# CATAC Meeting Minutes

*Tues March 7, 2017.  4pm EST*

CATAC Attendees:  Balogh (Chair), Abraham, Brooks, Carlberg, Davidge, Gallagher, Lafreniere, Richer, Simard, Wilson

Open to registered public via Webex

A Google Doc file was circulated prior to the meeting with some initial questions and thoughts from the committee.  The community was invited to add comments and edits to the file.

Balogh began the meeting with a short presentation that summarized the content of this document.

Topic:  What do Canadians expect from an ELT?
Three high-level issues were addressed:

1. Capability to do world-leading science
2. Share and timescale
3. How to engage with the observatory

These high-level considerations could be impacted by a move to ORM (Canary Islands).  Community input is critical.

In general there seemed to be good alignment within the community.  The ELTs are going to be highly capable facilities capable of serving a very broad user base.  A few highlights of the discussion include:

- The governance model is important, perhaps more so than the precise share. We want to be engaged with the observatory and able to influence the scientific direction.  Engaging the university community in instrument building is a key component of this.  The CFHT model is strongly preferred to the Gemini model in this respect.
- The community is very strongly in favour of an adaptive queue, along the lines of what exists at Gemini.  Anything else is wasteful.
- Similarly the community is strongly in favour of a highly capable archive. Again, not making the data widely useable in this way would be wasteful.
- A balance of  short, PI-led projects and Large Programs is strongly supported. Both are needed, with some appropriate balance that needs to adapt to needs.
- There is clear and justifiable concern about the timescale for TMT and whether the financial gap can be closed.  This is largely out of our control at the moment.   Among other things it is important to have a good

understanding of the timescale relative to EELT and GMT. There is much concern about the impact of being on sky much later than these.

What follows is taken from the community-available Google doc, with additional comments and thoughts that arose during the meeting.

## Capability to do world-leading science

The primary principle should be to ensure that ELT access allows Canadians to take a leading role in many forefront science projects. This must be considered in light of the competition.

Refer to the Detailed Science Case at https://arxiv.org/abs/1505.01195. The list below is not meant to be exhaustive but to stimulate thought about the relative importance of different capabilities to the Canadian community.

It would be useful to know how much time is spent in each of these modes (NIR AO, natural seeing, high-res spectroscopy etc) for 8-m class telescopes. This may not change radically despite the difference in capabilities.

### High spatial resolution (Adaptive Optics)

- This is clearly a big driver and needs little discussion here. The potential for D4 scaling in sensitivity is a huge advantage over 8-m.
- The DSC also describes many projects requiring high spatial resolution science alone, including gravitational lenses, spatial/kinematic mapping of galaxies (IFU), AGN fueling/feedback, exoplanets, disks, etc.
- Precision astrometry for galactic and extragalactic objects (e.g. SMBH) is a fundamental new capability
- Note the NFIRAOS spectral range is 0.8-2.4 microns. There is a question of what science drivers might require AO at 3-5 μm (see below)

### Natural seeing (e.g. optical)

- The question here is whether or not D2 gains are large enough to enable fundamentally new science? Or is this just viewed as “backup” science for when conditions are not good for AO.
- Note that GMOS is by far the most heavily used instrument on Gemini by Canadians. Many unanswered questions that require hundreds of hours to make progress on now, will be tackled with an ELT. e.g.
    - Stellar populations of distant and ultradiffuse galaxies
    - High resolution spectroscopy of distant quasars and galaxies
        - Outflows

        - Dynamics of low mass satellites
        - initial-final mass relation in stars
        - low mass halo stars and white dwarfs
        - supernova characterization
        - etc. etc. See DSC.
    - Combined with high resolution spectroscopy, larger collecting area opens up completely uncharted territory (see below)
    - Some feel ELTs should remain fundamentally AO telescopes, with natural seeing science staying with 8-m class telescopes and new highly multiplexed (10,000 spectra/shot) 10-15m telescopes.
        - While the same level of multiplexing may never be achieved, a moderate slit or slicer based multiplex (or MUSE-like IFU) could obtain large samples of very faint objects not accessible with a 10m.
        - The same claim was made going from 4-m to 8-m but it didn't happen. Certainly the 8m facilities is where you do AO today, but there is a large amount of good natural seeing science being done on those telescopes.
    - Depending on weather, AO will be unusable for some fraction of the time, need to be prepared to make the most out of these forced natural seeing observations.
    - Taking advantage of good natural seeing is related to how the observatory is run.

## Mid-infrared

- This is challenging from the ground even at the best sites. Competition with space leaves high spatial and spectral resolution as main drivers from the ground.
- People remain wary of the Gemini experience, where optimization in the MIR did not prove to be the right choice. Good instrumentation and adaptive queue observation are important factors.
- 3-5 micron
    - About 20% of time at ORM may be suitable for work at these wavelengths. The fraction is higher, ~50%, at Armazones.
    - Need AO in this spectral window. Past decade revealed that 3-5 um is the sweet spot for exoplanet imaging; we do as well there with a modest AO system as we do with extreme AO at JHK.
        - Could likely reach sub-Saturn mass planets at separation of ~10 AU or so, way beyond what JWST will ever be able to do. Doubtful we could do as well at JHK even with a better AO system.
        - This would open an entirely new parameter space, and would put us ahead of E-ELT (if they don't go for it).
    - High spectral resolution important? Disk chemistry (see below)
- 7-16 micron

- There was no discussion of this range, which would not be accessible at ORM.

### High spectral resolution

- Exoplanet transit/eclipse/phase spectroscopy at super high resolution (R~100000), i.e. high enough to resolve individual molecular lines. Does not require AO.
- Transit spectroscopy with an ELT is possibly the way we'll detect biosignatures in earth-like planets with confidence for the first time, and many many other things. If we could get TMT an echelle spectrograph for 1st light, we'd lead the field. Best spectral range?
    - The 1-2.5 um (or even better 0.7-2.5 um) range is very important, necessary, and perhaps even sufficient: it contains the main markers - $CH_4$, $O_2$, $H_2O$, $CO_2$- and is closer to the peak of the stellar SED (compared to >3 um).
    - Anthropocentric bias? Extra terrestrial life may (and will! somewhere) have different biomarkers than life on Earth, but it is more difficult to plan for these unknowns. Certainly, at some point we will want to find Earth-like life, and this is easier to plan for. For present-day Earth-life, the most important and most difficult molecule to detect is $O_2$, and is most easily detected at 0.76 um, and then at 1.26 um; the 1.26 may be preferable for late M dwarfs (more flux) which will likely be the first earth-like-planet hosts to be targeted for these searches. More generally, most studies agree that <2.5 um and >7 um are the preferred ranges.
- There is also the position-velocity distribution of complex, life-related molecules in proto-planetary disks. At such high-resolutions, the sensitivity ("Noise-Equivalent Line Flux" - NELF) of a ground-based telescope in the MIR is on par with JWST. Is MIR best range here? What about NIR?

### High time resolution

- 30-m class telescopes allow study of extremely rapid variability in the optical, previously inaccessible; measurement of radial velocities in very short orbital periods (enabling, e.g. measurement of high masses for neutron stars).
    - X-ray binaries
    - Exoplanet transits
    - Close white dwarf binaries (SN Ia progenitors/GW sources)

## What are the requirements on share and timescale?

- Maintaining our 15% share (well below what was advocated in the LRP) will require additional funds from government. Failing that our share will drop.

- Gemini oversubscription fluctuates but could probably stand to be a factor 2 larger. It was suggested that this indicates a 15% share is about right
    - But there is a noted lack of engagement in Gemini and appropriate instrumentation. Pressure could be much higher on a telescope with which we are heavily engaged.
  - A share in the 5-20% window is probably reasonable. Though 5% is definitely at the low end of acceptable.
  - It is very important to have a strong enough voice to influence the scientific direction of the observatory.
    - This is only partly influenced by share. Governance plays a big role. Even small partners can have influence in an appropriately open model.
    - Canadians prefer a CFHT-like governance to a Gemini-like governance. It is noted that a CFHT model would be difficult to implement if NSF gets involved.
- First light dates for the different ELTs remain uncertain. TMT Board is sticking to an April 2018 on-site construction start, though some activities will not proceed as quickly as originally planned until new funding is found. E-ELT is advertising first light expectations of 2024, but we have not seen detailed material to support this.
  - It is still not clear which of the three large telescopes will be first on sky. There are doubts as to whether TMT construction can really begin in 2018. Will partners be willing to start without a route to completion?
  - A way to counterbalance a delayed arrival wrt EELT would be to have some capability at first light that the EELT would not yet have.
    - Currently TMT has two MOS instruments, while EELT has none.
    - There are doubts about whether E-ELT MAORY (their NFIRAOS) will be ready at first light, so MCAO may also be unique
    - If significant delay is expected, could push for fast development of some instrument with a unique capability to be there at first light. The delay means this could be realistic.

# User Engagement: what kind of observatory do we want?

## Balance of PI science and surveys, large programs

- Our normally very PI-centric US friends have made a strong case for large programs. We certainly learned from CFHT and Gemini that it was much more effective to work with our partners whenever possible.

- Need to maintain opportunity for some small programs, sometimes needed to demonstrate and motivate a subsequent large program, and sometimes a small investment of time is all that is needed for new and exciting science
    - Consider JWST early release science.  Very large teams for small amounts of time.  Need to explore before doing large amounts of time.
- Time domain astronomy in era of LSST will be very important, so TOO should be a big feature.  These don't necessarily need a lot of time
- Whoever is on sky first will have a wonderful opportunity to do great things in just a few hours.  Really big impact comes from systematic studies of large samples - but that comes later on.
- ISDTs considered "key programs".  There is a political element, since there is not that much time for the general US community.

## Balance of queue and classical

- Very strong support for an adaptive queue.
    - This  is critical for MIR, time constrained and high time resolution observations, and likely XAO applications
- Experienced observers (staff astronomers doing queue observations) needed to ensure observing time is used most efficiently.
- Project resistance to queue and archive is partly financial and partly cultural. Queue capabilities are considered in the operations requirements – level of support will depend on funding.

## Balance of instruments developed by university/national groups and as facility instruments

- See Luc's presentation for future TMT instrument builders, here
- A sense of ownership comes from direct engagement in instrumentation programs. Desire to engage comes with alignment of instrumentation with our science.
- Individuals and students need to feel invested in the telescope; this can emerge in many ways, but one good way is to get close to the metal and the glass and interface very closely with the operation of the observatory.
- One of the problems with Gemini was insufficient money for an aggressive instrumentation plan.  Plus trying to predict the future and getting it wrong.

## Balance of standalone science and collaborative work with other 30m or smaller telescopes

- From the Detailed Science Case: "The most progress will come from combined studies at many different wavelengths using ground and space-based facilities."
    - JWST follow up will be a key capability
    - To some extent, everything benefits from additional complementary data, of course, but some truly spectacular advances may need only a single observation enabled by a new capability of an ELT; should not dismiss those.

- This may be an opportunity to consider a proposal process that allows observations at multiple facilities to be combined, like at NOAO

## A national facility, or an opportunity to work collaboratively with (mostly new) partners?

- The instrument development model will be very "international style" with a strong HQ management oversight and then biggish international teams that need to demonstrate sub-system competence and will be "managed to success". The instrument teams are also very international.

## Balance between unique, experiment-driven instrumentation and workhorse capabilities

- Instruments are going to be very expensive, and complex. Can we afford the luxury of high turnover in instruments with limited applicability?
    - Focused, niche instruments could in some cases be much cheaper and faster to develop than multi-mode workhorse instruments. Will still be expensive though. There are some doubts in the community about how large a role these will be able to play for a national facility.