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Executive Summary of White Paper (5000 character limit)

Internationally, wide field imaging and spectroscopy at optical/near-infrared wavelengths is having profound impacts in diverse areas of astronomy. The international portfolio of projects in this arena for the next decade has never been richer and the expectation for transformative discoveries has never been higher. We discuss numerous projects in which Canada has interests or involvement, many of which are the subject of dedicated white papers, and attempt to set the national and international context in which these projects should be viewed. Critically, we show that, without action being taken by the community and supported by the LRP, Canada is facing a lack of access to any of the emerging front-line ground-based optical wide field programs and facilities for almost the entirety of the 2020s. We provide a set of comments for consideration by the LRP and the community for how to ensure Canada instead is able to capitalize upon the riches of the next decade, to compete internationally, and to set itself in a leadership position fo the 2030s. These recommendations include obtaining new access to 2020 datasets and observatories, leveraging the enviable capacity and skills of CADC/CANFAR, and developing the community so it can excel in an increasingly crowded, and exciting, international scene.

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1 The International Context

Internationally, wide field imaging and spectroscopy at optical/near-infrared wavelengths is having profound impacts in diverse areas of astronomy. Gaia is rewriting much of what we know about the structure and substructure of the Galaxy, its stellar populations, different phases of stellar evolution, and the dynamics of dwarf galaxies. It has already become the fundamental astrometric and photometric reference system across the sky. The Dark Energy Survey is producing critical data for extragalactic science and cosmological studies and providing a comprehensive census of many types of stellar objects. Although focused on cosmology, it has led to a new surge in the number of known satellite galaxies of the Milky Way and provided insights into the accretion history of the LMC. SDSS is entering its fifth incarnation with a focus on Milky Way, Black Hole, and Local Volume mapping; the first four incarnations of SDSS have defined a new benchmark for survey astronomy, and have impacted literally every single area of astronomy. Soon, a new generation of 4m-class wide field spectrographs will enter operation (DESI, WEAVE, 4MOST) and will provide exquisite and large data sets for objects considerably fainter than can be targeted with SDSS. Subaru/PFS and VLT/MOONS will conduct excellent, targeted surveys of relatively faint objects. Numerous reports from the US, ESO and others all highlight the need for fully dedicated 10-m class spectroscopy, for which the Canadian-led MSE is the most developed concept. In space, Euclid and WFIRST are both expected to launch in early (Euclid) or mid (WFIRST) 2020s, providing exquisite and deep NIR data over much of the sky and making precision measurements of fundamental cosmological parameters. SphereX will provide all-sky NIR spectrophotometry on a similar timescale to Euclid, providing essential data not just for galaxy evolution and cosmology but also as an essential low-resolution spectroscopic reference dataset for any object that it observes. And LSST is nearing completion; in the 2020s, this facility will open up the transient and faint Universe, and can be expected to have a science impact as major and as broad as SDSS.

2 The Canadian Context and Major Programs

Canada has a history of leadership in wide field optical astronomy, originally facilitated, in most part, by our founding role in what was the largest optical facility capable of truly wide field observations, the Canada-France-Hawaii Telescope (CFHT). This role has been substantively augmented by the decision of the Canadian Astronomy Data Centre to provide detailed science ready data products for that telescope. Leadership in CFHT allowed Canadians to conduct the first of the 4m-class legacy imaging surveys, the CFHTLS using the MegaCam wide field camera, and also to access one of the first multi-object spectroscopic instruments, MOS. These have had lasting impact in the astronomy community, providing some of the most accurate SNe cosmology results and the first cluster redshift surveys. In imaging, the advent of Blanco/DECAM and especially Subaru/HSC, means that the MegaCam wide field camera is no longer the best of its type in the world, although it retains an important niche with u-band sensitivity. Further, easy access to its data products through CADC access points has added significant legacy value to this instrument. For MOS, Canada has not had any national access to a major survey instrument for more than 20 years.

Canada remains active in wide field optical astronomy and several current initiatives require highlighting:

- **The Uv-NIr-Optical Northern Survey (UNIONS)**: The Canada-France Imaging Survey (CFIS) is a current Large Program on CFHT that is obtaining deep u-band imaging over 10,000 square degrees (away from the Galactic plane and at declination greater than zero) and deep r band imaging over nearly 5000 square degrees (away from the Galactic plane and at declination greater than 30 degrees). In these regions of sky, it is unlikely that the combination of depth and area will be surpassed in the coming decade or more (LSST has poor response in the u bands when it observes at declination greater than 0 degrees, and it cannot observe any bands at declinations greater than approximately 30 degrees). In the past few years, the PanSTARRS consortium has signed an MoU with CFIS. The two PanSTARRS telescopes are obtaining equivalently deep imaging in the i-band and somewhat shallower imaging in z over the same footprint as CFIS-r. Through the Hawaii TAC, and Subaru exchange time in Canada, members of these consortia are also obtaining equivalently deep g-band imaging in the same area. Finally and most recently, a Japanese-based collaboration is applying for a new Subaru Large Program to obtain the complementary z-band imaging to the necessary depth. This entire multi-national collaboration, in which Canada is a leader, is called UNIONS, and by the early 2020s will have amassed the deepest and widest $ugriz$ survey of the northern sky, which will likely be unsurpassed as the go-to reference survey for the northern hemisphere. The UNIONS data are being served to the entire Canadian community through the CADC/CANFAR project: http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/community/cfis/csky.html

- **Euclid**: As a result of the CFIS survey ($u + r$ bands), Canada negotiated an MoU with Euclid, in which over 20 Canadian faculty became full members of the Euclid consortium. A call was issued to the CASCA exploder notifying everyone of this opportunity, and all faculty-level astronomers who wanted to join Euclid joined Euclid. Thus, while Canada is a late-comer to the project, Canadians have the same scientific opportunities for the exploitation of Euclid data as anyone else in the consortium. There has also been some interest in the past decade in Canadian involvement in WFIRST, but this has not developed into any hardware contributions or data access. *Please refer to the Euclid White Paper, Percival et al., for more details.*

- **LSST and HSC**: LSST will dominate ground-based optical imaging surveys come the start of survey operations in 2022, and will likely have major impacts on nearly all areas of astronomy, from the Solar System through to Dark Energy. Just now, HSC on Subaru is arguably the best imager in the world. Initiatives are underway in Canada to get access to both LSST in the south and HSC (and all the other Subaru instruments) in the north. *Please refer to the Subaru White paper, Balogh et al., and the LSST White Papers, Hložek et al., and Fraser et al., for more details.*

- **MSE**: The Maunakea Spectroscopic Explorer (MSE) is a Canadian initiative to build a 10m class fully dedicated spectroscopic telescope within the current three dimensional footprint of the CFHT. Major reports in the US, ESO, and elsewhere, all recognise the capabilities of MSE as an essential missing component of future wide field astronomy. Thanks in large parts to Canadian astronomers, MSE is currently the most advanced design of this type of facility, and the CFHT Board have officially recognized it as the scientific future of CFHT. *Please refer to the MSE White Paper, Hall et al., for more details.*

- **CADC/CANFAR**: CADC have been at the forefront of astronomy data services since the mid 1980s. Through the use of services following International Virtual Observatory standards, the CADC provides uniform access to data from over a dozen facilities. The CADC's 2PB data collection is mirrored into the CANFAR science portal to allow rapid access to large volumes of data from cloud computing provisioned by Compute Canada. Indeed, in the last decade, major efforts have gone into developing the CANFAR initiative to provide a cloud computing environment for astronomy. Recently, the CIRADA project has formed and is extending the capabilities of the CANFAR science portal to serve the wide field radio astronomy community. In addition, the CADC/CANFAR are currently engaged in an ALMA Development Project (known as ARCADES) to explore extending the CANFAR science portal for use by ALMA PIs. CADC is also leading the work to provide CFIS data to Euclid, and there are current efforts to leverage CADC/CANFAR to provide a data center for LSST, which would enable Canadians to join the project. *Please refer to the Digital Research Infrastructure in Astronomy White Paper, Kavelaars et al., and the LSST-light Science Portal White Paper by Fraser et al., for more details. Also refer to the Probing Diverse Phenomena through Data-Intensive Astronomy White Paper, Rahman et al., and the Machine Learning Advantages and Canadian Astrophysics White Paper, Venn et al.*

- **CASTOR**: CASTOR is a Canadian-led initiative to build a UV wide field space telescope with a 1m aperture. It will closely match the image quality of HST in this wavelength range, but with a 0.25 sq.deg. field of view, meaning that it will have a discovery efficiency that exceeds HST by a factor of 100. The absence of significant UV capabilities in space after HST is a well appreciated problem in astronomy and CASTOR, if successful, will provide unique imaging, grism and low-resolution spectroscopic capabilities. It is also a natural complement to the NIR-optimized wide field space telescopes, Euclid and WFIRST. *Please refer to the CASTOR White Paper, Côté et al., for more details.*

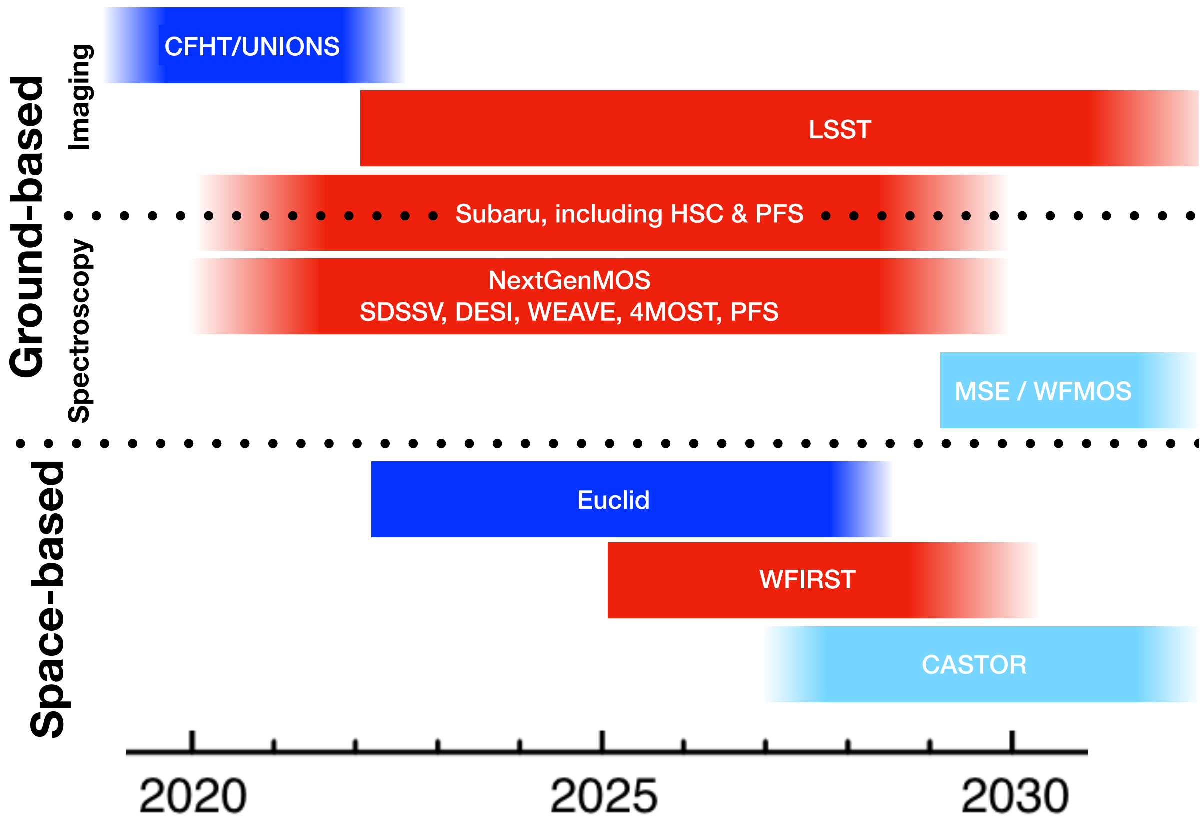

Figure 1: Timeline of wide field facilities for the 2020s and beyond. Projects/facilities with guaranteed Canadian access are shown in blue; projects of interest to Canadians but with no guaranteed access are shown in red; potential facilities with strong Canadian leadership are shown in cyan.

- **Current spectroscopic surveys**: There is no national-level participation in wide field spectroscopic surveys in Canada, and this has been the case for more than 20 years. However, the science remains of prominent interest to astronomers in Canada (e.g., the national-level participation in MSE development). Individual astronomers in Canada have been and are participants in various projects, however (e.g, SDSS-V). In addition, some Canadian members of the Pristine collaboration (a CFHT metal-poor stars project) have limited access to some upcoming WEAVE data as part of an MoU between these projects. There have also been some discussions between CFIS and DESI about data sharing, but if these come to anything it will likely only be for a limited number of participants in DESI community surveys (not the main DESI science, and not a large number of seats). *Please refer to the Spectroscopic Surveys White Paper, Bovy et al., for more details.*

3 Wide field astronomy, near and long term

The scene-setting in the previous section demonstrates the panoply of scientific and collaborative opportunities in international wide field astronomy, and the demonstrable interest in this field around Canada. Figure 1 shows the timelines of all of the major wide field facilities, instruments or surveys discussed so far. Blue indicates current or guaranteed Canadian access. Red indicates facilities that either are happening or will happen, but for which Canada is not yet a participant. Cyan missions indicates (Canadian-led) potential facilities.

We now turn our attention to how Canadian optical wide field astronomy efforts can develop in the short and long term, to ensure that Canadians enjoy a world-leading and scientifically productive wide field astronomy platform for the 2020s and beyond. To this end, many of the main advocates in Canada for these projects are authors on this White Paper. A subset of authors formed the organising committee for ”Wide field astronomy in Canada”, a community meeting held at the Perimeter Institute in Waterloo in October 2018 (a summary of which was published in *McConnachie et al. 2019, Nature Ast., 3, 121*) at which the idea for this white paper was seeded.

In these considerations, we recognise the following:

1. Wide field optical astronomy does not exist in a vacuum. Rather, in addition to extensive stand-alone scientific opportunities, wide field platforms can provide a feeder for narrower-field facilities, most prominently Gemini and a Canadian VLOT, and complement observations at other wavelengths. As such, it is advantageous for Canada's major facilities to have significant overlaps in sky coverage. The main focal point for Canadian ground-based optical astronomy is currently on Maunakea; it is important to realise that from this ”equatorial” site (latitude 19 degrees), more than half of the southern sky can be observed at good airmass. This ensures good overlap with Canada's major facilities at longer wavelengths (ALMA and, in the future, SKA), and also with LSST, which will be a defining international wide field facility for the 2020s.

2. An area that unites (multi-wavelength) wide field astronomy is data. From a science-user perspective, developing a coherent platform of wide field facilities is only worthwhile if scientific data taken by that platform can be readily accessed, combined and analysed. CADC/CANFAR is already independently providing a framework within Canada for astronomical data analysis, and we envision a future where Gaia, CFHT (UNIONS), SDSS, PanSTARRS, Euclid, LSST, SKA and other data sets can be (virtually) stored and analysed together. It is also important to stress that the skills and resources of CADC/CANFAR is one of the main reasons that Canada is a sought-after collaborator on the national level in wide field astronomy, despite our lack of leadership in any major new observing facility over the past decade or so.

3. Most wide-field astronomy is now driven by long-term, large-team, international projects. Impactful participation in such projects is enabled by stable funding opportunities that can cover both salary for postdoctoral researchers and survey buy-in costs not covered by in-kind contributions. Such funding opportunities do not generally exist in Canada, but the existence of these schemes would help Canada to capitalize on the scientific exploitation of this upcoming generation of wide field facilties.

4. A balanced portfolio of projects must include projects that allow *participation of a broad community to facilitate the development of the community and the training of HQP*. It should also include projects that demonstrate *Canadian leadership in the field and which set the stage for future projects with Canadian leadership*. Without the former, it is impossible to develop the latter; without the latter, there is little to differentiate Canada from the herd, and no reason that the best talent will seek to work or stay in Canada.

Figure 1 demonstrates the driving motivations for this White Paper, and that is the **absolute lack of participation in any of the emerging front-line ground-based optical wide field programs or facilities for Canada for almost the entirety of the 2020s**. Further, it demonstrates the **absolute absence of any Canadian national-level leadership in any front-line optical wide field astronomy (ground or space-based) in the 2020s**.

It is important to comment on the projects for which Canada does have guaranteed access. Euclid is a tremendous scientific opportunity for all Canadian consortium members (27 faculty-level researchers), and there are Canadians in leadership positions. However, financially, technically and in terms of the size of the consortium, Euclid is not a ”Canadian” facility. Nevertheless, it is clear from Figure 1 that Euclid *must* become a central pillar of Canadian wide-field efforts in the 2020s. As it stands, during science exploitation, Canadians have an opportunity to make major scientific contributions, but to do so effectively requires support in the form of funding for travel and postdocs. This is an immediate example of a project that requires a new funding opportunity to capitalize on the in-kind contributions that have already been negotiated by Canadian astronomers. The specific case of Euclid, and the general case of science-exploitation support for long-term projects, is an important discussion area for the LRP and the community (see the *Euclid White Paper* for more details).

For CFHT, by 2024 the telescope will be 45 years old, and MegaCam will be 21 years old. It is a testament to the Observatory, staff and user community that it is still competitive in the wide field domain. But by the early

2020s, after completing a deep legacy survey of the northern hemisphere (including exploiting its niche ability of u-band observations), and after large campaigns using niche narrow-band filters (Hα - VESTIGE; CaH&K - Pristine), and its unique wide field Fourier-Transform Spectrograph (the SIGNALS large program with SITELLE), it is currently difficult to conceive of internationally competitive programs it can conduct in the wide field arena that will sustain a national community.

Based on all of the items we have discussed, we make the following comments for consideration by the LRP and the community:

1. **Maintaining operations of CFHT in its current state should not be considered beyond the mid-2020s:** There are undoubtedly wide field observations that CFHT could conduct in the 2020s. However, as a national-scale facility, the question must be whether the facility is helping to develop and advance the community as leaders in astronomy. Will it attract the best scientists to stay in, or move to, Canada? Compared to the competition anticipated in the 2020s (the most relevant of which is shown in Figure 1), we anticipate it will be difficult to make this argument based on current expectations. Instead, we endorse the CFHT Board statement that MSE is the future of CFHT. Consequently, any events that caused CFHT to cancel MSE or delay it to a point where it would not allow Canadians to secure their leadership status in this capability, should cause the Canadian community to reevaluate the role of CFHT within its portfolio of astronomy facilities.

2. **Canada must obtain new access to a front-line ground-based wide field facility for the 2020s:** As it stands, Canada has no access to any leading ground-based large aperture wide field optical facility for most of the 2020s, for either imaging or spectroscopy. This lack of *participation*, let alone leadership, is worrying. This is occurring at a time when there is a vast number of new facilities and capabilities in operation, including LSST, dedicated MOS on 4m telescopes, and 8m MOS instruments. The obvious consequence of this lack of national participation will be a decline in Canada's standing in all of the related fields of research, especially through an inability to attract, or keep, the best students and faculty.

   There are three non-mutually exclusive actions that Canada can take to fill this critical gap in capabilities: (i) join one of the upcoming dedicated MOS surveys (ii) join Subaru, (iii) join LSST. We note that each of these three actions are quite different in terms of the nature of the collaborations. Perhaps most importantly, wide field MOS surveys and LSST are pre-defined surveys; the observations and data products are already largely defined and free to all members. This has tremendous advantages in terms of enabling broad participation within a community. In contrast, Subaru is an Observatory, and a large part of what we will do with Subaru is entirely in our hands (including enabling community-driven surveys). This has tremendous advantages in terms of empowering "scientific self-determination". Critically, these different actions are not in competition:

   - **Action (i) - Join a dedicated MOS survey**: There are actually limited opportunities in this arena, since WEAVE, 4MOST and DESI are all fully funded and imminent. SDSS-V is likely more feasible since it has a partnership model that encourages group buy-in (e.g., a Canadian participation group) at various stages. Similarly for the PFS strategic survey, although here a participation group of 10 faculty will cost around USD5M. *We refer to the Spectroscopic Surveys White Paper for more details.*
   - **Action (ii) - Join Subaru**: As a general purpose facility, multiple instruments are available on Subaru, not just wide-field. We refer to the *Subaru White Paper* for more details. A key appeal of Subaru is access to PFS, given the Canadian interest in MSE but the absence of any current national MOS capability. Much of the Subaru telescope time will be committed to the PFS Strategic Survey, and it should be a point for negotiation with Subaru that Canadians are able to benefit from these data (it is our understanding that the PFS Strategic Survey is being given special status, such that new partners in Subaru may not be allowed to participate in it). If Canada were to join Subaru, this may remove the need for Canada to join one of the dedicated MOS surveys (Action i) at a national level, at least with reference to the argument of needing access to wide field MOS in preparation for MSE.

Initially at least, joining the Subaru partnership will need ”new money”; the alternative would be to abandon successful collaborations in order to re-purpose the money. However, the recent Gemini assessment indicated strong interest in staying part of Gemini in the medium term (and there are numerous exciting developments occurring at Gemini right now, e.g., GNAOI), and large segments of the wide-field community are engaged in CFIS and MSE development on CFHT. Should the Subaru collaboration prove a success, however, then it would be seem sensible to reevaluate Canadian participation in our multi-instrument observatories at some future appropriate assessment point.

- **Action (iii) - LSST**: This leads us to our next major comment.

3. **CADC/CANFAR should be supported in its continued drive to become a major data hub and science portal for the wide field astronomy datasets of the 2020s:** The LSST survey project is now seeking ‘in-kind’ contributions to enable membership in the LSST survey. These contributions are sought to off-set operational costs for the project so that the LSST can expand the level of services offered beyond basic survey operations. We stress that LSST is likely to be the defining ground-based optical facility of the 2020s, and access to LSST data can only have a positive impact on our national astronomy community. CADC is well placed to provide a public data access portal for LSST by leveraging their existing infrastructure and data handling expertise. Provisioning of a multi-peta-byte data archive facility (see the *Canadian Participation in the LSST White Paper*) is seen as valuable and substantial contribution by the LSST operations leadership. Provisioning of bytes is, however, insufficient for Canadians to fully exploit this dataset and the CANFAR system will need to be expanded and enhanced to enable the platform to act as an LSST Science Portal for Canadian astronomers. A combination of an LSST-Light data centre with the science platform like that proposed to CFI by Hložek et al. (*The Canadian LSST Alert Science Platform*) would provide the framework for Canadian astronomers to exploit access to the LSST survey dataset.

4. **Canadian leadership in the development of large aperture MOS should continue with the intent of securing a leadership role in the first on-sky dedicated large-aperture MOS facility:** Canada has played a significant and founding role in MSE over the past 5 years, and there is intense international interest in the facility and especially the capability. Through these efforts, Canada is positioning itself as a leader of a front-line wide field facility for the 2030s (in contrast to the situation we are in for the 2020s, see Figure 1). Given the head-start Canada has had with MSE over the past 5 years, it would be intolerable for this community-wide effort to not result in Canada securing a founding stake in the first such on-sky facility. Canada must be cognizant of emerging international competition in this arena, and must be pragmatic in pushing forward its interests. All effort should be made to ensure MSE is advanced and constructed in a timely manner.

5. **CASTOR is a unique facility and can provide Canada with a strategic scientific capability and a flagship mission for the CSA:** The European and US focus on NIR wide field space telescopes in the last decade has allowed Canadian astronomers and industry to develop a unique mission with strong scientific synergies with numerous other facilities. There is international interest in these capabilities, but it will require decisive leadership by Canada and especially CSA in the coming year to turn these opportunities into reality. CASTOR has the scientific pedigree and technical grounding required for CSA to use it as a national flagship to revitalise Canada’s flagging space astronomy portfolio.

The launch of Gaia in 2015 marked the start of a new generation of international wide field optical astronomy initiatives that, over the course of the next decade, are expected to transform our understanding of the Milky Way galaxy, the transient Universe, exoplanetary populations, the bodies of our Solar System, the growth of supermassive black holes, the nature of dark matter, the growth of galaxies at cosmic noon, the expansion of the Universe, the properties of dark energy, and many other areas of astronomy. These fields of research are of immediate interest to large numbers of Canadian astronomers, and this is a field in which Canada has been recognised as a major player. The coming decade could be an exciting one for Canada as it grows its community, competes internationally, and prepares for projects in which it will be a world leader in the 2030s. But in order to chart this course successfully requires Canada to make major decisions regarding its involvement in current facilities and its plans for participation in new facilities. This White Paper describes the steps we believe need to be considered to ensure that Canada becomes a destination for the best astronomers in this arena, and a home that those already here have no need to leave.

1: How does the proposed initiative result in fundamental or transformational advances in our understanding of the Universe?

Wide field optical astronomy has an impact on literally every field of astronomy. In the coming decade, we can expect projects described in this white paper to provide the most complete census and quantification of low mass dark matter halos surrounding our Galaxy; to provide an inventory of objects in the Solar System to exceptionally low mass; to provide the most precise measurements of cosmological parameters, especially the dark energy equation of state; to probe dark halos through weak lensing; to better characterize the growth of supermassive black holes; to explore galaxy formation at cosmic noon, and to contribute to many other scientific studies, both as stand-alone projects and in terms of coordinated multi-facility programs.

2: What are the main scientific risks and how will they be mitigated?

The primary scientific risk is that Canada fails to obtain any access to any new wide field optical astronomy capability, especially on the ground, throughout the 2020s. This will largely leave Canada as onlookers in a field in which there are many Canadian experts at a time when the international portfolio of projects has never been richer and the expectation for transformative discoveries has never been higher. The long term risk is that this resigns Canada to a second tier player, with the expectation that the best talent will not choose to work here. This white paper discusses several options for Canada to mitigate this risk, including LSST participation via CADC/CANFAR and Subaru partnership.

3: Is there the expectation of and capacity for Canadian scientific, technical or strategic leadership?

In the 2020s, Canada's primary opportunity for technical/strategic leadership will be through CADC/CANFAR and the development of a data hub and science center for the exploitation of wide field data. Euclid, LSST and Subaru all provide potential avenues for Canadian scientific leadership but all require some form of investment to maximise these chances. Continued development for CASTOR in space and large aperture wide field MOS on the ground will position Canada as leaders in the field for the 2030s.

4: Is there support from, involvement from, and coordination within the relevant Canadian community and more broadly?

Multi-wavelength wide field astronomy was the subject of the October 2018 Perimeter meeting, which attracted around 70 astronomers from around Canada. The white papers to which this white paper refers have extensive author lists demonstrating the support for the projects under discussion. This white paper attempts to bring together many of these groups to describe the status of the current portfolio of national projects, and to emphasise areas that require actions or access to new capabilities.

5: Will this program position Canadian astronomy for future opportunities and returns in 2020-2030 or beyond 2030?

Yes. Canada cannot expect to be in a position to capitalize on future opportunities in 2020-2030 if it is resigned to the role of observer for many of the main projects in the 2020s. At the same time, active participation in wide field optical astronomy in the 2020s will help develop Canada for its leadership role in wide field MOS and CASTOR in the 2030s.

6: In what ways is the cost-benefit ratio, including existing investments and future operating costs, favourable?

In the near-term, access to some of these facilities requires either in-kind contributions (e.g., LSST via CADC/CANFAR) or modest operational investment for a time-limited period (e.g., Subaru). The new investments (in kind or cash) will result in Canadians being able to participate and potentially lead major scientific programs for the 2020s.

7: What are the main programmatic risks and how will they be mitigated?

All of Canada's potential wide field optical astronomy projects for the 2020s are reliant on other partners. However, all of the immediate opportunities either exist already (e.g., Subaru), or are all at very advanced stages of construction (e.g., Euclid, LSST, etc).

8: Does the proposed initiative offer specific tangible benefits to Canadians, including but not limited to interdisciplinary research, industry opportunities, HQP training, EDI, outreach or education?

Every single one of the projects under discussion include significant HQP opportunities, as discussed in the relevant white papers. MSE and CASTOR present numerous opportunities for Canadian industrial participation.