



2024 Pre-Budget Submission

Coalition for Canadian Astronomy

August 2023

Recommendation

Seize the opportunity for Canada to lead CASTOR, a Canadian space mission poised to be the unique successor to the Hubble Space Telescope, with funding of ~\$300 million over the next decade.

Introduction

Canadians are justifiably proud of the role this country has played in space, whether through the Canadarm, the amazing images and discoveries coming from the James Webb Space Telescope (JWST), or with a Canadian astronaut part of the crew for the upcoming Artemis II mission. Few fields captivate public attention to the same degree as space science and astronomy.

Canada now has the opportunity to lead a space mission – and not just any mission. The Cosmological Advanced Survey Telescope for Optical and UV Research, or CASTOR, is poised to follow and exceed the Hubble Space Telescope, one of the most well-known scientific instruments in human history. It will be more powerful than Hubble by a factor of about 100, but a fraction of the cost.

More fundamentally, this is Canada’s opportunity to take a giant leap on the global scientific stage and lead this project. CASTOR is Canadian conceived and designed. Other national space organizations want to join. This is the moment to put the Maple Leaf on the successor to Hubble, filling a unique gap in world-wide facilities.

This will solidify Canada’s global leadership in astronomy. At the same time, CASTOR will deliver significant economic returns in direct and spinoff work for Canada’s growing space industry, while ensuring our universities continue to attract the top talent in the field.

CASTOR is Canada’s first opportunity to lead an international space mission. It demonstrates our scientists and engineers are as strong as any. The 2024 budget is the vehicle to take advantage of this opportunity.

About the Coalition

The Coalition for Canadian Astronomy consists of:

- Academia: represented by the Association of Canadian Universities for Research in Astronomy (ACURA) and its 20 members;
- Professional astronomers: represented by the Canadian Astronomical Society (CASCA);
- Industry: represented by Canadian companies involved in major astronomy projects.

The Coalition is united behind the Long-Range Plan for Astronomy and Astrophysics (LRP), a community-wide decadal plan launched in 2000 and renewed in 2010 and 2020, with a view to sustaining Canada’s international leadership in this field. The LRP process, backed by Coalition support, has created a legacy of success, with astronomy consistently ranking as Canada’s top science¹ and Canadians at the forefront of this field globally.

Canadian Astronomy: A Scientific and Economic Success Story

In addition to being ranked as Canada’s top science, in standard analyses of per capita impact, Canada is ranked #1 in the G7 in astronomy and astrophysics.² The Council of Canadian Academies and a report by Hickling, Arthurs & Low to the National Research Council have documented this success, from which all astronomy stakeholders have benefited.

¹ https://cca-reports.ca/wp-content/uploads/2018/09/Competing_in_a_Global_Innovation_Economy_FullReport_EN.pdf

² https://www.scimagojr.com/countryrank.php?category=3103&area=3100&order=cd&ord=desc&min=1000&min_type=it

University astronomy departments are thriving, with Canadian institutions attracting top faculty and students. The membership of CASCA has doubled since the first LRP in 2000. Meanwhile, Canadian industry has reaped billions in direct astronomy support work and resulting spin-offs, with new industries and companies created – and with more to come.

None of this happened by chance; it is the outcome of the LRP and Coalition approach. The LRP calls for Canadian participation in a carefully crafted portfolio of next generation projects and is renewed each decade based on extensive consultation with the astronomy community and key input from the international community.

In addition to these project priorities in LRP2020, the plan recommends all Canadian astronomers make a personal commitment to equity and inclusion and that CASCA make EDI an explicit part of its ethics and values, including growing Indigenous engagement. The plan also recommends a commitment to sustainability, including a reduction of in-person conferences, consideration of the climate impacts of construction and operations when planning scientific infrastructure and, ultimately, a decarbonization roadmap.

The success of Canada’s astronomical community is inextricably linked to its close partnership with Canadian industry, with every new facility requiring highly sophisticated design, engineering and construction. In parallel with Canada’s scientific leadership, Canadian industry has a strong legacy of providing critical components for major international projects. For example, CASTOR will drive enormous progress in industrial capacity for high-throughput optical communications, high-performance optical design, and satellite construction and operations, all vital to Canada’s priorities spanning Arctic science, protecting the environment and national security.

History suggests, however, the most important impacts may be those not yet anticipated, with past astronomy investments delivering significant economic and technological returns, including WiFi, phone cameras, laser eye surgery, high-resolution x-ray imaging and even the technology being used to search for Ebola and Zika vaccines.

The broad skill set required means astronomy trains graduates who may go into careers as diverse as fundamental research, instrumentation, optics, data science, cybersecurity, satellite operations, laser technology, medical physics, archiving, and numerical modelling, to name a few. Graduates are also critical to Canada’s quantum computing needs.

Maintaining leadership requires access to world-leading facilities, which tend to be multinational, collaborative projects with costs in the billions and lifespans measured in decades. The Federal Government has funded a partnership in the two critical ground-based facilities identified in the LRPs: the Thirty Meter Telescope (TMT), which received funding in 2015, and the Square Kilometer Array (SKA), which received funding in 2023. The Coalition is extremely thankful for these investments.

The final piece of the puzzle is CASTOR, the top space-based priority in LRP2020. Together with TMT and SKA, CASTOR will keep Canada at the forefront of global astronomy for decades, inspire future generations to pursue a career in STEM fields, and position Canadian industry to secure billions in direct work and spin-offs. However, what makes CASTOR unique is that it is Canadian led. This is an outstanding opportunity to shape and define a project, but requires a change of mindset for the Government’s approach to major astronomy projects.

CASTOR: A Canadian-Led Space Mission

CASTOR is the natural successor to Hubble, perhaps the most famous telescope ever. CASTOR will be the world's preeminent telescope at ultraviolet and blue-optical wavelengths and will fill the widely acknowledged "UV gap" prior to the launch of a major US flagship mission in the 2040s. CASTOR will also provide unique widefield imaging to maximize the science outcomes of the NASA and European Space Agency infrared missions of Roman and Euclid. Its scientific impact will be immense, from exploring the nature of dark energy, detailing planets beyond the solar system, examining galaxy evolution, to chasing gravitational wave events, and much more.

For a decade, Canadian universities, industry and Government agencies have developed the concept for CASTOR, which will outperform Hubble (100x larger field of view) at a fraction of the cost. With Hubble likely to end its mission by decade's end, CASTOR is generating interest from space agencies and research entities in the US, UK, France, Spain and South Korea. India has also long expressed an interest in joining and continues to assess its potential role.

Along with 16 Canadian universities, three Canadian companies are heavily involved in project planning: Honeywell Aerospace (Cambridge and Ottawa), Magellan Aerospace (Winnipeg) and ABB (Montreal and Quebec City).

Project Cost and Prospective Partners

The full mission cost is estimated around \$485 million. A 60% share would ensure Canadian leadership in project science and technology. As such, the Coalition is seeking a commitment of \$304 million over the next decade, with the remaining \$181 million funded by project partners. While this is a large number, it is far less than the cost for Canada's participation in the International Space Station and Artemis II – projects we do not lead.

The UK Space Agency has already carried out a peer review of international space science projects and has approved participation in CASTOR. Their contribution is expected to be around \$56 million. France and Spain are looking to contribute one of CASTOR's key instruments, worth \$25 million. Talks are ongoing with South Korea to have it provide the launch, valued at \$40 million. Finally, discussions continue with NASA, which has been involved since 2017, to provide CASTOR's three imaging cameras (conservatively valued at \$60 million). Together, these contributions account for the \$181 million required from international partners.

However, it is critical to note partners cannot join a mission until it is real, and that requires Canada to approve and fund CASTOR.

Industry Involvement and Economic Impact

Of Canada's 60% contribution to CASTOR (\$304 million), roughly \$180 million would be allocated for project contracting. Roughly two-thirds of that would be divided among three Canadian aerospace companies – Honeywell, ABB and Magellan – with the balance spread among smaller Canadian companies subcontracted to perform specific tasks.

Also, with roughly a billion pixels distributed across its three focal planes, CASTOR will generate a remarkable 200 GB of imaging daily. Such data volumes will require a high-speed optical downlink – a technology that is now mature and will be enabled for the mission through an investment in a small number of geographically distributed optical ground stations. Several such

stations are envisioned for Canada, including at least one in the high Arctic. Together, this network of ground stations will be an enabling technology to avoid cloud cover in future satellite optical communication networks.

More broadly, CASTOR will showcase Canada's outstanding aerospace and engineering capabilities to a global audience and advance transformative technologies with immense export potential in high-tech markets poised to grow ten-fold in the coming decades. This includes low-cost and lightweight optical components, high-speed laser links, state-of-the-art optical communications hardware, massive data processing and archiving, and spacecraft bus platforms and subsystems. Potential commercial applications include optical sensing, high-speed communications, precision agriculture, disaster monitoring, and high-resolution Earth observations.

Positioning CASTOR

CASTOR represents a unique and powerful telescope that will position Canada at the forefront of space astronomy. Once constructed, it is baselined to a guaranteed five-year lifetime, with the expectation it will operate for ten years or more. It is the much-needed successor to Hubble, which will likely cease operations when CASTOR launches (targeted for 2029). CASTOR will provide a critical complement to several infrared space telescopes that have either launched (like JWST and Euclid) or will launch soon (Roman). Finally, CASTOR will be a scientific and technological pathfinder for the next great world observatory: NASA's Habitable Worlds Observatory (HWO) that is being developed for launch in the 2040s. Canada hopes to partner in HWO and expects NASA will view CASTOR as an important stepping stone to that project.

Timeline

To maximize synergies from other missions (like JWST, Euclid, Roman and Rubin) and ensure a path forward from Hubble, CASTOR must launch before the end of this decade. Its six-year development schedule means this is possible if CASTOR is funded and approved in early-2024. As such, the 2024 budget is a critical milestone. If it is missed, it will send a message to the prospective international partners that Canada is not serious about CASTOR and they will likely look elsewhere for project opportunities.

This is where Canada must show leadership. Whereas in most past big astronomy projects Canada has signed on, this one requires Canada to take the first step so the other international partners can formalize their commitments. While that perhaps implies more risk, it is the reality of leading a major international mission. More than 30 years since launch, Hubble is running out of time, and the global community is counting on Canada to lead humanity's foremost eye on the UV sky in the next decade.

Conclusion

Canada is a world leader in astronomy and CASTOR is the proof: our first opportunity to lead a major international space mission. Think how many times you have heard Hubble mentioned. Now imagine Canada leading its more powerful (and much less expensive) successor. This is Canada's opportunity to take an enormous leap on the global scientific stage, with the added benefit of significant economic impact for the growing aerospace sector. These opportunities are rare, which makes securing a commitment to CASTOR in the 2024 budget so critical.