Institution:
University of Cambridge

Unit of Assessment:
UoA9

Title of case study:
Assessing the effectiveness of bomb detection equipment

1. Summary of the impact (indicative maximum 100 words)

Research at the University of Cambridge, Department of Physics on sensitive techniques for measurements of magnetic and electrical properties of materials led to the selection of Dr Michael Sutherland as an expert witness in a series of major police investigations involving fraudulent bomb detecting equipment. Scientific evidence Dr Sutherland presented in court was key in securing guilty verdicts, leading to the breakup in 2013 of several international fraud rings with combined revenue in excess of £70 million. This criminal activity had caused significant damage to the reputation of the UK in Iraq and elsewhere.

2. Underpinning research (indicative maximum 500 words)

The Quantum Matter group at the Department of Physics, University of Cambridge, has established itself as a world leader in the detection of quantum oscillations in metallic materials. This technique requires extremely sensitive measurements of electrical resistivity, magnetization and magnetic susceptibility. Custom designed electronic circuits and cryostats for this purpose were pioneered by Profs. Gil Lonzarich (Reader from 1990, Professor from 1997) and Stephen Julian (University Lecturer from 1995, Reader from 2000 until 2004) in the late 1990s. The use of bespoke low temperature superconducting transformers and vibration isolation allowed the electrical noise levels on the group's dilution fridge system to reach levels as low as 1 pV/sqrt Hz, in the presence of large magnetic fields and at low temperatures.

Research in the group from 2005 focused on creating miniature-sized detection coils for use in high-pressure measurements of magnetic susceptibility [2,6], and on custom designing piezoresistive cantilevers to measure magnetization. These techniques have been employed in a number of recent studies of correlated electron materials in high impact journals [1-6].

Through this work, the group has built up significant expertise in detection of small signals, and accrued a scientific reputation for excellence in experimental physics. Dr. Sutherland joined the Quantum Matter team as an NSERC of Canada postdoctoral fellow in 2004, and was subsequently awarded a Royal Society University Research Fellowship from 2006 onwards. He began his research program investigating low temperature thermal transport in superconductors and magnetic materials, before becoming involved in using magnetic susceptibility techniques to measure quantum oscillation effects in high magnetic fields from 2005. He has been responsible for running the group's high field/low temperature facility since 2006.

3. References to the research (indicative maximum of six references)

[1] "Electronic Structure of $LuRh_2Si_2$: "Small" Fermi Surface Reference to $YbRh_2Si_2$" Sven Friedemann, Swee K Goh, Patrick M C Rourke, Pascal Reiss, Michael L Sutherland, F Malte Grosche, Gertrud Zwicknagl, Zachary Fisk, New Journal of Physics 15, 093014, DOI: 10.1088/1367-2630/15/9/093014 (2013)

[2] "Evidence of superconductivity on the border of quasi-2D ferromagnetism in Ca_2RuO_4 at high pressure" P. Alireza, F. Nakamura, F, S.K. Goh, Y. Maeno, S. Nakatsuji, Y.T.C. Ko, M. Sutherland, S. Julian, G.G. Lonzarich. J. of Phys: Cond. Matt. 22, 052202, DOI: 10.1088/0953-8984/22/5/052202, (2010).

*[3] "Quantum oscillations in the anomalous phase in $Sr_3Ru_2O_7$" J.-F. Mercure, S. K. Goh, E. C. T. O'Farrell, R. S. Perry, M. L. Sutherland, A. Rost, S. A. Grigera, R. A. Borzi, P. Gegenwart, A. P. Mackenzie Phys. Rev. Lett. 103, 176401, DOI: 10.1103/PhysRevLett.103.176401, (2009).

*[4] "Role of f Electrons in the Fermi Surface of the Heavy Fermion Superconductor beta-$YbAlB_4$" E. C. O'Farrell, D. A. Tompsett, S. E. Sebastian, N. Harrison, C. Capan, L. Balicas, K. Kuga, A.

Matsuo, K. Kindo, M. Tokunaga, S. Nakatsuji, G. Csányi, Z. Fisk, and M. L. Sutherland Phys. Rev. Lett. 102, 216402, DOI: 10.1103/PhysRevLett.102.216402, (2009).

*[5] "Fermi Surface Reconstruction in $CeRh_{1-x}Co_xIn_5$" Swee K. Goh, Johnpierre Paglione, Mike Sutherland, E. C. T. O'Farrell, C. Bergemann, T. A. Sayles and M. B. Maple Phys. Rev. Lett. 101, 056402, DOI: 10.1103/PhysRevLett.101.056402, (2008)

[6] "High pressure de Haas-van Alphen studies of Sr_2RuO_4 using an anvil cell" S.K. Goh, P.L. Alireza, PDA Mann, A.-M. Cumberlidge, C. Bergemann, M. Sutherland and Y. Maeno Current Applied Physics, Vol. 8, 304, DOI: 10.1016/j.cap.2007.10.020, (2008)

* References which best reflect the quality of the underpinning research

4. Details of the impact (indicative maximum 750 words)

The research described above and the group expertise led to the selection by the Metropolitan Police in 2010 of one of the group's members, Dr. Michael Sutherland, as an expert scientific witness in a series of fraud investigations involving bomb detection devices [8]. These devices were purported to detect small electrical and magnetic signals at great distances, in a similar manner to the techniques pioneered in the Quantum Matter group. Dr Sutherland devised and conducted a series of double blind tests on the separate substance detection devices to test their efficacy under scientific conditions, and also produced detailed critiques on the science that the devices claimed to use. He was also called to The Old Bailey on four separate occasions as an expert witness [8].

Fraudulent bomb detection devices were sold to police forces and the military in many countries, most noticeably in Iraq, where they contributed to significant loss of life through their inability to prevent suicide bombings. A UK government ban on exporting such devices was put in place in 2010 while the investigations were undertaken.

In considering the operating mechanism of these fraudulent explosives detectors, Dr. Sutherland drew heavily on his knowledge of the techniques employed in the above body of research to rigorously assess the physics of the devices. The ADE-651 device for instance was alleged to work on the principle of Nuclear Quadropole Resonance (NQR), which would require detection of small electrical signals in coils similar to those used in [2,6]. A calculation of the size of NQR signals that might be sensed by this device proved unequivocally that the NQR effect would yield signals far below the threshold detection limit. Similarly, the GT200 device was said to be sensitive to diamagnetic and paramagnetic responses of substances some 700m away from the operator. Using experience gained in designing detection coils for use in magnetic susceptibility measurements, it was possibly to demonstrate that the claims of the manufacturer of this device were similarly impossible.

The thorough scientific assessment of the operating principles of these devices, along with rigorous double blind testing of their effectiveness by Dr. Sutherland formed a key part of the prosecution case. Leading Counsel of the prosecution states, "Although his contribution to all of the trials has been invaluable, Dr Sutherland's considerable expertise in superconductors and novel magnetic and metallic materials, was essential in the trials relating to the ADE 651 and the GT200….The independence of Dr Sutherland's research, the quality of it, the clarity of his reports and the evidence he gave were all fundamental in securing convictions."[7]

The impact of this work is twofold. First, in 2013 convictions were secured in 3 of the 4 trials, with the fourth trial ongoing. This has disrupted several major international fraud rings, with an estimated combined turnover of £70 million. The use of the fraudulent bomb detection devices had caused significant human damage. On delivering a guilty verdict, Judge Richard Hone QC said that use of the devices "in all probability materially contributed to causing death and injury to innocent individuals" [9]. A former British Army bomb disposal officer stated "Countless tragedies have been caused, both directly and indirectly, because of these devices."[10]. The Detective Superintendent who led the Avon and Somerset police investigation said "I'm confident people have lost their lives because of this." [11]. The City of London Police confirm that "Dr Sutherland's contribution to the investigation was a key factor in securing guilty convictions for fraud at court, and for stopping the

manufacture and sale of these devices" [8].

A second impact has been the enhancement of the international reputation of UK science through significant national and international press coverage, much of which has reported on the work of Dr. Sutherland. Dr. Sutherland has made numerous media appearances to discuss these scientific findings, including BBC news, Channel 4 news, and SKY TV business report [12-16].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[7] Supporting Statement from First Senior Treasury Counsel to the Crown at the Central Criminal Court and Leading Counsel of the prosecution explaining the role of the scientific evidence in securing conviction.

[8] Supporting statement from City of London Police explaining the reasons for Dr Sutherland's selection as expert witness and the role of his scientific evidence in securing conviction

[9] Statement from Judge Richard Hone QC: http://www.telegraph.co.uk/news/uknews/crime/10032949/James-McCormick-hawker-of-fake-bomb-detectors-has-blood-on-his-hands.html

[10] Statement from a former British Army bomb disposal officer: http://www.channel4.com/news/bomb-detector-scam-james-mccormick-ten-year-sentence.

[11] Statement from the Detective Superintendent who led the Avon and Somerset: police: http://www.theguardian.com/uk/2013/apr/23/magic-bomb-detector-lives-risk

Selected International Media Coverage

[12] Mohammed, Riyadh and Norland, Rod. *"British Man Held for Fraud in Iraq Bomb Detectors"*, New York Times Jan. 24 2010.

[13] Schubert, Atica, *"Fake bomb detector maker made millions from his trick"*. CNN news website, May 2 2013.

[14] Londono, Ernest. *"In Iraq, no magic, or any use, for these wands"*. Washington Post, Nov. 3 2010.

Selected National Media Coverage

[15] *"Gary Bolton guilty of selling fake bomb detectors"* BBC news website July 26 2013

[16] Booth, Robert. *"Fake bomb detector conman jailed for 10 years".* The Guardian, May 2 2013