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PILOT-LIKE TELESCOPE POTENTIAL

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Abstract. In this paper we review the progress towards the deployment of a large "PILOT-like" telescope at Concordia Station, Dome C. PILOT is a proposed 2.4m optical/IR telescope that will cost in excess of EUR 10m, and is thus representative of the scale of facility that will transform Concordia into a significant international observatory. A design study of PILOT, funded by the Australian government, is currently underway. We describe the current status of this design study, and discuss the implications that major international projects such as PILOT hold for the future of Antarctic astronomy at Concordia.

1 Four years ago: Capri 2003

Two years before Concordia opened for year-round operation, a meeting was held on the beautiful island of Capri to discuss the potential of Dome C for astronomy. Seventy astronomers from Europe, Australia and the US met to discuss the scientific possibilities of Concordia. At that stage, however, no direct measurements had been made of site conditions during the winter, and so discussions were based largely on Automatic Weather Station data and models extrapolated from South Pole data.

Delegates at this meeting were very positive about the future, with the final summary noting that:

- Conditions at Dome C are unique, and extremely favourable.
- A medium-size telescope or interferometer could do ground-breaking science.
- A very large telescope could make some future space missions unnecessary.
- The opportunity awaits!

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In the intervening four years, we have learned a little more about the site. As expected, the free-air turbulence is extremely low—especially at the highest altitudes. As expected, there is an intensely turbulent surface layer. Perhaps disappointingly, this layer is tens of metres thick, rather than the <10 m that some had hoped for. However, initial expectations of very clear skies appear to be confirmed, making Dome C an attractive site for a wide range of astronomical endeavours.

2 Why PILOT?

The success of the SPIREX telescope (Herald 1994; Fowler *et al.* 1998) at the South Pole led almost immediately to proposals to build an optical/infrared telescope of at least 2 metres diameter. However, it was quickly realised that Dome C offered some advantage in terms both of cloud cover and in having a thinner atmospheric surface layer. The "Douglas Mawson Telescope" was thus proposed in 2000 for Dome C as a 2-metre class facility with partners from Australia, France and Italy (e.g., Lawrence *et al.* 2003).

In the intervening years, the proposal for an observatory-class optical/IR telescope has become more international, and the name has changed to reflect this. At the same time—partly to take advantage of technological advances and partly to make it more competitive with telescopes coming on line at other locations—the telescope has grown to 2.4–2.5 metres (Storey *et al.* 2007).

PILOT, the Pathfinder for an International Large Optical Telescope, must perform two roles. First, as the name suggests, it must act as a technological pathfinder for future, more ambitious facilities. Second, it must achieve scientific results that are both unique and important. Only in this way will sufficient support be forthcoming from the general astronomical community to justify the costs.

3 Science versus pathfinding

To be able to achieve exciting scientific results across a number of different research areas, PILOT must be large enough to compete with existing (and planned) facilities. This is discussed in more detail in the following section. The science goals for a 2m-class "PILOT-like" Antarctic telescope have been explored several times, most recently and in the greatest depth by Burton *et al.* (2005). The conclusion is clear—sufficient "discovery space" is accessible by such a telescope at present, but this discovery space is being continually eroded as new telescopes are brought on line at other sites (and in space).

Provided PILOT can be constructed in the next few years, it should have little difficulty delivering scientific results that will bring it to international prominence. However, it must also perform another role, and that is to demonstrate the viability of Antarctica as a site for even larger optical/infrared telescopes. In this "pathfinder" role, PILOT must show that there are no obstacles—technical, operational or logistic—that cannot be overcome. Technical solutions to the major challenges such as the extreme cold and the high relative humidity should, if possible, be scalable to larger facilities. In addition, if PILOT is to be a useful precursor to a range of other facilities (for example, interferometers) it must be designed from the outset to address at least some of the particular technical challenges that these facilities will face.

Some of the key technical decisions currently facing the design team are:

- Conventional or off-axis?
- Ritchey-Chretien or Gregorian?
- Focal station behind primary mirror, or purely Nasmyth?
- Active or passive optics?
- Mirror material (Zerodur, silicon carbide, aluminium, or other)?
- Tower height
- Enclosure design
- Solar observations to be possible?

4 The niche occupied by PILOT

In order to justify construction of a telescope the size of PILOT, it is necessary to take an objective look at alternative ways of achieving the same scientific goals. For every scientific program proposed for PILOT, there is at least one existing or planned facility that could also tackle the same problem. If this competing facility can achieve one of PILOT's goals sooner, or cheaper, then this goal can no longer be considered part of the core science case of PILOT

The most relevant competing facilities include:

- Existing 8m-class telescopes
- HST
- WISE
- VISTA
- PanSTARRS
- APEX
- SOFIA
- Herschel

Some other planned facilities can, however, be considered as non-competing for the simple reason that when they do come on line, their sensitivities and/or mapping speeds are so much greater than PILOT's that they will quickly dominate those areas of science they choose to tackle. These are the facilities that, to a large extent, mark the end of the window of opportunity for PILOT. They include: JWST, ELTs, and DUNE.

Finally, it must be recognized that there are several other sites on the Antarctic plateau, and these may offer advantages in some areas. If placing PILOT at one of these other sites can be shown to lead to a more satisfactory outcome, then such an option must be investigated.

These competing sites include:

- South Pole
  - Less high-altitude turbulence
  - Well established, with extensive (if expensive) logistics
  - "Internationalised"
  - Well documented access arrangements
- Dome A
  - Higher, drier, colder
  - Lower wind speed
  - Thinner boundary layer
  - Likely to be superb at THz frequencies
- Dome F
  - Higher, drier, colder

Of course, these sites also have their own disadvantages relative to Dome C. A well-argued proposal for a PILOT-like telescope at Dome C must therefore take into account not only the capabilities of existing or near-term telescopes at temperate sites (or in space) but also weigh up the advantages and disadvantages of other possible Antarctic sites.

5 PILOT current status

Towards the end of 2006 the Australian government, through its Department of Education Science and Training, announced funding for a suite of programs across a range of scientific "Capabilities". The Radio and Optical Astronomy Capability was funded to maintain and enhance existing facilities, and in addition to explore the possibilities offered by three proposed new facilities:

- An Antarctic Telescope, PILOT

- The Square Kilometere Array
- The Giant Magellan Telescope

One million Australian dollars (∼EUR600k) has been allocated to a design study of PILOT. The past twelve months has been spent largely in the negotiation of contracts, including a major sub-contract to the Anglo-Australian Observatory to carry out the technical aspects of the study.

In February 2007, a Risk Workshop was held in Sydney to assess the high-level risks to the project. This workshop identified a total of 29 risks, with 8 of these rated as "high". Each of these risks will now be studied in detail, and strategies developed to reduce them to a manageable level.

Studies at the Anglo-Australian Observatory (Saunders *et al.* 2008) have refined the technical specification to include the potential for diffraction-limited imaging at 500 nm, and a field of view of at least 1 degree. Over the next six months, detailed engineering studies will address the major challenges of designing a telescope to work reliably in Antarctic conditions, and deliver a robust estimate of the total, whole-of-life cost for the facility.

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References

Burton, M.G., Lawrence, J.S., Ashley, M.C.B., *et al.* 2005, PASA, 22, 199

Fowler, A.M., *et al.* 1998, Proc. SPIE, 3354, 1170

Herald, M. 1994, in Astrophys. & Sp. Sci. Lib., 190, Infrared Astronomy with Arrays, the Next Generation, ed. I. McLean, 248

Lawrence, J.S., Ashley, M.C.B., Burton, M.G. & Storey, J.W.V. 2003, Memorie della Societ Astronomica Italiana Supplementi, 2, 88

Saunders, W. *et al.* 2008, these proceedings

Storey, J.W.V., Ashley, M.C.B., Burton, M.G. & Lawrence, J.S. 2007, PILOT-the Pathfinder for an International Large Optical Telescope, Proceedings of the 1st ARENA Conference (Eds. N. Epchtein & M. Candidi), EAS Publications Series, 255