Institution: University of Leicester

Unit of Assessment: 9: Physics

Title of case study: Research affecting UK Government Space Policy and the UK Space Industry.

1. Summary of the impact

Space has been identified as an area of economic growth by the UK Government as a direct result of the 2010 Innovation and Growth Strategy (IGS) for Space. This study has resulted in a transformational change with the formation of the UK Space Agency, significantly increased investment and new opportunities. The Unit contributed critically to the IGS and resulting actions by stressing the underpinning nature of academic space research and providing academic lead on key recommendations of the IGS and its subsequent technology plan. The research has also significantly impacted a number of companies increasing their research and development and economic bases e.g. a Leicester based SME Magna Parva Ltd.

2. Underpinning research

Space research within this Unit started in 1960 in X-ray astronomy and has continued with Earth observation science being added in 1993 and planetary science in 1997 (including planetary magnetospheres since 2000) and space astronomy evolving to other wavelengths IR, UV etc. throughout this period [**1**]. The Unit, as a world leading institution in Space research, has played critical roles as principal or co-investigators i.e. instrument, mission and technology developers, and science leads in a number of key "cutting edge" missions and instruments throughout this period [**1**]. Examples include Ariel V in 1974 which transformed X-ray astronomy through to XMM [**2**] which has been the main stay of X-ray astronomy since its launch in 1999 with the Unit providing the XMM-Newton Survey Science Centre. Others include the SWIFT mission which has transformed our knowledge of gamma-ray bursts [**3**], along with Beagle 2, the ExoMars Raman instrument and the James Webb Space Telescope Mid Infra-Red Instrument which will explore fundamentals of the early Universe.

The research has enabled the Unit and its related Space Research Centre (SRC) to evolve an "end to end capability" i.e. from science through instrument design, engineering, development, build and test for flight, through mission operations to data analysis and new science. This has enabled the staff to have a wide and "systems" view of space science, its engineering and implementation, and hence be invited to provide invaluable input to the IGS, the UK Space Agency and UK Government, especially in areas of technology, capability and facilities as well as academic based space research emphasising the underpinning value of space science.

The relevant research is predominantly based around novel instrument development and their science. This work includes construction of X-ray astronomy instruments built round charge coupled devices (CCDs) such as ESA's XMM-Newton mission [**2]** the first mosaiced set of 7 X-ray astronomy CCDs to cover a wide field of view which has provided new catalogues of X-ray sources as well as studies of individual X-ray sources. Research on X-ray optics has led to a unique new class of lightweight X-ray optics which has found its first application in planetary science measuring elemental composition on the planet Mercury via the Bepi-Colombo mission [**4**].

The Unit led the instrumentation for the Beagle 2 lander to Mars as well as the mission operations based at the nearby National Space Centre enabling the public and school children to directly witness spacecraft operations. This work, despite the failure of the lander to communicate after entry, has led to a capability resulting in further novel planetary science instrumentation. This includes the Life Marker Chip (LMC) [**5**] a world leading organic detection instrument based upon using biotechnology based immuno-assays to detect organic molecules at the ppm-ppb level and the Raman instrument the first such instrument to go to Mars where the Unit is providing the focal plane as well as leading the organic molecule/carbon detection aspects of the instrument [**6**]. Similarly Earth observation research has been involved in instruments and resulting science from

the Advanced Long Track Scanning Radiometer on EnviSat and the Global Earth Radiation Budget instruments on various operational METOP satellites [**1**].

3. References to the research

[1] *Planetary, Earth Observation, Technology and Application Research at Leicester:* Sims, M., Pye, J. and Remedios J. (all UL), Observing the Earth and Planets a Leicester Symposium, Astrophysics and Geophysics, 2012, 53, 2.1-2.8

[2] *XMM-Newton:* M.J.L. Turner (UL) *et al.* 63 co-authors including following other UL personnel A. Abbey, M. Denby, L. Gretton, A.D. Holland, K.A. Pounds, J.N. Reeves, S. Sembay, A.D.T. Short, J. Spragg, M.J. Ward and S. Whitehead, Astronomy and Astrophysics, 2001, 365, L27-L35.

[3] *SWIFT:* N. Gehrels *et al.*, 71 co-authors including following UL personnel A.A. Wells, J. Osborne, A.T. Short, M.J.L. Turner, M.J. Ward, R. Willingale, Astrophysical Journal, 2004, 611, 1005-1020.

[4] *BepiColombo:* G.W. Fraser (UL) *et al.* 47 co-authors including following other UL personnel J.D. Carpenter, J.F. Pearson, A. Martindale, J. Bridges, E.J. Bunce, T.J. Stevenson, D. Talboys, C. Whitford, The Mercury Imaging X-ray Spectrometer on Bepicolombo, Planetary and Space Science, 2010, 58 (1-2), 79-95.

[5] *Life Marker Chip:* M.R. Sims (UL) *et al.* 29 co-authors including following other UL personnel D. Pullan, J. Holt, O. Blake, J. Sykes, P. Samara-Ratna, M. Canali, Development Status of the Life Marker Chip Instrument for ExoMars, Planetary and Space Science, 2012, 72, 129-139.

[6] *ExoMars Raman:* H.G.M. Edwards, I.B. Hutchinson, R. Ingley (all UL), Raman spectroscopy and the search for life signatures in the ExoMars Mission, International Journal of Astrobiology 11(4), 2012, 269-278.

4. Details of the impact

The wide areas of research covered by the Unit have resulted in a very considerable knowledge base, allowing the Unit to provide critical input to the IGS study which has transformed UK Government Space policy and to emphasise the underpinning value of academic space science and technology. The 2010 IGS report [**a**] resulted in the formation of the UK Space Agency in 2010 and Government recognition of Space as a key growth area. The Unit was represented in the IGS by Prof. Mark Sims, co-chair of the IGS Capabilities, Technologies and Facilities group who also sat on the executive committee responsible for drawing up the final 16 recommendations. His knowledge of space science, technology, instrumentation and mission implementation backed by departmental input enabled him to play a leading role in the areas of the science and academic related recommendations i.e. the need for a National Space Technology Strategy, Skills Base, Science and ESA missions as well as others. The IGS led to the National Space Technology Plan (NSTP) [**b**] where as the only academic on the report's editorial board he again supplied key input, and emphasised the underpinning role of academia. This led to the formation of the National Space Technology Steering Group (NSTSG) where Sims is one of only four academic members in an industry dominated group totalling 27. The NSTSG advises the Government's Space Leadership Council on Space independently of the UK Space Agency.

Similarly Prof. John Remedios has provided the science lead and academic input as a member of the Steering Committee for the IGS restack/update process just completed, which has further developed the original recommendations and will be a key input into future policy. He has championed the role of bilateral and science missions to build links for export markets.

The impact of the IGS and NSTP and their transformation of space policy are fully acknowledged

by the UK Space Agency [**c**]. In March 2011 the UK Government announced an initial £10M contribution to the NSTP which resulted in a delivery programme [**d**] which states that the NSTP is based directly upon the work and recommendations of the IGS Capabilities group (co-chaired by Sims).

In 2012 as a result of the change in policy the UK made a ~25% increase (~£50M/yr) in its ESA subscription [**e**] securing an estimated £1Billion in UK industrial contracts which along with the NSTP will lead to substantial additional opportunities for UK industry and academia. In order to further promote growth the Technology Strategy Board has funded a Satellite Applications Catapult Centre, a successor to International Space Innovations Centre where the Unit was a founding academic member and Prof. Martin Barstow was a board member.

Regarding direct work on influencing industry, one example here is the development (started in 2007) of feature detection algorithms for autonomous detection of geological features on Mars. This catalysed in conjunction with industrial research on autonomy a series of EU and ESA funded studies which have involved UK industry including Scisys Ltd. a UK space software company. These include the ProViScout EU study [**f**] and the related follow-on ESA SAFER study [**g**] where Leicester supplies the project geologist and consultant regarding the algorithms, a study critical post. ProViScout was the first of a number of space autonomous vehicle projects undertaken by Scisys which has led to further studies (e.g. SAFER), income and development research for the company including a recent study for use of such vehicles in nuclear waste repositories.

Research impact has also occurred locally. The SRC has worked with an SME Magna Parva Ltd (MP) company to develop technology for the LMC instrument, originally intended for ExoMars and for the Bepi-Colombo MIXS instrument. MP provided management and technical support to the LMC under a contract with a total value of £0.9M (2008 to 2013). Immediate impact to the company along with ESA contract work for MIXS was an income stream and increased employment, which helped aid growth of the company and gained it direct experience in working with ESA on large projects. In 2010 in an UL/MP internal case study [**h**] the collaboration was estimated to be worth an increased turnover of £650k and 7 new members of staff for the company (doubling company size). LMC also led to spin-off developments such as the ExoLab a stand-alone sample processing system, and recently a new MP-funded spinoff company MPDx Technologies [**i**] which aims to exploit such technologies in other important fields including medicine.

There are many other examples of the Unit producing industrial impact provided additional income to larger companies including consultancies for ESA studies on missions and technologies with for example EADS-Astrium and Systems Engineering Assessment Ltd. For example, the Unit had a preferred partnership with EADS-Astrium 2007-2012 [**j**] (currently being renegotiated).

5. Sources to corroborate the impact

[a] *Space Innovation for Growth Study (IGS) Summary Report:* http://www.bis.gov.uk/assets/ukspaceagency/docs/igs/space-igs-exec-summary-and-recomm.pdf

[b] *National Space Technology Plan (NSTP):* http://www.slideshare.net/Stellvia/uksa-national-space-technology-strategy and associated presentations

[c] *Role of IGS and NSTP in UK Space Policy:* http://www.nceo.ac.uk/assets/presentations/2011_conference_WARWICK/Session6_3_David_PARKER_UKSA.pdf

[d] *NSTP delivery Plan:* http://www.bis.gov.uk/assets/ukspaceagency/docs/national-space-technology-programme.pdf

[e] *UK Increase to ESA Subscription:* http://www.bis.gov.uk/ukspaceagency/news-and-events/2012/Nov/uk-secures-1-2-billion-package-of-space-investment

[f] *ProViScout EU Project:* http://www.proviscout.eu/

[g] *SAFER ESA Funded Study:* (http://safertrial.wordpress.com/

[h] *Magna Parva Ltd. and UL:* https://www2.le.ac.uk/projects/space-ideas-hub/Case%20Studies/Case%20Studies/a-case-study-magna-parva-working-with-university-of-leicester

[i] *MPDx Technologies:* www.mpdx.co.uk/

[j] *UL- Astrium Partnership:* http://www2.le.ac.uk/projects/space-ideas-hub/Case%20Studies/Case%20Studies/astrium-case-study