Institution: University of Leicester

Unit of Assessment: 9 Physics

Title of case study: The National Space Centre (NSC)

1. Short summary of the case study

The National Space Centre (NSC), sited in the Abbey Meadows area of the City of Leicester, combines elements of museum and visitor attraction with an educational mission to attract 8-14 year olds to the Science, Technology, Engineering and Mathematics (STEM) subjects using the inspiration of space science and exploration. Since its opening on June 30th 2001, the NSC has welcomed almost 2.5 million visitors to its galleries and full-dome planetarium. Space science research within the UoA was a driving force in the establishment of the NSC and continues to contribute to its success. Members of the Unit serve as non-executive Directors on the NSC Operating Company (OPCO) Board and as Trustees, while others contribute to its Space Now public outreach programme and to the Space Academy teacher engagement project which began in the East Midlands region, but now has national scope. The claimed impact is not only related to outreach and quantitative educational outcomes, but also to long-term economic benefit to the City of Leicester, through the regeneration of a brownfield site in a disadvantaged inner-city district, now featuring the development of a science park with the National Space Centre as its focus.

2. Underpinning research

The space research activity at the University of Leicester dates from 1960 -- beginning with the study of the Sun in X-rays, the first sounding rocket measurements p of cosmic X-ray sources in the southern sky followed in 1967. Leicester's heritage in satellite-borne experimental space science dates from Ariel 1 in 1962. The underpinning research is, therefore, an evolving large-scale activity encompassing instrument design and construction, data processing and interpretation, now coupled to astrophysical theory, planetary science and the microscopic investigation of planetary materials. This long-term, large scale research programme has been based on continuous funding via Rolling/Consolidated Grants from PPARC and now STFC and by major project grants for satellite missions in X-ray astrophysics, planetary science and Earth observation science. In the assessment period relevant to this REF, these missions include the X-ray observatories XMM-Newton (launched 1999 in the European Space Agency programme), Chandra (NASA, also launched 1999), Swift (NASA/UK/Italy, 2004), the ESA Envisat mission (2002) and the ESA Mars Express/Beagle 2 Mars probe, launched in 2003, whose Lander Operations Centre was physically located within the main NSC building. It was the international reputation of Leicester as a centre of excellence in space science – particularly in X-ray astronomy – which made the City the natural home for the National Space Centre, when the concept began to be discussed in the late 1990s.

Individual researchers from the Department of Physics and Astronomy (which is coterminous with the UoA) continue to bring their experience of major space projects and their knowledge of space science and astronomy to bear in the governance of the NSC, to the content of its galleries, and in the shaping of its educational initiatives. These individual researchers include : Professor Alan Wells (emeritus professor of space technology ; founding Director of the University Space Research Centre 1988-2003 and a key member of the original University of Leicester / Leicester City Council NSC project team and of the current NSC Operating Company (OPCO) board) ; Professor Ken Pounds FRS (emeritus professor of space physics and active X-ray astronomy researcher, current member of the NSC's Board of Trustees) ; Professor Martin Barstow (University pro-vice chancellor, Chair, NSC Education Committee and currently member of National Space Academy Advisory Board) and Professor George Fraser (professor of detector physics, Director, SRC since 2003 and member, OPCO Board). In total, approximately one-quarter of the academic staff complement of the Unit have a regular, active engagement with the NSC, contributing to the rolling "Leicester in Space" display screen in the Space Now gallery, giving evening and lunchtime talks (e.g. Dr John Bridges, on the arrival and subsequent operations of

NASA's lander Curiosity at Mars), working alongside NSC staff in the development and delivery of new national training initiatives (e.g. Dr Graham Wynn, theoretical astrophysicist and Director of Teaching in the Department of Physics and Astronomy - in the case of the Higher Apprenticeships for Space Engineering scheme, involving Loughborough College, the NSC and the University of Leicester). The University's space research, finally, provides artefacts for the NSC exhibition – most recently, a model of the Mid Infrared (MIRI) Instrument for the James Webb Space Telescope, a centrepiece of the Space Now Gallery.

The current scale of the Department's space-related activity is indicated by the £5.1M STFC Consolidated Grant (Prof .Mark Lester, PI) awarded to four of its six constituent research groups for the three-year period beginning April 1st, 2013. The Department is currently involved in the operational missions Cassini, Cluster, Chandra, XMM-Newton, Swift and Curiosity; has contributed hardware and /or software to Gaia, James Webb Space Telescope, the Indian national Astrosat and three GERB radiation monitors on the operational Meteosat Second Generation spacecraft; and, as part of international consortia, is building instruments for the European Space Agency missions BepiColombo to Mercury and EXOMARS to Mars.

3. References to the research

The choice of only six references to represent a long-term, highly-diversified programme in Earth observation, space astronomy and planetary science is inevitably arbitrary. Focusing on University of Leicester involvements in major space missions operating throughout the assessment period 2008-13 (or under construction in the same period) is one way of indicating both the diversity and (through Google Scholar citation count) the significance of the Leicester research. References (i) and (ii) are instrument descriptions published close to the time of launch. References (v) and (vi) describe the use of data or returned sample material.

(i) ***XMM-Newton*** ; M.J.L. Turner et al., Astronomy and Astrophysics 365 (2001) L27.
(ii) ***Swift:*** N.Gehrels et al., Astrophysical Journal.611 (2004) 1005.
(iii) ***Envisat ;*** SP Lawrence, D Llewellyn-Jones and SP Smith, Journal of Geophysical Research 109 (2004).
(iv) ***BepiColombo*** : G.W. Fraser et al. "The Mercury Imaging X-ray Spectrometer on Bepicolombo", Planetary and Space Science 58(1-2)(2010) 79-95.
(v) ***Cassini/Hubble*** : E.J.Bunce et al., "Origins of Saturn's aurora: simultaneous observations by Cassini and the Hubble Space Telescope", Journal of Geophysical Research 113 (2008) A09209.
(vi) ***Stardust*** : J.C. Bridges et al., "Iron oxides in comet 81P/Wild 2", Meteoritics and Planetary Science 48 (2010) 55.

4. Details of the impact

The National Space Centre (NSC), which opened on June 30th 2001, was conceived by its founding partners (the University of Leicester and Leicester City Council) as a £50 million flagship Millennium Commission project for the English East Midlands and has, in the intervening decade, established a reputation as one of the foremost science visitor centres in the UK. The space science and astronomy programmes of the Unit gave rise to the NSC and continues, throughout the 2008-13 period of interest here, to make significant inputs to many of its activities (**A**).

The NSC's rocket tower, designed by the Nicholas Grimshaw architectural practice, houses original Thor and Blue Streak rockets raised to the launch position and has become a regional icon, featuring each evening on the introduction to the BBC East Midlands early evening news bulletin. Since its opening, over 2.5 million visitors have passed through its doors (including Buzz Aldrin, the second man on the moon, in 2005). Visitor numbers are on an upward trend. The yearly rolling average number of visitors was 235,000 in December, 2012 but the most up-to-date data (March 2013) indicates an 11% year-on-year increase in visitor numbers. The number of schoolchildren on educational visits reached the NSC's capacity in 2008 and has remained at that level (65,000 students per annum) ever since. The staff complement is 127 (92 FTE) and the Centre's turnover in the last year was £4.0M, returning a small surplus for re-investment in the

exhibit (**C**). The NSC's growth has given rise to two subsidiary business units. The first of these – NSC Education - is responsible for the Challenger Centre (where students fly simulated space missions) and for the major initiative for science teacher engagement, Space Academy. Originally Space Academy was a regional activity funded by the East Midlands Development Agency (EMDA) but from 2011 has become a national programme, with a second Space Academy office on the Harwell campus in Oxfordshire. The funders include the UK Space Agency and the European Space Agency. The second NSC business unit – NSC Creative – produces 2D and 3D full-dome planetarium shows for the in-house Sir Patrick Moore space theatre and, increasingly, for other science-based visitor centres throughout the world. Twelve such shows have been variously translated into the major European languages, Hebrew and Russian. Shows have now been sold to 230 venues in 30 countries.

The impact claimed consists of the following distinct elements:

(i) The establishment and continuing growth of a centre of national scale and significance in the communication of science to the general public and, more significantly, to 8-14 year old school children faced with career choices, so that they may be more likely to pursue the STEM subjects vital for a competitive UK economy (see details of early measured outcomes in section (ii) below). The current Innovation Growth Strategy (IGS) for the UK space industry, in particular, is wholly dependent on increased numbers of trained young people in order to meet its ambitious goals for the period 2015-30.

(ii) The resulting influence on the UK national and European STEM agendas, through the demonstration of better learning outcomes for those who have visited the NSC and participated in educational programmes using space as an instructional theme. Evidence for these improved outcomes has been collated, with the intention of future publication in the science education literature, by NSC staff (**B**). In particular, the August 2013 AS level outcomes for the first cohort of Space Academy students are, on average, significantly higher than would have been expected from the same students' results at GCSE, traditionally taught. Using Monte Carlo techniques to randomly sample the national distribution of AS grades, Professor Fraser, has shown that there is only a 6% probability that the Space Academy results were down simply to chance (**D**).

(iii)The establishment of a physical focus for the regional space industry in the East Midlands. The first innovation /incubation centre component (recently christened "The Dock") of the Leicester Science Park (now called "Pioneer Park") has just (September, 2013) opened on the Abbey Meadows site adjacent to the NSC. Ten initial company tenancies have already been agreed (**E**).

(iv) A significant and continuing contribution to urban regeneration; the NSC was built on a brownfield site associated with waste water management in the River Soar. The new adjacent Innovation Centre is accompanied by a bridge over the River Soar which will begin to realise that neglected waterway as an asset for the City of Leicester.

(v)The establishment of a first point-of-contact for regional and national media enquiries related to space science and technology and for the dissemination of space and astronomy news and information (including under this heading the UK National Near-Earth Object (NEO) information centre, funded until 2012 by the UK Space Agency is at the NSC).

(v) The substantial local economic benefit of a successful, established visitor / education attraction which provides employment to over 100 people. The total turnover since the NSC's establishment has been £36 million, which, when the construction cost is added and the spend by out-of-region and overseas visitors on items such as overnight accommodation is taken into account, may signify a total benefit to the economy of Leicester and Leicestershire approaching £100 million. The new innovation centre adjacent to the NSC represents a £5.9 million investment by Leicester City Council, while a second innovation space funded by the Science Park site developer (Sowden plc) adds another £2.2 million leveraged investment (**C**).

5. Sources to corroborate the impact

[A] The question most commonly asked by the public regarding the NSC's location -"why Leicester? – was definitively answered by the NSC Chief Executive during an appearance on the BBC Radio 2 Breakfast Show on December 4th 2012. When tasked by host Chris Evans, Chas Bishop replied that ;
"..it was all down to the brilliance of the Space Research Centre at the University of Leicester"
This simple and very public answer confirmed that the NSC's presence in the city of Leicester arose from and is underpinned by the broad programmes of space science and astronomy undertaken by the Department of Physics and Astronomy and its Space Research Centre (SRC).

[B] The National Space Centre website's education page (http://education.spacecentre.co.uk) describes in full the various forms of STEM engagement undertaken by the NSC, together with testimonials from students and their teachers.

[C] The description of the trading status of the NSC given in this Case Study is based on the General Manager's report to the Operating Company Board, April 23rd 2013. Staff and visitor numbers have been subsequently verified by the NSC Chief Executive.

[D] The influential (90 citations) original study of the NSC and the STEM subjects by T. Jarvis and A. Pell (Factors influencing elementary school children's attitudes to science before, during and after visits to the UK National Space Centre, Journal of Research in Science Teaching 42(1) (2005) 53) has recently been augmented by an internal NSC review "Impact of the Space Academy" by C.Bishop and A.Ojha. This as-yet unpublished document, together with Fraser's Monte Carlo analysis, is available to the REF Panel on request.

[E] Science park data provided by Dock Project Manager, Leicester City Council, July 2013. The 32,000 sq. ft building, opened in September 2013 will eventually host 150-200 jobs.