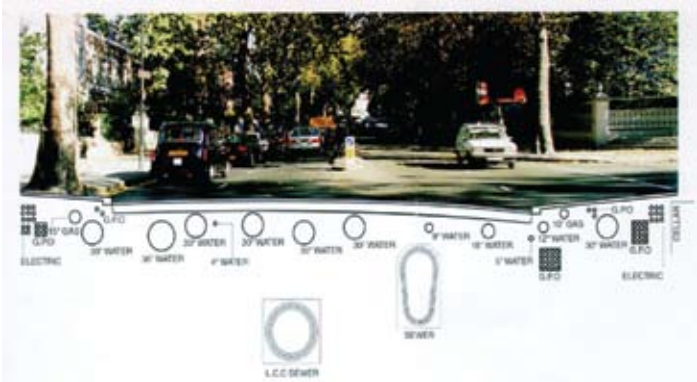
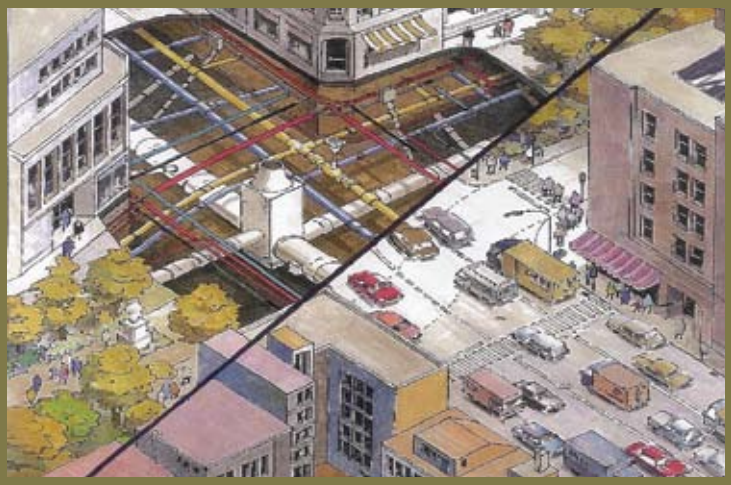
Mapping the Underworld

Mapping the Underworld (MTU) is a multi-disciplinary, multi-university, research project that aims to develop the means to locate, map in 3-D and record, using a single shared platform, the position of 100% of buried utility service pipes and cables without excavation.





MTU covers the following initiatives:

- Locating all types of buried pipes and cables in all types of ground in all conditions
- Mapping the position of the assets accurately in 3-dimensions… even in a crowded urban environment
- Integrating existing data sets from various utility companies into a common framework
- Creating resonating RFID tags to make new or repaired pipes more visible to GPR so they can be relocated efficiently
- Establishing a knowledge transfer network between academia and industry
- Investigating national and international sites for prototype testing and operator training

For further information on MTU and allied initiatives, please visit the MTU website or contact Dr Alexander Royal.

www.mappingtheunderworld.ac.uk/
Email: a.c.royal@bham.ac.uk

Phase 2 of the MTU Location Project, worth £3.5 million, has been funded by EPSRC to research in detail a multi-sensor device that can detect all buried pipes and cables (termed buried assets), building on the promising results of the feasibility study and using every possible advantage to see through the ground and focus on the targets.

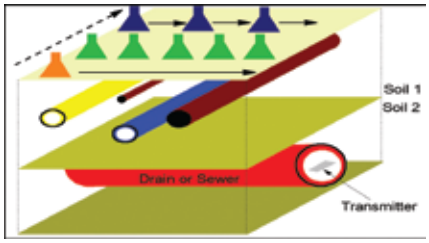
It is estimated that up to 4 million holes are cut into the UK road network in order to repair, or install, buried assets. Failure to identify accurately the location of buried assets results in needless damage being caused to the roadway, increased congestion, and potential damage to third party property, and puts both the construction workers and the general public at risk of injury.

Current geophysical techniques are unable to identify the location of all types of buried assets in all types of ground condition; plastic pipes and saturated clay soils are particularly problematic. To meet the primary project goal, both development of existing geophysical technologies as well as investigation of novel detection techniques are included in the research programme with the aim of creating a multi-sensor device that has the capabilities to detect all of the buried assets in even the most complex of burial conditions. The data streams from the individual sensors will be fused with each other and with existing records to enhance the probability of location.

The prototype multi-sensor device will be trialled at specialist testing facilities overseas and at well-characterised UK sites. Since the UK currently lacks a specialist testing facility, specifications for a national test site will be drawn up. The research into the multi-sensor device is subdivided into seven complementary work packages and these are summarised overleaf.

University of Birmingham · University of Bath · University of Leeds · University of Southampton · The University of Nottingham · University of Oxford · UKWIR · The University Of Sheffield. · EPSRC Engineering and Physical Sciences Research Council

Mapping the Underworld: Location Project



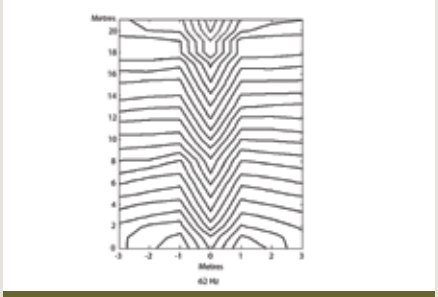
GPR Approaches using Multi-Head Systems.

Advancing Ground Penetrating Radar Technology – University of Bath

Led by Dr S.R. Pennock email: s.r.pennock@bath.ac.uk

The aim of this work package is to advance GPR technologies specifically in support of the multi-sensor device, for deployment both alone at the surface and in combination with in-pipe GPR transmitters / receivers. Novel arrays of GPR antennas and their integration with the multi-sensor arrays will be researched to increase the probability of target detection and accuracy of location information (in both plan and depth).

The anticipated deliverables of this project include recommendations on antenna deployment strategies for surface and in-pipe deployment and to create specifications and a prototype in-pipe device that meets current standards for safe, practical applications in sewers.



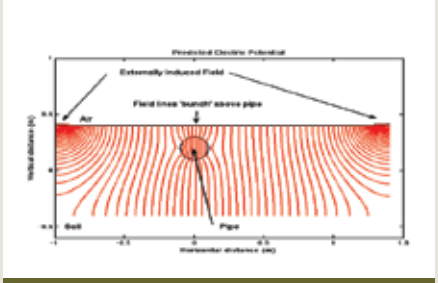
Wave-fronts measured using an array of geophones. The outline of the pipe can be clearly seen.

Acoustic Technologies Advancement – University of Southampton

Led by Professor M.J. Brennan email: mjb@isvr.soton.ac.uk

The aim of this work package is to determine the effectiveness and limitations of acoustic technologies for buried utility service location, based on both pipe and ground excitation techniques, when operated alongside the complementary sensor technologies in the multi-sensor device.

The predicted deliverables include the design and construction of a prototype acoustic sensor for stand alone use and as part of the multi-sensor device; a comparative performance assessment between the outputs and usefulness of geophones and scanning laser technology; operational protocols when deployed in isolation and in the multi-sensor device; the issues of sensor interference when deployed with other technologies will be investigated.



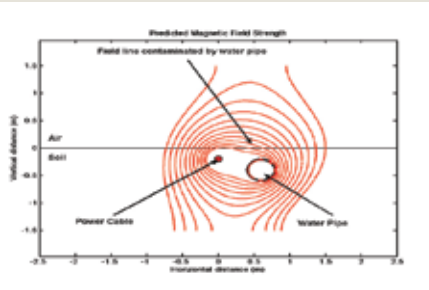
Ionosphere Induced Fields-of-Opportunity.

Low Frequency Electromagnetic Field Technologies – University of Birmingham

Led by Mr P.R. Atkins email: p.r.atkins@bham.ac.uk

The aim of this work package is to conduct four inter-related studies based on low frequency electromagnetics.

The predicted deliverables include an improved prototype low frequency electromagnetic detection device for mapping the underworld (particularly small, near-surface services), both as a stand alone device and when incorporated into the multi-sensor device; a new methodology to predict insulation breakdown failures, and therefore the potential to detect leaks; and a matrix of operational capability of low frequency electromagnetic field systems will be developed.



Power Cable Induced Fields-of-Opportunity.

Magnetic Field Technologies – University of Southampton

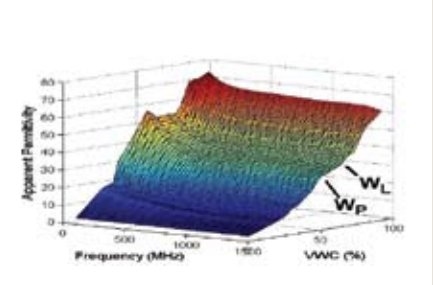
Led by Professor S.G. Swingler email: steve.swingler@soton.ac.uk

The aim of this work package is to utilise a passive array of magnetic sensors together with advanced signal processing techniques to detect underground electricity cables and other metallic buried infrastructure, even when stacked or laid in close association, and to develop the technique so that it can be integrated in the multi-sensor device.

The predicted deliverables include a new finite element model to analyse magnetic fields and to locate 'metallic' buried infrastructure, particularly when in complex, close association; design and construction of a prototype sensor to be tested alone and in conjunction with the multi-sensor device; a matrix of the operational characteristics of magnetic field technology for implementation within a multi-sensor head device.

UNIVERSITY OF BIRMINGHAM · UNIVERSITY OF BATH · UNIVERSITY OF LEEDS · UNIVERSITY OF Southampton · The University of Nottingham · UNIVERSITY OF OXFORD · UKWIR · The University Of Sheffield. · EPSRC Engineering and Physical Sciences Research Council

Mapping the Underworld: Location Project

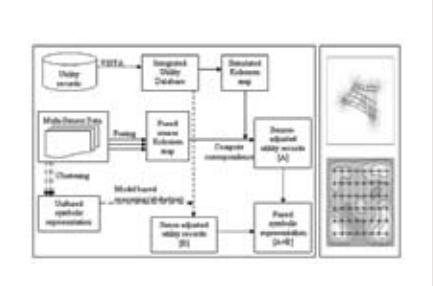


The electromagnetic properties of clay soils.

Tuning of the Multi-Sensor Device to the Ground Conditions – University of Birmingham

Led by Dr D.N. Chapman email: d.n.chapman@bham.ac.uk

This work package aims to develop equipment for use in field testing of geophysical soil properties and, in conjunction with the British Geological Survey (BGS), to create a Knowledge Based System (KBS) that will allow geophysical soil data to be predicted using geographically mapped geotechnical and geological data. Both are intended to inform, and significantly improve, utility location during the planning, site operations and data interpretation phases of site surveys. The deliverables from this research project include a KBS for application with the new multi-sensor device; a set of soil suitability maps for the four geophysical techniques, based on the KBS and associated geographical software model, for a number of case study sites; and a set of test methodologies, and associated apparatus, suitable for providing data on soil geophysical properties in the field, to further optimise the KBS and multi-sensor device, at survey locations where access to soil can be obtained.



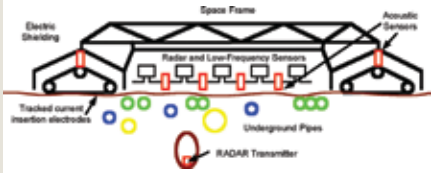
Relations between tasks (Flow diagram) and a Kohonen map of a disparate database.

Fusion of Sensor Data with Buried Asset Records – University of Leeds

Led by Professor A.G. Cohn email: a.g.cohn@leeds.ac.uk

The aim of this work package is to fuse geo-referenced information from multiple sensors and to combine this with an integrated database of buried asset records to increase confidence in their presence and location, and to determine missing asset records.

The anticipated deliverables from this research include techniques to resolve differences in resolution, positioning and depth sensitivity for the sensor types and the available buried asset records; techniques to compute spatial correspondences between interpreted sensor readings and utility records; to determine whether a sensor has located an unrecorded asset or whether a recorded asset is undetected.



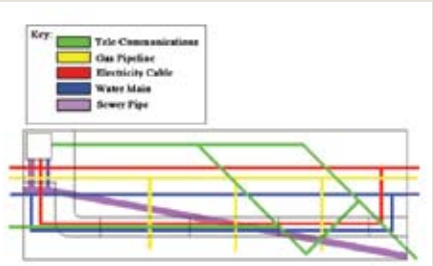
Possible configuration for Multi-Sensor Device.

Development of Multi-Sensor Array and Signal Processing – University of Bath

Led by Dr M.A. Redfern email: m.a.redfern@bath.ac.uk

The aim of this work package is to develop a multi-sensor array demonstration unit, bringing together the outputs of all of the previous work packages, which are all specifically focussed on supporting the device's creation. This will include bespoke software to integrate data processing, fine-tuning to ground parameters and supply of data in an appropriate form for data visualisation.

The predicted deliverables include a surface multi-sensor array device that may be used to 'map 100% of the underworld' at shallow depths; an in-pipe device for use in tandem with the surface device; protocols for the use of the devices; and a means of data fusion that will result in a cross-sectional probability map of the likelihood of an asset being present.



Possible (plan) configuration of a test bay at the proposed National MTU facility.

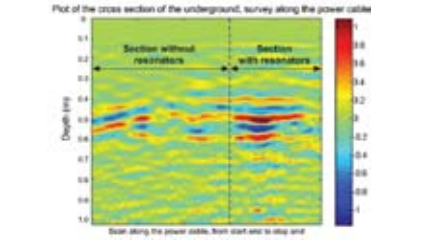
Proving Trials and Specification of a National MTU Test Facility – University of Birmingham

Led by Dr N. Metje email: n.metje@bham.ac.uk

The aim of this work package is to conduct a comprehensive and rigorous programme of proof tests of the above technologies both when applied in isolation and when combined in the multi-sensor device, and prove the efficacy of accurately tuning the devices to different soils and groundwater conditions. A further objective is to refine the set of criteria compiled in MTU Phase 1 for a UK National Test Facility. This work package will be assisted by Professor A. J. Saul of the University of Sheffield. The deliverables will include objective reports on the performance assessment of both existing technologies and the prototype technologies being developed by MTU; and development of a specification and construction guidelines for a new UK National Test Facility including layout and best practice for operation.

Mapping the Underworld: Complementary Research Initiatives

Creation of the multi-sensor device to locate, map in 3-D and record this information using a single shared platform the position of buried assets forms only part of MTU's activities. The other complementary research initiatives are:



Resonant tags on a power cable showed that they can enhance the visibility of the power cable by 60%.

Asset Tagging – University of Oxford

Led by Dr H J Burd email: harvey.burd@eng.ox.ac.uk
and Professor D J Edwards email: david.edwards@eng.ox.ac.uk

The aim of the project is to create a cheap, passive system that may be incorporated within the wall of the pipe and which will resonate when subsequently scanned using GPR. In the initial phase (funded by EPSRC under the MTU umbrella) a system of pipe-mounted passive tags were developed. Tests, conducted at the Gaz de France test site in Paris, confirmed the effectiveness of the system. In the current phase (supported by the EPSRC Follow-On Fund) further development is being conducted to bring the results of the project closer to commercial realisation.

An example of augmented reality.

Positioning Buried Pipes and Cables in Urban Environments – University of Nottingham

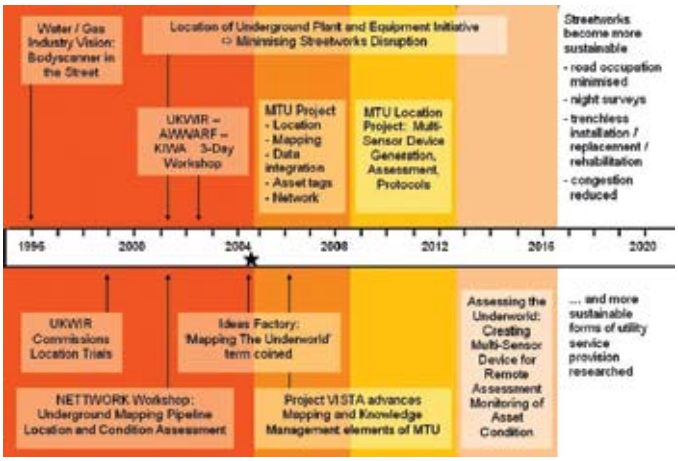
Led by Dr G W Roberts email: Gethin.Roberts@nottingham.ac.uk

Surveying in urban environments provides a severe challenge in being able accurately to determine the position of buried assets due to 'urban canyons' limiting the access of surveying equipment to satellites during surveys. This research project, also funded by EPSRC under the MTU umbrella, is investigating various novel surveying strategies to try to improve the ability to accurately position the assets in a crowed urban environment. Such novel strategies included the use of ground-based transmitters to augment satellite data; the potential of using multiple satellite constellations; and the use of augmented reality when determining the position of the assets.

Knowledge and Data Integration and the VISTA Project – Universities of Leeds and Nottingham

Led by Professor A G Cohn email: a.g.cohn@leeds.ac.uk

The research into Knowledge and Data Integration (KDI) is funded by EPSRC under the MTU umbrella and seeks to unify the datasets from utility companies to produce a common approach to recording utility data. VISTA is a follow-on project, funded by the DTI, which aims to advance both the KDI and accurate positioning MTU initiatives with the active involvement of more than 20 companies that make up the direct stakeholder community.



MTU is part of a 25 year vision. If you would like to become involved, or you would like more information on the projects, please contact us or visit our websites.

Email: a.c.royal@bham.ac.uk
MTU: www.mappingtheunderworld.ac.uk/
VISTA: www.vistadtiproject.org/

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