Report of the CASCA Ground-based Astronomy Committee (GAC): May 2019

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

We have legal right to begin construction. There is a lot of work going on to prepare for construction, both in terms of permitting and in consulting with stakeholders. A lot of progress in communication with other MK Directors. A Hilo Office has been established, with an Associate Project Manager resident in Hawai'i. Coordination with government and local police force is active and the whole thing is being overseen by the highly capable Maunakea Site Access Committee. So the project is doing everything it can to be ready for the protests when construction restarts, and thus give the project the best chance of success. Construction should begin this summer. New science team has formed for WFOS. SAC is considering next generation instrumentation priorities.

SKA

There have been exciting developments in the SKA project over the last six months. Here, we summarize developments in the design and governance of SKA1, the first phase of the SKA facility that is scheduled to begin construction early in the next decade, over the last ~6 months. A detailed account of the recent history and current status of the SKA project in Canada can be found in the initial report to the 2020 LRP Panel by Spekkens et al. that was submitted at the end of May, a summary of which is also contained in the initial LRPIC report to the 2020 LRPP by Hutchings et al.

The SKA1 Baseline Design is mature, and the focus of the SKA Organisation (SKAO) over the last several months has been the planning and execution of SKA1 element consortia critical design reviews (CDRs). Seven of the nine SKA1 element consortia have completed CDR and

closeout and have since dissolved, with outstanding work being carried out by the SKAO during a Bridging Phase that is expected to last another year. Notably, the Canada-led Central Signal Processor (CSP) achieved a major milestone in late 2018 by completing its CDR, which passed with “no action” (the only consortium to have received this high rating) to mark the end of nearly six years of development work. The Low-Frequency Aperture Array (LFAA) consortium has passed CDR, and closeout is pending. Only outstanding element CDR is that for the Dish (DSH) consortium, which has been scheduled for Q1 2020 to provide enough time for prototyping lessons learned to be incorporated into the design and for outstanding IP issues to be resolved. SKA1 system CDR is scheduled for Q4 2019, an externally-reviewed bottom-up Cost Book is planned for Q2 2020 and construction is currently projected to start in Q2 2021.

As SKA1 transitions from pre-construction to construction, governance of the project will transition from the SKAO, a not-for-profit company in the UK, to an intergovernmental organisation (IGO) that is established by treaty convention. A signing ceremony for the IGO Treaty Convention and Final Record was held in March 2019, and seven countries have insofar signed the Convention to become Founding Members of the IGO: Australia, China, Italy, Portugal, South Africa, the Netherlands, and the United Kingdom. The IGO will come into existence when the treaty is ratified by five of these signatories, and the IGO is currently anticipated to become fully functional in Q4 2020, at which time the IGO council is expected to take full control of the project. In the interim, a Council Preparatory Task Force (CPTF) is representing the interests of current and anticipated IGO signatories and drafting accession, procurement and IP policy among other goals.

It is still possible for Canada to sign and ratify the Convention to join the IGO if governmental approval is obtained, but the sovereign nature of an IGO treaty makes that option unattractive to lawmakers. Instead, it remains most likely that Canada will participate in SKA1 via some form of Associate Membership, a position that is now shared with New Zealand. The terms of Associate Membership will need to be negotiated with the IGO Council, which will not come into force until the IGO Convention is ratified. This key policy is currently being developed by the CPTF for handover to the Council when it comes into force. Governmental permission for NRC to participate in the CPTF would therefore be an important step towards clarifying Canada's options for participating in SKA1, and negotiations on this front are progressing well.

(Many thanks to Kristine Spekkens for this update)

LSST

No Updates.

MSE

Substantial progress continues to be made surrounding the MSE project. The MSE project welcomed a new Project Scientist in January 2019 and a Deputy Project Scientist in February 2019. Prof. Jennifer Marshall (Texas A&M) was appointed Project Scientist, and Dr. Andreea Petric (IfA/CFHT) was appointed Deputy Project Scientist.

In February 2019, more than 90 astronomers and engineers gathered in Tucson for the workshop "Massively multiplexed spectroscopy with MSE: Science, Project and Vision". This meeting brought together the MSE Project Office, the Science Team, and members of the international community, to discuss the status and immediate development plan for MSE, and to unite in a shared vision for this transformation scientific facility. Program and oral presentations from the meeting can be viewed at: https://www.noao.edu/meetings/mse2019/agenda.php

In April 2019 the Detailed Science Case for MSE, 2019 edition was the released. This was a significant effort by 263 scientists across the MSE community. This new document is a comprehensive revision of the original DSC, first released in 2016, and captures the key science ambitions of the MSE community for this transformational facility.

In June 2019 the ACURA Institutional Council will vote on whether ACURA will become the Canadian signatory on the Statement of Understanding for the MSE preliminary design phase. The current nominal timeline for MSE (subject to successful funding) is that if CFHT is shuttered in mid-2024, MSE can begin science operations in 2029.

CCAT-p *(Thanks to Michel Fich for providing input to this report.)*

In December 2018, Cornell University announced it would fund internally the development of pCam, the main CCAT-p instrument. It will have a 350-micron camera, two Fabry-Perot spectrometers, and four longer-wavelength camera modules. These funds will provide for design work but also the fabrication of a very large cryostat and much of the internal structural components for various subsystems. Funding for the construction of these subsystems is being sought through proposals to various funding agencies.

The Canadian CCAT-p team is currently preparing an Infrastructure Fund proposal for the upcoming competition from the Canadian Foundation for Innovation (CFI). Canadian efforts to support CCAT-p development continue. Norm Murray and Mike Nolta (CITA) continue to lead the facility software effort. Also, Scott Chapman (Dalhousie/UBC/NRC) continues to lead development of CCAT-p's near-infrared pointing camera. More recently, however, new potential Canadian contributions have emerged. For example, Scott Chapman has taken on the new role of leading development of pCam-350, the central camera of pCam. In addition, Erik Rosolowsky (Alberta) has become the lead of pCam's Data Reduction pipeline development effort. Also, Doug Johnstone (NRC) is now leading an NRC team designing a possible back-up instrument for commissioning the telescope.

Meanwhile, road construction is underway at the CCAT-p site. The first Chilean full-time employee has been hired as Construction Manager. The Final Design Review for the telescope is scheduled for October 2019, although those components with long lead-times have already been ordered. Telescope installation is still scheduled for 2021, only a few months later than projected when the project began in 2016. CCAT-p acceptance testing and commissioning is then expected to begin between November 2021 and January 2022.

ngVLA

The ngVLA project continues to be very active, with recent highlights including:

- Publication of the ngVLA Science Book in December 2018 – with almost 90 chapters, 285 authors (including many Canadians), and more than 800 pages, this is an impressive if not exhaustive summary of the science allowed by the ngVLA;
- Submission of numerous US Decadal Survey (Astro2020) White Papers, including ~9 focused specifically on the ngVLA;
- A special session on the ngVLA at URSI and a broader session at the AAS (Theoretical Advances Guided by Radio-Millimeter-Submillimeter Arrays), both in January 2019;
- A dozen new ngVLA memos, on topics ranging from the imaging of protoplanetary disks to methods for dealing with radio frequency interference;
- The release of four major project documents in June (scientific requirements; legacy science program; reference observing program; and operations concept) as well as updated simulation configuration files in December.

The ngVLA project timeline was last updated in April. The next major milestones are the external Reference Design Review and the formal ngVLA submission to Astro2020, both in Q2/Q3 2019. 2020 will be spent developing the conceptual design; Astro2020 should deliver its final report at the end of that year. Should ngVLA receive the hoped-for high ranking, NRAO would then follow up with a proposal to MREFC, leading to preliminary design work in 2021-2023. Construction could begin as early as the end of 2025, with full operations starting around 2034.

Canada continues to play a key role in ngVLA definition and design, with representation on both the Scientific and Technical Advisory Committees and the Science Working Groups. On the engineering side NRC is providing the reference designs for both the antennas and the correlator/beamformer, building on long-term R&D efforts for the Square Kilometre Array (SKA).

The ngVLA web site (ngvla.nrao.edu) remains the best source for detailed scientific and technical information on the project. Those interested are also encouraged to join the ngVLA-Canada mailing list by sending an e-mail to james.difrancesco@nrc-cnrc.gc.ca .

Current facilities

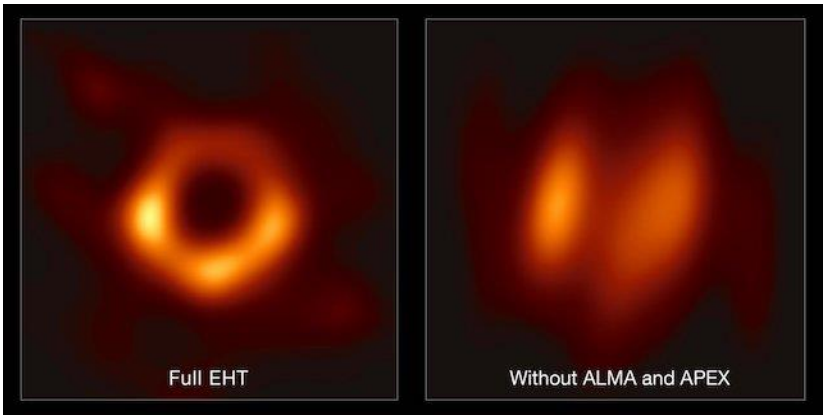
ALMA

Over the past six months, ALMA continued Cycle 6, which began in October 2018. Observations have been going largely smoothly. The planned shutdown in February 2019, however, had to be extended by about a week due to record rainfalls in the Atacama region. Indeed, the intense storms washed out a section of the access road between ALMA's Operational Support Facility (OSF) at 2900 m and its Array Operations Site (AOS) at 5000 m and exposed power cables at six locations along the road. In addition, the fibre-optic cable link between the nearby Chilean town of Calama and the AOS was damaged. Fortunately, ALMA was able to recover relatively quickly, thanks to actions by its dedicated staff. The only other period of scientific inactivity of

note occurred in May 2019, when ALMA reconfigured its antennas out to their most distant pads, a planned task that took the better part of the month.

In April 2019, the call for Cycle 7 ALMA proposals was answered with 1785 unique proposals from around the world. This number is only 3% less than the record number of proposals submitted for Cycle 6. For the 12-m Array, for which 4,300 hours will be available for Cycle 7, a total of 19,338 hours of observing were requested, for a global oversubscription rate (OSR) of 4.5. The highest demand for time was from Europe, with a regional OSR was 5.8. For North America (in which Canada is a partner), however, the regional OSR was 3.6. For the 7-m Array, for which 3,000 hours will be available for Cycle 7, a total of 9.019 hours were requested, for a global OSR of 3.0. Among partners, the regional OSRs are largely similar. In addition, fourteen Large Project proposals were also received. All Cycle 7 proposals will be ranked at the next meeting of the Proposal Review Committee in Atlanta, U.S.A. in June 2019. Proposers should learn the results of the review process by the end of July 2019.

In April 2019, ALMA participated in the global reveal of the Event Horizon Telescope's image of the supermassive black hole in M87. A press conference was held at ALMA's Santiago Central Office, simultaneously with five other locations around the world. The announcement galvanized the world, with an estimated 2 billion people having seen the image. ALMA was very important to the success of the EHT. When phased up, the high sensitivity of all of ALMA's antennas combined and their location in northern Chile were major boosts to the production of the now iconic image. For example, the attached Figure shows M87 EHT images made with and without data from ALMA and nearby APEX. After the M87 announcement, the ALMA staff members who participated in the EHT work were awarded Medals of Honour from the Chilean Senate for their efforts.



JCMT

In March 2019, it was announced two days before the semester 19B proposal deadline that Canadian researchers would be ineligible to be PIs of JCMT proposals for that semester. Canadian PI time had been over-allocated in semester 19A, due to the decrease in Canada's funding contribution to JCMT operations over that period, and this move was made accordingly

to rebalance Canada's PI time with its actual contributions. (Canada still manages the JCMT data archive via the Canadian Astronomy Data Centre (CADC)). Given the late notice of this announcement, Canadians were advised for their proposals to elevate any co-Is from other JCMT partners to PI status. It is anticipated that Canadians will become eligible again for PI time in semester 20A. This event, however, highlights Canada's increasingly fragile association with JCMT.

The East Asian Observatory (EAO) has signed a new agreement with the University of Hawaii to operate JCMT for another five-year period (2020-2025). Indeed, lots of exciting science continues to come out of the telescope. For example, JCMT also participated in the Event Horizon Telescope project that imaged the supermassive black hole in M87. Indeed, a Hawaiian outreach effort led by JCMT Director Jessica Dempsey led to the (informal) naming of the object as "Powehi," which in Hawaiian lore translates to "the embellished dark source of unending creation."

In May 2019, the EAO hosted a meeting in Nanjing, China to look at future science drivers and the instrumentation needs of submillimetre EAO astronomers. The meeting included discussions about the new "Namakanui" three-band (86 GHz, 230 GHz, 345 GHz) heterodyne instrument, which has been delayed slightly but should be available for semester 19B. In addition, meeting attendees discussed possibilities for a new wide-field 850-micron continuum instrument at JCMT to replace SCUBA-2. Following the Nanjing meeting, a solicitation for science white papers in support of this as-yet-unnamed instrument was sent out to EAO astronomers with a deadline of June 30. In addition, an announcement was made for the third Call for Large Programs, for which 4,800 hours will be available through the end of semester 22B. The deadline for the new Large Program proposals is September 15, 2019. Following their previous associations with earlier Large Programs, Canadians have already begun to participate in discussions about both science white papers and Large Program proposals. Finally, an announcement was made that the next JCMT Users Meeting will be held at ASIAA in Taipei, Taiwan on November 6-7, 2019.

Gemini

Results based on the data from Gemini telescopes continue to attract attention of the international astronomy community. Research highlights of the last six months include GeMS+GSAOI imaging that enabled age detection for stars in one of the oldest globular clusters, located in the bulge of the Milky Way, and the NIR spectroscopy (with GNRIS) of the most distant quasar to date (at z=6.51). The first priorities in the instrument development remain Gemini North Adaptive Optics system + Real Time Computers (GNAO+RTC), as part of the the NSF-funded program Gemini in the Era of Multimessenger Astronomy (GEMMA), and the Natural Guide Star Next Generation sensor (NGS2) that will improve sky coverage of GeMS. The other next-generation instrumentation projects under development, SCORPIO (wide-band imager and medium-resolution spectrograph simultaneously covering grizYJHKs bands) and GHOST (high-resolution (R~50,000-70,000) spectrograph in the visible wavelength range), are advancing. However, Gemini Board has voiced a concern about not having a scientist as the Principal Investigator on the GHOST instrument project. MAROON-X, a fiber-fed red-optical (700-900 nm) spectrograph with unprecedented radial velocity precision that allows detection of Earth-size planets around M

dwarfs, has been constructed at the University of Chicago and is currently being prepared for its first light at Gemini North. IGRINS, a cross-dispersed near-IR spectrograph with a resolving power of R=45,000 that was in high demand during its 2018 visit from McDonald Observatory, will be back in 2019B for another extended visit to Gemini South. A number of new members joined Gemini Board and STAC; Dr. Luc Simard (NRC Herzberg) is the only new (Board) member from Canada. Korea officialy became a partner in the Observatory at 5% level in January 2019. The next Gemini Science meeting is to be held in Seoul, South Korea, in June 2020. (Many thanks to Marcin Sawicki for providing information for this

No mid-IR instrument was offered on Gemini in cycle 2019B (1 August 2019 - 31 January 2020).

CFHT

CFHT continues to produce good science for the Canadian community and maintains a strong 3 - 1 oversubscription rate for telescope time. The most requested instruments for CFHT from CanTAC are now SPIRou and ESPaDOnS, followed by SITELLE and MegaCAM.

SPIROU's first data for PI and LP programs were taken in February 2019.

Technical problems led to switching the order of some observing runs but things are now back on track - http://www.cfht.hawaii.edu/en/science/QSO/

In November 2018, the SAC issued a completion policy for all Large Programs started in 2017A and onward. Starting with a Large Program's mid-term review, an LP completion review will be triggered if a LP has an expected program completion below 80%, and/or SAC considers that the LP may not achieve the proposed science goals. If the review is favorable, the LP will be allocated time in future semesters in order to bring the program completion to at least 80%. Depending upon the available pool of future unallocated LP time (considering the maximum fraction for LPs set by the agencies), these allocations could be in semesters during and/or after the term.

The CFHT users meeting was held in Montreal in May 2019. The program can be viewed here: http://www.cfht.hawaii.edu/en/news/UM2019/scheduleprogram.php

CHIME

The three aspects of CHIME, the cosmology project, the Fast Radio Burst project, and the pulsar timing project, are all advancing. The instrument is moving from the commissioning phase into the operational phase on all three fronts. The key to reaching the cosmology goals is stability, and stability is improving steadily. Good progress is being made with understanding the effects of temperature on the telescope. The telescope beams will have to be measured very exactly. Along this path the not-so-simple properties of cylindrical antennas are slowly being unravelled, as are the complexities of the Fourier-transform generated beams. Map making techniques are improving rapidly.

CHIME/FRB is also moving from commissioning to science operations. Two papers were published in Nature in January 2019, and CHIME was featured on the cover of Nature, elevating the international profile of the project. Very active work is being done to understand amplitude calibration as well as gain variations with beam number and with frequency, all in the interests of placing credible errors on published results. CHIME/FRB has now established a high detection rate, and the group is actively studying the construction of outriggers to permit precise localization of bursts through interferometric means.

The pulsar backend is in steady use for pulsar timing, and is occasionally used for FRB work. New funding has been received to carry out a slow pulsar search, and the necessary equipment will be purchased in the near future.

JVLA

The JVLA, operated by the National Radio Astronomy Observatory, continues to run normally. The JVLA just is in the 19A semester which runs from February 2019 to October 2019 in A- and B-configuration. The next proposal deadline is August 1 2019 for the 20A semester for the observing period from February 2020 to October 2020 in C- and B-configuration.

SOFIA

We are currently in the nominal cycle 7 observing period (April 27, 2019 to April 24, 2020). Cycle 7 includes 9 weeks of southern observations, including operation of 3 instruments. Two proposals were selected for the new proposal category “SOFIA Legacy Programs”: “Radiative and mechanical feedback in regions of massive star formation (FEEDBACK)” PIs Tielens & Schneider and “Constraining Recent Star Formation in the Galactic Center: A SOFIA/FORCAST Legacy Program” PI Hankins for a combined total of ~120 hrs.

The Cycle 8 call for proposals was issued on May 31, 2019 with a proposal deadline of September 6, 2019 (US) and September 7, 2019 (Germany). The total number of hours available is approximately 670 (of which 70 hrs are available for the German Guest Observers via the German CfP). The nominal Cycle 8 observing period runs from April 25, 2020 to April 25, 2021. Cycle 8 will offer six instruments (EXES, FIFI-LS, FORCAST, FPI+, GREAT, upGREAT, and HAWC+).

The HIRMES instrument (High Resolution Mid-Infrared Spectrometer; R=600 - 100,000; 25 – 122μm) is currently behind schedule and over cost (was scheduled to be delivered by Spring 2019). NASA HQ will make final decision on HIRMES fate. HIRMES is not offered for cycle 8 but may be available for DDT.

SOFIA underwent a SOFIA Operations & Maintenance Efficiency Review (SOMER). The internal report was submitted to NASA on March 20, 2019 and the SOMER recommendations are currently being addressed. SOFIA also underwent a 5-year flagship mission review (FMR). The report was submitted on March 22, 2019, and the site visit occurred on April 24-26, 2019. A debrief by the FMR panel chair was scheduled for May 31, 2019.

DAO

The deadline for 2019B proposals was March 1, 2019 and ten proposals were received. The oversubscription rate (OSR) for the 1.8-m Telescope was 1.07, with requests for imaging, spectroscopy, and spectropolarimetry corresponding to 72%, 14%, and 14% of the available time, respectively. Meanwhile, the OSR of the 1.2-m Telescope was 1.01. The DAO telescopes continue to be excellent national facilities for long-term observing programs.

Over the last six months, observing with the DAO telescopes mostly continued when weather allowed. February 2019 had particularly poor weather for Victoria, due to unusual amounts of snow. In addition, the annual inspection of the dome of the 1.8-m Plaskett Telescope in early May 2019 revealed a crack in its dome wheel track. As a result, scientific operations of the Plaskett Telescope were paused until a proper engineering assessment could be made. In early June 2019, Dynamic Structures (DS) of Port Coquitlam, BC, made such an assessment and indicated it was safe to rotate its dome. Operations of the Plaskett Telecsope resumed soon afterward. In addition, DS has begun to explore the root causes of the torques that have caused several 1.8-m dome wheels to be bent over the past year. Replacement wheels are being used as an interim solution. Meanwhile, operational upgrades were made or are now planned for improved robotic usage of the 1.2-m Telescope.
(*Thanks to David Bohlender for providing input to this report*.)

DRAO

Galt Telescope:

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

1. *Opening of New Spectrum Above 275 GHz*

When the spectrum from 71-275 GHz was reorganized by the ITU, the radio astronomy community was ready, while the communications industry had not yet cracked the problem of achieving usable transmitter power levels at those frequencies. The result was a coup for radio astronomy. Studies for spectrum at even higher frequencies, into the far infrared, are now in progress. The communications industry has now developed usable transmitting devices so this promises to be a tougher fight. This will not just be a matter of establishing band requirements, but also, taking into the poor selectivity and linearity of current low-noise radio astronomy receiving systems at millimetre and submillimetre wavelengths, the assessment of coordination issues with active bands operators.

2. *5G, Bluetooth and Other Mobile Devices*

Interference issue in radio astronomy used to be largely a matter of dealing with individual interference sources, which were often contravening regulations on unwanted emissions. This is no longer the case. We are moving to a world of many mobile, low-power devices that are individually operating legally but can add up to an interference issue for radio astronomy. Typically these devices use spread-spectrum or similar modulation methods which are essentially unmitigatable without the encoding keys. The net result could be a general rise in the background noise level at the observatory. Spatial separation is the only current avoidance technique. This issue has been discussed in the spectrum management community for some time, but as yet nobody has any ideas. The advent of thousands of Low-Earth-Orbit (LEO) satellites to support 5G services are going to compound the problem. A sky full of satellites with their collective unwanted emissions being picked up through antenna sidelobes is discussed in Recommendation ITU-RA1513, but this issue will need to be revisited.

3. *Opportunistic Observing*

Having bands allocated to radio astronomical use is essential for the viability of our favourite science, but since we cannot grab spectrum for all radio astronomical observations “opportunistic” observing is of rapidly growing importance. If the interference level in a band not allocated to the radio astronomy service is low enough at a particular observatory, observations can be made in it. The CHIME radio telescope at DRAO is an excellent example. However, in cases where a substantial investment is being made in projects dependent on opportunistic observing, there needs to be an effort to keep the band usable for the intended duration of the experiment. With the current feeding frenzy by other services for frequency space, this cannot be taken for granted. To keep the project viable, the local and possibly national spectrum managers need to be consulted and kept in the loop. The International Radio Regulations provide no protection whatsoever for opportunistic radio astronomical observations.

4. *A Canadian Radio Astronomy Representative*

The above issues underline the need for a national representative to promote the needs of Canadian radio astronomers nationally – to protect our national facilities, and internationally - to ensure Canadian needs are taken into account in the formulation of new spectrum management regulations. With our substantial investment in offshore facilities, such as ALMA, representing Canadian needs at the international level is important. For the last few years Canada has had no such representative, which is a situation currently receiving attention.