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TRANSFORMING THE RELATIONSHIPS BETWEEN GEOSCIENTISTS AND URBAN DECISION-MAKERS: EUROPEAN COST SUB-URBAN ACTION (TU1206)

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Abstract

The European COST Sub-Urban Action (TU1206) has had the fundamental aim of closing the knowledge gap between subsurface experts and potential users of subsurface knowledge - urban decision- makers, practitioners and researchers. The Action assembled a network involving >30 countries, 23 actively participating cities, researchers, practitioners and urban decision-makers, and brought together the fragmented research and good practice across Europe in sustainable urban sub-surface use. Development of national exemplars has been encouraged, and good practice identified to inspire others, using a lighthouse-follower approach to cascade knowledge and good practice across Europe and further afield.

Experts from both sides of the knowledge gap were brought together to assess and synthesise the state-of-the-art in lighthouse cities with respect to urban sub-surface knowledge, understanding, and use of that knowledge. This was achieved in 19 City Studies, with findings encapsulated in an over-view report “Out of Sight - Out of Mind”.

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Expert sub-groups then identified good practice in subsurface data and knowledge locally, nationally, and Europe-wide. These are highlighted in the synthesis report "Opening up the subsurface for the cities of tomorrow", and expanded on in seven topic review reports. These also identified key gaps in knowledge, and its use. A new concept, GEOCIM is proposed for City Quarter to Conurbation scales, combining subsurface and above-ground models. These enable: a.) holistic urban planning; b.) identifying subsurface opportunities; and c.) saving costs by reducing uncertainty in ground conditions.
Finally, the Action's reports and outputs were integrated within an online toolbox, and will be further outlined in the Final Report of the Action, to be made available on the Action's website. The Sub-Urban Toolbox promotes and disseminates the good practice, and decision-support tools: a.) to help better inform and empower city decision- and policy-makers about the sub-surface and the vital importance of its early-stage consideration; and b.) accelerate uptake amongst sub-surface experts of sub-surface modelling workflows. Users with different backgrounds and needs, require different access to, and appropriate translations of, the Sub-Urban Toolbox. Therefore different entry points are provided for sub-surface technical experts, and urban planners, and decision- and policy-makers.
As the critical mass of city decision- and policy-makers that is better aware of the sub-surface and its sustainable use expands, the potential for higher level policy consideration of the subsurface grows, and a wider range of impacts will become achievable.

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Keywords: COST Action TU1206; Sub-Urban; urban subsurface; urban planning; urban policy; urban decision-makers; data management; 3D/4D models; groundwater; geochemistry; geotechnical data ; hazards; online Sub-Urban Toolbox

1. Introduction

Sub-Urban was initiated in 2013, as a European Cooperation in Science and Technology (COST) Action (TU1206), with the intention of improving understanding and use of the ground beneath our cities.

The Action emanated from an initiative within the North-east Atlantic Group of EuroGeoSurveys, recognizing the increasing importance of urban issues within their strategies, and especially of the impact being achieved by a multi-disciplinary project CUSP (Clyde-Urban Super-Project) then nearing completion at the time by the British Geological Survey. CUSP concentrated on the City of Glasgow (UK) and its surrounding catchment and was led also by the Sub-Urban Action's proponent.

The background to the Action is the increasing role of cities worldwide as engines for economic growth and as a focus for infrastructure development and investment (e.g. World Economic Forum [1]). Europe's population is already substantially urbanised, and by 2050, UN-HABITAT [2] estimates two-thirds of the global population will be too. Sustainable urban development (a measure of social, economic and environmental factors) is therefore being challenged globally by this urbanisation.

In contrast to the attention given to the visible (above ground) expressions of cities, there is a marked lack of appreciation of the importance of the subsurface amongst those who plan, develop and manage cities [3, 4], and a lack of integrated policy with respect to the subsurface. For example the European Commission's Science for Environment Policy [5], addressing indicators for sustainable cities, makes no specific reference to the subsurface. Hence, the ground beneath our cities is: a.) used inefficiently or even unsustainably; b.) urban subsurface ecosystem services are not effectively safeguarded; and c.) conflicting uses of the subsurface are unappreciated and largely unaddressed [6, 7].

Better use of the subsurface can make a significant contribution to urban sustainability, and resilience [8]. This requires, however, the integration of broad-ranging, multi- and transdisciplinary research (under the convenient umbrella of the so-called 'Science of Cities') to create improved urban subsurface knowledge which must then be effectively communicated, delivered and accessible to, and useable by, urban planners and other decision- and policy-makers, and practitioners.

Under the EU's Horizon2020 Framework Programme, the Action has operated through a Memorandum of Understanding (MoU) accepted by 30 COST and 1 COST near-Neighbour countries. The key objective of the Action has been to transform relationships between: experts who develop urban subsurface geoscience knowledge - principally national Geological Survey Organizations (GSOs), but also university researchers and others; and those

who can most benefit from it - urban decision makers, planners, practitioners (private consultants and contractors) and the developers they serve, as well as the wider research community.

The Action reached its culmination in April 2017, following the Final Action Conference in Bucharest, which was organized as part of the "Urban Subsurface Planning and Management Week, SUB-URBAN 2017, 13-16 March 2017, Bucharest, Romania": the collection of papers presented in this volume emanate from the conference but most of them draw on the work of the Action as a whole.

2. Process an Achievements

Sub-Urban has made significant progress, and in a variety of ways, towards achieving its key intention as outlined in the Action's MoU (2013). Its activities have involved development of a network of >150 researchers, (17 Geological Survey Organisations, 22 Research Institutions) and 23 actively participating cities. (http://www.cost.eu/COST_Actions/tud/TU1206).

2.1. Knowledge Exchange

To date, the Action has:

a.) Established a network of urban geoscientists/subsurface experts, mainly from European Geological Survey Organisations (GSO) and universities, but also including other researchers, to draw together and evaluate their urban geoscience research, often world-leading but typically fragmented, especially in monitoring, 3D/4D characterisation, prediction and visualization.

b.) Initiated and encouraged, using a "lighthouse and follower approach" (as used widely within the Horion2020 Framework), the exchange of knowledge between the researchers and the Action's City-partners (planners and other decision- and policy-makers). The City-partners have played a key role in influencing the activities of the Action. Their expertise in planning and policy, management and delivery of city infrastructure, and approval of licenses and plans submitted by developers, has been crucial in guiding the Action, and its priorities.

c.) Facilitated/shared experience, with new city-scale national exemplar subsurface projects (e.g. in Oslo (Norway), Odense (Denmark), Lisbon (Portugal), Bucharest (Romania), Rotterdam (Netherlands), etc.) delivered during the lifetime of the Action. These projects have been employing ambitious and multi-disciplinary teams, engaged in data management and modelling (2.5D, 3D and 4D) of the shallow subsurface, including its buried infrastructure, and developing comprehensive new subsurface planning and management systems, .

d.) Encouraged further bespoke developments, linkages, and uses of existing subsurface urban 3D/4D models (e.g. Glasgow, Hamburg, Basel) which draw on extensive digital ground investigation data, to enable predictive modelling of groundwater behaviour (e.g. Hamburg, Basel, Rotterdam and Bucharest), heat (e.g. in Basel and Barcelona), lithology, Sustainable Drainage Systems (SuDS) and engineering properties (e.g. Glasgow), and combined subsurface and above-ground (GeoCIM (see below), BIMs (Building Information M0delling)) models are also in progress, which can/will enable: holistic urban planning; identifying subsurface opportunities, and; saving costs by reducing uncertainty in ground conditions.

e.) Supported a series of 15 Short Term Scientific Missions (STSMs) (http://sub-urban.squarespace.com/stsm/); exchange visits between colleagues in the Sub-Urban network, enabling experience to be gained, and knowledge to be exchanged, and gathered for benefit both of the participant, and of the Action as a whole.

f.) Supported the production of peer-reviewed and "grey literature" (i.e. not formal) publications linked to the aims and objectives of the Action (many of which are referred to, elsewhere in this volume).

g.) Drawn attention to innovation: for example in the Netherlands under pioneering legislation, consultation of, and contribution of data to BRO, its national subsurface key-register, is mandatory. Alternatively, in Glasgow, free-flow of subsurface data is encouraged on a voluntary basis by BGS and Glasgow City Council through the ASK (Accessing Sub-surface Knowledge) KE network. Innovative knowledge transfer has been pioneered in Rotterdam (Netherlands) between its geoscience specialists and planners, through use of a 'Serious Game'.

h.) Promoted: i.) economic assessments of improved subsurface data and knowledge delivery; ii.) conurbation scale near-surface geochemical surveys (2D) and shallow subsurface 3D geochemical characterisation, and interpretation of contamination; and iii.) protection of buried archaeological and heritage assets from threats from variations in groundwater level and quality.

3. Reviews and Reports

The overall challenge of Sub-Urban is to be able to:

a.) understand and identify the city needs in order to develop/provide appropriate knowledge and products/tools for the municipality, city region, Water Board or other end-user(s), and
b.) identify good practice and relevant technologies when mapping and modelling the subsurface of the urban areas to enable improved and sustainable use and management of the urban subsurface.

The COST Sub-Urban Working Group Reports addressed these two elements of the overall challenge through two of its working groups: i.) Working Group 1 and its reporting activity related to the former [9]; and ii.) the Working Group 2 reports [10, 11, 12, 13, 14, 15, 16] addressed the latter. The Action's reports and other deliverables can be downloaded at the Action's webpage, www.sub-urban.eu.

3.1. State-of-the-art (Working Group 1)

A review of the prevailing state-of-the-art with respect to knowledge, planning, and use of the subsurface was established in a series of reports for 17 selected cities across Europe (http://sub-urban.squarespace.com/city-studies/); a synthesis of these is contained in the report [9] "Out of Sight, Out of Mind". Although the importance of understanding the ground beneath cities may seem self-evident, these studies demonstrated that the urban subsurface is still largely unappreciated. It does not present a daily concern to city planners and managers, and when it does, this is generally because of a problem that has occurred.

The overview report, and the Action as a whole, was intended to help identify options for cities to grow and develop more sustainably that are currently overlooked, and to increase the predictability of those ground conditions that are now considered unforeseeable. In addition, the overview report helped guide the subsequent topic-based reviews (Working Group 2 "Sub-groups") of good practice, with special reference to the acquisition of subsurface data, their interpretation into useful subsurface models, and the transferability of data and models to planning documents.

3.2. Identifying Good Practice (Working Group 2)

An evaluation of practices and techniques relevant to needs expressed by City-partners was undertaken, and as a result, identified examples of existing good practice and best effort (the core activity of Working Group 2 and its 7 sub-groups). These are highlighted in the synthesis report "Opening up the subsurface for the cities of tomorrow" [10], and expanded on in a series of seven topic reports, produced by the seven Working Group 2 Sub-groups of the same name, addressing (http://sub-urban.squarespace.com/new-index-1/):

a.) Subsurface information and planning
b.) Data acquisition and management [11]
c.) 3D urban subsurface modelling and visualization [12]
d.) Groundwater, geothermal monitoring and modelling [13]
e.) Geotechnical data and hazards [14]
f.) Subsurface geochemistry[15]
g.) Cultural heritage [16]

4. Dissemination and Impact

Dissemination and wider use of subsurface good practice in relation to a range of subsurface topics, technologies and practices, supported by COST Sub-Urban reports, and the Sub-Urban Toolbox, are anticipated.

4.1. Working Group Reports

The studies by the Action's Working Group 1 [9 and references therein] confirmed that the urban subsurface is in fact still largely 'out of sight, out of mind', and that there is a knowledge and communication gap between subsurface experts, urban planners and decision makers. The only possible way to bridge this gap is considered to be through providing the right type of subsurface information, in the right format, and at the right time and make sure that the people receiving the information (urban planners and decision makers) are able to understand and use the information to take decisions.

The anticipated impact of the Working Group reports [9, 10, 11, 12, 13, 14, 15, 16] and their content will be over the next 2-5 years, to help close the knowledge and communication gap between subsurface experts, urban planners and decision makers. This will be possible particularly in those cities which have already participated in the Sub-Urban Action, but, through the 'lighthouse and follower approach', this is anticipated to extend to other cities, particularly on national scales. The impact will be particularly in relation to science and technology, but should, increasingly with time, have an economic impact as more efficient use of the subsurface becomes achievable, and costly problems, particularly related to conflicting uses of the sub- surface subsurface are anticipated and avoided.

Embedding subsurface experts within the decision-making structure of a city (as is the case in Hamburg, and Hong Kong, for historic reasons, or in Glasgow currently as a result of a targeted NERC Knowledge Exchange Fellowship NE/N005368/1: Integrating subsurface environmental data and knowledge into city planning, held by Helen Bonsor) has substantial benefits in enabling appropriate translations of subsurface data and knowledge to be made into forms useful and usable to city planners, and other decision-makers. Early career investigators are particularly well suited to the role of the targeted expert within a city.

4.2. Sub-Urban Toolbox

An online Sub-Urban Toolbox (http://sub-urban.squarespace.com/toolbox-1/) was formally launched during the Bucharest Conference (March 13-15, 2017), to provide access to the various assets (reports, publications etc.) assembled by the Action, and including for example, a fit-for-purpose suite of recommended methodologies, good practice, guidance, and case studies to enable the free flow of key subsurface data and knowledge.

The Sub-Urban Toolbox has different entry points for practitioners, planners and policy makers, to help them: a.) plan and manage uses of the subsurface; b.) protect subsurface ecosystem services on which cities depend; and c.) recognise and address conflicting uses of the subsurface. To achieve maximum effectiveness, Sub-Urban and the Sub-Urban Toolbox encourages planning of urban areas that goes beyond spatial (2D) arrangement of surface and subsurface facilities and considers 3D (volumetric and depth zonation), and 4D (temporal) interactions between the built environment above and below ground, its supporting infrastructure, and multiple and co-existing uses of the subsurface.

4.3. Improvements in the ways in which sub-surface related issues can be brought into urban planning.

Sub-Urban examples describe practices both on municipal and national scales for different geographical settings/typologies, and access to and use of the Sub-Urban Toolbox can stimulate greater consideration of the urban subsurface within urban planning.

There has been an important collective realization (through cooperation between subsurface experts and planners) that delivery of geoscientific data and knowledge (through standardized and bespoke products) early on in the planning process (Concept Decision Phase) to reduce the current large uncertainties in infrastructural projects is essential for economic savings for society.

Unforeseen ground conditions are, next to market mechanisms, the biggest uncertainty in urban infrastructure projects. Geological Survey Organisations, and University research groups performing similar functions (e.g. University of Basel) can potentially save billions of euros for society by delivering bespoke products at the right time and at the right place. NGU (Norway) is currently reassessing priority tasks through the "Subsurface Project", which is strongly influenced by COST Sub-Urban. See also the toolbox; planning phases etc.

4.4. Movement towards improved standardisation of sub-surface data

The main focus of data standardisation (recording, acquisition, transfer and archiving) during the Action, has been largely on national scales and to compare the differing approaches that have been taken (legislation as opposed to voluntary codes of practice for example).

There is a relative lack of standardisation in European countries, and across Europe as a whole, with regard to sub-surface data in terms of policy and practice on an EU scale, although Eurocode 7 in particular applies, as well as INSPIRE for public sector spatial (though not 3D/4D model) data. It is intended that the Final Action Dissemination will enable further advance towards this, and engagement with JPI UrbanEurope will also be valuable.

One standard that was particularly emphasised in the Action's reports is the industry standard for geotechnical and site investigation data, AGS (Association of Geotechnical and Geo-environmental Specialists), although there are many other opportunities for standardization in relation to hydrogeological, geothermal and other forms of data acquisition which have been considered. A member of the AGS standards committee attended several workshops and within the UK the British Geological Survey are currently involved in discussions with the committee and key stakeholders about developing a totally new 3D model related concept for inclusion in the standard. Such an addition would directly relate to most of the case studies described in the Action reports.

Improvements in the ways in which sub-surface related issues can be brought into urban planning have been considered. Sub-Urban examples describe practices both on municipal and national scales for different geographical settings/typologies, and access to and use of the Sub-Urban Toolbox can stimulate greater consideration of the urban subsurface within urban planning.

4.5. GEOCIM

Implementation of the newly proposed GeoCIM principle (Geo(logical) City Information Modelling), which basically results from the comprehensive national exemplar model approach**,** should be at the City Quarter to Conurbation scales, for development of combined subsurface and above-ground models. Together these models can enable: a.) holistic urban planning; identifying subsurface opportunities, and b.) saving costs by reducing uncertainty in ground conditions. GeoCIM is analogous to Building Information Modelling used on a smaller scale by the architecture and construction industries on project scales - an approach which is rapidly gaining traction across Europe.

4.6. The policy perspective

Development and implementation of higher level, trans-national policy which fully and explicitly recognises, the importance, the need for, and the benefits from sustainable use, effective stewardship, and avoidance of conflicting use, of the urban sub-surface is a longer term ambition. It would require further development over 2-5 years of city and national initiatives, the accumulation and sharing of experience, and the development and implementation of related national policy, before transnational policy which takes account of the breadth of this accumulated experience and the variety of approaches, can potentially emerge.

The time frame for implementing policy at national and transnational levels might be accelerated by:

a.) further development of links, knowledge/experience sharing, and concerted action, between the Sub-Urban network and sister subsurface organisations with interests in the use of the subsurface within and beyond Europe (ITA, ACUUS, 100 Resilient Cities, SmartCities, EuroGeoSurveys),

b.) potentially important links and sharing of knowledge with China through its hugely ambitious National Science and Technology Project (2016-2030): Collaborative Development of Underground Space, and

c.) through gaining of further knowledge and experience in rapidly urbanising parts of the worlds (Asian and Africa) as a result of the International Development programmes of some European Countries.

In all of these possibilities, the accumulated assets of the COST Sub-Urban Action can provide a platform on which to build.

5. Capitalising on the Sub-Urban network

Within its formal lifespan of 4 years (2013-17), the pioneering European COST Sub-Urban Action (TU1206) has achieved a measure of success, and achieved some momentum, in bringing together: a.) urban subsurface research, capability, and good practice; and b.) in making it accessible, and readily useable through an online Sub-Urban Toolbox, for use by subsurface experts, urban planners, and other urban decision and policymakers.

The formal Action ended in April 2017, although an additional Final Action Dissemination grant will enable a further high-level publication to be produced in 2017-18, aimed mainly, but not exclusively, at decision-makers.

However, the Sub-Urban network is looking forward, and in several directions. These are intended not simply to extend the life of the network, but to expand its critical mass, extend its influence, and increase its impact, locally, regionally, nationally, and globally. In this regard, linkages with other networks whose aims and objectives overlap with Sub-Urban, and which have global reach, have, and are being developed and will be crucially important in maintain momentum. Some of these networks and organisations were represented at this conference, (e.g. ACUUS (Associated research Centres for the Urban Underground Space), ITA/ITACUS (International Tunnelling Association's Committee on Underground Space), etc.).

The Sub-Urban website (www.sub-urban.eu) will play a key role, also in perpetuating the Sub-Urban Toolbox, which must be further developed and refreshed. Bespoke versions of the Sub-Urban Toolbox, tailored to specific requirements, and city typologies may be useful in this regard, for example by the British Geological Survey (UK) in relation to Asian cities. Individuals, and organisations, are revising their strategies, to take account of the Action's progress. Sub-Urban is also looking towards its younger colleagues to take ownership of the networks assets.

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