Report of the CASCA Ground-Based Astronomy Committee (GAC): December 2016

Membership and Activities
Craig Heinke, University of Alberta (chair, 2013-2016)
John Hutchings, National Research Council (2009-2016)
Jon Willis, University of Victoria (2014-2017)
David Patton, Trent University (2016-2019)
Roland Kothes, National Research Council (2016-2019)
James Di Francesco, National Research Council (2016-2019)
Els Peeters, Western (2016-2019)
Kenneth Tapping, National Research Council (continuing member, spectrum management)

Future Facilities:

TMT:
The TMT project has faced significant challenges and decisions in the past few months, most of which are widely known. The ongoing delays in approval to build on Maunakea are leading to large funding shortfall, and the project has made a selection of an alternative site. A small committee was set up to inform and consult the community on Canada's preferences. The group was selected jointly by LRPIC and GAC, and given a detailed charge by the NRC and ACURA members of the board. The full report was used to advise the board members prior to the decision, and a summary report has been issued on the CASCA mailer and website, so we will not repeat those details.

It is clear that the community prefers Maunakea as the site, if it can be approved in a timely way. The alternative ORM site is regarded as problematic for some areas of Canadian science, and further consultation and discussion is desirable to decide what the best Canadian reaction should be. **GAC is ready to support any such consultation as required, but such consultations should be broad-based and involve LRPIC and ACURA.**

Regardless of the site, the overall funding shortfall is a major concern, so that seeking further funds or further partners needs consideration. The situation is expected to evolve considerably over the next few months. While the major construction is on hold, instrument development and review work are continuing well.

The status and future of TMT are a major issue in planning for future Canadian facilities, with no easy options available. **GAC recommends that the community be well informed and consulted as the situation evolves.**

SKA:
The SKA is continuing preparatory projects and holding meetings to discuss science plans, such as a conference in Goa in Nov. 2016, and Mauritius in May 2017.

At the SKA Board meeting in late Nov. 2016, the Board directed the SKA Office to review the existing design and to implement cost-saving measures in order to bring the SKA1 project cost back in line with the originally approved cost cap. Currently the project cost is about 35% over the 674 million Euro budget. The intention is to preserve as much of the science capability as possible - possibly re-using some of the precursor and pathfinder technologies - and to maintain the current schedule of Critical Design Reviews in late 2017, and construction start in late 2018.

This directive does not, at this point, imply a new rebaselining, but is a potential concern.

Agreement on the SKA Intergovernmental Organization (which at this point will not include Canada as a treaty member) is still envisioned for the first half of 2017 with establishment of the SKA Observatory in mid-2018.
Canadian activities and interests continue to be monitored by Science Director Bryan Gaensler, and an advisory committee.

LSST:
The Large Scale Synoptic Telescope (LSST) is an 8.4m telescope under construction on Carro Pachon in Chile. The University of Toronto has signed a memorandum of agreement with the Large Synoptic Survey Telescope Corporation (LSSTC) that provides access to LSST for a Canadian Consortium. The Consortium currently consists of fourteen confirmed LSST PIs from six Canadian institutions. The agreement allows for additional PIs at any time, and additional potential PIs are considering membership. PIs will have full access to LSST data, tools and working groups, along with up to four postdocs or students per PI.

The Dunlap Institute has committed to subsidizing up to 50% of the funding for the first ten PIs over ten years. The remaining PIs have agreed to provide full funding. Work continues on a legal agreement that would commit Canadian partner institutions to making their annual payments to the University of Toronto for the full ten years of the project, with U of T then making an overall annual payment to LSST. In addition, work is underway to set up a Canadian LSST Steering Committee to oversee the project.

Spectroscopic followup of LSST targets could be provided by facilities such as the proposed MSE, but there is no formal connection at the moment. The wide-band medium-resolution spectrograph being planned for Gemini South is designed in large part to enable rapid follow-up of transients identified by LSST.

MSE:
The Maunakea Spectroscopic Explorer (MSE) is an ongoing project which intends to replace the Canada France Hawaii Telescope (CFHT) on Maunakea with a 10m class telescope dedicated to deep- and wide-field optical spectroscopic surveys.

The current partnership includes astronomers from Australia, Canada, China, France, India, Spain, the University of Hawaii and CFHT.

The MSE project office continues to pursue energetically a range of development activities: 2016 has been marked by the release of a 300-page Detailed Science Case (DSC) which provides a detailed scientific reference for the project and features some 180 co-authors. Both the DSC and a 10-page summary document are available on astro-ph. The annual MSE All-Team meeting was held in spring this year and hosted in Madrid.

An important governance development this year has been the establishment of a MSE Management Group (MG) and Science Advisory Group (SAG). The Management Group consists of senior astronomers and executives from each partner. In the case of Canada, France and Hawaii, one of their representatives is the relevant Financial Authority from the CFHT Board. The relationship between the MG and SAG is modeled on the relationship between the CFHT Board and SAC.

Detailed development projects (systems, engineering and instrumental design) are proceeding at Universities and laboratories throughout the partner nations and institutes.
However, the overarching uncertainty facing MSE and all observatories on Maunakea, both current and future, is the path towards renegotiation and continuance of the MK site master lease (which expires at the end of 2033). To this end, the MSE project office has been instrumental in leading and resourcing the coordinated efforts of all MK observatories to engage with the people of Hawaii on this issue.

CCAT:
CCAT is a planned wide-field 25 meter telescope optimized for operations at a wavelength of 350 microns. The US partners in CCAT have been unable to obtain sufficient NSF funds to support construction, in part because of the perceived risk involved. The international CCAT team has embarked on a staged approach towards CCAT that will address the risk issues while permitting unique and exciting science: the construction of a 6 meter-class CCAT pathfinder on the CCAT site. This telescope will demonstrate the feasibility of constructing and operating a telescope at 5600 m, slightly below the summit of Cerro Chajnantor, and provide an infrastructure on which continued technology and instrumentation development can be based. This approach provides a pathway towards construction of a telescope similar to the original 25 m design hopefully within the next decade, when the funding situation and science policies in the US, Canada, and Europe might support such a project.

The baseline option for the CCAT consortium for the pathfinder telescope is a cross Dragone off-axis design, to provide a large field-of-view with a flat focal plane and an unblocked aperture and obtain a low telescope emissivity and an Airy beam pattern. This design allows for future large format focal plane instruments, particularly for cosmology and star formation/ISM studies. Thus, even the smaller telescope will be able to meet many of the original CCAT science goals. The telescope will have a sufficient surface accuracy to exploit fully the highest frequency atmospheric windows from the CCAT site at 200 μm. Pre-studies indicate that this telescope and the implementation of the necessary infrastructure at the high site has a price tag of about

$18-20M**,** which is not affordable by the present CCAT partners. The CCAT consortium is therefore working to bring on board at least one additional partner, to provide the additional $5-7M necessary. **The Canadian CCAT team has been searching for possible sources of funding to allow continued Canadian involvement in this project.**

CCAT has started two competing industry design studies which will give a firm price offer around January/February 2017. If the outcome of this study confirms the price estimate of $18-20M for the telescope and additional partners are on board with sufficient monetary commitments, CCAT will release the contracts for building the cross-Dragone design telescope by an April 2017 deadline of the German Research Foundation, DFG, and German funds will be allocated to building this telescope. A commitment by the additional partner(s) is required not later than February 2017.

If the money necessary for this pathfinder option does not become available, Cornell will not be able to contribute money for a different, less costly, and more conventional telescope. The German CCAT partners, however, supported by the MPIfR in Bonn are pursuing an alternative telescope design, a more traditional 6m-class on-axis telescope with an ~0.35-0.5 degree field of view. According to present price estimates, this design will be affordable by the money available on the German side and additional support from MPIfR. A design-to-build contract was scheduled to be issued in October/early November 2016, which will provide a fixed-price offer for this 6-m telescope in time for the April 2017 DFG deadline. DFG has agreed that an appropriate fraction of the German CCAT money can be spent on this design-to-build contract, which will have a decision point towards construction in time for the April 2017 deadline. Also in time for this deadline, the DFG expects a decision by CCAT on whether the cross-Dragone off-axis telescope will be built, in case at least one additional partner brings in the rest of the funds needed for this telescope option or whether the German funds will be spent to build the 6-m on-axis telescope. *(Thanks to Mike Fich for assistance.)*

ngVLA:
NRAO and the cm-wave radio community are discussing next-generation Very Large Array (ngVLA) concepts. These center around a 10-fold increase in collecting area from the current VLA, frequency coverage from 1.2-116 GHz, interferometric baselines up to 300 km for milli-arcsecond resolution, and a dense antenna core for high surface brightness imaging. NRAO invites participation of the scientific community via the ngVLA mailing list (https://listmgr.nrao.edu/mailman/listinfo/ngvla) and conferences and workshops, and has accepted proposals for several ngVLA Community Studies projects (see https://science.nrao.edu/futures/ngvla/ngvla-community-studies-approved-programs), several of which are led by NRC-Herzberg. The expected outcome of the Community Studies projects is a series of scientific papers and presentations at a ngVLA Science Conference to be held mid-2017, which will inform the science case for ngVLA for the 2020 US Decadal Survey. The ngVLA Science Advisory Council has been created, https://science.nrao.edu/futures/ngvla/science-advisory-council, including NRC members James di Francesco and Brenda Matthews. **Canada has a clear path to collaboration and a**

significant voice in the ngVLA, which represents an opportunity to be kept in mind in our long-term planning.

Current Facilities:

ALMA:

i) Cycle 4

ALMA Cycle 4 proposals were reviewed by the ALMA Proposal Review Committee (APRC) over the summer and proposers were notified of their grades on 08 August 2016. There were a record 1571 Cycle 4 proposals, include 27 Large Proposals, 22 mm-VLBI proposals, and 21 Target of Opportunity proposals. A total of 476 Grade A + B programs were allocated 4083.7 hours of time, leading to an oversubscription factor of 4.6. A further 231 Grade C programs were allocated 2209.8 hours of time.

There were 31 Cycle 4 proposals with 19 unique Canadian PIs, and 82 Canadians from 19 institutions were co-Is on a further 122 proposals. In terms of time, Canadian PIs or co-Is requested 3443.2 hours. Six proposals with a Canadian PI received Grade A or B and three received Grade C. Forty-four proposals with a Canadian co-I received Grade A or B, and 19 received Grade C. Canadian PI or co-I ALMA projects account for 10.8% of the time allocated for Grade A or B projects. Within North America, Canadian PI projects amount to 5.2% of the allocated Grade A, B, or C time in North America, a fraction similar to those in previous Cycles since Cycle 1. For reference, Canada contributes 7.25% of the North American operating costs of ALMA. **We recommend discussion of what can be done to improve the ALMA proposal success rate of Canada's PIs.**

After proposal acceptance, the North American ALMA Science Center, including the Millimetre Astronomy Group at NRC Herzberg, has assisted the PIs of successful projects with scheduling block (SB) implementation. In this Cycle, PIs were for the first time responsible for submitting SBs directly to the archive, and these were reviewed by NAASC staff. SB submission was completed on 15 September, and Cycle 4 observing began on 01 October.

ii) Canadian involvement in ALMA

Sean Dougherty (NRC) continued in his role as the Canadian member of the ALMA Board, and has been involved with reforming the ALMA Budget process. Douglas Scott (UBC) continued his role on the ALMA Science Advisory Committee (ASAC), and will be replaced in 2017 by Christine Wilson (McMaster). The Canadian ALMA Science Advisory Committee (CASAC) currently consists of Scott and Wilson as well as Brian McNamara (Waterloo) and Martin Houde (UWO), with participation from NRC Herzberg Millimetre Astronomy Group. The CASAC meets semi-regularly to advise NRC and the ASAC member on ALMA matters of Canadian interest.

Canadians successfully proposed for North American ALMA Development Study Project funds in 2016. The two funded projects are "Prototype of a Complete Dual-Linear 2SB Block and a Single-Polarization Balanced 2SB Block" by D. Henke et al. at NRC Herzberg, and "Cleaning up Interacting Cleaning" by E. Rosolowsky et al. at the University of Alberta. The deadlines for

Cycle 5 of ALMA Development Project and Study proposals are 30 January 2017 and 01 May 2017, respectively. ALMA Vision and Roadmap documents to guide ALMA Development proposals are available on the NRAO NAASC website as supporting documents under the current Call.

NRAO is now providing funding for American PIs to visit either NRC Herzberg in Victoria, BC, or the NAASC in Charlottesville, VA to obtain in-person data processing assistance. **We recommend a discussion as to whether Canadians want similar support.**

iii) Other news
As of October, there were 55 available antennas, with 52.6 being used on average. In Cycle 3, ~2600 hrs of time were used to complete 70-75% of Grade A or B projects, with more Grade C projects completed than expected.

An international conference celebrating "Half a Decade of ALMA" was held in 20-23 September at Indian Wells, CA, U.S.A., and was attended by eight Canadians.

As of October, there were 486 ALMA papers published, with 159 already in 2016.

Sixty Band 5 cartridges are expected to be installed by August 2017. Some test work is being done on Band 2 or Band 2+3 receiver cartridges in Europe and North America. Band 1 cartridge work is proceeding in East Asia, and a Band 1 science workshop will be held in Taipei, Taiwan on 16-18 January 2017.

JCMT:
i) Continued Canadian participation:
JCMT is now managed by the East Asian Observatory (EAO), and participation by Canada has been enabled by funds from six Canadian universities (McMaster, Alberta, Dalhousie/SMU, Lethbridge, Western, and Waterloo) and in-kind support of the JCMT archive at the CADC. The funding enables Canadians to apply for PI time and the in-kind support enables participation in JCMT Large Programs. The current agreement with EAO will end on 31 January 2017. At least three of the universities will be unable to continue contributions beyond that date. Alternative mechanisms are currently being explored. For example, members of the six universities have sent in a proposal for operations funding via a new mechanism in NSERC's RTI program. In addition, they have submitted NSERC proposals to provide the JCMT with "operationally necessary" equipment. The success of one of these proposals will enable Canadians to continue to access a modest amount of PI time. The in-kind support will continue. **We recommend that options be considered to continue Canadian access to PI time at JCMT should these proposals fail.**

ii) Large Programs:
A Call for new JCMT Large Programs (> 200 hours each) will go out soon, with proposals due on 15 March. EAO has graciously allowed Canadians to continue to participate despite the

uncertainty of funding. Canadians are involved in the current round of JCMT Large Programs, e.g., SCOPE, BISTRO, Transients, MALATANG, JINGLE, S2-COSMOS, and STUDIES. These Programs will each face a formal Mid-term Review in March, providing the Board input on their decisions on whether to let these Programs continue. The respective teams are having or planning to have team meetings around Asia, and are actively working to publish the data acquired so far. *(Thanks to Chris Wilson for assistance.)*

Gemini:
Both Gemini telescopes are functioning well, with press releases since May from a wide range of instruments (e.g. direct imaging of exoplanets with GPI and DSSI, GEMS/GSAOI resolution of young and old star clusters and distant galaxies, GRACES discovery of a newborn hot Jupiter, NIFS discovery of explosive outbursts from newly forming massive stars, GNIRS spectroscopy of a brown dwarf, studies of Io's volcanoes and atmosphere using NIRI/Altair and TEXES, and GMOS identification of dark-matter-dominated galaxies and high-redshift star-forming galaxies). The Fast Turnaround program has become quite popular, and has contributed to some of the above-mentioned results.
The new, more red-sensitive, Hamamatsu CCDs will be installed in Gemini-North's GMOS instrument in Feb. 2017, after very long delays, while maintenance on the dome shutter will take place in July 2017. In addition to the GRACES fibre link from Gemini-North to CFHT's ESPaDOnS high-resolution spectrometer, each telescope will have visitor access to a high-resolution mid-IR spectrometer (TEXES or Phoenix) and to the DSSI Speckle Camera, which can give diffraction-limited optical images of bright objects.
The next two instruments are moving forward; the Gemini High-resolution Optical SpecTrograph (GHOST) is being built by NRC-Herzberg with software design by ANU, with commissioning to be done in 2018 on Gemini-S. The wide-band medium-resolution spectrograph (Gen 4#3) selection process has been completed, and the Gemini Board is currently negotiating the contract with the selected designer. The spectrograph design will enable rapid broadband spectroscopy of newly discovered transients, and will be operational on Gemini-S when LSST begins operations in 2022.
An important near-term question that should be discussed by the Canadian community: what is our ideal proportion of time between regular programs, Fast Turnaround programs, and Large and Long programs? Should Gemini shift substantially more time to the Fast Turnaround program, and suggest this as the default for proposals asking for small amounts of time? *(Thanks to Laura Parker for assistance.)*

CFHT:
The Canada France Hawaii Telescope continues to operate as a valuable facility for Canadian astronomers. Telescope operations feature four principal instruments: Megacam, WIRCam, ESPaDOnS and Sitelle. New large programs have recently been approved and will commence in semester 2017A, they are: VESTIGE (50 nights, Megacam), CFIS (271 nights, Megacam) and the CFHT Infrared Parallax Program (60 nights, WIRCam).

Future CFHT development is focussed on the SPIRou near-infrared spectro-polarimeter and the MSE observatory project.

In November 2016, SPIRou was subject to a successful cooldown test featuring a dummy optical bench. In May 2017, the SPIRou team will report to CFHT the results of further cooldown tests with a full optical system. At this point, the CFHT SAC will recommend whether to proceed with a supplemental call for SPIRou Large Programs. A science-grade HR4G detector is expected to be delivered in late 2017/early 2018 for characterisation in Montreal prior to shipping to Hawaii and instrument integration.

MSE developments are described elsewhere in this report.

CHIME:
The CHIME (Canadian Hydrogen Intensity Mapping Experiment) telescope is under construction at DRAO. CHIME is a Canadian university project, comprising UBC, University of Toronto, and McGill University, with participation from DRAO. The majority of the capital cost of CHIME is funded by the Canada Foundation for Innovation (CFI).

CHIME was designed primarily as a cosmology experiment, aimed at measuring the distribution of red-shifted atomic hydrogen in the range $0.8 < z < 2.5$. The goal of the experiment is to detect the signature of Baryon Acoustic Oscillations (BAO) in the universe at the time when dark energy became significant in cosmic expansion. BAO-like structures have been detected in the Cosmic Microwave Background, and can be seen in the distribution of galaxies in the present-day Universe.

The CHIME telescope uses four stationary cylindrical reflectors, each 100 m long and 20 m wide, each equipped with 256 feeds to collect signals over the entire range 400 to 800 MHz. The signals are fed into a massive computing engine, based on FPGAs and Graphical Processing Units (GPUs), which will form 1000 dual-polarized beams along the meridian. Nothing moves, and the beams are swept across the sky by Earth rotation, so that the entire sky from equator to pole is mapped every 24 hours. Even with this massively parallel approach to signal acquisition, two years of data gathering will be required to detect the BAO signal, which lies beneath Galactic radio emission by a factor of 100,000. With a collecting area of 8000 square metres, CHIME is one of the biggest radio telescopes in the world. With 1000 beams it will have a large field of view. These facts prompted a Canadian group (from McGill, Toronto, and UBC, with DRAO and US partners) to request CFI funds (successfully) to add a second digital backend to search for Fast Radio Bursts (FRBs). FRBs are enigmatic events known only since 2007, single radio pulses that are so highly dispersed by intervening plasma that their origin is most likely extragalactic. CHIME is very likely to increase the detection rate of FRBs by a large factor.

Progress on the telescope is good. The CHIME Pathfinder, a smaller instrument comprising two cylinders of the same 20-m width, but only 35 m long, has been running for over a year. Data

processing methods are being tried out on the Pathfinder. Construction of the main telescope was completed in 2015. One cylinder has now been fully equipped with feeds and receivers (developed at UBC). The entire telescope has been cabled (with over 100 km of coaxial cable). Some of the analog-to-digital converters and digital processing electronics (developed at McGill) have been installed. The GPU system is under construction at the University of Toronto. DRAO has installed new power infrastructure required for CHIME, which will consume 300 kilowatts.

The CHIME-FRB development is very active. Development of innovative burst detection and de-dispersion algorithms is well advanced, and schemes for the recognition and classification of significant events are going well too. The FRB detection rate is imprecisely known because only about 25 such events have been detected worldwide; the CHIME detection rate is expected to be between a few and 50 every day. CHIME will also be a very useful telescope for pulsar discovery, pulsar timing, and other pulsar research.

The two CHIME groups together include about 40 graduate students, postdocs, professional staff, and professors. Recently this team has been joined by a research associate at DRAO to work on CHIME-FRB. The CHIME group is hiring a postdoctoral fellow to be based at DRAO to work on removing the Galactic signal from CHIME data and using those data (daily maps of the entire Northern sky measured with full polarization and 400-kHz resolution) for Galactic research.

Jansky VLA:
The JVLA, operated by the National Radio Astronomy Observatory, continues to run normally and is not a subject of divestment efforts like Arecibo, the VLBA, and Green Bank. Canadian access to JVLA observing time is secure through at least 2018 via the North American Partnership for Radio Astronomy (NAPRA). Currently the JVLA is observing the 16B semester which runs from 23 September 2016 through 23 January 2017. During this period the JVLA operates in A-configuration. The last proposal deadline was 1 August 2016 for the 17A semester, which will run from 10 February 2017 through 28 August 2017. During this time the JVLA will observe in D and C-configuration. The next proposal deadline is 1 February 2017 for the observing period from 13 September 2017 through 29 January 2018 in B-configuration. For a summary of the status of the JVLA and the instruments available for the 17B semester, please consult: https://science.nrao.edu/facilities/vla/docs/manuals/oss

The JVLA has decided to commit substantial resources to a VLA Sky Survey (VLASS). From the NRAO website: “The VLASS will consist of a survey of the entire sky visible to the VLA (34000 square degrees) in three epochs, each epoch reaching a flux density limit of 0.12mJy at 3GHz. The survey will have a resolution of 2.5" and be carried out in the S-band of the VLA in B configuration. The survey will cover the range 2-4GHz (less some excisions due to RFI) and be carried out in full polarization. Observations will be spread out over seven years (six cycles of the B configuration) to both minimize the impact on PI science and to deliver a long time baseline for studies of transients and variability.” A pilot survey, covering 2400 square degrees, has been allocated 200 hours, and test observations began in June.

Arecibo:
The Arecibo Observatory continues operating at normal capacity, with most of its time in open-skies mode, but its funding forecast is poor. The US National Science Foundation has taken several steps towards divesting its funding support for Arecibo, which is currently 8.1 million USD, split between AST and Atmospheric and Geospace Sciences (AGS), with the other 4 million USD from NASA, supporting planetary and asteroid radar. Although NSF's preferred path forward is to transfer some or all funding costs of the observatory to other entities, NSF is also preparing to shut down and possibly deconstruct the Observatory, and restore the site, should an alternative funding solution not be found. Although drastic, this path would follow the recommendations of the astronomical community, as voiced in the 2012 US Astronomy Portfolio Review Committee and 2016 Midterm Assessment of the Decadal Survey. Furthermore, a 2016 review of NSF's AGS division recommended a 75% reduction in the AGS portion of NSF's contribution (from $4.1 million to $1.1 million) to Arecibo operations. (See https://www.aip.org/fyi/2016/nsf-decide-fate-arecibo-june-2017-green-bank-winter-2017-18)

In May 2016, the NSF began the development of an Environmental Impact Statement (EIS) covering possible future plans for Arecibo, including continued operation, mothballing, conversion to an educational facility, or (partial or) complete deconstruction and restoration of the site (the last option has been estimated to cost of order 100 million USD). The draft EIS was released in October (see https://www.nsf.gov/mps/ast/env_impact_reviews/env_rev_arecibo.jsp), and is open for comments until December 12, 2016. This draft EIS suggests saving costs by turning off the planetary radar system, while maintaining astrophysical observations, as one means towards identifying a path towards continued operations, though this would cast continued NASA funding into doubt. The final EIS will be published in summer 2017.

In September 2016, the NSF gave notice (https://www.nsf.gov/pubs/2016/nsf16144/nsf16144.jsp) that they will solicit the submission of proposals to operate, or help to operate, Arecibo in early 2017. The current operating agreement for Arecibo has been extended to March 31, 2018, after which time it appears Arecibo will transfer to a new ownership model or, more likely, close. Although Arecibo is currently a major part of pulsar timing projects with Canadian involvement such as NANOGRAV (a search for low-frequency gravitational waves), it is possible that the new 500-m radio telescope FAST in China can fill this niche.

Long Baseline Observatory (LBO):
The NSF is also seeking to divest from the LBO (formerly the Very Long Baseline Array), which has been separated from the National Radio Astronomy Observatory. The NSF is providing reduced funding for the LBO through September 2018, and expects to provide diminished funding for five years after that. The LBO has succeeded in attracting financial support from the US Naval Observatory, which has purchased half of LBO time to perform repeated accurate astrometry of reference quasars, allowing careful measurement of the motion of the North American crust. The 2017A call for proposals for the LBO (a call still issued and run by NRAO,

continuing to offer joint VLBI observations of the LBO with other telescopes as part of the High Sensitivity Array) thus offered substantially fewer open-time hours than previous calls, due to the transfer of time to the US Naval Observatory. In particular, joint time with the Green Bank Telescope in 2017A is substantially reduced as the GBO is also transitioning to a new funding model. The LBO's future prospects are better than Arecibo's or Green Bank's, due to the LBO's success in attracting other funding, which is good news for its Canadian user base (who use it to measure parallaxes, study jets from X-ray binaries, study expanding supernova remnants in other galaxies, etc.).
An NSF summary of the divestment process on Oct. 31, 2016 indicated the LBO's situation as "green" (along with several Kitt Peak optical telescopes), suggesting that a favorable solution for continued operations with funding from other partners is on track, while Arecibo and Green Bank were coded "yellow", and the McMath-Pierce Solar Observatory at Kitt Peak, which has no obvious partner opportunities, was coded "red", suggesting that closure is imminent. (http://sites.nationalacademies.org/cs/groups/bpasite/documents/webpage/bpa_175046.pdf)

Green Bank Observatory (GBO):
Finally, the NSF is seeking to divest from the Green Bank Telescope, which has separated from NRAO this year as the Green Bank Observatory. The NSF suggests that it may be able to provide 35% funding support in the future (currently it provides 60% of funding support). GBO has attracted a range of partners to purchase chunks of its time; Yuri Milner's Breakthrough Listen (2 million USD/year for 5 years, or ~18%), West Virginia University, NANOGRAV (a North American consortium using pulsar timing to search for low-frequency gravitational waves, 5%), and RadioAstron (a Russian radio telescope in orbit, which participates in very-long-baseline interferometry); see e.g. http://greenbankobservatory.org/science/nsf-open-skies/ . As for Arecibo, the NSF has begun (in October 2016) the process of designing an Environmental Impact Statement for GBO, addressing possible future scenarios including partner sharing, mothballing, and deconstruction (https://www.aip.org/fyi/2016/nsf-decide-fate-arecibo-june-2017-green-bank-winter-2017-18).
The GBO's future is less secure than the LBO's, but the diverse range of partners gives it a better outlook than Arecibo. **As the GBO has a diverse Canadian user base, we suggest beginning consideration of a possible future Canadian purchase of time on GBO, especially if the NSF eventually chooses to eliminate its Open Skies observing policy (not imminent, but a definite potential on the horizon).**

SOFIA:
We are currently in the nominal cycle 4 observing period which runs from Feb.1, 2016 to January 31, 2017. Program operations continue to ramp up with increasing annual flights and research hours. Cycle 4 included a successful southern deployment with instruments GREAT, FIFI-LS, and FORCAST (and completed 19 of 25 planned science flights from New Zealand). The GREAT instrument was upgraded to include two new receivers (upGREAT) in 2015 and 2016. upGREAT has already produced impressive maps in [CII] and [OI] (e.g. Horsehead Nebula). Cycle 4 has suffered Research Hour impacts due to flight cancellations (aircraft issues) and flight schedule changes driven by HAWC+ technical issues; four additional flights are

scheduled to achieve 80% of the anticipated cycle 4 Research Hours. The second series of commissioning as well as science flights for HAWC+ are currently in progress.

The Cycle 5 call for proposals was issued on April 29, 2016 with a US proposal deadline of July 1, 2016 and a German proposal deadline of July 8, 2016. The submitted proposals were reviewed on Aug 17-19, 2016 (US) and Sept. 1-2, 2016 (Germany) and selections were announced on Oct. 24, 2016. A total of 205 proposals have been received (US: 179; Germany: 26) for a total of 1970 requested hours. The total number of hours awarded is 535, leading to an oversubscription rate of ~3.7. An additional 36 hrs are carried over from the highest rated cycle 4 programs. After proposal acceptance, SOFIA staff have assisted successful PIs with their phase II observing planning. The nominal Cycle 5 observing period runs from 1 Feb 2017 to 31 January 2018. Cycle 5 will include a southern deployment with three instruments (upGREAT, FIFI-LS, and FORCAST) and will support the Triton occultation event on 5 October 2017.

Future Instruments:
The High Resolution Mid-Infrared Spectrometer (HIRMES, PI: Harvey Mosley, NASA/Goddard) was selected as the 3rd Generation Instrument. It covers the wavelength range from 25 to 122 μm in four spectroscopic modes with spectral resolution between 600 and 100,000. First flights with HIRMES are anticipated to occur in spring 2019.
To ensure continued development of science instruments at a rapid pace, a 4th generation science instrument call is being planned for 2017 and is anticipated to be issued through NASA-ROSES in the 1st half of 2017.

DRAO:
The Dominion Radio Astrophysical Observatory (DRAO) operates several observing facilities: the Synthesis Telescope (ST), a 7-element aperture synthesis array; the 26-m single-antenna John A. Galt Telescope; the 10.7cm solar radio flux monitor; and nearing completion is a "next-generation" solar radio flux monitor.

The ST is capable of simultaneous observations at 1420MHz and 408MHz. It offers wide-field continuum polarimetry and neutral hydrogen spectroscopy at the former frequency (1' resolution over a 2-degree field), and continuum total intensity only at the latter (3' resolution over a 6-degree field). Telescope time is allocated via a competitive, peer-reviewed process, with deadlines at both equinoxes each year. Both short-term and long-term proposals are undertaken, with past projects ranging from targets of opportunity to surveys aimed at wide sky coverage or deep integrations. Although best-known for its work on the Galactic ISM, in particular the Canadian Galactic Plane Survey (CGPS), the ST is also used for targets from solar system to nearby galaxies. The telescope continues to be fully subscribed with projects for observers at Canadian universities, including graduate students, and also internationally.

The John A. Galt Telescope is also open to external users via peer-reviewed proposals, but there are no proposal deadlines for this instrument, and the dominant use is long-term projects.

The telescope has been used to observe in various bands from 400MHz to 8GHz, but the majority of experiments focus on neutral hydrogen spectroscopy at 1.4GHz. That said, the Galt telescope is currently fitted with a receiver covering the 400-800MHz band and is dedicated to calibration work related to the CHIME telescope presently under construction on the DRAO site. Once that work is done the Galt telescope will be upgraded to use a new cryogenic L-band receiver acquired from EMSS, who is providing similar receivers for the MeerKAT telescope in South Africa. Once commissioned, this receiver will be used to make exacting polarization measurements in a survey to learn about cosmic magnetic fields via the Zeeman effect in neutral hydrogen.

Solar radio monitoring is also flourishing at DRAO, with the long-running Solar Radio Flux Monitor experiment - operated in partnership with NRCan - continuing to provide thrice-daily measurements of the 10.7cm (2.8GHz) radio flux to the space environment community. Most non-mechanical systems of the two redundant telescopes are in the throes of an upgrade. So far the old Windows XP control computers are being replaced with Linux-based ones, with new digital I/O modules. Upgrades to the signal path components will be proceeding over the next year. The "next-generation" instrument is nearly complete, and is now making regular flux measurements at 2.8GHz that compare well with the existing flux monitors, as well as thus-far uncalibrated ones at additional frequencies of 1.4, 1.7, 3.3, 5.0, and 8.3GHz. Work on calibration horns for those frequencies is progressing well. Note that the solar monitors are not available for external use, as they are dedicated, single-purpose instruments. *(Thanks to Andrew Gray.)*