

The Sustainable Infrastructure for Resilient Urban Environments (SIRUE) project has been carried out at the University of Birmingham, Birmingham, UK, and is funded by European Commission 7th Framework programme during 2012-2014. The project aims to identify how the use of underground space and its physical infrastructure influence, interact with, and impact on sustainability, vulnerability and resilience of urban areas, both now and in the future. Sustainability, in the context of Urban Infrastructure (UI) taking into account the rights of the future generations, including important issues such as ‘quality of life’, resource efficiency, biodiversity conservation and clean environment restoration. Sustainable UI facilitates a city (or region) in achieving sustainable urban development. The SIRUE project focuses on physical infrastructure, which is a set of physical objects, structures, and buildings interconnected functionally. Urban Physical Infrastructure (UPI) is assumed to encompass a set of man-made structures (e.g. roads, bridges, canals, tunnels, conduits, pipes and cables) that provide transport and communication links in addition to energy and matter flows.

Urban Underground Infrastructure (UUI) forms a key component of UPI, and the SIRUE project. UUI represents a very important, in many ways critical asset of any city; however its visibility during planning and urban development decision-making processes is often overlooked because the service functions it provides are secondary to the (re)development agenda (Bobylev, 2012) and this is a mind-set the SIRUE project would wish to change. By focusing on UUI, the family of UI has been considered within SIRUE, this includes transport, water, waste, and energy. This highly integrated approach is important because of common features and interconnections of different UI types. In so doing the SIRUE has been showing that the contemporary challenges related to sustainability and resilience are paramount for envisioning UI and UUI within the context of a modern city.

The project consists of four work packages: WP1 Investigating the role and requirements of the UUI; WP2 Developing a UUI framework for assessment of sustainability and resilience; WP3 Assessing strengths and vulnerabilities of present day UUI solutions; and WP4 Assessing UUI solutions for future resilience and sustainability. Each work package represents a study of an array of challenges, phenomena, and analytical outputs. Work packages are designed to be focused on specific scholarly problems, rather than on research areas, objects, or subjects; thus many phenomena (like urbanization, impacts of UUI) are studied in each work package, but from different angles / perspectives. Contents and outputs to-date of the work packages are detailed below.

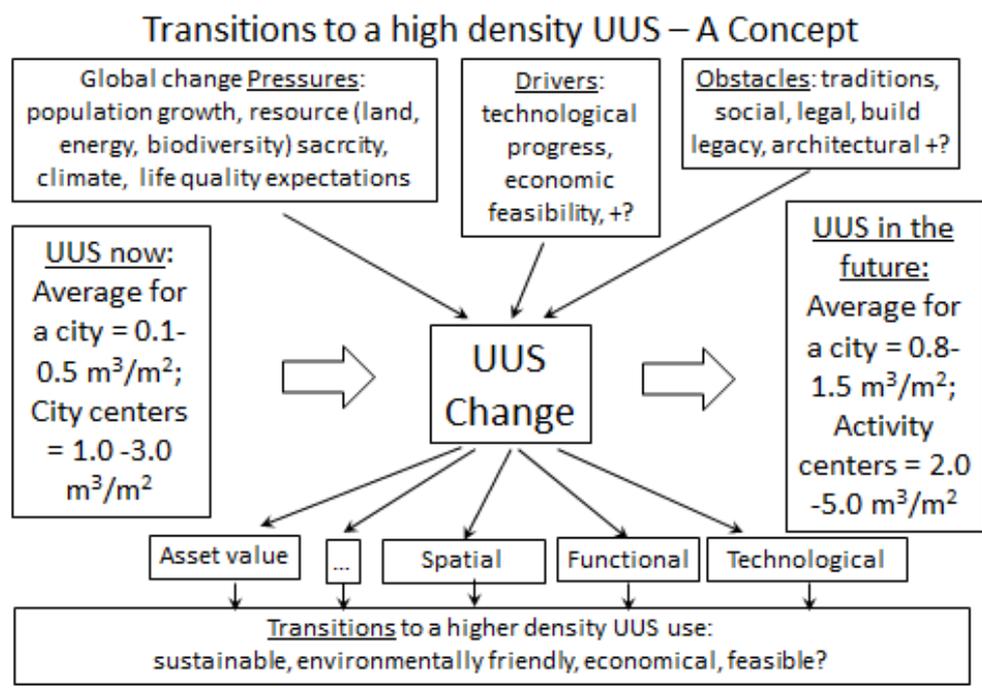
UUI has been characterised in terms of its role within urban centres as a key element of critically functioning system, enabling resilience of urban areas and uninterrupted provisioning of critical services. The key contributing elements to understanding of holistic UUI role in urban resilience has been identified as (1) the functional mix of provided services, their critical nature and possible interdependence, (2) coverage of services by specific infrastructures, including alternative providers, (3) energy/matter share flowing through specific infrastructures compared to a total in a specific area, (4) density of physical structures constituting the UUI.

Acknowledging the complex inter-relationships that exist between UUI and the urban environment, a pool of issues has been identified including environmental benefits and risks, and, likewise, UUI-environment synergies and risks for services provisioning. Interdisciplinary has been highlighted by developing a comprehensive table of disciplines and issues in Urban Underground Space (UUS), which can be useful for further research, and not limited to the current project. The role of intangible assets has been developed along with socio-cultural aspects of UUI and UPI in the city. Methodological review of the UUI ‘sustainability performance’ has been extensively studied, the results has been presented at the working groups meetings of International Tunnelling and Underground Space Association (ITUSA), conferences of Associated Centres

for Urban Underground Space (ACUUS), Saint Petersburg Underground City Forum, seminars on Energy Landscapes (KTH Royal Institute of Technology) and Building the Cities We Want (United Nations ECE).

Vulnerability analysis has been addressed by broadening knowledge and hand on expertise in risk analysis. A list of ‘key’ vulnerabilities to UUI has been identified as (1) inflexibility in functional change, and hence failure to meet dynamic demand (2) structural decay and technological difficulties in upgrading (3) climate change risks has been limited in detailed understanding regarding UUI so far, and this is a challenge for SIRUE on-going research.

SIRUE most significant research result to date has been a clear understanding that density of UUI will increase dramatically in the next decades in the most developed cities, SIRUE estimates a density of the developed underground space as up to 3-5 m³/m² in central areas of advanced cities and megacities. This change needs to be further investigated and characterised, since it will have the major impact on the socio-economic development of urban areas, as well as wider societal implications associated with sustainable life styles, namely transport, mobility, and energy consumption. Figure 1 provides a conceptual overview of transitions to a high density UUS including implications for urban areas and further research and development needs.



Bobylev, 2013

Figure 1. A Concept of high density urban underground space

An important policy implication is that we need to consider UUI and UPI planning at present, that it would fit future expectations regarding its functions and performance, both of which are expected change in the future, depending on the socio-economic development. SIRUE has been using Urban Futures method to assess sustainability and resilience of a set of UUI solutions against several socio-economic development scenarios.

The SIRUE has made an important impact on the co-operation in the field of UUI science in the European Research Area, most notably, facilitating discussions at Saint Petersburg Underground City Forum, which has a strong presence by the SIRUE main partners (University of Birmingham and the Russian Academy of Sciences), as well as advisers to the project from Germany, France, Switzerland and the USA. The Forum had an extensive media coverage, which helped in highlighting the UUI futures vision and disseminate SIRUE findings.

Contact: Scientist in Charge: Dr. Ian Jefferson email: i.jefferson@bham.ac.uk; Fellow: Dr. Nikolai Bobylev email: n.bobylev@bham.ac.uk. University of Birmingham, Birmingham, B15 2TT, UK.