Institution: University of Birmingham

Unit of Assessment: UOA17 - Geography, Environmental Studies and Archaeology

Title of case study: **Keeping transport systems running in winter: the contribution of Route-Based Weather Forecasting**

1. Summary of the impact

Route-based weather forecasting is being increasingly adopted by local authorities and other organisations to help achieve more efficient and effective operational delivery of their winter resilience measures. This approach takes advantage of GPS and GIS technologies to provide weather forecasting information for particular routes, rather than relying on forecasts for a wider area. Transport agencies have adopted products based on this approach over the last five years to improve their decision making and achieve cost savings. These benefits are passed on to the public who receive a more efficient service without compromising their safety. **Research by Chapman and Thornes identified the original concept used in these products, leading to a patent and spin-out company. Subsequently, the ideas were taken up by major companies in the weather forecasting industry** who have marketed a series of products based on this innovative approach.

2. Underpinning research

The original research was carried out between 1998 and 2004 at the University of Birmingham by Lee Chapman (then PDRA) and John E. Thornes – (then Reader). The research worked towards what was then entitled 'A Blueprint for 21st Century Winter Road Maintenance' and led to a series of early publications in international journals introducing the terminology and detailing the foundations of the route-based forecasting (RBF) approach. These papers focussed on developing ways in which the then-emerging GPS and GIS technologies could be assimilated into a forecast solution. The blueprint was then presented to an international audience (as an area of research requiring further development) at the Standing International Road Weather Conference in 2000 and 2002. A University of Birmingham spin-out company, Entice Technology Ltd, was then formed in May 2002 using funding from the *NERC Small Business Research Initiative (£125k)* which enabled follow-on research and ultimately the commercialisation of the RBF concept.

A number of further scientific publications followed this award as the research matured into a full forecasting solution [1-3]. Findings were published for international scrutiny in leading, high impact, applied journals which target practitioners as well as academics. All are now well cited for such a niche area of research. However, challenges were faced here in protecting the intellectual property and techniques were patented prior to publication [6]. For example, a key aspect of the research was the patented technique which enabled the measurement of the sky-view factor under any weather conditions [2]. The sky-view factor is the most influential parameter controlling surface temperature and hence is an important component in surface temperature models [3, 4]. Further research was also conducted during this time to transfer the technology from the road to the rail market [4], funded by a £220k award from the Railway Safety and Standards Board.

The RBF product was ready for local authority trials in winter 2004-2005, and was continually refined until the sale of Entice in 2006 for an initial six figure sum to Weather Service International (WSI), a major US-based provider of business-to-business weather services. Post-sale, further research was conducted at Birmingham on improving the product by Chapman (now Reader of Climate Resilience) and Thornes (retired as Professor of Applied Meteorology, Sept 2011). WSI also funded a PhD student (Hammond supervised by Chapman and Thornes) to further the research. Hammond was taken on in 2007 and completed in 2010 and his model improvement work led to a string of other applied publications during the REF period (e.g. [5]).

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

[1] Chapman, L. & Thornes, J.E. (2004) Real time sky-view factor calculation and approximation. Journal of Atmospheric and Oceanic Technology 21: 730-741 DOI: 10.1175/1520-0426(2004)021<0730:RSFCAA>2.0.CO;2

[2] Thornes, J.E., Cavan, G. & Chapman, L. (2005) XRWIS: The use of geomatics to predict winter road surface temperatures in Poland. Meteorological Applications 12:83-90 DOI: 10.1017/S135048270500157X

[3] Chapman, L. & Thornes, J.E. (2006) A geomatics based road surface temperature prediction model. Science of the Total Environment 360:68-80 DOI: 10.1016/j.scitotenv.2005.08.025

[4] Chapman, L., Thornes, J.E., Huang, Y, Sanderson, V.L., Cai, X., & White, S.P (2008) Modelling of rail temperatures. Theoretical and Applied Meteorology 92:121-131 DOI: 10.1007/s00704-007-0313-5

[5] Hammond, D., Chapman, L., Thornes, J.E. & White, S.P. (2010) Verification of route-based winter road maintenance weather forecasts. Theoretical and Applied Climatology 100:371-384 (to be submitted in the REF) DOI: 10.1007/s00704-009-0189-7

[6] International Patent: Road Weather Prediction System & Method, Inventors: Lee Chapman & John Edward Thornes, International Application Number: PCT/GB2002/003521, International Filing Date: 31/07/2002, Granted: 30/08/2006

Grants:
Dr John E Thornes, Research, trailing and commercial development of a second generation of road ice prediction systems, NERC SBRI, 01/05/2002 – 31/04/2004, £125,000

Dr John E Thornes & Dr Lee Chapman, Measurement, modelling and mapping to predict rail temperature, RSSB (Railway Safety and Standards Board), 01/06/2003 – 01/12/2005, £220,000

4. Details of the impact

Route-based weather forecasting (RBF) is being increasingly adopted by local authorities and other organisations to help achieve more efficient and effective operational delivery of winter resilience measures. In the case of highways authorities, it assists them in meeting their statutory responsibilities under the Highways Act 1980. **Highways authorities with some of the most extensive road networks in the UK are now making use of this approach and requiring it be embedded when they procure weather forecasting services**. Therefore, although the approach was launched prior to 2008, it has moved on from the development stage to wider implementation and is now delivering impact in economic terms for highways bodies, leading to reduced disruption and improved safety for road users and contributing to reducing losses from winter weather for the UK economy. The importance of winter resilience measures, and the risks associated with the issue, was illustrated recently by the challenging weather experienced in the UK in 2008/9 and 2009/10; the subsequent government report estimated the costs of winter weather disruption at around £1 billion annually [source1].

Attribution chain: The benefits being achieved from RBF can be strongly attributed to the research undertaken by Chapman and Thornes. In direct terms, their patented method was utilised by the University's spin-out company ENTICE Technology Ltd and subsequently sold to WSI in 2006. Evidence of the attribution of ENTICE's work to this research group can be found in a report published by NERC in 2006 [source 2]. WSI expanded the market for the product to around 20 local authority clients, achieving sales of £344,000 for this product in 2008, and of £600,000 in total between 2008 and 2013, generating over £60,000 in royalties for the University [source 3].

The research findings and the sales achieved by WSI also stimulated wider interest in the industry, highlighting the potential of this approach and leading to further impact. Two other major forecasting providers, Meteogroup and the UK Met Office, subsequently launched their own products [sources 4 & 5]. These products were also based on the concept developed by Chapman and Thornes, but it is believed that they used an alternative way of calculating the sky-view (which had been the thrust of the Birmingham patent). A clear audit trail of the development of rival products can be discovered in the biannual proceedings of the Standing International Road Weather Conference [source 6] A series of papers and presentations can be found by both Meteogroup and UKMO documenting the development of their systems clearly based on the earlier discoveries made by the Birmingham academic team. Meteogroup and the Met Office have been successful with their new products, although one consequence of this was that they gained market share from WSI.

Adoption of RBF by road authorities: The adoption of RBF was initiated by around eight local authorities from 2000 working with ENTICE, but has now spread much more widely to form part of the approach taken in the areas of the UK which face the greatest difficulty with winter weather such as Wales and the Scottish Highlands. Over the last five years, RBF has established itself as the premier approach used by winter road maintenance professionals, with whole sessions now devoted to the topic at trade conferences [source 7]

One early adopter of RBF was Neath Port Talbot Council, which worked with ENTICE through the research and development phase and has used the approach operationally subsequently. The Council's Project Director, Network Management (retired) has said:

> *"The operational benefits of RBF's, initially provided by Entice, allowed nightly gritting decisions to be made on a route by route basis rather than mobilising all routes, which would have been the general case with the traditional forecast. The ability to visualise how weather was to develop over individual routes at 1hr intervals over 24hrs has resulted in improved decision making, achieving significant savings in plant labour and salt costs*." [source 8]

Following Neath's successful experience, the contract for a RBF service from WSI was adopted by the South Wales Trunk Road Agency to cover a larger road network. The Welsh Assembly Government then took up the idea and included a requirement for this service as part of the specification for a principality-wide daily weather forecasting service for unitary authorities and trunk road agencies that it issued in 2008; the specification was for a four year contract expected to be worth up to £1m in total [source 9].

The requirement for RBF was also included in the specification for Weather Forecasting Services issued by the Highland Council on behalf of themselves and Scotland TranServ which between them are responsible for all trunk and non-trunk roads across the Highlands Area. The service required included the following:

> *"The Parties require a route based forecasting service (RBF) delivered as two lots. Details of the routes to be included, lengths and segments are included with the Tender Documentation (Arcview GIS files). For The Highland Council the total length of road network for which route based forecasting is required amounts to approx 2,620km, made up of 97 routes. For Scotland TranServ the total length of road network for which route based forecasting is required amounts to approx 1369 km, made up of 24 routes"* [source 10].

MeteoGroup presented an analysis in March 2013 of the forecast savings that the Council could achieve in the variable costs of road treatments by using a route based approach to prioritise their work; this showed a £390,000 saving in a single winter (8% of their £4.7m winter budget)

from reducing the amount of salt used and the fuel cost of gritting [source 11]. Further reports of the contribution of RBF from Lincolnshire County Council were publicised by the Met Office in 2011 [source 5].

International impact: Meteogroup are trialling the approach extensively in the Netherlands and the Danish Meteorological Institute is developing their own similar model.

Beneficiaries: The main beneficiaries have been local authorities who use the new technology to better inform their decision making and ultimately to make cost savings. These benefits are passed on to the public who receive a more efficient service without compromising their safety.

Reach and significance: The impact of RBF now extends to major components of the UK road network. The significance of the approach is in the operational benefits being achieved by transport authorities who are better able to optimise the application of their de-icing and related measures through the application of route-based rather than generalised weather information. This is contributing to reducing the costs of winter weather disruption, estimated in a recent government report as around £1 billion annually, of which half is 'hard' cost to the economy, and half is 'welfare' costs to the individual [source 1, Executive Summary para 109], as well as achieving environmental benefits through reducing salt usage. The approach also assists highway authorities in achieving their statutory duty under the Highways Act 1980 to ensure, so far as is reasonably practicable, that safe passage along a highway is not endangered by snow or ice.

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

[1] Department for Transport, *The Resilience of England's Transport Systems in Winter: An Independent Review,* Final Report, October 2010
[2] *Economic benefits of environmental science: a study of the economic impacts of research funded by the Natural Environment Research Council*, November 2006. http://www.nerc.ac.uk/publications/corporate/economic.asp
[3] Data on University of Birmingham earn-outs and related WSI sales provided by the Academic Consultancy Manager, Alta Innovations Limited, 11/10/12
[4] MeteoGroup RoadCast leaflet (copy available from the University)
[5] UK Met Office, News Release, Route based forecasts, issued 2/11/11 (copy available from the University)
[6] see UK Met Office presentation in 2008 http://www.sirwec.org/Presentations/prague/16.pdf and MeteoGroup presentation http://www.sirwec.org/Presentations/helsinki/39.pdf - MeteoGroup 2012 and Birmingham team prior presentations in 2004 and 2006 http://www.sirwec.org/Papers/bingen/15.pdf and http://www.sirwec.org/Papers/torino/23.pdf
[7] Cold Comfort (2009) Route Based Forecasting Session. Cold Comfort Event Catalogue, Cardiff
[8] Statement from Project Director, Network Management, Neath Port Talbot County Borough Council. (copy available from the University)
[9] Welsh Assembly Government – Transport Wales, Tender Specification, Weather-forecasting services, document ref: 147857-2008, published 7th June 2008
[10] Highland Council, Tender Specification, Weather Forecasting Services, published 6th July 2012
[11] From presentation by Richard Hogg, Business Manager Transportation, MeteoGroup, Developments in Weather Predictions (UK Road Network) at National Roads, Street Lighting and Winter Maintenance Seminar 2013, Association for Public Service Excellence, 7th and 8th March 2013 http://www.apse.org.uk/presentations/2013/03/Highways-seminar/index.htm (copy available from the University)