

<b>Institution:</b> University of Leeds		
<b>Unit of Assessment:</b> 11		
<b>Title of case study:</b> Safer and more efficient street works through the real time provision of integrated utility data		
<b>Period when the underpinning research was undertaken:</b> 2004-2012		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Anthony G Cohn	Professor; PI of all projects	1990-date
Anthony Beck	PDRA on VISTA project	01/03/2006-31/10/2013
Gaihua Fu	PDRA on MTU then VISTA	1/07/2005-31/07/2009
Brandon Bennett	Co-I on MTU project	1/4/1994 - date
John Stell	Co-I on MTU project	1/1/2001 – date
<b>Period when the claimed impact occurred:</b> 1/8/2013 – 31/12/2020		
<b>Is this case study continued from a case study submitted in 2014? No.</b>		
<p><b>1. Summary of the impact</b></p> <p>The provision across the whole of Scotland, for the first time in any country, of a system able to deliver in real-time <b>integrated</b> information, 24/7, about buried apparatus/infrastructure. Launched in 2012, with impact on:</p> <ul style="list-style-type: none"> <li>• street workers: enhancing safety and operational efficiency</li> <li>• streetworks planning: instant, customized, integrated vectorised maps</li> <li>• utility companies and associated contractors: efficiency savings by faster and digital delivery of pre-integrated information (and thus potentially on utility consumers) and the public, as emergency works may be effected faster, leading to fewer delays to journeys.</li> <li>• policy of the Greater London Authority, and the Geospatial Commission (part of the Cabinet Office).</li> </ul>		
<p><b>2. Underpinning research</b> (indicative maximum 500 words)</p> <p>A requirement under Health and Safety regulations is that on-site workers undertaking excavations have current information about what lies beneath a road to help prevent injuries (e.g. from electrocution or gas explosions).</p> <p>Emergency work may be required 24/7, so fast access to information can be crucial. At the planning stage of works, this information is also vital, allowing utilities and road authorities to optimise their designs.</p> <p>Traditionally, underground apparatus information is provided in a variety of formats including: emailed pdf maps; CDs containing Geographic Information System (GIS) data; paper plans; individual company web sites.</p> <p>Although GIS are now commonplace for the storage of underground assets data, information about what and how it is stored varies considerably across organisations. There have been previous initiatives to try to standardise this information in the UK and develop an integrated records system; however, all of these failed to deliver.</p> <p>In 2004 Cohn attended an EPSRC 'Ideas Factory'/Sandpit on "Mapping the Underworld" (MTU). As a result, Leeds received funding (EP/C014707/1, GBP158,437) to research and develop a prototype system able to deliver integrated utility information – a real challenge considering the large number of utilities and variety of data recording practices. Further DTI/TSB (now Innovate UK) funding (Project 5820, VISTA, GBP629,793 to Leeds) broadened the scope (Nottingham also received VISTA funding for an entirely separate subproject). Several successful technology trials were held, including two in Scotland at the invitation of the Scottish Road Works Register (SRWR). They already had a simpler system which allowed users to request maps from companies, but this could take weeks and data integration was left to the end user to be done manually. A company called Symology ran this platform and received SRWR funding for the two trials (Perth and Kinross; Tayforth); Symology subcontracted Leeds (GBP14,000)[A] to provide the VISTA technology for this purpose. The trials were successful and SRWR decided to implement a system (subsequently called Vault) based on this technology across all Scotland -- demo: <a href="http://www.youtube.com/watch?v=nck0nsDo_gQ">www.youtube.com/watch?v=nck0nsDo_gQ</a>.</p>		

Each organisation's pipes or cables are held as a separate layer and can be displayed to show the all the pipes and cables or only those of a specific domain (electricity, water etc) as required. Other information such as proposed works can also be accessed as individual layers.

The main challenge which this research had to address was the heterogeneity across the sector (both schema-level and taxonomically). This was solved with the industry-validated design of the global schema and taxonomy, and the design of the rule-set which automatically translates from individual company databases to the integrated system.

Symology confirm [B] that "the key principles that were taken from the VISTA research were:

- *"Establishing a single data schema for apparatus across all domains of Gas, Electricity, Water, Sewer, Telecoms. [1,3,5]*
- *Translating from heterogenous datasets into a single homogenous dataset. [1,3,5]*
- *Using a thesaurus-based approach to harmonise industry terms from different asset owners into a single set for presentation to the end-user [2,4]"*

also saying that "during the 10 years of operation there has been no questioning about the validity of [the] schema" and that adding a new utility now usually takes about a day of staff time.

Vault won two awards:

- a) IET Innovation Awards 2012(Built Environment category), and "Highly Commended" in the IT category<sup>1</sup>. The judges commented: "...*supporting the integrated planning and maintenance of underground infrastructure assets & improves the safety of works on & around buried utility services ... Wider benefits include reduced disruption to the public and significant time and cost savings to utility suppliers by accessing a comprehensive asset database.*"
- b) joint winner in NJUG Awards 2012(Avoiding Damage category)<sup>2</sup>. The citation reads: "*The fact that up-to-date underground apparatus information is a now immediately available in the office and on site to everyone who requires it, means this revolutionary system will certainly reduce the damage caused by road works to underground apparatus.*"

### 3. References to the research

*All the conferences below are of international status, moving from country to country, with international programme committees, and competitive review of full papers. The rigour of the research is evidenced by the enthusiastic involvement of all the industrial partners (>20) who all validated the schema, thesaurus and the mapping rules.*

- 1) *A framework for utility data integration in the UK*, Beck, A R; Fu, G; Cohn, A G; Bennett, B; Stell, J G. *in*: Rumor, M., Coors, V., Fendel, E. M. and Zlatanova, S. (editors) *Urban and Regional Data Management - UDMS 2007 Annual*, Taylor and Francis, pp 261-276, 2008. [eprints.whiterose.ac.uk/4876/](http://eprints.whiterose.ac.uk/4876/). 30 Google Scholar citations on 5/2/21.  
*UDMS is an international conference/symposium organised by the Urban Data Management Society, moving countries each year. 2007 was the 26<sup>th</sup> instantiation ([www.udms.net/proceedings/](http://www.udms.net/proceedings/)). This is the first paper published on the MTU/VISTA projects and gives the overall architecture, methodology and techniques. Several follow up papers were published (see below) giving more details as the project progressed.*
- 2) *Semantic Integration for Mapping the Underworld*, Fu G, Cohn AG. *In*: Proceedings of the SPIE Geoinformatics 2008 and Joint Conference on GIS and Built Environment: Geo-Simulation and Virtual GIS Environments. 2008, Guangzhou, China: SPIE. [doi.org/10.1117/12.812608](https://doi.org/10.1117/12.812608) pdf: [tinyurl.com/yhn8vznz9](http://tinyurl.com/yhn8vznz9). *Gives details of the ontology creation process.*
- 3) *UK Utility Data Integration: Overcoming Schematic Heterogeneity*, Beck, A; Cohn, A.G.; Sanderson, M; Ramage, S; Tagg, C; Fu,G; Bennett, B; Stell, J, *In*: Proceedings of the SPIE Geoinformatics 2008 and Joint Conference on GIS and Built Environment: Geo-Simulation and Virtual GIS Environments. 2008, Guangzhou, China: SPIE. doi:[10.1117/12.812600](https://doi.org/10.1117/12.812600) [eprints.whiterose.ac.uk/4894/](http://eprints.whiterose.ac.uk/4894/) . *Largely an update on the UDMS paper a year on. Sanderson, Ramage and Tagg are employees of 1Spatial Ltd who made a small contribution to the paper through their knowledge of 1Spatial's "Radius Studio" Software which was used to represent the rules to map to the global schema.*

<sup>1</sup> <https://web.archive.org/web/20140701000000/http://conferences.theiet.org/innovation/-documents/be-case-study.cfm>.

<sup>2</sup> [streetworks.org.uk/wp-content/uploads/2016/11/NJUG-CASE-STUDY-66-Avoiding-Damage.pdf](http://streetworks.org.uk/wp-content/uploads/2016/11/NJUG-CASE-STUDY-66-Avoiding-Damage.pdf)

- 4) *Utility Ontology Development with Formal Concept Analysis*, Fu, G. and Cohn A.G in Proceedings of the 5th International Conference on Formal Ontology in Information Systems, pp.297-310, Germany, 2008: [pdf: tinyurl.com/3mnk8k9t](http://tinyurl.com/3mnk8k9t). DOI: [10.3233/978-1-58603-923-3-297](https://doi.org/10.3233/978-1-58603-923-3-297) Describes further work on the ontology development process and its verification.
- 5) *Seeing the Unseen: delivering integrated underground utility data in the UK*, Beck, A, Cohn, A.G., Parker, J., Boukhelifa, N. and Fu, G. Proceedings of the GeoWeb conference, The International Archive of Photogrammetry, Remote Sensing and Spatial Information Systems, Volume XXXVIII-3-4/C3, Vancouver, July 2009: [www.isprs.org/proceedings/XXXVIII/3\\_4-C3/Paper\\_GeoW09/paper07\\_beck.pdf](http://www.isprs.org/proceedings/XXXVIII/3_4-C3/Paper_GeoW09/paper07_beck.pdf)  
*In the academic track of an industrially oriented conference, presents another update of the system (also including work in the VISTA project on visualisation, not used in the Vault system). Parker was the project manager (subcontracted by the VISTA coordinating node, UKWIR); Boukhelifa was a Leeds RF working on the visualisation aspects of the research.*

#### 4. Details of the impact

We describe, in turn, two kinds of impact:

- 1) The Vault system which has been securely delivering integrated real-time underground asset information across Scotland throughout the REF period.
- 2) Policy impact on the Greater London Authority HADES project which built directly on Vault. Vault and HADES then led to a policy impact on the Geospatial Commission, which is building a nationwide system, NUAR (National Underground Assets Register).

##### 1) The Vault system

Vault went live in 2012<sup>3</sup> – the Scottish Road Works Commissioner said: *“an excellent example of collaboration with Scottish utility companies and roads authorities working closely with partners from Leeds University, [...] to take research work [...] and turn it into a world leading working system.”* *“Vault came about as a direct result of the VISTA project”*[B, also confirmed in C]. *“The Vault initiative ... is an example of best practice”*(Network Rail)[E:a]. See §2 for awards won in 2012.

Summary of impact:

- the supply of utility records across Scotland has been transformed owing to real-time, 24/7 integrated, vectorised, query-able data, via a secure web interface;
- improved efficiency of back office planning owing to instant integrated vectorised records;
- improved safety of streetworkers owing to instant information for emergency works;
- improved efficiency and speed of operations, as records provision is automated rather than manually extracted from each individual asset owner’s records, and manually integrated;
- records are presented in a uniform way, irrespective of the source, providing more comprehensible information with reduced likelihood of misinterpretation causing negative safety impact;
- impact on the public owing to more efficient roadworks, and reduced likelihood of third-party strikes<sup>4</sup> (which typically result in service outage for consumers);
- improved efficiency for utilities as satisfying record requests from third parties is automated.

*“This was a world first and has been hailed by users in Scotland as a huge step forward, saving both time and money for all the road works community and now enshrined in Scottish legislation”*[D]. One daily utility user describes it as *“An essential tool in the planning process of our programme of works”*[C].

*“The apparatus database contains over 13,000,000 features, with 57 different organisations submitting data on a 2-monthly update cycle. The apparatus database contains data from all Water, Electricity and Gas companies, a variety of Telecoms and Multi-Utility companies and all Scottish Road Authorities....it has been used by over 500 unique users across 60 different organisations and on a daily basis there are usually 150-200 unique users accessing the system... Whilst these statistics reflect the most recent usage, the levels have been consistent*

<sup>3</sup>Vault launch press release from SRWC:

[webarchive.nrscotland.gov.uk/20180403091034/http://www.roadworksscotland.gov.uk/nmsruntime/saveasdialog.aspx?IID=969&SID=446](http://webarchive.nrscotland.gov.uk/20180403091034/http://www.roadworksscotland.gov.uk/nmsruntime/saveasdialog.aspx?IID=969&SID=446)

<sup>4</sup> I.e. accidentally damaging a utility from a different owner to the one being worked on.

*since day one of live implementation ... The system is available 24/7/365 thus facilitating out of hours usage...Lastly, as a result of the success of the Vault project, the Scottish Road Works Commissioner was keen to ensure that this carries on in the future. As a result, Section 119 of the Transport (Scotland) Act 2019 contains provision to make submission of apparatus data to Vault mandatory for asset owners”[B]. “There is also now a Vault mobile system which allows for urgent and out of hours access to the information within, arising from the need for such a service being strongly communicated through the roadworks community in Scotland”[C] – this would have been impossible without the Vault system enabled by Leeds’ research. The Health and Safety department of Scottish Gas Networks notes that “Surveyors do not always have underground plant details – [Vault gives] them all plant information, at the proposed location as well as alternatives that can be checked while onsite, removing the need for multiple visits, saving travel, cost and making the process more efficient” and that “Remedial works do not always have underground plant details, especially reactive works – [Vault] makes works safer and quicker to carry out”, with estimated savings of more than 500 hours p.a. in administration time alone[.]*

The cost of running Vault annually amounted to GBP850K in 19/20 which was paid for by subscriptions from the asset owners[B].

There are no figures for societal costs caused by roadwork delays across Scotland, but an estimated figure from a government commissioned report in 2004 for England is GBP4.3B<sup>5</sup>; extrapolated to Scotland on the basis of population, this would equate to GBP423M (or GBP655.4M if uprated using Bank of England inflation figures). If Vault only reduced costs by 1% that would still save the Scotland at least GBP4.23M (GBP6.55M if uprated) annually in addition to the direct savings to the utilities. Moreover, the true costs (including all indirect, e.g. social costs) are 29 times larger than the direct cost of making good a utility strike[G]; thus any contribution to avoiding utility strikes because of the easier and faster access to integrated maps has a very large effect -- e.g. the 16 case studies alone in [G] have a total cost of GBP1.75M – whilst in 2017-18 it has been calculated by [www.utilitystrikeavoidancegroup.org](http://www.utilitystrikeavoidancegroup.org) that the *direct* cost of *reported* strikes across the UK as GBP7M, and the average true cost of each utility strike is over GBP100,000<sup>6</sup>.

*“It is difficult to convey to those not involved in the daily activity of working in the street to maintain highway and utility assets, the importance of the VISTA project and the subsequent implementation in Scotland. It has truly transformed the ways of working, dramatically improved safety for operatives and streamlined the design of projects to install or replace new utility assets in the street”[D].*

## **2) Policy impact:**

There is impact on the rest of the UK utility sector. Cohn was invited to join the steering committee of an initiative in London coordinated by the Greater London Authority (GLA) called BIM-VAULT, or HADES, (Highways Asset Data Exchange System) with funding of GBP66K from the London Lane Rental Fund, to implement a Vault-like system[H]. On Cohn’s recommendation, Symology was chosen as the implementation partner, and the trial successfully replicated Vault technology and benefits [D,H]. HADES was “Highly Commended” for the UKSTT 2019 Awards (Application of Digital Technology category).

Vault/MTU/VISTA has influenced Project Iceberg<sup>7</sup> which “*aims to address the serious issue of the lack of information about the ground beneath our cities and the un-coordinated way in which the subsurface space is managed*”, saying “*Vault’s success validates the need for a similar platform in the UK and can be leveraged for Iceberg’s development and commercialisation*”[E:b]

Based on Project Iceberg, and HADES/Vault success, in April 2019, the Geospatial Commission announced a **national** initiative, NUAR[E:c] to ensure that all buried utilities in the UK are digitally mapped. As part of their initial planning they noted[E:d] that “*...Scotland has a working system called Vault managed by the Scottish Roadworks Commissioner. We have spent considerable time engaging with the teams who have built these systems*”. The initial phase of NUAR involved 2 pilots, with total available government funding of GBP3.9M[E:c], with London/HADES being one of these (LUAR –London Underground Assets Register), showing a

<sup>5</sup> [www.ukpopulation.org/scotland-population/](http://www.ukpopulation.org/scotland-population/)

<sup>6</sup> [www.utilitystrikeavoidancegroup.org/uploads/1/3/6/6/13667105/usag\\_201718\\_report\\_final.pdf](http://www.utilitystrikeavoidancegroup.org/uploads/1/3/6/6/13667105/usag_201718_report_final.pdf)

<sup>7</sup> Iceberg partners: British Geological Survey(BGS), Connected Places Catapult and the Ordnance Survey.

clear influence on the Geospatial Commission and national policy: “*LUAR builds on.. HADES, a proof of concept that created a similar map*”[E:e]. LUAR was tested on 150 users using assets from ~25 organisations[E:f]. “*Currently, different organisations have their own maps showing where such things as gas pipes and electricity cables are, but the lack of a combined map creates an increased risk of potentially lethal accidents*”[E:e]. Cohn is on the NUAR Advisory Group[E:f, J] and contributed ontologies and data models from the VISTA system. NUAR was one of the 2019 top-3 finalists for the “Cross Sector Digital Collaboration of the Year”[F]. Feedback from the NUAR pilot is very encouraging[E:f]: “*the creation of a job pack was reduced from 1 hour 30 minutes to just 7 minutes*”; “*a Civils Manager stated that as a high level estimate they could save up to GBP1M per year just on streamlining the planning process for obtaining utility plans*”; “*From a safety perspective you cannot put a price on this – it’s absolutely amazing*” (Team Leader, Northumbrian Water Group). This feedback thus also provides additional evidence on the savings that have been being achieved in Vault across Scotland. The NUAR pilot has been a “*resounding success*”[H]. A Geospatial Commission report (24/11/20) states they are “*committed to preparing for a national roll-out of a National Underground Assets Register*” (NUAR)[E:g].

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

**A:** Copy of Collaborative Research Agreement between Symology and Leeds granting Leeds GBP14,000 for the Scottish Phase 2 Trial. Dated 7/6/2010.

**B:** Letter from Symology Ltd giving key facts and statistics on Vault (2/11/2020). Further statistics can also be found in the annual reports: up until 2017 these can be found here: <http://webarchive.nrsotland.gov.uk/20180403091029/http://www.roadworksscotland.gov.uk/Publications/AnnualReports.aspx> and from 2018 onwards here: [roadworks.scot/publications](http://roadworks.scot/publications)

**C:** Letter from Road Works Policy Manager at Transport Scotland(17/11/20), which is responsible for the legally mandated framework SRWR which includes the Vault layer. It confirms the heritage of Vault from the Leeds research and confirms statistics of usage.

**D:** Letter from Watershed Associates, independent utility sector contractor and project manager for VISTA and HADES. *Evidences the critical role of the University of Leeds in the VISTA project, and then Vault, and also the influence of Vault on Hades.*

**E:** Evidence from various gov.uk web sites giving relevant factual information

a) [www.gov.uk/government/publications/geospatial-commission-call-for-evidence-responses](http://www.gov.uk/government/publications/geospatial-commission-call-for-evidence-responses)

b) [futurecities.catapult.org.uk/project/future-planning-project-iceberg/](http://futurecities.catapult.org.uk/project/future-planning-project-iceberg/) [WP1, page 37]

c) [www.gov.uk/government/news/map-of-underground-pipes-and-cables-designed-to-save-lives-and-prevent-major-disruption](http://www.gov.uk/government/news/map-of-underground-pipes-and-cables-designed-to-save-lives-and-prevent-major-disruption)

d) [geospatialcommission.blog.gov.uk/2019/12/18/getting-under-the-surface-of-our-national-underground-assets-register-nuar-team/](http://geospatialcommission.blog.gov.uk/2019/12/18/getting-under-the-surface-of-our-national-underground-assets-register-nuar-team/)

e) [www.london.gov.uk/press-releases/mayoral/london-to-create-digital-map-of-underground-pipes](http://www.london.gov.uk/press-releases/mayoral/london-to-create-digital-map-of-underground-pipes)

f) [www.gov.uk/government/publications/national-underground-asset-register-project-update/national-underground-asset-register-project-update](http://www.gov.uk/government/publications/national-underground-asset-register-project-update/national-underground-asset-register-project-update)

g) [www.gov.uk/government/publications/enhancing-the-uks-geospatial-ecosystem/enhancing-the-uks-geospatial-ecosystem](http://www.gov.uk/government/publications/enhancing-the-uks-geospatial-ecosystem/enhancing-the-uks-geospatial-ecosystem)

**F:** [http://digileaders100.com/cross-sector-digital-collaboration?vgo\\_ee=AQGixpxTEV5La9kCafg3xdDaFMBOV2EsCfRmJL%2B7qkzS5LcRP0ySJ9uBErSU1Is](http://digileaders100.com/cross-sector-digital-collaboration?vgo_ee=AQGixpxTEV5La9kCafg3xdDaFMBOV2EsCfRmJL%2B7qkzS5LcRP0ySJ9uBErSU1Is)

**G:** Cost estimation of utility strikes: towards proactive management of street works, Lewis O Makana, Nicole Metje, Jefferson, Margaret Sackey, and Chris D F Rogers, Infrastructure Asset Management 2020 7:2, 64-76 [doi.org/10.1680/jinam.17.00033](https://doi.org/10.1680/jinam.17.00033)

**H:** Letter from Infrastructure and Data and Innovation Lead at the greater London Authority (GLA) 30/11/2020. *Confirms details of the HADES project, including the GBP66K TFL funding, the success of the trials, and subsequent follow through in the LUAR/NUAR initiative.*

**I:** Document from SHE (Health and Safety department of Scottish Gas Networks(SGN) 24/2/2021. *Confirms benefits of Vault and saving of administration time in Health and Safety.*

**J:** Agenda of NUAR Advisory Group confirming Cohn’s membership of it. Also letter of thanks (2/7/2020) from Director, Geospatial Commission for “...sharing your vast knowledge and experience, as well as your constructive criticism and challenge,...”