Report of the CASCA Ground-based Astronomy Committee (GAC): December 2018

Membership and Activities

Chair: Roland Kothes, National Research Council (2016-2018, Chair 2018-2019)

James Di Francesco, National Research Council (2016-2019)
David Patton, Trent University (2016-2019)
Els Peeters, Western (2016-2019)
Ivana Damjanov, Saint Mary's (2017-2020)
Stefi Baum, University of Manitoba (2018-2021)
Adam Muzzin, York University (2018-2021)
Ken Tapping, National Research Council (continuing member)

Future facilities

TMT

The Hawai'i Supreme Court has ruled in favour of TMT in both of the cases that were before it. This is excellent news for the project and now provides the legal right to restart construction on Mauna Kea, the strongly preferred site of TMT. Protests are expected, but there is now broad support for the project among the people of Hawai'i and the local government. Work continues on the two first light instruments, WFOS and IRIS. White papers for future instrumentation ideas have been solicited and considered by the Science Advisory Committee. It is expected that a proposal will be submitted to fund multiple design studies as a result. For more detail, see the CATAC report.

SKA

The SKA project has passed several major milestones in the past six months. In South Africa, the 64-dish MeerKAT telescope (which will also form the first 64 dishes of SKA1-Mid) was inaugurated in July 2018; Canada was represented at the inauguration ceremony by Canadian SKA Directors Greg Fahlman and Bryan Gaensler, and by Canadian High Commissioner Sandra McCardell. In Australia, a full 256-element prototype of the SKA1-Low antennas has now been completed. The Australian site also now has a fully integrated hybrid power station, and is the only major observatory able to run purely on solar power. Many elements of the SKA have now completed critical design review, most notably the NRC-led Central Signal Processor package, which passed with "no action" (the only consortium to have so far received this rating). France and Spain are now members of the SKA Organisation, bringing the number of participating countries to 12. A signing ceremony is planned in early 2019 for the transition into an

intergovernmental organisation (IGO); Canada continues to plan for Associate Membership in the IGO. Each country or region will require an SKA Regional Centre (SRC) for access to SKA data; Canada has shown particular leadership in this area, with substantial joint work already undertaken by CADC, CANFAR and CIRADA to develop the required framework and specifications. The CHIME telescope has recently been named an SKA pathfinder, with a formal announcement made in late November. The SKA Office is about to release their first SKA data challenge, which will provide simulated SKA data to the community and allow teams to begin testing their algorithms and pipelines; the next international SKA science meeting will be held in Manchester in April 2019. Canadians continue to chair four of the SKA Science Working Groups, and are also active participants in the SKA Science and Engineering Advisory Committee and SKA Regional Centres Coordination Group. On the SKA Board, Michael Rupen has now replaced Greg Fahlman; Fahlman continues to serve on the SKA's Strategy and Business Development Committee. The SKA Board met in July, September and November 2018, with upcoming meetings in March and July 2019. Current focuses of the Board include overseeing governance and funding structure for the SKA Regional Centres, finalising a bridging plan between the SKA Organisation and the IGO, and developing a procurement policy for SKA construction commencing in 2020. The ACURA Advisory Council on the SKA (AACS) continues to meet regularly, and provides advice and information to the Canadian SKA Directors and members of other international SKA committees.

LSST

Construction of LSST on Cerro Pachón continues. The coating chamber is now in place on the summit and the secondary mirror system is in transit. Canadian interest in LSST remains strong, with 16 Canadian faculty currently planning to participate in LSST via membership of the Canadian LSST consortium. Six of these 16 have secured full funding for their participation, while the other ten will be seeking a 50% subsidy on membership fees from the Dunlap Institute. LSST has recently increased their membership fees by increasing the number of annual payments from 10 to 12, and by increasing the annual access fee. The Canadian LSST Consortium held a face-to-face meeting in Waterloo on October 12, 2018, at which they discussed payment options, funding sources, science focuses, approaches to the Long Range Plan, and internal governance structure for the Canadian consortium. The first annual membership payment will be due to LSST on October 1, 2019.

MSE

After completion of the Conceptual Design Review (CoDR) in January 2018, MSE is now moving forward towards a Preliminary Design Phase (PDP).

ACURA has been asked to be the signatory for Canada on a Statement of Understanding setting out rules for the PDP. That is one area where CASCA can express its support: that Canada must sign on as a PDP partner as the project progresses in parallel with prioritization in the upcoming Long Range Plan.

NOAO and Texas A&M have been granted observer status in the project, as they explore partnership options.

In November 2018 MSE released its Project Book, which is a detailed engineering description of the new observatory. It summarizes the technical status of MSE along with the science motivations and plan to progress the project forward. In total, the book is 160 pages in length with 125 contributors from the international MSE team.

Also announced was an MSE science conference to be held on Tuesday 26 - Thursday 28 February 2019 at the DoubleTree by Hilton, Tucson Reid Park, in Tucson, Arizona. The conference is co-sponsored by NOAO.

Progress on the PDP is being made in several ways. Soon after the design review, a call was issued to the astronomical community to join the MSE's international science team, with the purpose of "reaffirming" the science case, before starting the Design Reference Survey (DRS) process. Since then, the size of the science team has more than tripled: there are currently 327 members from thirty countries. Nine different Science Working Groups (SWG) have been created to focus on different areas of the MSE science case. Each SWG has two co-leads. The SWGs are the primary groups responsible for the ongoing development of the MSE Science Case and the development of the DRS. A new version of the Detailed Science Case will be published at the start of 2019, and the DRS activities will start soon thereafter.

CCAT-p

On November 1, 2018, after a successful Critical Design Review, the CCAT Board of Directors approved the expenditure of the first funds for manufacturing CCAT-prime (CCAT-p). Up until that date, all costs had been in design work. Such work will continue, as there are some details that still need to be worked out. Procurement of long-lead-time items for the telescope structure must start now, however, to meet the installation goal of mid-July 2021. The project is on track to meet this schedule that leads, after telescope commissioning and then instrument installation and commissioning, to a science observing start in 2022.

The Canadian CCAT-p team (aka CATC – the Canadian Atacama Telescope Consortium) is preparing a proposal for the next round of the CFI Infrastructure Fund, expected within a couple of months. The Canadian team has been developing planned contributions to CCAT-p. Much of the software for the facility and for its principal camera (p-Cam) will be Canadian responsibilities. Several hardware contributions are presently in conceptual design stages. This latter work includes NRC-HAA involvement through Doug Johnstone, to develop a CCAT-p commissioning camera at 350 microns.

(Thanks to Mike Fich and Doug Johnstone for kindly contributing items for this report.)

ngVLA

The ngVLA continues very active development, heading towards a submission to the US Astro2020 Decadal Survey. The US community has begun writing white papers for the Astro2020 process that are due February 9, 2019. The ngVLA Science Advisory Committee is encouraging authors of white papers that include ngVLA-related science topics. Canadians are encouraged to contribute to white papers of interest to them.

Among recent ngVLA highlights are:

- Release of the first draft of the ngVLA Science Book in June (including a number of articles featuring Canadian co-authors). The project has also identified five Key Science Goals for the ngVLA:
    - unveiling the formation of solar system analogs on terrestrial scales;
    - probing the initial conditions for planetary systems and life with astrochemistry;
    - charting the assembly, structure, and evolution of galaxies from the first billion years to the present;
    - using pulsars in the Galactic Center to make a fundamental test of gravity;
    - understanding the formation and evolution of stellar and supermassive black holes in the era of multi-messenger astronomy.
- Astrophysical Frontiers conference held in Portland in June, with a strong focus on ngVLA science, and a significant Canadian presence.
- Extension of ngVLA concept to encompass continental baselines, allowing sub-milliarcsecond imaging, potentially including one or more stations in Canada.
- Revision of ngVLA Reference Design performance estimates in October.
- ngVLA Optics Workshop held at Caltech in June, focusing on ngVLA reflector optics and feeds, with several scientists and engineers attending from NRC.
- Internal review of the full ngVLA reference design in September, with NRC the major non-NRAO presence. The current plan has NRC providing the reference design for the correlator/beamformer, and one of two reference designs for the dishes. NRC is also working with the ngVLA project to explore novel techniques for phasing the array, with the aim of avoiding the requirement for coherent clocks and frequency references for distant sites.
- A ngVLA conference entitled “Radio/Millimeter Astrophysical Frontiers in the Next Decade” to discuss science themes raised in the Astro2020 white papers will be held in Charlottesville, VA on June 25-27, 2019.

Work continues at a breakneck pace, with a substantial ngVLA presence at a Special Session of the January 2019 AAS meeting in Seattle (including a number of contributions headed by Canadian astronomers and engineers), and coordination of a number of White Papers to be submitted to the US Astro2020 Decadal Survey between Jan 7 and Feb 18, 2019. A formal external review of the ngVLA reference design is to be held in the first quarter of the coming year, with significant design effort in areas ranging from algorithmic development to dish design continuing through 2019.

The Canadian presence remains very strong, with representation on both the Scientific and Technical Advisory Committees as well as the Science Working Groups; numerous contributed articles in the ngVLA Science Book; and a major presence in the ngVLA reference design, leveraging Canada's work towards the Square Kilometre Array (SKA).

Much more detail, as well as information on how to get involved in both scientific and technical efforts, is available through the ngVLA web site: nglva.nrao.edu .

Current facilities

ALMA

Cycle 6 of Atacama Large Millimetre/submillimetre Array (ALMA) operations began on 01 October 2018. By all accounts, the transition between Cycles, typically involving new versions of operations software, went very smoothly. ALMA received another record-breaking number of proposals for the new Cycle, 1839 unique proposals in all. Some 44 of these had a Canadian PI and 239 had either a Canadian PI or co-I. The global oversubscription rates for the 12-m Array and the Atacama Compact Array (ACA) were 4.9 and 4.5, respectively, indicating that ALMA time is still in very high demand globally. The Cycle 6 proposal review was held in Tokyo in July 2018, and the panels there awarded A/B grades to 369 proposals and C grades to a further 292 proposals. Of these, Canadian PIs led ten and seven proposals, respectively. In terms of allocated time, Canadian PIs received 9.7% of the North American share, 7.1% from the 12-m Array and 13.3% from the ACA. For context, Canada contributes 7.25% annually to the North American share of ALMA operations. Globally, Canadians continue to do quite well in ALMA, with 16.2% of allocated 12-m Array time and 24.2% of allocated ACA time going to projects with a Canadian PI or co-I.

ALMA is generally getting more efficient as the observatory moves closer to steady-state Full Science operations. Cycle 5 finished only 5% shy of its goal of 4000 hours of available observing time, largely due to winter weather. Also during Cycle 5, the 12-m Array typically included more antennas than the 43 targeted. In addition, 66 antennas (50 in the 12-m Array, 12 in the ACA, and 4 in the Total Power Array) have been used simultaneously for observations for the first time this fall for a few brief periods; in general, it is operationally expected some antennas will be unavailable for observing due to scheduled maintenance or particular receiver availability. Improvements in the calibration pipeline have resulted in shorter periods between observation and data delivery. For example, as of last August, ~75% of pipeline-processed datasets were delivered to PIs within 30 days of observation and ~66% of manually processed datasets were delivered within 45 days. The Joint ALMA Observatory (JAO) has initiated a program to reduce the time to recover from bad weather, which should lead to more available observing time. The JAO projects that 4300 hours may be available for observations in Cycle 7.

The partners of the North American ALMA Science Center (NRC and NRAO) are organizing "New Horizons in Planetary Systems," a conference in Victoria, BC on 13-17 May 2019. The meeting

will highlight the latest results from ALMA about proto-planetary and debris disks, as well as new developments on exo-planets and the January 2019 New Horizons fly-by of the Kuiper Belt object Ultima Thule. For more meeting information, please go to http://go.nrao.edu/newhorizons.

(Thanks to Gerald Schieven for kindly providing statistics for this report.)

JCMT

The James Clerk Maxwell Telescope (JCMT) continues to be operated by the East Asian Observatory (EAO), and a five-year extension of their agreement with University of Hawaii to operate JCMT is being pursued. NAOJ (Japan), however, has announced it will not contribute funding to JCMT beyond the current five-year agreement that ends in February 2020. EAO is searching for additional funding partners within Asia, with some promising leads.

The weather on Mauna Kea has been unusually poor over the past semester, inhibiting completion of Large and PI programs. Nevertheless, the telescope has been productive, with exciting new results coming from its "flagship instrument" POL-2. This instrument is a SCUBA-2 add-on that was developed in Canada. Another Canadian-developed instrument, RxA3, was recently retired from the telescope after 20 years of service. Work to replace 1-mm capability with a new camera called "Namakanui" is progressing with the plan to have it ready for the next mm-VLBI campaign in late March 2019.

NSERC funds to provide Canadian contributions to JCMT operations over the past two years have run out. A consortium of Canadian universities, including McMaster, Montréal, Manitoba and UBC, have begun working on a CFI proposal (due likely in fall 2019) to contribute to a new 850 micron wide-field camera that will replace SCUBA-2. This new camera is expected to have a mapping speed a factor of 20 greater than that of SCUBA-2 with excellent polarization capabilities. Due to this effort, and Canada's contribution of the JCMT data archive at NRC Herzberg's Canadian Astronomy Data Centre, the EAO Director and Deputy Director intend to allow Canadian access to PI time on the JCMT in 2019. The Canadian oversubscription rates for the 18B and 19A semesters were relatively low, 1.8 and 2.5, respectively, possibly due to fatigue from previous semesters very high oversubscription rates or uncertainties in future telescope access.

A meeting on new JCMT instruments and science has been planned for the week of May 20, 2019 at Purple Mountain Observatory in Nanjing, China. In addition, the next JCMT Users Meeting has been planned for the week of Nov. 4, 2019 in Taipei, Taiwan.

(Thanks to Christine Wilson for kindly contributing items for this report.)

SOFIA

We are currently in the nominal cycle 6 observing period. Cycle 6 has a total of 811 research hours (575 General Observer, 110 GTO, 61 DDT, 100 Calibration). Due to maintenance issues,

SOFIA's return to Palmdale (US) from Germany was delayed from Jan. 6, 2018 to May 18, 2018 resulting in a loss of 44 flight opportunities. To recover, the start/end of cycle 6 was delayed to May 19, 2018/April 26, 2019.

The Cycle 7 call for proposals was issued on June 1, 2018 with a proposal deadline of September 7, 2018. The total number of hours available is approximately 570 (of which 70 hrs are available for the German Guest Observers via the German CfP). The nominal Cycle 7 observing period runs from April 27, 2019 to April 27, 2020. A new proposal category was introduced "SOFIA Legacy Programs" which replaced the "Impact Proposals". This new category is for 2-year proposals of high legacy value to the community and have no proprietary period. A total of 100 hrs have been allocated to this program. Cycle 7 will offer six instruments (EXES, FIFI-LS, FORCAST, FPI+, GREAT, upGREAT, and HAWC+). A Southern deployment made up of two science flight series is expected for cycle 7. Cycle 7 had an over-subscription rate of 4.5, the results will be announced mid-December.

The HIRMES instrument (High Resolution Mid-Infrared Spectrometer; R=600 - 100,000; 25 – 122μm) is scheduled to be delivered by Spring 2019. HIRMES is not offered in cycle 7 and will likely not be available for DDT. Proposals for SOFIA's next generation instrumentation were due Aug 2018. Step 1 selection occurred in October 2018, the Instrument Concept Study phase begins in November 2018 and final selection will be made by July 2019. These instruments are expected to be delivered by July 2022.

Gemini

The Korea Astronomy and Space Science Institute (KASI) has become a full participant in the Gemini Observatory. KASI will provide a Visitor Class Instrument for ether Gemini North or Gemini South; detailed specifications will be determined by the end of 2020. KASI will contribute more than 2 million USD to the construction of this instrument. The contributions for the operations continue to be shared among the participants, and Canadian (NRC) contribution is at 18.15% level. At the Assessment Point, all participants have confirmed their intention to remain in the partnership beyond 2021.

On October 1st, 2018 Dr. Jennifer Lotz started a five-year appointment as Gemini Director. As an expert on galaxy morphology evolution, high redshift universe, and gravitational lensing, Dr. Lotz held an associate astronomer position at the Space Telescope Science Institute before joining Gemini Observatory.

Observatory have secured funding from the NSF for the development of a new generation AO system on Gemini North (GNAO), new real-time computer system, and software for rapid transit follow-up. STAC and Gemini Board recommend incorporating the adaptive secondary mirror into the GNAO design from the beginning.

After GNAO, the first development priority of Gemini Observatory is SCORPIO (8-channel imager and long-slit spectrograph for simultaneous observations in grizYJHKs bands, formerly known as

OCTOCAM). The instrument development is currently in the Critical Design stage. The project remains on budget and is scheduled for commissioning in 2022. Observatory development priorities also include GHOST, high-resolution optical spectrograph. The instrument is currently in its building stage at the National Research Council of Canada: both blue and red science detectors are assembled into their cryostats and are being tested.

STAC and Gemini Board endorsed Observatory proposal to acquire a GNAO Imager using the Instrumentation Development Funds (~3 million USD). The instrument should be decommissioned when GIRMOS (new generation Infrared Multi-Object Integral-Field Spectrograph) becomes available.

Based on the relocation study on moving GPI to Gemini North, STAC members do not support the move unless GPI wavefront sensor is upgraded to enable fainter stars. The GPI team is expected to secure external funds for this upgrade.

After successful visiting run on Gemini South, IGRINS - A high-resolution near IR (1.45 - 2.5 microns) immersion grating spectrometer - is back at the Lowell Observatory. Due to its popularity among users in 2018A (35% of the time request on GS), the Observatory is looking into brining the instrument back before new instrument (of similar design) provided by KASI becomes available.

CFHT

CFHT is now functioning with an impressive 5 instruments in rotation: MegaCam, WIRCAM, ESPaDOnS, SITELLE, and SPIRou.

The CFHT call for large programs received a total of five proposals requesting 670 nights of observations. Two proposals were accepted. The SPIRou Legacy Survey (SLS) will use 300 nights of SPIRou time to characterize exoplanets around M dwarfs. SLS will search for Earthlike ones located at the right distance from their host stars to lie in the habitable zone

The Star formation, Ionized Gas, and Nebular Abundances Legacy Survey (SIGNALS) will use 54.7 night of SITELLE time to conduct a detailed survey of nearby star- forming galaxies.

Several issues about CFHT's future remain to be resolved. This includes the Mauna Kea summit lease renewal which is being worked on by UH. Also, with MSE scheduled to replace CFHT, the future of the observatory will be determined by whether MSE moves forward as proposed. If MSE moves forward as planned, CFHT would be decommissioned in ~2022.

CHIME

CHIME is an innovative radio telescope, built at the Dominion Radio Astrophysical Observatory (National Research Council). CHIME will study the expansion history of the Universe by tracing the distribution of atomic hydrogen over the redshift range z = 0.8 to 2.5. It will also search for and

study Fast Radio Bursts (FRBs), make accurate and long-term measurements of pulsar timing, search for new pulsars, and study the magnetic field of the Milky Way by mapping the polarized sky. CHIME was built by a consortium of Canadian universities, UBC, Toronto and McGill, joined by scientists from DRAO. The project involves about 50 people in the Canadian astronomy community. Recent CFI funding will help realize searches for slow pulsars, for 21-cm absorbers, and for variable sources. The funding will also provide equipment for better internet connectivity for CHIME, and will provide tools for astronomers using CHIME foreground polarization data and variability data.

All science goals share the signal acquisition system of reflectors, receivers, analog-to-digital converters, and FPGA processing of the 400-800 MHz frequency band into 1024 frequency channels. Reaching the objectives of the cosmology experiment will require precise characterization of telescope properties, and that long process is underway, converging gradually on its objectives. Month-long data-gathering runs alternate with brief periods for upgrades, both hardware and software enhancements.

FRB events must be identified in real time. The CHIME/FRB pipeline forms 1024 beams on the sky over a field of view of 200 squaredegrees. Subsequent operations increase frequency resolution, flag radio-frequency interference, and de-disperse received signals. Routines for recognition of significant pulsed events follow, with reporting of relevant parameters, and baseband data around each event are stored. The first CHIME/FRB detections were announced in an astronomical telegram in late July 2018. The first science papers based on CHIME/FRB data have now been submitted. The CHIME pulsar backend is in full operation.

The Square Kilometre Array organization has now designated CHIME as an SKA Pathfinder.

JVLA

The JVLA, operated by the National Radio Astronomy Observatory, continues to run normally. The JVLA just entered the 18B semester which runs from November 19 2018 to February 4 2019 in C-configuration. The next proposal deadline is February 1 2019 for the 19B semester for the observing period from November 20 2019 through February 10 2020 in D-configuration.

The VLA Sky Survey (VLASS) began observing on September 7 2017. VLASS will cover the entire sky visible from the JVLA at a frequency range from 2 to 4 GHz. The observations will be done in B-configuration providing a resolution of about 2.5 arcsec down to a sensitivity of 69 microJy. All raw visibility data are available immediately from the NRAO archive at: https://science.nrao.edu/facilities/vla/archive/index

Quicklook imaging of the first half of the first epoch of VLASS is now complete. The images cover 17,000 square degrees distributed over the sky. An interactive viewer based on Aladin Lite and HiPS showing the survey coverage (and zoomable to investigate individual sources) is now available. The quicklook images (1" per pixel scale, Stokes I continuum) are posted to the VLA

Sky Survey Resources web page. This link also provides the sky tile definitions and observing/processing status. (https://archive-new.nrao.edu/vlass/)

DAO

The 100th anniversary of first light with the 1.8-m Plaskett Telescope on May 6, 2018 was celebrated with a ceremony that day which included NRC President Iain Stewart and local Victoria dignitaries. David Bohlender and John Pazder of NRC Herzberg recreated observations of the very first spectrum obtained by the telescope (of the star beta Canum Venaticorum) almost precisely 100 years later. Indeed, NRC Herzberg has been celebrating 100 years of Canadian astrophysics with events all year, including special session talks at the Victoria meeting of CASCA in late May 2018.

Between July and September 2018, the 1.8-m Plaskett Telescope and 1.2-m Telescope were nominally over-subscribed by factors of 1.22 and 1.11, respectively. Between October 2018 and December 2018, the Telescopes are over-subscribed by factors of 1.15 and 1.13, respectively. About two-thirds of the 1.2-m Telescope time requested in both quarters was for robotic observations. Work on making robotic observing available for the 1.8-m Telescope is progressing. Also, the 1.2-m dome will have new network cabling installed to enable further modernization of its operations.

On August 31, it was discovered that three of the wheels the 1.8-m Plaskett Telescope dome uses to rotate had become offset and tilted, and in some cases were rubbing against the support structure. These wheels had been recently refurbished due to the same behaviour by Dynamic Structures of Port Coquitlam, BC. Operations of the 1.8-m Telescope were ceased until October 23, when the tilted wheels were replaced temporarily by smaller wheels. Operations have resumed and the tilted wheel have been sent back to Dynamic Structures for tests. Investigations to determine the ultimate cause of the 1.8-m dome wheel problems are continuing.

DRAO

Galt Telescope upgrade:

Most of the work on the spectro-polarimeter back-end is now complete. The final correlator design will use a CHIME ICE board as the F-engine, with a GPU-based X-engine. Computers for data processing and archiving have been acquired, and work on a new common telescope control system has advanced well, and will be applicable to other telescopes on site (already in use on the NGSFM).

The study of the Galt feed legs is also progressing. A laser metrology system is currently being used to characterize how the legs and reflector structure - and hence relative position of the focus and vertex - change over the operating envelope of the telescope. This has required a mounting tube to be manufactured to secure the laser head to the telescope, and retro-reflector targets are now being attached in key locations. The results of this work will inform both feed and focus box

design. This work is being done with the assistance of members of the HAA Astronomy Technology Directorate (ATD).

The final area of work on the Galt currently is the cryogenic system. Assistance has been sought from experts at HAA Victoria and other observatories, with the key problem being how to get the cryogenic lines into the moving portion of the telescope, as the equatorial design of the mount forces the compressor (which cannot be tilted) to be located in the stationary base. A rotating joint design is currently being considered.

During this upgrade work the sole user of the telescope continues to be CHIME, who are using their own receiver and backend, and thus only rely on DRAO equipment for telescope control.

Solar Telescopes:

As mentioned above, work has been done on the control system for the Next-Generation Solar Flux Monitor (NGSFM). A new TANGO-based system has been implemented to replace the original VLBI control system that was supplied with the antenna. This new system has general applicability, and will be used on several telescopes at DRAO, including the Galt telescope and the DVA antennas being developed by ATD. Once calibration work is complete, the NGSFM will be in a position to start reporting daily flux measurements at 1.4, 1.6, 2.8, 3.3, 4.9, and 8.3 GHz.

The "classic" 2.8GHz (10.7cm) solar flux monitor is also undergoing upgrades. FM2 was recently upgraded to a new linux-based control system and associated data acquisition system, which replaced the old Windows-based system and a significant portion of the older analogue components. These upgrades have been commissioned and debugged, so now they are being rolled out to FM1. In parallel, a new software-defined radio (SDR) system will be implemented on FM1 to replace most of the remaining analogue signal-path components. Once debugged, this SDR system will be also implemented on FM2. Throughout this work the redundant nature of the two flux monitors means that the data service providing F10.7 to the world continues uninterrupted.

Synthesis Telescope:

New conduit has been laid for a power upgrade to the Blockhouse. Although there will be no change to the amount of power available, one of the two new power feeds will provide generator-backed power. While this will not prevent power-related observing interruptions for the Synthesis Telescope, as the generator cannot supply enough power to support all systems and the HVAC required to cool them, it will protect critical systems (and enough HVAC to cool them) such as the sidereal clock and observing computer, making resumption of observing faster and easier when power is restored. The upgrade will also benefit other equipment that shares the building with the Synthesis Telescope and requires reliable power, such as the NGSFM and DRAO weather station. Only minor disruptions are expected while the power upgrade is completed.

On the observing front, the telescope continues to function well. Proposals received for the next semester have been well received by the referees, and cover a range of galactic and extragalactic science topics. The total number of fields requested in 4 proposals was 66, while we complete ~50 fields per year. This should not be directly interpreted as an over-subscription, however, as the low observing rate and other scheduling issues may require that larger projects be completed over multiple semesters.

Radio Spectrum Management

Although the implementation of new services and systems are generating new interference issues (such as the deployment of new Radarsats (satellites with ground-facing radar systems) and unwanted emissions from systems providing internet access on commercial flights), the main threat to radio astronomy is still the gradually rising background noise level due to the integrated emission from a growing number of low-power transmitters. WIFI, Bluetooth, smartphones, vehicle electronics, collision avoidance systems, all operating legally, generate a noise background that is hard to mitigate, particularly when using spread-spectrum modulation.

Radio astronomy depends upon the bands that are officially allocated to it, since some degree of protection is guaranteed by national and international spectrum managers. However, opportunistic observations outside allocated radio astronomy bands has become necessary for many areas of radio astronomical research, for example observing highly-redshifted HI emissions. How long we will be able to do this is problematic. The latest concern at the international level is "spectrum efficiency" - how can we get more information into a fixed amount of spectrum. The movement of communication and other active (transmitting) services to shorter wavelengths is not seen as a solution in all cases because of problems with range, building penetration, hardware design and so on. Therefore they have to be accommodated at lower frequencies, which means a movement towards more data-efficient modulation systems and something more like an internet-like arrangement where packets of information are launched into clear channels within a defined frequency band. The result will be a more “filled” spectrum and a reduction in the possibility for opportunistic, out-of-band observing. There will also be an increased risk of interference from unwanted emissions in radio astronomy bands due to the digital modulation.

5G is coming. The intention is to provide data download speeds to your 5G smartphone of up to 20 gigabits per second. The bandwidth needed to provide this means typical operating frequencies will be 15 GHz and higher, although a modification of the system will include lower frequencies, between 600 MHz and 6 GHz. Achieving such data rates for mobile devices will require a far denser concentration of connection points than is the case now with cell towers. No accommodations have been offered to protect radio astronomy.

Canada’s radio spectrum management is one of the activities of ISED (Innovation, Science and Economic Development). That organization also leads our involvement in international radio spectrum management under the UN’s International Telecommunications Union. Up to a few years ago, we had a Canadian radio astronomer representing the interests of Canadian radio astronomy nationally and internationally, as a member of the Canadian Delegation to the ITU.

Since then there has been nobody. To quote a senior person in ISED, “If protecting radio astronomy is so important, why aren’t you guys here helping to do it?” If we are truly committed to the continuing viability of radio astronomy, we radio astronomers need to make a national and international commitment toward protecting it.