

Impact case study (REF3b)

Institution: University of Glasgow
Unit of Assessment: B9: Physics
Title of case study: LightTouch: Low-cost, rapid oil and gas prospecting technology
1. Summary of the impact

The future of the world's energy supply is a global concern, as the demands of a growing population rise and the ability to locate precious oil and gas resources becomes increasingly difficult. Researchers at the University of Glasgow have made a fundamental contribution with the development of LightTouch™ – a Shell proprietary ultrasensitive, technologically advanced gas sensing survey method. In fourteen years of cooperation with Shell, the University of Glasgow has delivered multi-million dollar savings and improved the delivery of efficient survey data, substantially decreasing the economic impact associated with unsuccessful drilling.

2. Underpinning research

Professor Miles Padgett (Professor of Physics, 1999-present) has led the successful University of Glasgow Optics Group comprising Graham Gibson (Research Associate, 2003-present); Laura Thomson (PhD Student 2005-08); Johannes Courtial (Research Associate from 1999 and Lecturer from 2001-present); Kenneth Skeldon (Research Associate 1995-2006) and Steve Monk (PhD Student 2000-2003). The fourteen year collaboration with Shell (1999-2013) has been centred on the development and validation of LightTouch™, a novel, ultra-sensitive oil and gas prospecting technique. The sensor, a portable absorption spectroscopy system, is able to detect sub part per billion (ppb) concentration of ethane gas from a range of several kilometres, allowing large areas to be surveyed quickly and efficiently.

Compared with other gases, ethane is an ideal indicator of hydrocarbon reservoirs. The background concentration of ethane in the atmosphere is only around one ppb, making detection of seepage possible, provided a high sensitivity detector is employed. LightTouch™ relies on the ultra-high sensitivity performance of the detector to measure ethane concentration at a fixed point in space, while the corresponding wind distribution is simultaneously recorded. Sophisticated algorithms, also developed by the University of Glasgow's Optics Group, are at the core of the system and allow for the distribution of ethane concentration over a large area upwind from the detector to be precisely inferred from the point-concentration and wind-field data.

In its early form (2001), the portable gas detection system utilised laser diodes shone through a cell in which air was continuously sampled. The system measured trace ethane down to around 0.1 ppb with a 1-second response time and accuracy better than 0.1 ppb, sufficient to detect significant emissions from a range of several kilometres and making it, at the time, the world's most sensitive ethane detector.

The operation of the spectrometer was fully automated for ease of use in the field. Data from the anemometer was automatically logged with the corresponding ethane concentration and fed to the algorithms to reconstruct the ethane distribution map. The ethane concentration was derived by dividing the area to be surveyed into a grid of point sources of gas seepage of unknown strength. The ethane concentration at any point in the grid could then be derived from an algorithm correlating the measured gas concentration at the sampling location, the wind strength and direction with the offset of each point in the grid with respect to the sampling point. Because the same concentration of ethane can be originated by a weak source located in the proximity of the sampling point or by a strong source located at a distance from the sampling point, multiple measurements at different locations or under different wind strengths were taken to reduce ambiguity.

In its first field implementation trialled in 2002 the prototype spectrometer, complete with wind sensors and computer control, was mounted on an off-road vehicle for deployment in field trials.

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The technique was validated by taking measurements of a known distribution in a desert environment and also by direct comparison with the results obtained from established techniques during the survey of oil fields. LightTouch™ was also deployed by Shell from an aircraft in two key on-shore oil prospecting missions over areas of 10,000km². During its deployment in Algeria and Tunisia between 2001 and 2002, seepage maps obtained from LightTouch™ were employed simultaneously with gravity sensors and magnetic survey data.

The reliability of the sensor and data analysis systems developed in collaboration with the University of Glasgow has been demonstrated in field deployment in Dubai, Oman, Canada and the UK. The data collected gave Shell confidence that seepage maps obtained from spectroscopic techniques could substantially help to refine subsurface models obtained from other survey data sets and play a major role in revealing the structure and conditions necessary to generate and trap hydrocarbons.

3. References to the research

Key Publications:

- Bill Hirst, Graham Gibson, Steve Gillespie, Ian Archibald, Olaf Podlaha, Kenneth D. Skeldon, Johannes Courtial, Steve Monk and Miles Padgett, Oil and gas prospecting by ultra-sensitive optical gas detection with inverse gas dispersion modelling, [Geophys. Res. Lett. 31, L12115 \(2004\)](#), DOI: 10.1029/2004GL019678.*
- Graham Gibson, Stephen D. Monk and Miles Padgett, A field-portable, laser-diode spectrometer for the ultra-sensitive detection of hydrocarbon gases, [J. Mod. Opt. 49, 769-776 \(2002\)](#) (details of the Gas Sensor), DOI:10.1080/09500340110108639.*
- Laura C. Thomson, Bill Hirst, Graham Gibson, Steve Gillespie, Philip Jonathan, Kenneth D. Skeldon, and Miles J. Padgett, An improved algorithm for locating a gas source using inverse methods, [Atmospheric Environment 41, 1128-1134 \(2007\)](#) (public domain refinement of the data analysis software), DOI:10.1016/j.atmosenv.2006.10.003.*

The project was exhibited at the Royal Society Summer Exhibition 2003: 'From oil prospecting to cancer detection' (<http://royalsociety.org/summer-science/2003/oil-cancer-detection/>).

4. Details of the impact

Energy supply remains a key technological challenge and the development of alternative sources is central to future energy security. In the short and medium term, however, hydrocarbons are set to remain fundamental to energy provision. Shell UK employs around 7,000 people and produces almost 13% of oil and gas in the country. Exploration is required to identify new reservoirs and maintain hydrocarbon supplies, but major hydrocarbon discoveries are becoming increasingly rare and situated in remote, inaccessible places. This is reflected by the increase in exploration costs, which have risen for Shell and its subsidiaries from \$3.9 billion per annum in 2009 to \$5.7 billion per annum in 2011.

The greatest financial risks sustained by oil companies are associated with 'frontier' exploration, where crucial licensing and development decisions are made on the basis of limited and often unreliable survey data. For this reason, cost effective survey methods that can rapidly screen large geographical areas for promising sedimentary conditions (indicating the likelihood of oil reservoirs) are particularly important. Traditionally, such tools scan the ground for gravitational and magnetic anomalies commonly associated with oil fields. These methods, costing hundreds of thousands of dollars per square kilometre, only represent the first step – when potentially promising regions are identified, techniques such as 3D seismic surveys are deployed to refine the understanding of geological conditions. These further explorations can cost an additional \$25,000 per square kilometre for acquisition and interpretation of underground data.

The LightTouch™ technology, developed in collaboration between Shell and Padgett's team at the University of Glasgow, has made and continues to make significant contributions to the company's survey campaigns and exploration decision-making across the world. Since transition to airborne

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deployment, LightTouch™ has evolved from the initial design conceived by the University of Glasgow and now detects methane concentrations in the atmosphere. Fourteen years from the start of the collaboration with Shell and despite evolution in the hardware set-up, the University of Glasgow algorithms still remain at the heart of the company's data analysis. These algorithms continue to provide a well-proven system against which to benchmark any new developments in data collection or numerical methods.

It is estimated that the costs associated with a LightTouch™ survey are around 10% of those associated with seismic methods over the same area. Moreover, the data from seepage maps can be accessed immediately to help guide the deployment of other, more expensive exploration resources. Onshore wells can each cost up to tens of millions of pounds depending on the difficulties presented by terrain and geology; in frontier exploration, three quarters of these wells on average, fail to deliver any return on investment. LightTouch™ can be deployed in parallel to more traditional large-scale survey technologies with minimal added costs. Its hydrocarbon seepage maps help guide, complement and refine survey data from other techniques and substantially increase confidence in their accuracy. Reducing uncertainty around survey data is crucial in ultimately reducing the costs associated with drilling unsuccessful wells, delivering substantial economic impact.



Figure 1: Glasgow team performing field trials in Dubai

In fourteen years of cooperation with Shell, the University of Glasgow has developed sensors and data analysis code that have been instrumental in completing seven surveys that (since 2008) have directly contributed to investment decisions involving several hundred million dollars.

5. Sources to corroborate the impact

[‘Shell-Oil exploration with a light touch’ \(www.GulfOilandGas.com\)](#), 27 November 2003
[JIP Oil in Ice Website, LightTouch System](#)

Principal Scientist of Measurement and Instrumentation at Shell Global Solutions can corroborate the statements regarding the impact of LightTouch for Shell.