

The Case for Irish Membership of the European Southern Observatory

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Summary

The European Southern Observatory (ESO) is universally acknowledged as being the world leader in observational astronomy bringing together the very highest calibre of scientists and drawing together knowledge across many areas of science and technology.

Irish membership of ESO would bring significant benefits to the country. In particular it would:

- ◆ allow Irish astronomers to expand their research strengths in an international community, which is a must for a country aspiring to develop a world class research base.
- ◆ provide Irish scientists with the prospect of working at the most cutting edge technology in such areas as detectors, high-speed micro and opto-electronics, high-performance computing, high-speed networking, large volume data storage, mechanical and electrical engineering – all areas with tremendous potential for technology transfer and industrial spin-offs in Ireland.
- ◆ provide a springboard for excellent outreach activities. Astronomy has exceptional appeal to young people and to the broader public and as such acts as an outstanding tool to attract much-needed students into science.

Astronomy research has a strong base in Ireland, but without membership of ESO, there is a serious deficit in the type and scope of work which researchers can do.

In the drive to ensure Ireland's position in the global knowledge economy, the Institute considers membership of ESO to be critical.

European Southern Observatory (ESO)

The European Southern Observatory (ESO) is an intergovernmental European organisation for astronomical research and is widely regarded as the best astronomical observing facility in the world. As the USA National Science Foundation commented in 2006 that “there is no US organization that provides a suitable match to ESO.”¹ Headquartered in Munich, Germany, it consists of a suite of telescopes located in the high Andes of Chile giving access to research in infrared, optical and radio wavelengths. It is also a significant driver and consumer of advanced technology generating large industrial R&D contracts and spin-offs for its 14 member states². In Western Europe, only Ireland, Norway (with a much smaller astronomy community than Ireland) and Luxembourg (with no astronomical community) are missing.

ESO is constantly developing new instruments and technologies, while simultaneously taking the lead in ICT developments particularly in sophisticated analysis software and also supporting the wider astronomical community through outreach activities and education.

Its current flagship project in operation is the Very Large Telescope, which uses the most advanced technology available to achieve a higher resolution in the infra-red than the Hubble Space Telescope – a remarkable achievement given that the instrument corrects for atmospheric effects in real time using adaptive optics.

Its next major project, the Atacama Large Millimetre Array (ALMA), will push the boundaries between radio and optical astronomy and will require significant technological developments in antenna design, high-frequency radio detection and robotic operation at high altitude.

In addition, approval has recently been granted by the ESO's governing body to proceed with detailed studies for the European Extremely Large Telescope (EELT). This study, with a budget of €57 million, will make it possible to start, in three years time, the construction of an optical/infrared telescope with a diameter around 40m that will revolutionise ground-based astronomy. This telescope will enable astronomers to study the earliest and most distant galaxies, right back to the era of the first light in the Universe. Scientists will be able to look deep into the dust-obscured regions where stars are born to examine the details of star and planet formation. It will be feasible to image planets around other stars and possibly identify planets on which life might be possible.

While such research might seem esoteric, it is of note that a recent report from the UK Russell Group of universities, shows that the commercialisation of blue-skies research generated more than twice the average returns from applied research. Of the top ten projects measured by financial return, eight were the product of basic research.³ In addition the UK Royal Astronomical Society, in its submission to the Wakeham review on Physics in 2008⁴, noted that the UK space industry supports 70000 jobs and contributes around £7bn per annum to domestic GDP. The submission also documented significant numbers of spin out companies derived directly from research in astronomy.

Irish Astronomy Strengths

As indicated by the Georgia Tech Group report⁵ to Forfás in 2001 on Irish membership of intergovernmental instruments, astronomy is a particular strength in Irish research with around 150 researchers working in this area across almost all of the of the Irish universities and in a specific research institute.⁶ There is a high publication and citation rate. For example, in the period 2003-2007, there were 334 publications in peer reviewed journals with a total citation tally of around 3500.

The 2009 National Plan for Astronomy in Ireland of the Royal Irish Academy's Astronomy and Space Science Committee⁷ makes clear the enormous range of research areas under investigation in Ireland including stellar formation and evolution, extra-galactic astronomy, high-energy astrophysics, instrumentation, archival research and computational astrophysics.

It is notable that because of Ireland's membership of the European Space Agency (ESA) observations can regularly be made with satellites, primarily using X-ray and gamma-ray telescopes. This access means that high-energy research is a notable strength in Irish astronomy⁷ and that a network of industries has grown around contracts with ESA. With this template there is every reason to believe that Ireland can gain immensely from membership of ESO.

In recent years there has been a significant increase in astronomy degree programmes which are now offered in six of the universities. Such programmes are clearly attractive to young people and buck the trend in declining interest in science. However success at degree level teaching depends upon maintaining and recruiting dedicated researchers and teachers. For Ireland to be an attractive destination for world-class researchers, it is imperative that they should have access to world-class facilities. At present this is not the case.

Difficulties

Since the termination in 2003 of the international agreement, whereby Irish astronomers had access to telescopes on La Palma in the Canary Islands, Ireland now has no formal access to any leading ground-based astronomical facility which use optical wavelengths. Access to telescopes has become extremely patchy and dependent on good will from other countries and certainly provides no basis on which to build a strong research programme with international linkages. This situation, unique within the pre-enlargement of the EU is a severe

blow to the Irish astronomical research community. There is a strong consensus across the Irish astronomy research community that ESO membership is their highest priority as this would significantly redress this and enhance opportunities for astronomical research in Ireland. It is estimated that around 80% of astronomers in Ireland would be in a position to use ESO.

In European astronomy, the norm is to be embedded in intergovernmental research organisations. Joining ESO means becoming part of a coherent, long-term programme, which so far has provided for a remarkable come-back for astronomy in the member states that has enabled Europe to regain a leading position in the world. Indeed, ESO's cross-disciplinary and trans-national approach to research and development has set the standard for the European Research Area. Without membership of ESO, Ireland cannot hope to be fully integrated into European research or to take its place within the global knowledge economy.

Government Reports on Membership of ESO

The Georgia Tech Report⁵ recommended in 2001 that the Irish government should give strong consideration to joining ESO. In the 2006 report, 'Strategy for Science, Technology and Innovation (STI)', the Irish Government stated that its vision is that:

*'Ireland by 2013 will be internationally renowned for the excellence of its research, and will be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture'*⁸.

The same report clearly acknowledges the benefits of international engagement in STI. In 2007, the Higher Education Authority report on research infrastructure in Ireland⁹ noted that membership of ESO is a matter to be discussed at government level. In 2008 in the Advisory Science Council's report¹⁰ to Forfás on Ireland's international engagement in STI, it is noted:

'that there are strong economic arguments in favour of taking an international approach to the construction of highly specialised and expensive research infrastructures and for making arrangements to share access to these facilities across many countries.'

This same report gives a list of factors relating to science, enterprise, management and culture which should be used to determine Irish membership of intergovernmental research organisations. For each of these factors, membership of ESO clearly meets the listed criteria. (See Appendix I)

It is also of note that in 2000, the UK International Review Panel for Physical Sciences recommended that the UK should join ESO. This recommendation led to the UK joining ESO in 2002 and the 2005 report of the International Panel highlights the highly significant benefits to UK astrophysics of having joined ESO.¹¹

Industrial Return

ESO is heavily involved in many aspects of cutting edge technology development in fields such as active optics, fibre lasers, Virtual Observatories, dynamic scheduling software, instrument interfaces, data archiving/mining, and automated data reduction pipelines. ESO actively promotes technology transfer into the broader economy and there are many examples of ESO developments that have been taken over by a manufacturer or produced commercially for a wider market including liquid nitrogen cryostats for charge-coupled devices (CCDs), flexible mirrors and infra-red detectors. For instance, producing the giant mirrors blanks for the VLT gave European industry global leadership in the manufacturing and polishing of large optical mirrors.

Membership of ESO would allow Irish firms to bid for significant R&D contracts. In addition, there is a very substantial multiplier effect in that by working at and beyond the limits of standard technology, firms gain a competitive edge in the global market place and benefit from inward technology transfer. This would be particularly true for firms in the ICT sector but

also radio communication and advanced optics, all areas where Ireland has growing strengths.

Although, unlike ESA, ESO does not operate a 'juste retour' policy, there is every reason to believe that Irish companies would benefit significantly from ESO membership. Over the period 1995-2005 for example, countries like Denmark, France, and the Netherlands all won contracts for companies and research institutes that (on average) *exceeded* the corresponding annual membership fee. More recent ESO members such as the UK, which joined in 2002 are rapidly approaching such levels of success with UK companies gaining contracts worth around 80-90% of the UK annual ESO subscription.

It is of particular note that Ireland has achieved exceptional success in obtaining contracts with ESA, primarily through the work of Enterprise Ireland in identifying such opportunities. With an annual membership fee of €10 million, in the period, 2000-2006, Irish firms have won ESA contracts worth an estimated €25 million with spin-off business worth an estimated €100 million and more than 60 Irish companies to date have engaged with ESA¹². Certainly, many of these companies would be in a position to benefit from membership of ESO. Potential strength areas would be in ICT and electronics with firms such as Captec and Farran Technologies having exceptional capabilities in these sectors.

There are also significant opportunities for technology transfer from third level, particularly in detector systems, applied optics, millimeter wave optics and high-performance computing. Ireland already has a number of well established research groups in these areas – for example, adaptive optics at NUI Galway and far infrared optics at NUI Maynooth which already have strong links with ESA.

More generally, ESO has a strong interest in broadening its contacts with industry, and in developing fruitful relations with suppliers in all member-states. Its technology transfer programme is highly developed and to have access to this would perhaps be the biggest industrial benefit from Irish membership.

Education and Training

As previously noted, astronomy is one of the main drivers of interest in third level physical sciences courses. This is also a highly significant area for attracting Ph.D. students. Membership of ESO would provide opportunities for world-class postgraduate training and hence a major boost to government plans to double Ph.D. numbers. Through its Student, Fellowship and Associate Programmes, ESO has contributed to the training of hundreds of young scientists and engineers over the years who have since returned to their own countries bringing significant value to their national research programmes.

Access to its excellent outreach programmes could be used as a corner stone in current Irish science outreach activities. Such ESO activities are particularly geared towards secondary schools and include teaching materials, courses for teachers, summer schools and specific educational projects, often in collaboration with partners such as the [European Association for Astronomy Education \(EAAE\)](#), the [EIROforum](#), the European Commission and others.

ESO Membership Fee and Benefits

Countries that become ESO members pay an entry fee, which takes into account the large investments that the other member countries have already made. The initial entry fee is calculated using a number of factors, ESO's budget, investment value, the size of the Irish economy relative to that of the current member states. Assuming a joining date of 1 January 2010, the entry fee is estimated to be about €21.4 million and an annual fee of around €2.2 million. This may be open to negotiation and payable over an extended timescale. Such fee levels are of the order of typical SFI grants.

It is of interest to note the range of other countries which have recently joined or are in the process. Because there is no comparable USA telescope, this has led to considerable demand from countries with six joining in the last ten years and another six from outside Europe. ESO is currently in membership negotiations with a number of Eastern European states, some with considerably lesser economic resources than Ireland. Austria, ESO's most

recent member, made joining a priority in order to be able to attract Austrian born top scientists to return to research positions in the leading Austrian universities.

With planning underway for the ESO's next big instrument, the European Extremely Large Telescope, the time is particularly opportune to join ESO. Ireland would be in a position to benefit from potential industrial contracts and to participate in setting the science agenda.

The time is surely long overdue for Ireland to demonstrate its commitment both to its vision for the country's knowledge economy and to European cohesion by taking its place in the world's foremost astronomical research facility.

Notes:

1. From the ground up: balancing the NSF astronomy program. Report of the National Science Foundation Division of Astronomical Sciences Senior Review Committee October 22 2006
2. ESO member states: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.
3. Reported in the Times Higher Education Supplement, 13th Nov 2008. Report still being finalised.
<http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=404301>
4. Royal Astronomical Society Submission to the Wakeham Review of the Health of Physics, May 2008.
5. Cozzens, S., Shapira, P., Krige, J., and Porter, A. (2001). Assessment of Irish Participation in Inter-Governmental Research Organizations. Final Report. Prepared for Forfás (National Policy and Advisory Board for Enterprise, Trade, Science, Technology and Innovation in Ireland). Georgia Tech School of Public Policy and Technology Policy and Assessment Center, Atlanta, GA.
6. Namely, DCU, NUIG, NUIM, TCD, UCC, UCD and also CIT and DIAS
7. Royal Irish Academy, Astronomy and Space Science Committee, 2009. National Plan for Astronomy in Ireland.
8. Strategy for Science, Technology and Innovation, 2006-2013, June 2006. Dept. of Enterprise, Trade and Employment.
9. Research Infrastructure in Ireland, Building for Tomorrow, 2007. Higher Education Authority.
10. Ireland's International Engagement in Science, Technology and Innovation, December 2008. Advisory Council for Science, Technology and Innovation. Forfás.
11. The Second International Review - International Perceptions of UK Research in Physics and Astronomy 2005

http://www.iop.org/Our_Activities/Science_Policy/Projects/International_Review/file_6363.pdf

12. Annual Implementation Report, 2005 for the Productive Sector Operational Programme, 2000-2006. Dept. of Enterprise, Trade and Employment.

***The Institute of Physics in Ireland**

The Institute of Physics in Ireland (IOPI) is the professional and scholarly organisation for physics in Ireland, both Northern Ireland and the Republic. It represents over 1700 physicists active in education, research, industry, the public service and commerce in Ireland. It is a branch of the London-based Institute of Physics, a leading international body and learned society with over 37,000 members in Ireland, the United Kingdom and elsewhere, which promotes the advancement and dissemination of knowledge and education in the science of physics, pure and applied.

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Appendix I

Criteria Employed by GeorgiaTech to Assess Ireland's Membership Status of Intergovernmental Research Organisations

Science Factors

1. *Is the organisations's research world class and unique?* Yes – ESO is globally acknowledged to be the world's leading optical viewing facility. It is definitely ahead of the USA using any benchmark – for example publications, technical achievements and time spent in research activity (90% compared with 50% in any USA facility). In addition it has sub-millimetre capacity and might move into other fields
2. *Does the opportunity fit national strategic research goals?* Yes, government strategy over the past 5 years has clearly been to place Ireland as a leading knowledge economy with a priority to establish international linkages with the potential for industrial returns.
3. *Is Ireland's research base capable of taking advantage of the opportunity?* Yes. Of the 150 astronomers in Ireland around 80% could use ESO. In addition with the advent of astronomy degree programmes there are around 160 undergraduate astrophysics students providing a significant pool of potential PhD students in this area.
4. *Does the organisation provide opportunities for training new scientists in this field?* Yes, ESO has world-class training opportunities for third and fourth level students. These in turn would lead to enhanced opportunities for international research linkages.
5. *Will the membership enhance Ireland's set of international collaborative relationships in science?* Yes. This is particularly the case given Ireland's longstanding membership of ESA.
6. *Are the entry fee, annual cost of membership and cost of participating affordable?* The costs are comparable to current typical SFI grants which to date have mostly been concentrated in the biological and IT areas. However funding of more fundamental science has been shown to have significant benefits both industrial and scientific.³
7. *In comparison with other science investments, and in relation to goals for science, does the membership give value for money?* Yes. Given the strength of the astronomy research community in Ireland there will be an immediate uptake in use of the instruments – i.e. no protracted lead in time to build up expertise. As the world leader in observing facilities carrying out research at ESO is the most effective way of advancing scientific goals.

Enterprise Factors

8. *Does the country's industrial strategy call for development in an area that the organisation is working in?* Yes, industrial spin offs from ESO are particularly relevant to Ireland, given their concentration on IT, electronics and applied optics
9. *Are there significant opportunities for Irish firms to participate in leading-edge technology development?* Yes. Ireland has particular strengths in IT and electronics which are already benefiting from Ireland's membership of ESA.
10. *Are there significant new opportunities for skills development relevant to Irish firms?* Yes, ESO is constantly working at the cutting edge in new technologies and has frequently driven much innovation in companies working with it.

11. *Will membership enhance Irish industry's international collaborations?* Yes. Given the large scale nature of ESO's work particularly in relation to the upcoming EELT project, there will inevitably be opportunities for Irish industries to work collaboratively with other international companies.
12. *Will membership enhance the country's reputation as a high-technology environment?* Yes. Without doubt this is true and the corollary is also true that without membership of ESO, Ireland's international reputation as high-tech environment is severely compromised
13. *In comparison with other industry investments, and in relation to goals for industry programs, does the membership give value for money?* Yes. On the assumption that Ireland can match its industrial performance with its current membership of ESA there is every prospect that ESO membership will give excellent value for money.

Management Factors

14. *If a member, will Ireland be able to influence the future direction of the organisation's research and technology projects?* Yes. All members are able to contribute to this.
15. *Does Ireland need to maintain a liaison office to get full benefits?* It would certainly help to have an active presence with ESO's industrial office.

Cultural Factors

16. *How important is international co-operation with other countries that belong to the organisation?* This is very important as much of astronomy research is carried out in large trans-national groups. Ireland already has good relationships with researchers internationally in this field and could certainly hope to build upon these.
17. *Will membership contribute to a culture of science in the country?* Yes. Astronomy is one of the key drivers of interest in science and its uptake at second and third level. Ireland has a long tradition of scientific expertise in this area and the subject has undoubtedly captured the imagination of the public.