companies have established themselves as world leaders in the design and construction of highly complex astronomy projects. The international astronomy community looks to Canada when it needs help building one of these projects – and the capital required to build them flows here (even if the projects themselves are located offshore). This was clearly demonstrated with the Thirty-Metre Telescope; the American partners sought out Canada’s participation because of our expertise in this particular area of astronomy. Given that these projects have budgets that run into the hundreds of millions of dollars; this is a significant amount of capital coming into Canada.

Lastly, innovation is at the heart of the success of Canadian companies involved in astronomy projects. To put it in the simplest terms, astronomers conceive an idea for a project and then challenge industry to come up with a way to design and construct it. These projects have never been built before, so there is an automatic requirement for innovation.

Then, as noted throughout this paper, the skills and expertise generated when working on these projects lead to technological spin-offs and innovations in a variety of different areas: health care, laser technology, computers, digital imaging and even amusement park rides, to name just a few.

Section 4: Responses to Questions Raised in the Consultation Paper

Please find below our specific answers to some of the questions raised in the Consultation paper. We did not see fit to respond to all the questions since some are clearly beyond the scope of our interest or expertise, such as those sections dealing with investment policies, sectoral investment regimes, and competition law.

Canada in a Global Context

Question 4: *Do Canada's economic policies appropriately reflect our increased integration with the North American and global economy? How might these policies be changed to better reflect this new competitive environment?*

Much of this section deals with concerns about foreign takeovers and the loss of corporate headquarters to other countries. We are pleased to report that the firms enjoying success as a result of astronomy investments are largely Canadian owned and operated.

Our main recommendation surrounding Canada's position in the global context is to ensure that Canada is keeping up with the rest of the world when it comes to investing in science. There are two reasons for this. First, science, education and the economy go hand-in-hand. The better educated the Canadian population, the stronger our economy, productivity and competitiveness.

Second, other countries will use their science investments to help stimulate their economies, through direct contracting, R&D, and so on. Canada has a budget envelope for scientific investment that has little coherence with national strategic goals. Effort should be made to ensure that those investments are being made in a strategic manner that maximizes the potential for scientific excellence and economic success. We believe our Long Range Plan and Coalition approach is a model that should be emulated.

Finally, we would only add that Canada must take a long-term view to these investments. Previous investments have helped make Canada number one in the world in astronomy. Continued investments are needed to stay on top, however. Canada can be mediocre in many disciplines, or a world leader in a few. We believe investment should be targeted at the latter.

Recommendation 8: Since foreign governments are using their scientific research dollars to help stimulate their industries and make them more competitive, the Federal Government should do the same.

Promoting Canadian Direct Investment Abroad

Question 3: *Are there policies or approaches that would be useful in addressing the particular challenges faced by small and medium-sized enterprises as they seek to become global competitors and participants in global value chains?*

Our only recommendation here is to not overlook the potential of scientific investment as a stimulus for helping small and medium-sized Canadian firms become established and then compete on the world stage. We have already cited examples earlier in this document of exactly this resulting from Federal Government investments in astronomy. Science and industry working in partnership can be a powerful force for creating innovative economic opportunities.

All countries have budget envelopes for scientific investment. As mentioned in the previous section, we would encourage the panel to consider how best those Canadian dollars can be used to enhance this country's competitiveness.

Becoming a Destination for Talent, Capital and Innovation

Question 1: *How can Canada better promote inward FDI? What policy change could contribute to the achievement of this objective?*

Our simple answer to this question is to have the best firms in the world right here in Canada. That is the case with astronomy. Canadian companies are world-renowned for their expertise working on astronomy projects. For example, when a Canadian company is building the national observatory for Japan, you know you are doing something right.

While it is only a small part of the broader economic policy, we would echo our earlier recommendation that Canada continue to invest in science and do so in a strategic way.

Question 3: *Is the modernization of Canada's competition and investment laws sufficient for successfully attracting foreign direct investment in Canada? What other priorities and policy issues should governments address?*

The Government needs a strategic scientific investment policy that recognizes the role it must play in funding this research. While the very nature of our Coalition demonstrates our support for things like private sector partnerships, the funding needed only has one source – the Government. Astronomy is not like medical or pharmaceutical research. There is no cure that can be mass marketed when we discover something new. That is why we need the Government to invest.

As noted previously, scientific investment should be strategically focused:

- In which fields is Canada a world leader?
- Which fields have developed a coherent plan for excellence that is supported by all the key stakeholders?
- Which fields are delivering economic returns for Canadian industry and Canadian taxpayers?

Just asking these three simple questions can help ensure that Government investments provide the maximum potential to grow Canada's economy and enhance our competitive position.

The Government's whole approach to funding science needs to change. In astronomy, we developed the Long Range Plan to achieve excellence in our field. Unfortunately, funding mechanisms are anything but long range. While we are extremely grateful for the investments that have been made, huge amounts of time are spent trying to ensure that we can find the funding we need.

Government scientific investments are rarely long term. There are examples in astronomy wherein Canada made an initial investment in a project, but then made no firm commitment to see it through. For example, the Federal Government earned a 25 percent share in the Thirty-Metre Telescope because of a \$20 million contribution to the initial \$80 million design phase. The rest of the project is expected to cost \$1 billion, with hundreds of millions of dollars in potential contracts for Canadian industry hanging in the balance. Because of the initial investment, Canada will be invited to maintain its 25 percent share. However, whether we receive that funding is still up in the air.

Quite simply, we have a Plan to achieve scientific excellence, but lack the funding framework needed to implement it fully. Our recommendation to fix this state of affairs is included in our response to the next question.

Finally, if Canada cannot or will not commit, the other international partners in this project will look elsewhere. It will be their scientific communities and their industry that reap the rewards. Furthermore, several countries are eagerly standing by waiting to take Canada's place if the opportunity arises.

Question 5: What further could be done in Canada to promote an ongoing review of Canadian competition, investment and productivity performance aimed at Canada's sustained competitiveness?

As described previously, Canada needs a strategic scientific investment policy, in particular a policy dealing with major science initiatives like astronomy. We are now in the era of "big science" – projects that cost hundreds of millions of dollars, lifespans in decades, and multiple international partners. Unfortunately, while science has changed, government funding approaches have not. There is no one agency or department that can currently fund such projects. When funding has been provided, it is often short-term and piecemeal, forcing us to spend time and energy lobbying for dollars, rather than conducting research. As our colleagues in other disciplines have also discovered, our inability to plan beyond the yearly Federal Budget cycle is a constant challenge.

There is incredible potential to stimulate Canadian industry and enhance Canada's competitive position by developing a funding approach for "big science" projects.

Furthermore, the Government of Canada must back such projects with long-term financing to assure our international partners that our participation rests on a sufficiently stable foundation to entrust critical project work to Canadians. The private sector cannot play that role. If Canada wants to establish itself as a world leader in scientific research, the Government must provide the financial investment. This does not mean investing in every project that comes along. As we have outlined, the Coalition clearly identified those projects that would launch Canada into an international leadership position in astronomy. Investments must be made strategically.

Recommendation 9: The Federal Government needs to adjust its scientific funding approach to take into account the realities of "big science", which is the future of disciplines like astronomy.

Section 5: Conclusion

The link between astronomy funding and competitiveness now should be clear:

- Canadian companies are winning hundreds of millions of dollars in contracts to work on astronomy projects;
- Canadian companies are developing world-leading expertise in a number of fields as a result of working on these projects;
- Spin-offs generated from technological knowledge derived from working on astronomy projects are generating new business opportunities for Canadian companies at home and abroad;
- The original contracts and the resulting spin-offs are providing jobs for Canadians;
- Through working on these projects and their spin-offs, the Canadian labour force is becoming more skilled;
- Interest in astronomy at our universities is thriving, thereby ensuring Canada can remain at the forefront of this field and continue to attract top scientific talent;
- Canada has developed an international reputation for excellence in this field.

We feel strongly that Government investments in science can and should be a major element of any review of Canada's competitiveness. Unfortunately, the positive link between Government scientific investment and competitiveness continues to be ignored. In *Advantage Canada*, for example, the paper focuses heavily on more participation and investment by Canadian companies in research and development. While certainly necessary, that is only one piece of the puzzle.

Canada cannot solely rely on the private sector to achieve scientific excellence, particularly in the era of "big science". As we have outlined, there is no business case for the private sector to invest in these projects. The returns are there for industry in the future, but they may not be obvious initially, or the initial investments may simply be too large. Furthermore, many are international endeavours that require the Government to be a signatory.

We believe that Canada's astronomical community, through our Long Range Plan and Coalition approach, is an example of how to develop an effective strategy to achieve scientific excellence in a way that most efficiently uses Government dollars and maximizes the return to the economy. Our Plan has created jobs and generated economic and intellectual wealth in the ever more competitive global environment. The LRP was in many ways our response to enhanced competition in our field.

Investments by the Federal Government in astronomy have paid huge dividends to the Canadian economy, providing hundreds of jobs, hundreds of millions of dollars in business revenue and, of particular note, technological advances and expertise that have helped establish Canadian industry as recognized world leaders in fields ranging from telescope design and the construction of theme park rides.

The Coalition for Canadian Astronomy feels strongly that strategic investments in scientific research will help improve Canada's global competitiveness. Moreover, our Coalition approach serves as a model for the efficient and productive use of scientific investment that Government can use to determine how future funding should be allocated. When carried out in a coordinated way, Federal Government investment in scientific research will improve Canada's competitiveness and economic growth.

We strongly encourage the Panel to address scientific funding in your final report and to do so in a way that recognizes the realities of "big science". Investments in science are delivering tremendous benefits to the Canadian economy and our competitiveness. Those benefits will be enhanced with a coordinated Canadian approach to scientific funding. In developing such an approach, sciences like astronomy that have a clear plan that involves all relevant stakeholders, a demonstrated record of delivering scientific excellence, and proven economic returns should be rewarded with continued funding.

The Dark Side of the Moon

We do not wish to dwell on the negative; however, we would like to briefly touch upon what would happen if astronomy was no longer funded by the Canadian Government. We would never suggest that such a turn of events would lead to economic doom for Canada. That being said, there would be repercussions and those would have some impact on Canada's competitive position.

For example, if funding was discontinued, Canada would ultimately be forced to withdraw from its partnerships in international astronomy projects. For Canadian astronomers, this would mean no more access to these projects, most likely resulting in our astronomers moving to another country to pursue research opportunities. Universities would also lose access to these projects, which currently serve as a major drawing card for attracting the best and brightest academics and students in this field, who would also have to go elsewhere to pursue their studies. Ultimately, you would see astronomy departments at several universities wither and even die.

For Canadian industry, our partnership in these projects is a prerequisite for bidding on the contracts that accompany them. The hundreds of millions of dollars that would flow to Canadian companies over the course of our Long Range Plan would be lost. The potential spin-off technologies generated from this work would also be no more.

On a non-economic level, walking away from astronomy funding would raise serious questions about Canada's commitment to scientific excellence. If the Federal Government is not going to support its number one science, and one with a clearly laid-out plan for sustaining excellence, are there any scientific priorities at all?

There is also the question of why the Government would make a significant initial investment in astronomy (approximately \$85 million thus far for the LRP), let it build up to such a strong position with the potential for huge economic rewards, and then walk away before that potential can be fully realized? The initial funding allowed us to begin work on major international projects, but we are now scrambling to find resources to continue our participation. We cannot overstate how serious a blow it would be to Canada's international scientific reputation if we were forced to withdraw from signed international agreements because of a lack of funding.

As noted earlier, these investments must also be considered in the competitive global context. Scientific investments are a tool available to governments to help stimulate industry and the economy, much the same way defence contracting has often been regarded. Other countries are using their scientific investments to help their industries compete on the world stage. Canada should take advantage of the same opportunities.

An Industrial Strategy for Science

Given the Coalition's scientific background, obviously our ideal scenario would be one in which the Federal Government invests more and more money into scientific research. That being said, we recognize the financial constraints of the Government. Therefore, we return to our primary recommendation that the Government invest strategically in scientific research in disciplines with clearly laid out plans for excellence and a proven track record.

To date, astronomy is delivering a direct economic return of two-to-one for every dollar invested by the Federal Government. The indirect return is as high as ten-to-one. Contracts are flowing to Canadian companies, our workforce is becoming more skilled, and the next generation of astronomers is being trained to ensure that we remain at the forefront of this field.

Research, development and innovation are at the heart of competitiveness. Science, academia and industry working together encourage all three. Our Long Range Plan, if funded, will continue to deliver economic returns to Canada. This is not a request for speculative purposes. It is a clearly defined and tightly coordinated plan, which, as we noted earlier, provides a model for an industrial strategy for science.

This relationship is not only advancing Canada's scientific knowledge and international standing, but it is also doing so in a way that is delivering concrete benefits to our universities and our economy. Investments in astronomy are encouraging research and development, helping build a skilled workforce, and projecting an image to the world that Canada is serious about the pursuit of scientific leadership.

It is because of these successes that we feel our experience can serve as a model for a science-based strategy to enhance the competitiveness of Canadian industry. The Coalition strongly recommends that the Government continue to fund this sort of scientific research as part of its broader competitiveness agenda. Investments to date have more than paid for themselves.

Section 6: Summary of Policy Recommendations

Recommendation 1: *Our primary recommendation is that the Canadian Government continues to fund the projects identified in the Long Range Plan. This is critical to ensuring Canadian companies are still provided the opportunity to bid on major astronomy projects.*

As we outlined, these projects generate hundreds of millions of dollars in contracts for small and medium-sized Canada companies. Canadian companies can only bid on those projects if Canada is a partner in them. The Federal Government has received a two-to-one direct return thus far for every dollar invested in astronomy.

Recommendation 2: *The Government should recognize the spin-off potential that exists when making investments in scientific research.*

Astronomy projects today require highly advanced design and construction. In working on such projects, Canadian companies are developing skills and expertise that can then be marketed in the private sector and/or spun-off into new product lines. As a result, the indirect return to the economy for every dollar invested in astronomy is estimated to be as high as ten-to-one.

Recommendation 3: *The Federal Government should recognize that highly skilled labour can be created in Canada through strategic investments in scientific research.*

Canada's investments in astronomy are permitting our academics, students and industry to work on the world's leading projects, thus giving them the skills to remain at the forefront of this discipline. For industry, it is creating new private sector opportunities.

Recommendation 4: *Canada should invest in public education campaigns that showcase Canada's scientific and industrial success.*

Canadians should know that we are world leaders in astronomy. Likewise, they should know that Canadian industries are enjoying great global success resulting from this work. Public education campaigns would create excitement in the population about our field, which should encourage more young people to pursue an education in the sciences, while also demonstrating to taxpayers that they are getting an excellent return on Federal Government investments.

Recommendation 5: *Federal Government scientific investments should be strategically targeted at those disciplines that have a clearly defined strategy for achieving excellence.*

Canada can be mediocre in many fields, or we can excel in a few targeted areas. Our Long Range Plan and Coalition approach were the result of a lengthy internal process to chart a course for Canadian excellence in this field. Disciplines that have taken this approach should get funding priority.

Recommendation 6: *The Federal Government must recognize its role as the primary financier of major scientific pursuits.*

The private sector cannot and will not make the investments that are needed to support scientific endeavours like ours. There is no business case to do so. The private sector will ultimately benefit from Canada's participation in major astronomy projects, but they cannot be expected to make the initial investments.

Recommendation 7: *The Federal Government should recognize that scientific research dollars can be used as an industrial stimulus.*

Through its various granting agencies and foundations, the Federal Government has a sizeable scientific investment budget. We believe those dollars can be used to stimulate Canadian industry when invested in a strategic way. In astronomy, the LRP not only laid out a plan for scientific excellence, but is also took into account Canada's industrial strengths and identified those projects that would maximize the potential economic return.

Recommendation 8: *Since foreign governments are using their scientific research dollars to help stimulate their industries and make them more competitive, the Federal Government should do the same.*

As noted previously, Canada has a sizeable scientific investment budget. This is an example of where Government spending power can be used to help stimulate economic activity in a way that does not distort the market or lead to allegations of unfair trade practices. Strategic investments in science will provide unique opportunities for small and medium-sized Canadian companies to build their expertise and compete on the world stage.

Recommendation 9: *The Federal Government needs to adjust its scientific funding approach to take into account the realities of "big science", which is the future of disciplines like astronomy.*

The Federal Government needs to find a way to fund projects that cost into the hundreds of millions of dollars, have lifespans in decades, and involve multiple international partners. Existing funding programs today rarely extend beyond the two or three year time frame. The amounts required are often beyond the scope of any single agency. When you consider that the other international partners often require firm financial commitments and the confidence that the other partners are going to be involved for the long term, this puts Canadian participation in major projects in jeopardy. Lots of countries are willing to take Canada's place. If those countries have a streamlined funding system that allows large, long-term financial commitments, that is going to appear much more attractive than Canada's short term, piecemeal approach.