

## JCSA Input to MTR

### JCSA Input to Mid Term Review Panel

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#### The JCSA

The Joint Committee on Space Astronomy (JCSA) advises CASCA, the CSA, and the community at large on matters of space astronomy. Its mandate and terms of reference are available on the CASCA website. LRP2010 and its predecessor advocated an exciting array of space astronomy missions. Notably, JWST, the highest priority space astrophysics mission in LRP2000, is on track for a 2018 launch. ASTROSAT/UVIT and ASTRO-H are prepared for launch in 2015; MOST completed its mission in 2014; the BRITE constellation of nano satellites is, for the most part, functioning well. However, uncertainty clouds the space astronomy agenda advocated by LRP2010, as discussed below.

#### 2. Status of LRP2010 Space Science Priorities

The space science priorities that emerged from LRP2010, categorized into large, medium, and small missions, are summarized in the table below. Participation in a dark energy mission is the top priority in the large mission category (\$100M). The highest priorities in the medium (\$15M) and small (\$5M) categories are X-ray missions. The numbers quoted in LRP2010 are not based on real cost accounting, and thus serve only to guide. The top priority stems from the discovery of cosmic acceleration and the emergence of dark energy among the most important unsolved problems in science. Following on the remarkable discoveries from the Chandra and XMM observatories, flagship missions in X-ray astronomy's "Golden Age," high-energy astrophysics grew faster than any other subfield of astronomy in Canada over the past decade.

We briefly summarize the status the space astronomy portfolio advocated in LRP2010, with space science priorities linked in brackets to the original recommendation. Interested readers are referred to the CASCA/JCSA website and other sources for details.

1. (6) Completing and launching JWST is the top priority for Canadian Space Astronomy.

Canada's contribution to JWST, FGS/NIRISS, is on track and being readied for launch in 2018.

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2. (21) A cost exercise should be started immediately by CSA and Canadian astronomers to identify and cost instrumentation contributions to space missions of interest.

Costing and contracts were successfully completed and issued for ASTRO-H. CASTOR's concept study has matured and a request for proposals for Phase 0 studies was to be released by Fall 2014, but has not appeared. Lethbridge is developing concepts for an FTS imaging spectrometer for SPICA/SAFARI, and a Canadian contribution to the complex filter assembly for WISH is in discussion, although no CSA funds have been allocated to the project. The cost exercise process is slow and ad-hoc. Realistic cost estimates for the science missions advocated by LRP2010 are generally not available, yet they are an essential input to the MTR process.

3. (22) Highest priority space science for decade 2010 would be Canada's participation in a major, wide-field Dark Energy mission through some combination of WFIRST, EUCLID, or a Canadian space telescope.

The leading contender at this writing would be the US-led WFIRST. M. Hudson (Waterloo) has been appointed an ex-officio member of the WFIRST Science Definition Team. Several possible Canadian contributions are under consideration, including a stake in the coronagraph, used for exoplanet studies. Another avenue would be a contribution of deep U & g imaging from CASTOR in support of gravitational lensing studies. CASTOR's design has matured, and detector technologies are being explored. While CASTOR's contribution to Dark Energy would be significant, its greatest scientific potential would be the broad array of UV science, including star formation, AGN, and galaxy evolution. Unfortunately, the CSA has not yet issued the RFP for Phase 0 studies. Prospects for participation in EUCLID have waned.

4. (23) ASTRO-H is top priority small-scale space mission.

The CSA is supporting the ASTRO-H mission through the \$7M Canadian ASTRO-H Metrology System (CAMS). CAMS is a laser alignment system being developed by Neptec to provide precision focal plane metrology for the Hard X-ray Imager. Although the CAMS team is working through technical issues at this writing, the instrument seems to be on track for a 2015 launch. The CSA continues modest financial support through launch to three Canadian members of the Science Working Group.

5. (24) Canadian R&D involvement in the International X-ray Observatory (IXO) is the highest medium-scale space priority.

IXO was a notional US-European large aperture X-ray observatory with novel instrumentation including an X-ray calorimeter. NASA pulled out due to budget constraints, leading to the European lead ATHENA mission concept.

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ATHENA has been approved for development toward a 2028 launch. Canadian expressions of interest have been forwarded to ATHENA leadership, but the route to Canadian participation is unclear. ATHENA is a ~1.4B Euro project with international participation limited to less than 20% of total expenditures. Potential Canadian contributions include, warm electronics for the calorimeter imager, metrology, and calibration support. Indications are that partnership will be open only to agencies able to contribute a significant piece of the mission. It will not be cheap. The project is moving quickly, so an agreement must be in place before 2018.

<b>Category</b>	<b>Project</b>	<b>\$</b>	<b>\$</b>
<b>Large</b>	Dark Energy Satellite (e.g. Euclid or WFIRST or CST)	5.1	\$100M
<b>Medium</b>	1. IXO R&D	5.2	\$15M
	2. SPICA	5.3	\$10M
<b>Small</b>	1. Astro-H	5.2	\$5M:
	2. Stratospheric Balloon Programme	5.5	\$5M:
	3. Nanosat/Microsat Programme	5.4	\$5M:

6. (25) The CSA and other funding agencies should develop procedures enabling them to react quickly to international opportunities on relatively short timescales.

Advocacy by Discipline Working Groups and the JCSA is the current route to opportunity in space astronomy. It works (eg., ASTRO-H) slowly and is perceived as ad hoc. A formal process that involves Announcements of Opportunity akin to NASA's model has been proposed by the JCSA but has not been adopted by the CSA.

7. (26) Canadian participation in SPICA is given high priority under medium-scale space projects.

The second priority medium class mission involves partnership in the Japanese-led SPICA infrared observatory, now known as SPICA/SAFARI. The mission was restructured in response to funding pressure at JAXA. SPICA is led by JAXA but ESA will partner at a significant (~50%) level. ESA's commitment is contingent on a successful outcome of the M5 Cosmic Vision call expected in the near future. Despite the restructuring, the project remains a top priority within JAXA and is apparently well regarded in

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Europe. An advanced, Fourier Transform Spectrometer and cryostat being developed at Lethbridge would be Canada's route to partnership. Canada is well placed as a world leader in FTS technology, and IR space instrumentation.

8. (27) As a world leader in micro- and nano-scale satellite technology, the LRPP strongly supports this program, and urges the CSA to issue a call for proposals as a cost-effective way to answer targeted science questions.

The MOST satellite mission ended successfully on April 30, 2014, is now in safe-mode. Science funding continues until early 2015. MOST demonstrated the novelty, power and cost-effective use of small satellites targeted to important but specialized science. The near-earth asteroid mission NEOSat is experiencing problems with pointing stability, but is being worked. The small satellite program is a cheap and effective means to target specific scientific problems, such as stellar variability near earth asteroids, and has been successful by almost any measure.

9. (28) Continued support of balloon-born experiments will realize the scientific potential of these missions as a cost effective means of accessing a near-space environment for technology development.

The CSA's stratospheric balloon program is a thriving test bed for space instrumentation and for research in its own right. Partnerships with NASA and CNES have led to funding a number of balloon experiments including BLAST and its successors, and SPIDER, which is being readied for a launch at this writing. Like all areas, balloon-born technology development suffers from tight funding. The JCSA recently recommended the CSA review the low, \$450K cap on FAST grants. Allowing multiple institutions to combine two or more FAST grants may be an avenue to fund more ambitious payloads within current spending constraints.

10. (32) The CSA should move toward a system that enhances the role and involvement of science teams in instrument delivery. (34) The CSA should allocate funds to the SSEP program to provide financial support for 4 PDFs in support of JWST and other CSA missions.

Support for science done with CSA hardware (32), including PDF support (34) is a long-standing issue. The CSA's progressive SSEP program, which awarded grants of up to \$200K over three years was discontinued, leaving a large hole in Canadian space science funding. No program has emerged to replace it. The JCSA has recommended science support for successful proposers on CSA assets, such as JWST, UVIT, ASTRO-H, following NASA's model. The CSA has voiced support, although funding has not materialized.

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In an encouraging step, the JCSA has initiated joint discussions between NSERC and the CSA to develop a solution.

### **3) Space Astronomy in the Current Climate**

LRP2010 presented an exciting and ambitious agenda for space astrophysics in this decade, with its top priority being dark energy. While opportunities to join Euclid have faded, the WFIRST mission is moving quickly, with NASA's decision expected in mid-2015 for a 2017 start. In a positive step, the CSA has appointed a pool of advisers to guide the effort. At the same time, exoplanet research has blossomed in Canada since LRP2010. With a coronagraph complementing WFIRST's wide-field imaging capability, the mission would appeal to a larger fraction of the Canadian community. Nevertheless, even a small stake in the ~\$1.5-2B project will be costly.

At the same time, the Canadian-led CASTOR could fulfill, in part, the aspirations for a dark energy survey mission by providing photometric redshifts in the UV and blue bands in support of WFIRST's lensing studies. More importantly, CASTOR would fill the broader need for a world-class, far-UV observatory operating long after HST has retired. A leadership stake in CASTOR would be a source of national pride and would provide wide-field imaging in the ultraviolet that would serve astronomers in Canada and around the globe. However, the CSA must identify one or more significant partners in order to drive down cost and risk.

The JCSA recommends the CSA continue to explore WFIRST and CASTOR. WFIRST will likely be a ~\$2B mission, and CASTOR may exceed \$500M. Participation in WFIRST, even as a minor partner, will be costly, possibly rivaling a leadership stake in CASTOR. The JCSA recommends the CSA to complete the CASTOR Phase 0 study. Should money become available to fund a large mission, the MTR or its successor should advise the CSA maximizing Canadian scientific and industrial return on cost.

Canadian participation in a major X-ray mission was the highest priority midsize mission in LRP2010. The European ATHENA mission is maturing rapidly, and several options for Canadian participation, including metrology and detector electronics, have been identified. However, the stakes are being carved up quickly. Canadian participation will surely require a significant investment in the upwards of \$1B project. The CSA must explore options with ESA soon for a Canadian stake. At the same time, the second midsize priority, SPICA, has transformed from a JAXA led mission to primarily a European mission. The shakeup has placed Canada in a position to lead in the development SPICA's far infrared imaging spectrometer, an area of expertise in which Canada is already a world leader. Given budgetary realities, participation in both would be unlikely, and decisions based on cost effectiveness and scientific payoff must be considered.

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Against this backdrop, opportunities have emerged post LRP2010, including JAXA's notional wide-field infrared telescope, WISH, and JAXA's cosmic microwave background polarimetry mission, LiteBIRD. Canadian stakes through the development of mechanical filter assembly, and detector readout electronics, respectively, are being explored. These opportunities should continue to be explored but with priorities in keeping with LRP2010. Realistic cost estimates for all missions is a missing but essential input to the MTR, an issue which is discussed at length in the LRPIC white paper.

Space astrophysics continues to enjoy exciting mission opportunities set against grim budgetary realities. The CSA's budget for astrophysical science is currently too small to fund any of the proposed missions beyond that of a minor partner. The departure of President Natynczyk after only year or so on the job adds uncertainty. The new space advisory board struck by industry minister Moore, which includes Natynczyk, offers hope post LRP2010 going into the mid-term review.