**GAC Report as Dec 12 2020**

**Gemini**

After COVID-19 related closures, science operations at Gemini North resumed on May 19th, and Gemini South returned to nighttime operations in the second half of October. Notable examples of publications with Gemini instruments and Canadian involvement that have been announced in the meantime include: 1) discovery of a giant planet orbiting a white dwarf, where GNRIS was used to confirm that the planet is extremely cool and intact (Nature), 2) GPI polarimetric imaging of debris disks around 26 young stars, majority of which display evidence of planet formation (ApJ). A major update on the instrument development is related to the Canadian-led project: 5.1M USD of the Observatory's instrument development funds (IDF) have been allocated to the development and construction of GIRMOS. Gemini STAC and BOD support the original scope of the instrument that includes 4 IFU arms and the BOD will consider requesting additional IDF for this purpose. At the same time, the GNAO has been rescoped into a ground-layer correction for GIRMOS. Due to the budget shortfall for SCORPIO, the instrument may lose its K-band capability. In the current instrumentation-related news, GPI is being upgraded and prepared to move to Gemini North and Flamingos-2 is off the telescope awaiting cry-cooler repairs. Dr. Sarah Gallagher has replaced Dr. Marcin Sawicki as a member of the BOD. The STAC and BOD support the plan to hold next Gemini science meeting in Seoul, Korea, in August 2021 either fully in-person or in a hybrid form.

**CCAT-p / FYST:**

Since the last report, the CCAT-p telescope has been renamed the Fred Young Submillimeter Telescope (FYST). Ground-breaking for the telescope began on Dec 1, 2020 after delays due to the Covid-19 situation. The CCAT-p collaboration is also preparing a survey and instrument document, with contributions from 8 working science groups, to be published in the new year.

**SOFIA**

(from Sarah Sadovy, with thanks to Simon Coude for the update)

Initially grounded in March due to the pandemic, SOFIA has since implemented new safety procedures to minimize the risk of COVID-19 infections within the crews and successfully resumed science flights in July with FIFI-LS and HAWC+. The plane is currently in Hamburg, Germany, for its regular maintenance period, and science operations are expected to resume in February. SOFIA was in the spotlight in October for the discovery of water on the sunlit surface of the Moon with its mid-infrared spectrocamera FORCAST.

**ALMA**

ALMA has been shut down since 18 March 2020 due to COVID-19. The observatory was closed with all antennas and receivers powerd down. The only instrument which is being powered is the master timing maser, via solar-charged batteries and a backup generator. A caretaker team remained on site to inspect the site and ensure safety and security. Employees in Santiago were in a work-from-home mode.

The Santiago offices opened for a maximum of 10 essential personnel on September 28 and with limited occupancy (max. 25) on November 9. A review for reduced occupancy (max. 50) is scheduled for Dec 11.

At the Operations Support Facility (OSF), preparations for re-occupation began October 1, with the first power generator restarted October 6, having been offline for 199 days. On October 21 limited staff moved back into the Residencia for cleaning, opening the data centre, beginning cafeteria services, and establishing stable utilities (power, water, water treatment). First re-occupancy by staff was at the end of October. Work is progressing well.

The first phase of the planned return to the high site (the Array Operations Site or AOS) is planned for December 10. The status of critical equipment other than the maser is unknown. The goal for the next phase is to recover enough antennas (10-15) so that science operations can begin a basic system checkout. There are significant technical risks remaining e.g. powering up the correlator, the central local oscillator, infrastructure such as power and water, as well as a backlog of maintenance.

If all goes according to plan, the majority of the recovery would be completed by the end of January. ALMA would then enter its normal February maintenance shutdown (weather is too poor for significant observing in January), and PI science could resume in early March 2021, after a nearly full year hiatus.

**JCMT**

The JCMT continues to be operated by the East Asian Observatory (EAO). The U.K. contributes financial support to JCMT operations as well. Canada continues to manage the JCMT archive through the Canadian Astronomy Data Centre (CADC). As a result, astronomers based at Canadian institutions continue to be eligible to lead and participate in JCMT Large Programs (>200 hours over several semesters).

JCMT ran into budget difficulties in the late summer 2020. In response, a collection of Canadian universities, astronomers, and institutions organized themselves to contribute $100,000 ($CA) to JCMT operations. As a result, Canadians can be PIs on proposals again for semesters 2021A and 2021B. The call for proposals for 2021B will be issued in February 2021.

After a 2-month COVID-19 shutdown, the JCMT reopened with fully remote night-time operations in late May 2020. The new receiver at 230 GHz, U'u, has been made available for shared risk observations in the 2020B semester.

Unfortunately, the proposal to contribute funds to build a new 850 micron camera for the JCMT was rejected by CFI.

**DAO**

(from Dave Bohlender)

For the last two quarters of 2020 the 1.2-m telescope was fully subscribed while the 1.8-m Plaskett Telescope had a subscription rate of 135%. Robotic use of both telescopes is very popular. 68% of the 1.2-m nights and 78% of the Plaskett 1.8-m nights are scheduled for this mode of operation and both telescopes have continued to operate throughout the COVID-19 pandemic. Partly because of pandemic restrictions only 22% of the time on the 1.8m was scheduled for classical spectroscopic or spectropolarimetric observations in the last two quarters of 2020.

While a thorough search of publications has not been conducted yet, we are aware of more than 60 publications (refereed and circulars) based in part on DAO telescope data so far for 2020.

Robotic operation of the Plaskett Telescope is currently only available for direct imaging observations. Robotic operation of the telescope when it is configured for spectroscopic observations is a goal but requires a significant amount of software and hardware development including target acquisition software, and fabrication of a new CCD dewar since the existing dewar used with the spectrograph is incompatible with the telescope's closed-cycle cooler.

Both telescopes are operating very reliably with a total of only 2 or 3 night lost on each since 1 July because of various problems. The most serious of these was the failure of various components of the approximately 15-year old 1.2m data acquisition computer (video card, memory) but these have been resolved and a more modern computer is being configured to replace this old system.

We are currently reviewing a proposal from Dynamic Attractions (formerly Dynamic Structures) of Port Coquitlam, BC, to measure lateral loads on the Plaskett Telescope's dome wheels before continuing with efforts to refurbish or replace the 24 wheels. In the meantime we continue to operate the dome with a few temporary replacement wheels and inspect the wheels and rail regularly.

HAA staff are nearing completion of the optical design for a new direct-imaging camera for use on the Plaskett Telescope. This will make use of a 6K x 6K drift scan CCD that had been used for previous instrument development at HAA. The new camera will increase the scientific imaging field of view by a factor of approximately 4.5 and will also benefit public outreach activities since visitors will be able view real-time projections of stars, nebulae, and galaxies passing through the telescope's field of view instead of the usual static images.

When time permits we continue to add locally stored DAO spectra and images to the CADC's DAO archive after correcting and enhancing FITS header content. At the time of writing Plaskett Telescope datasets from 2000 are being added to the pubic archive. In recent months this effort has been curtailed somewhat as we invest some time into creating a similar archive for the David Dunlap Observatory.

Unfortunately COVID-19 restrictions have meant that public outreach activities at the Plaskett telescope and Centre of the Universe conducted by the Friends of the DAO (FDAO) with the support of RASC Victoria members continue to be suspended.

Finally, in September an external review panel met with DAO Telescope and management staff via Zoom for a virtual tour of the two DAO telescopes as part of NRC's review of all of their research facilities. The committee's assessment of the facilities was received recently and our hope is that the panel's assessments will provide us with ammunition for us to receive more support from the NRC for a refresh of the ageing spectrographs and detectors of both DAO telescopes.

Thanks to M. Balough

**TMT**

In response to the initial planning proposal for the US Extremely Large Telescope Program (submitted in May), the National Science Foundation (NSF) announced the initiation of an informal outreach process to engage stakeholders interested in the Thirty Meter Telescope (TMT). If, following their consultation process, they decide to proceed, it will trigger a process to complete an Environmental Impact Statement, including the important Section 106 process of the National Historical Protection Act. The prospect of this type of review led by a respected organization is having a positive impact and, as it progresses, will shed light on the future prospects for TMT and astronomy in general in Hawaii. Engagement of the NSF will also likely have an impact on partner shares and the governance model. The outcome of the Astro2020 planning exercise, expected mid-2020, will be another key milestone for the project. More details on this and more are available in the CATAC report.

**SKA**

The ACURA Advisory Council of the SKA (AACS) will produce reports to the CASCA Board on the same schedule as the GAC. For the latest international developments and the status of the SKA project in Canada, please look for the latest AACS report at:

https://casca.ca/?page_id=11242

(Many thanks to Kristine Spekkens for this update.)

**ngVLA**

The US National Science Foundation has continued to support the design and development of the ngVLA concept by recently providing US$10M to the project for work on key subsystems like antennas, electronic and computing. An ngVLA Project Office is also in the process of being formed, so design and development can be more formally guided. Meanwhile, the project recently had five conceptual design studies for the ngVLA 18-m antenna completed, which has led to four concepts that meet key requirements in different ways. Accordingly, the project has put out an RFP for the final design and prototype of the 18-m antenna, with proposals due in early December. (HAA is presently working with Calian, Advanced Technologies in Saskatoon, SK (formerly SED Systems) on a proposal based on DRAO's composite antenna technology.) A award of the antenna downselect should be made by April 2021. On the science side, the project has released a notional "Envelope Observing Program" to guide operational and design planning, a prediction for community use of the ngVLA based on the science use cases including 8330 hours of available time over a year. Also, the ngVLA project supported various online meetings, some technical, such as last July's NARSM 2020 conference and the upcoming large SPIE AT&I meeting, and some science-focused like last July's "Compact Objects in the Multi-Messenger Era" meeting and this December's "Five years after HL Tau" meeting . Also, the project ran a very successful Summer Short Talk Series over this past summer, where every week an expert from an astronomy subfield gave an ngVLA-themed 30-minute presentation online to ~150-450 participants. The ngVLA Science Advisory Committee continues to explore continued community engagement with new initiatives. Scientific or technical collaboration within the ngVLA project is still welcomed and members of the Canadian community are encouraged to become more involved!

(Many thanks to James Di Francesco for this update.)

**CHIME**

CHIME has three major thrusts---the investigation of cosmic expansion that motivated its construction, the study of Fast Radio Bursts, and the study of pulsars. To this has been added Galactic foreground science, development of a dedicated data-processing pipeline for HI absorbers, and development of algorithms for searching for slow pulsars. Steady progress is being made on all fronts by the group of approximately fifty scientists involved in the three consortia. The cross-Canada, and now international, teams working on these fronts collaborate through many ZOOM sessions. Operational efficiency of CHIME is now high, with science runs of duration several months, interspersed with upgrade campaigns where software improvements are installed and tested. A roster of individuals from the cosmology and FRB-pulsar groups serve as "data tsars", remotely checking operation and data quality.

CHIME operates unattended, and continues full operation through the COVID-19 pandemic. This is possible because software and hardware were designed to enable remote scrutiny of key parameters and diagnosis of problems. CHIME has been operating for more than 90% of days from May to November 2020.

The key to success with the cosmological goals is precise characterization of the telescope, in particular the properties of antenna beams and the stability of the signal path with temperature. Real progress has been made on beam modelling and measurement, through interferometric beam mapping using the DRAO John A. Galt 26-m Telescope as a reference antenna, through beam measurements using the Sun, and through improved fitting techniques to data. There is continuous improvement in map-making algorithms. All-sky images are regularly produced from about 100 night-time sky transits. Innovations introduced in recent months include real-time calibration on a 10-second cadence, and improved RFI excision. A major step in efficiency has been gained through software-controlled mapping of frequency channels to GPUs: frequency channels rendered unusable by RFI can now be assigned to GPUs that require maintenance.

Fast Radio Bursts are energetic millisecond transients, arising at cosmological distances. Since July 2018, CHIME/FRB has detected over one thousand events, placing CHIME as the undisputed world leader in FRB detection. Four papers from CHIME/FRB were published in 2019, and eight have been published in 2020 or are in press. Three papers from CHIME/pulsar were published in 2020. Recording of baseband data from detected FRBs now enables improved positional accuracy and determination of Rotation Measures. CHIME/FRB has published details of seventeen repeating FRBs, a small fraction of the FRB population. Repeating FRBs can be studied with other telescopes to provide precise locations in order to identify host galaxies. Location of one of these repeaters (using long-baseline interferometry) to a galaxy at the relatively close distance of 154 Mpc has been reported in Nature. A periodicity of about 16.3 days has been detected in the probability of receiving bursts from this FRB, also reported in Nature. An extremely powerful burst from a Galactic magnetar was detected in the sidelobes, 20 degrees from the main CHIME beam. This burst strongly resembles other FRB events, implying that some FRBs may originate in magnetars in external galaxies. A catalog paper, giving details of events recorded over a period of one year, is nearing completion. This is the first large sample of FRBs, measured with one instrument with uniform selection criteria. An important aspect of the work is calibration through injection of simulated events into the detection pipeline to shed light on selection biases.

The CHIME/FRB Consortium has obtained funds to build outrigger telescopes with the purpose of localizing bursts to high precision. Long-baseline interferometry techniques will be used between the main CHIME instrument and the outriggers to provide sub-arcsecond localizations. The remote receiver will be triggered by the detection of an FRB at CHIME. This has been successfully demonstrated between CHIME and the CHIME Pathfinder at DRAO. While this baseline, about 450 m, does not provide interesting angular resolution, the experiment has demonstrated the viability of the technique, and the equipment stands ready to be deployed to more distant sites. The CHIME Outrigger VLBI system will be calibrated with pulsars. Time has been allocated on the US VLBA for a large program to establish positions for several hundred pulsars.

Three outriggers are planned. The first outrigger will be 90 km west of DRAO. The antenna

structure has been designed and fabrication of receivers is underway. Construction is planned for Spring, 2021, with operation by the Fall of that year. A postdoctoral fellow is now working at DRAO on outrigger operations and science data.

(Many thanks to Tom Landecker for this update.)

**JVLA**

The JVLA, operated by the National Radio Astronomy Observatory, continues normal operation. The array is in the A configuration for the duration of the 2020B semester through at least 2021 Feb 15. The next proposal deadline is 2021 Feb 01 for the 2021B semester, which will span 2021 Sep 08 through 2022 Jan 17 and include only the B configuration.

The VLA Sky Survey has completed first-epoch observations of the entire sky north of declination -40 degrees. The second epoch of VLASS observations began in the summer of 2020. The Canadian Initiative for Radio Astronomy Data Analysis (CIRADA) project has produced source catalogs from the VLASS Epoch 1 Quick Look images, available from www.cirada.ca/catalogues (Gordon et al. 2020). They are also now serving cutouts of VLASS QL images from cutouts.cirada.ca.

**DRAO**

COVID-19 update: most staff are still teleworking, so modified operations continue. The Galt Telescope remains stowed at present, pending mechanical maintenance to ensure it is ready for winter operations, with plans being developed to resume observing before the end of the calendar year. Upgrades to the telescope are continuing throughout this period. The Synthesis Telescope is operating normally, with staff required on site only for maintenance activities and array reconfigurations, which are carried out as needed without schedule disruptions. The solar telescopes are also operating normally.

Galt Telescope: the Galt Telescope is a 26-m single-antenna telescope with interchangeable receivers. At present it is equipped with a 400-800 MHz receiver to support the CHIME project, which processes the signals using their own back-end. A new spectropolarimeter will be commissioned over the winter and a cryogenic wideband receiver covering 900-1800 MHz should be installed by summer 2021.

Other than CHIME operations, the telescope is currently in an upgrade cycle, aimed at equipping it with a cryogenic wideband receiver (900-1800 MHz) and modern spectro-polarimeter for Zeeman studies. The latest development is that test mounting of the new focus box was successfully carried out on Nov 20.

Solar Telescopes: the Solar Flux Monitor program (SFM) at DRAO records and distributes the F10.7 solar activity index used worldwide. The primary instrument employs redundant 2-m

antennas (FM1 and FM2) to measure the solar radio emission at 2.8 GHz (10.7 cm wavelength), with carefully calibrated measurements made thrice daily and distributed to the data service. This system is undergoing upgrades to modernize the telescope control and data acquisition systems. FM2 is performing well on the updated linux/software-defined-radio system, with plans to roll out the same upgrades to FM1 starting before the end of the calendar year. This will remove the last of the antiquated software and hardware in this signal path of this system.

The Next-Generation Solar Flux Monitor (NGSFM aka FM3) is a single 4-m antenna with a wideband feed and receiver system that records data at 1.4, 1.6, 2.8, 3.3, 4.9, and 8.3 GHz. Pointing measurements---which must span the range of solar declinations and thus take 6 months to acquire---have been obtained and a pointing model implemented, with good results, however horn calibrations are still required to get accurate flux measurements. These cannot be completed before next Spring now, as the Sun is too low in the sky now and ground radiation would complicate interpretation of the results.

Synthesis Telescope: the Synthesis Telescope (ST) uses seven 9-m antennas in an interferometric array operating at 408 and 1420 MHz, with a 256-channel spectrometer measuring the HI line.

The NRC Small Teams project to upgrade the ST and explore new technologies---known as the Advanced Radio Telescope Test Array, 4-Antenna, or ARTTA-4---is progressing well. It has been six months since the kick-off, and science requirements have been written to drive the engineering, with various elements of the new hardware being worked on by the engineering teams, ranging from focus-box mechanical design to digital systems. Changes to the telescope are not expected for another 18 months, so operations are nominally continuing as before for now.

Site Backup Generator Upgrade Project: the site generator is being updated and upgraded, to provide reliable power to more areas of the site. This will include the Blockhouse, which is the hub of operations for the Synthesis Telescope and also houses the FM3 control systems and provides power to the FM3 antenna. FM1 and FM2 already have reliable power in the Solar Hut, but once it is available in the Blockhouse the control systems will be moved there and the Solar Hut decommissioned, leaving only the antennas in place at that location. FM3 will be moved to reliable power, so that all solar operations will be uninterrupted by power outages. ST control systems will also move to reliable power (they are currently on a UPS with ~20min run time), although the antennas themselves will still go down in a power outage. This change should nonetheless aid in rapid recovery from such a situation. The Galt Telescope is already on reliable power to allow stowing should the power fail; this will not change with the new generator.

(Many thanks to Andrew Gray for this update.)

**Vera C. Rubin Observatory**

For the first ten years of operation, Vera C. Rubin Observatory will perform the Rubin Observatory Legacy Survey of Space and Time (LSST). From the Rubin Observatory news digest (see https://www.lsst.org/news/digest/21oct2020 for more information): "Limited construction activities on Cerro Pachón are continuing successfully after the Phase 1 restart on September 28th." Meanwhile, the ramp-up to operations continues with the first Operations Boot Camp held virtually on October 13-15

The participation of international partners in LSST and the associated issues around data rights for international partners are being assessed through a Contribution Evaluation Committee (CEC). The Canadian contribution was based on a few components, including a public Archive, personnel support for infrastructure work in various Science Collaborations, and the Canadian LSST Advanced Science Platform (CLASP), which was a CFI proposal led by Renée Hlozek. CLASP was to be part of the Canadian Astronomical Data Centre (CADC) and included the development of software infrastructure to process LSST data and enable science with the associated data products. The CFI proposal was unfortunately not funded, but the Canadian LSST Consortium continues to refine its in-kind contributions and will use potential direct support from institutional partners within Canada (including University of Toronto/Dunlap Institute and University of Waterloo) and an NRC-supported Public Archive for LSST to put make the case for LSST Data rights for this LRP-supported project.

**MSE**

Canadian MSE participation was evaluated as part of the LRP2020 plan. Canadian participation in MSE was denoted as “recommended but unranked” in the final LRP report. The report did express enthusiasm and recommended continued Canadian participation in MSE as the project develops. Specifically, the report states: “We recommend that Canada play a leading and substantive role in a next-generation widefield spectroscopic survey facility. Meaningful Canadian participation should be at a level of at least 20%, which will also ensure a prominent Canadian role in driving and participating in the VLOT science that will be enabled by such a facility. The best option at present is to pursue the development, design and construction of the Maunakea Spectroscopic Explorer (MSE) at the current CFHT site on Maunakea; this offers a compelling and timely science case with significant history of and potential for Canadian leadership. Should it not prove possible to transition CFHT into MSE, we recommend that Canada play a substantive leadership role in developing the MSE concept at a different site.“

Earlier this year a CFI proposal was submitted to fund prototype hardware and software development as part of the MSE preliminary design phase. Although assessed positively the proposal was not funded. There were 2 engineers and 8 scientists as Co-Is on the proposal, and the feedback was: "Although there seems to be all the expertise needed to conduct the proposed research, the committee was concerned with the balance of expertise between engineering and science; 50-50 would be better."

Kung Hee University joined the management group of MSE in October. The current management group consists of Canada, France, Hawaii, Australia, China, India, and Texas A&M University and observers NOIRLab (formerly NOAO) in the US and the UKATC, a consortium of institutions from the UK.

In August, MSE Project Manager Kei Szeto initiated plans to develop a formal system-level Preliminary Design Phase Readiness Review (PDPRR). The purpose of the review is to set work objectives for the Project Office (PO) in attaining Preliminary Design Phase readiness. After assessing the work required and PO resources available, Kei proposed an end of 2021 readiness date. The proposed readiness date is consistent with the expected timeline of current MSE participants' national funding availability.

MSE held its annual collaboration meeting virtually this year in October. The meeting consisted of telecons updating 3 topics: Design progress and partnership engagement, science instrument updates, and plans for data calibration and distribution.

**CFHT**

CFHT continues to operate under COVID-19 restrictions which means night observations are executed from HQ in Waimea. No other significant changes in the CFHT status since May 2020.

(Thanks to Adam Muzzin for the MSE and CFHT update)

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