Gemini and Additional 8m time

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W.J.Couch

Gemini

Funding Countries: US, UK, Canada, Australia, Brazil, Argentina, Chile

Background:

The Gemini Observatory was first mooted in the mid-80's, initially as an effort by the US National Science Foundation to build a new generation large optical/infrared telescope for the entire US astronomical community. However, it was quickly realized that a partnership with the United Kingdom and Canada (who had similar observatory plans) could produce twin 8-meter telescopes – one in each hemisphere – more economically, while providing the same amount of total telescope time for US astronomers. At this point it was envisaged that the UK and Canada would each be 25% share partners in Gemini, while the US would be a 50% share partner. However, Canada was unable to raise the funding required for a 25% share, and in the end entered the partnership at only the 15% level. The remaining 10% share was then picked up by Chile (5%), Argentina (2.5%), and Brazil (2.5%).

In 1997, the partnership was expanded by a further 5% to allow Australia to join, giving it an effective 4.76% (5/105) share. Australia's entry into Gemini was funded by the Department of Education, Training & Youth Affairs (DETYA) and the Australian Research Council (ARC; the Partner Agency), at a cost of A$17.9M. As Australia's signatory to the International Gemini Agreement, the ARC has ultimate responsibility for Australian participation in Gemini, and funds through the LIEF scheme the annual operations costs associated with Australia's 4.76% share.

Gemini-North was the first of the two telescopes to be completed, with 'first-light' occurring in 1999. It commenced science operations in 2000. The Gemini-South telescope was completed in 2000, with science operations commencing in 2001.

In 2001, Chile gave notice of its desire to relinquish its 4.76% share (which gave it time over and above the 10% of time on Gemini-South that it receives for 'site rental'). After protracted negotiations, agreement was reached that the US, Australia, Canada and Brazil would purchase 52.5%, 30.0%, 15.0% and 2.5% of Chile's share, respectively. This increased Australia's share in Gemini by an extra 1.43% to 6.19%, with the capital and annual operations costs associated with this extra share being funded from the A$24M Major National Research Facilities (MNRF-2) grant "Gemini and SKA: Australia's Astronomy Future", that was awarded in 2001 and will run through to 2007.With observing time on the Gemini telescopes being allotted to each partner country in direct proportion to their share, Australia currently receives ~12 nights per telescope per year (at 80% operation).

The Gemini Observatory is managed by AURA under a cooperative agreement with the NSF, which is the Executive Agency for Gemini.

Role of the Facility:

The Gemini Observatory consists of twin 8.1 meter optical/infrared telescopes located on two of the best mid-latitude observing sites in the world: Mauna Kea in Hawaii and Cerro Pachon in Chile. The latest technologies in dome and telescope design, optic control systems, mirror coatings and thermal controls have been used to ensure the Gemini telescopes excel in a wide variety of optical and infrared capabilities. There is a particular emphasis on providing superlative spatial resolution over narrow fields, with diffraction-limited performance being achieved at infrared wavelengths, with the assistance of advanced Adaptive Optics (AO) systems in the near-IR. The primary role of Gemini therefore is to provide Australian astronomers with access to 8m-class telescopes equipped with state-of-the-art general-user instrumentation which exploits these capabilities, allowing a diversity of science programs to be pursued across the areas of planetary science, stellar astrophysics, extragalactic astronomy, and cosmology. It also provides Australian institutions the opportunity to bid for and be awarded multi-million dollar contracts to build such instruments, hence returning some of our investment in Gemini to this country and further enhancing its instrument-building reputation and expertise.

In terms of specific instrumentation, the Gemini telescopes are now equipped with facilities instruments that provide imaging/spectroscopic capability in each of the uv/optical, near-IR and mid-IR wavelength regimes. The GMOS instrument, identical versions of which are on each telescope, provides for uv/optical imaging and low-medium resolution spectroscopy, with there being long-slit, multi-slit and IFU modes for the latter. NIRI provides for near-infrared imaging and low-resolution spectroscopy on Gemini-North, and can also be used with the facility AO module, ALTAIR, for very high spatial resolution imaging and spectroscopy. On Gemini-South, GNIRS provides for long-slit and IFU near-IR spectroscopy, while higher-resolution spectroscopy at these wavelengths is catered for with PHOENIX. In the mid-IR, imaging and spectroscopy can be conducted on Gemini-North using MICHELLE, and on Gemini-South using T-ReCS.

Immediate Future of Facility:

The capabilities of the Gemini telescopes are soon to be significantly expanded with the arrival of several new instruments/modes/facilities:

- Laser guide star facility, with the first system to be commissioned on Gemini North in 2005, and a second system to be installed on Gemini South in 2006-7.
- Near Infrared IFU Spectrograph (NIFS), built be RSAA at ANU, to be commissioned on Gemini North in early 2005, and which will use the LGS facility.
- High resolution (R=150K) optical spectrograph, to be commissioned on Gemini South in 2005, with an anticipated high demand from Australian astronomers.
- Near Infrared Coronagraphic Imager (NICI), whose main mission is the direct

detection of massive planets around other stars; to be commissioned in late 2005 on Gemini South.

- Flamingos-II, which is a near-IR imager/multi-object spectrograph that will provide unrivalled capability in the south; to be commissioned in late 2006 on Gemini South.
- Multi-Conjugate Adaptive Optics (MCAO), which will provide fully- and uniformly-corrected AO imaging over an ~80 arcsec field of view. Due to be commissioned in 2007, and will be used with the GSAOI imager being built by RSAA at ANU.

Australian astronomers can also look forward to having additional time on Gemini over the 2005-2006 period, through the purchase of nights from the UK on Gemini-South using the MNRF Gemini funding. It is likely that 8 extra nights (over and above those that Australia gets through its 6.19% share) will be available in the semesters 2005B, 2006A, and 2006B. These will be allocated by ATAC with the intention that they be used for more major programs with a potentially higher scientific impact than those supported with the existing time.

Future Vision of Facility:

In 2003, the Gemini partnership undertook a major initiative to determine what its partner communities' future scientific visions and aspirations were, with the goal of defining the next generation of instruments for the Gemini 8m telescopes. This so-called "Aspen process" involved grass-root consultation within all the partner communities (Australia being no exception), which then culminated with all the partners coming together for the Second Gemini Instrumentation Workshop in Aspen in June 2003. This lead to the identification of a set of big science questions which the partnership wanted to address over the next 5-8 years, which in turn mapped to a clear set of new instrument capabilities that would be required to address them. These questions, which are presented and elucidated in the Aspen science document Scientific Horizons at the Gemini Observatory: Exploring a Universe of Matter, Energy, and Life, can be summarized as follows:

Generic area	'Big Questions'
Universe of Matter	• How do galaxies form?
	• What is the nature of dark matter on galactic scales?
	• What is the relationship between SMBHs & galaxies?
Universe of Energy	• What is dark energy?
	• How did the cosmic dark age end?
Universe of Life	• How common are exoplanets, including earth-like planets?
	• How do star and planetary systems form?
	• How do stars process elements into the chemical building-blocks of life?

At the end of 2003, the Gemini Science Committee and the Gemini Board determined that the minimum core set of instruments of highest priority for tackling these questions were:

- Wide Field Multi-Object Spectrograph (WFMOS) – an optical spectrograph with a 1.5 degree field of view, a multiplex gain of ~5000, and a spectral resolution covering the range R=1000–30000.
- Extreme AO Coronograph (ExAO-C) – a next generation AO imager with a spatial resolution of 0.02 arcsec and capable of achieving contrast factors of 10^7.
- High-Resolution Near-Infrared Spectrograph (HRNIRS) – with spectral resolution in the range R=40000-70000, and with an MCAO-fed MOS capability.

The following capability was also identified as having sufficiently high potential to warrant further investigation:

- Ground Layer Adaptive Optics (GLAO) system – built around an adaptive secondary mirror, such a system has the potential to provide a spatial resolution of ~0.2 arcsec over a ~10 arcmin field of view over the range 0.6-2.2μm.

Feasibility studies for WFMOS and GLAO and concept design studies ExAO-C and HRNIRS are currently underway and will be completed in early 2005. Subject to funding being found, the WFMOS, ExAO-C and HRNIRS should proceed to the final design and build phase in late 2005, and be expected to come online at the Gemini telescopes sometime in the period 2009 (ExAO-C, HRNIRS) to 2012 (WFMOS).

The WFMOS instrument is of particular strategic importance to Australia. Our community has had strong involvement right from the outset, being highly involved and proactive in forming a working group to develop the science drivers for this instrument and lobbying hard for them within the Aspen process. These science drivers, along with the technical requirements, are very effectively presented in the KAOS Purple Book. Now that WFMOS has been chosen as one of the top priority Aspen instruments, the AAO is the lead institution in the feasibility study of this instrument. This will place it in a very strong position to compete for key components of the contract to construct WFMOS. Finally, a proposal to build WFMOS for the 8.2m Subaru Telescope as part of a collaboration between Gemini and the Japanese astronomical community (where the two communities would have access to each other's telescopes), is gaining considerable momentum. This has the potential to further strengthen the AAO's position, given its successful track-record in building the Echidna positioner for FMOS on Subaru, a technology that is also likely to be used for WFMOS.

Looking further ahead in time, the current International Gemini Agreement will expire in 2012, at which point the involvement of all the partners will be up for renegotiation. This is within the time-frame of the current decadal planning process, and Australia needs to consider its options in this context.

Current Impact

With the Gemini telescopes having been in operation for only 4 years, it is too early for high impact papers (with 200+ citations) to have emerged. However, the following programs are almost certain to have a high scientific impact:

- Gemini Deep Deep Survey – characterization of the galaxy population in the range $1<z<2$.
- Gemini Lyman Alpha Reionization Epoch Survey – detection of the very first light-emitting galaxies in the universe at $z>6$ (Australian involvement).
- The nature of the galaxy hosts of $z\sim2$ QSOs (Australian led).
- Stellar population studies in Local Group galaxies, in particular those where individual stars are resolved through the use of AO (Australian involvement)
- Stellar population studies at the Galactic Centre (using AO).
- Detection of faint companions to nearby normal stars (using AO).
- Studies of proto-planetary disks, their structure and mineralogy (Australian involvement)

Gemini:
Strengths - international partnership, queue observing, North and South sky access, good sites, well engineered, emphasis on image quality, ability to contribute to instrumentation

Weaknesses - small fraction of partnership, narrow field-of-view, lack of high dispersion optical spectrograph, queue observing means difficult for people to feel ownership

Opportunties - drive new science and instrumentation directions, increase access

Threats - becoming marginal if community doesn't grasp science opportunities and if new instrumentation opportunities don't come our way.

Additional 8-meter time.

As part of the 1995 Decadal Plan, Australia emphasized gaining membership to ESO, a plan which would have given Australia access to an equivalent of 25% of an 8m telescope. Australia has since joined Gemini as a 6.19% partner (initial+MNRF) and therefore has a 12.38% share of an 8m-class facility, a level which puts Australian Astronomers at a significant disadvantage to our overseas competitors, and does not provide access to a wide-field 8-m class facility, nor a high resolution spectroscopic capability. The MNRF program has closed this gap in 2005/6 with the purchase 24 nights of Gemini-S time over 18 months from Great Britain. This is an equivalent of increasing our share in 8meter class facilities (over this time period) by approximately 7.5% (once overheads of host country, engineering, and directors time are taken into account) – taking Australian Astronomy much closer to its goal of 25% of an 8-meter telescope. However the MNRF is a temporary measure, and once this program finishes in 2007, Australia will once again be well below a viable 8-meter investment.

There are limited possibilities for further investment in 8-meters.

- ESO remains a distance possibility, which would provide Australia access to 8-metre class telescope, a pathway to ELTs, and a share of ALMA. But we are no longer first in-line for joining, and this seems a difficult proposition.
- Joining SALT is another possibility. This facility would provide high-resolution spectroscopy for Australian at a relatively modest cost, but is not a fully flexible facility like Gemini, VLT, and Keck.
- Joining in Magellan/GMT is also a possible way forward. This would provide widefield and High-resolution capabilities through the 6.5m Magellan telescopes, as well as giving Australia a path forward to an ELT.

Additional 8m time SWOT analysis:

Strengths – Essential to continued Australian Excellence in optical Astronomy.

Weaknesses – Will be a small fraction of any partnership. Late arrival in partnership means we do not drive facility from outset.

Opportunties – New instrumentation possibilities. Make up for wide field and high resolution capabilities missing in Gemini.

Threats – No opportunities to join an 8m partnership. Or choosing to join an 8m class facility which is not technically competitive.