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SUSTAINABLE INFRASTRUCTURE FOR RESILIENT URBAN ENVIRONMENTS

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Ongoing research

Sustainable Infrastructure for Resilient Urban Environments (SIRUE) 2012 - 2015

University of Birmingham, UK

St. Petersburg Research Centre for Ecological Safety of the Russian Academy of Sciences, Russia

The aim of the project is 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 (and vice versa), both now and in the future.
Ongoing research

Sustainable Infrastructure for Resilient Urban Environments (SIRUE) 2012 - 2015

There are 4 work streams:

1. Investigating the role and requirements of Urban Underground Infrastructure (UUI)

2. Developing a UUI framework for assessment of sustainability and resilience

3. Assessing strengths and vulnerabilities of present day UUI solutions

4. Assessing UUI solutions for future resilience and sustainability
Ongoing research

Definitions:

**Urban Physical Infrastructure (UPI)**
- a set of artificial structures interconnected physically or functionally

**Urban Underground Infrastructure (UUI)**
- a specific part of UPI interacting with Urban Underground Space (UUS)
Ongoing research

Contemporary Global Knowledge Challenges for UPI, UUI, and UUS:

(\textit{contents of the presentation})

- Modernization of UPI
- Keeping pace with urbanization
- Addressing Climate Change (adaptation, mitigation)
- Holistic approach to UUS resource management
- UUS planning and urban development
- Quantification & statistics on UUI
- Governance of UUI
- Perspectives for urban resilience: SIRUE
Urban Physical Infrastructure Challenges – fit for purpose, upgrade, modernize

Infrastructure: transport, resource supply networks, waste management, civil defence, other

Photo: Nikolai Bobylev
UUI Challenges
– fit for purpose, upgrade, modernize

Boston

Tokyo

Photo: Nikolai Bobylev
Global [Urban Physical] Infrastructure Challenges – not enough, not catching up with development

Global growth by 2030, %
data sources: population (UN, 2007); area (Angel et al, 2005); infrastructure (OECD, 2006)

### Urban Physical Infrastructure & global change

#### Outlook: UPI characteristics and factors of global change

<table>
<thead>
<tr>
<th>UPI characteristic</th>
<th>Evolution associated with urbanization</th>
<th>Evolution associated with adaptation to climate change</th>
<th>Opportunities for climate change mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interdependence</td>
<td>Increase (current trend)</td>
<td>Aim: to decrease due to increase in vulnerability</td>
<td>-</td>
</tr>
<tr>
<td>Convergence</td>
<td>Increase (current trend)</td>
<td>Aim: to increase due to opportunities for resource saving</td>
<td>Can save resources such as energy</td>
</tr>
<tr>
<td>Critical facilities</td>
<td>-</td>
<td>Aim: to increase number due to need to respond to extreme weather events</td>
<td>None</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Increase due to higher number and volume of infrastructures and their interdependence</td>
<td>Will increase due to extreme weather events</td>
<td>-</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Increase due to higher volume of infrastructures and opportunities for optimisation of their performance (e.g. convergence)</td>
<td>Will decrease due to need to adjust to new climate (resource expenditure on adaptation)</td>
<td>Sustainable, well planned infrastructure can help to mitigate climate change</td>
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## Urban Physical Infrastructure & global change

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# Urban Underground Infrastructure & global change

## Climate change related threats to UUI and vulnerabilities

<table>
<thead>
<tr>
<th>Climate-related threat</th>
<th>Impacts on UUI</th>
<th>Vulnerability</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods, Extreme rainfall</td>
<td>Inundation of underground structures through open structural elements, like entrances, sewers or ventilation shafts</td>
<td>High</td>
<td>Structural damage is low; damage to equipment is high unless waterproofing doors are used</td>
</tr>
<tr>
<td></td>
<td>Inundation of underground structures through leakages in retaining structure due to high water pressure</td>
<td>Low</td>
<td>Low if leakages are not continues</td>
</tr>
<tr>
<td></td>
<td>Suffusion of surrounding soil due to change in water level during the flood</td>
<td>Low</td>
<td>Extremely high, up to structural collapse</td>
</tr>
<tr>
<td></td>
<td>Sewers and rainwater collectors overcapacity operation, which might result in their structural damage</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Sea level rise, and subsequent rise of surface and groundwater levels</td>
<td>Structural damage due to changing soil stress-strain condition, “floating up” of underground structures</td>
<td>Low</td>
<td>Medium. High in case of prolonged UUI maintenance neglect</td>
</tr>
<tr>
<td>Extreme atmospheric temperatures</td>
<td>Ventilation systems can become temporary not operational.</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Extreme wind</td>
<td>Ventilation shafts can be structurally damaged</td>
<td>Low</td>
<td>Medium</td>
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Urban Underground Infrastructure & env. resources
UUS resources (after Parriaux, Bobylev, Sterling)

UUS planning & urban development

City Spatial Structure – Policy, Management, Land & Energy Consumption

Monocentric
Sprawling
Polycentric
Compact
Combination of activity centers

Images: Nikolai Bobylev
Urban Underground Infrastructure & its services (mobility&t)

Analytical estimation of urban underground space use by function
(Berlin, Alexanderplatz)

Quantification & statistics on UUI

Quantification & statistics on UUI

Correlation between dwelling units density and UUI public transport infrastructure

**UII Governance**

Governance - an umbrella term to aggregate systems of formal and informal rules, and actor-networks, including government, industry, and civil society.

Actors in urban development and UII:

(1) government via policy, laws, norms, and regulations
(2) investors via promoting and financing certain projects in specific areas
(3) interest-groups: e.g. environmental movements
(4) self-regulatory professional organizations, ex-officio representing e.g. specific industrial sectors
(5) businesses, usually having specific interest in specific areas or sectors
(6) individuals, including top decision-makers and celebrities
UUI Governance

UUI state of the art:

• UUI has been viewed as a service
• UUS Actors are not at all or indirectly involved in urban development
• UUI comes to a consideration at a late stages of urban planning process
• UUI is lagging behind in urban development
• The result – deficiencies in provisioning of urban services
UUI Governance

The result of not considering UUS in urban planning – deficiencies in provisioning of urban services

Example: lack of emergency response infrastructure in London and Saint Petersburg

Photo: Nikolai Bobylev
UUI Governance

(1) City needs infrastructure provides services
e.g. traffic congestion ➔ highway

(2) Planning
infrastructure implements policies
e.g. highway ➔ use of private car, commercial development in the surrounding area
UPI Governance

UPI interaction with urban development:
Reactive - UPI is implemented as a response to city needs.
Proactive - urban development follows UPI.

Diagram: Nikolai Bobylev
Governing and planning urban development: UUS early stage involvement for big decisions

Example: which spatial structure to choose?

- Do we need to choose? – yes to some extent (extent of planning)
- **Goals:** minimizing CO$_2$, maintaining high environmental quality, proximity of facilities …
- **Infrastructure** is one of a number of policy instruments
UUS Governance – vision, strategy, and recommendations

On-going research

- The role of professional community is important;
- Vision behind UUS and planning (global planning?)
Ongoing research and perspectives

Current SIRUE research agenda

Tasks:
UUI quantification
Criteria/indicators
Vulnerability/resilience
UUI policy under future scenarios

Co-operation:
International Tunneling and Underground Space Association (ITUSA),
Associated Centers for Urban Underground Space (ACUUS),
International Association for Impact Assessment (IAIA)
ICLEI,
UN Habitat.

Ambition:
To deliver knowledge base on integrated physical and socio-economic aspects of resilience and sustainability of UUS, UPI, and UUI.
Ongoing research and perspectives

Background papers


