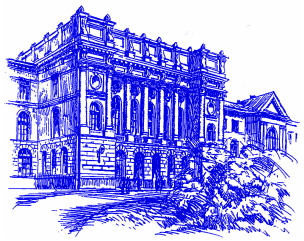
Nikolai Bobylev, PhD, Dexter Hunt, PhD,
Ian Jefferson, PhD, and Christopher D.F. Rogers, PhD

SUSTAINABLE INFRASTRUCTURE FOR RESILIENT URBAN ENVIRONMENTS

E-mails: n.bobylev@bham.ac.uk, i.jefferson@bham.ac.uk, huntd@bham.ac.uk, c.d.f.rogers@bham.ac.uk



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: *(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

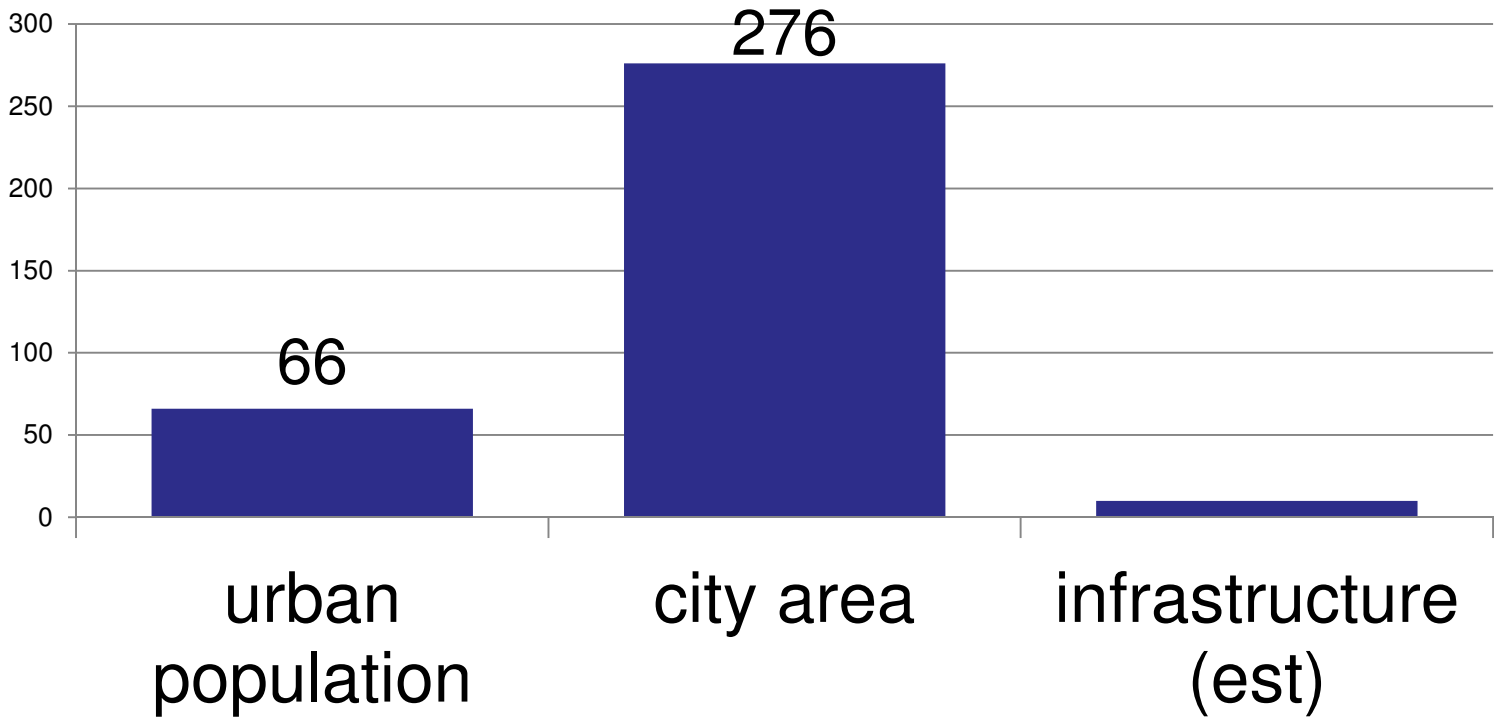
Boston

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)



Source: Bobylev, N (2013) Urban physical infrastructure adaptation to climate change. In: J.B. Saulnier and M.D. Varella (eds.), Global Change, Energy Issues and Regulation Policies, Integrated Science & Technology Program 2, DOI 10.1007/978-94-007-6661-7_4, Springer Science+Business Media Dordrecht 2013, pp. 77-102.

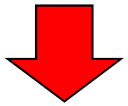
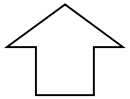
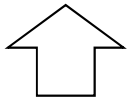
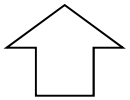
Urban Physical Infrastructure & global change

Outlook: UPI characteristics and factors of global change

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

Urban Physical Infrastructure & global change

Outlook: UPI characteristics and factors of global change

UPI characteristic	*Evolution associated with urbanization*	*Evolution a w adaptation to climate change*	*Opportunities for climate change mitigation*
Interdependence			-
Convergence			Can save resources such as energy
Critical facilities	-		None
Vulnerability			-
Sustainability			Sustainable, well planned infrastructure can help to mitigate climate change

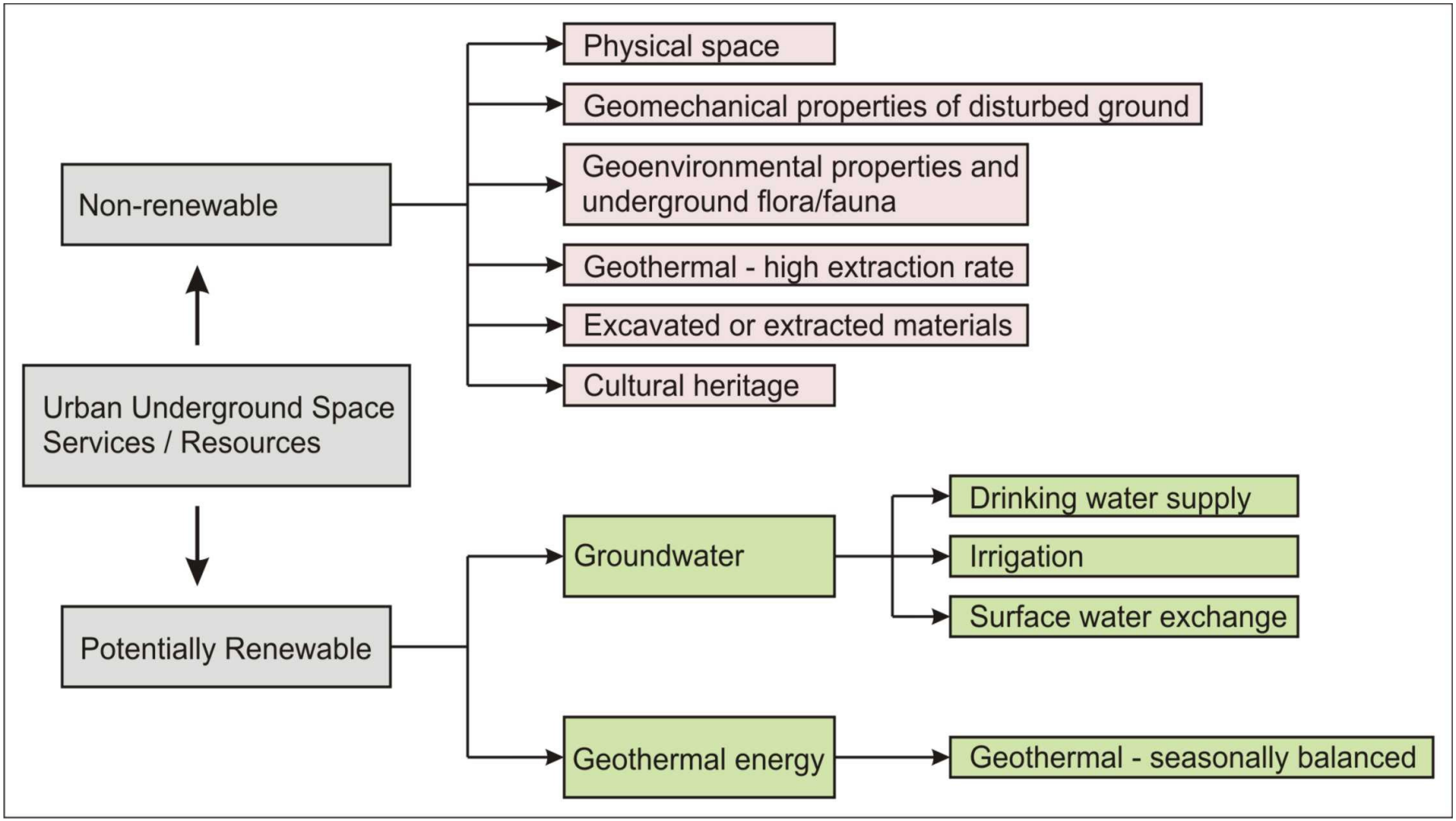
Urban Underground Infrastructure & global change

Climate change related threats to UUI and vulnerabilities

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

Urban Underground Infrastructure & env. resources

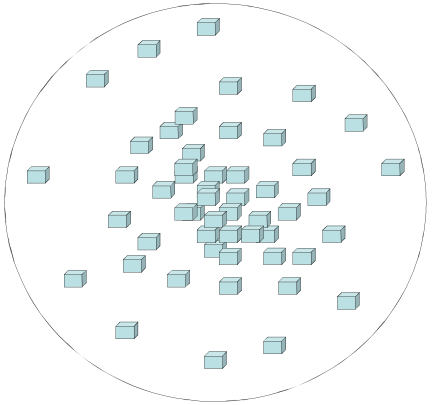
UUS resources (after Parriaux, Bobylev, Sterling)



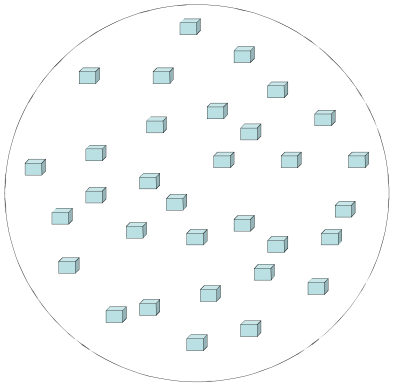
Source: Sterling, R., Admiraal, H., Bobylev, N., Parker, H., Godard, J.P., Vähäaho, I., Rogers, C.D.F., Shi, X., Hanamura T. (2012) Sustainability Issues for Underground Space in Urban Areas. *Proceedings of the ICE - Urban Design and Planning*, Volume 165, Issue 4, December 2012. pp. 241–254 (14). DOI: 10.1680/udap.10.00020

UUS planning & urban development

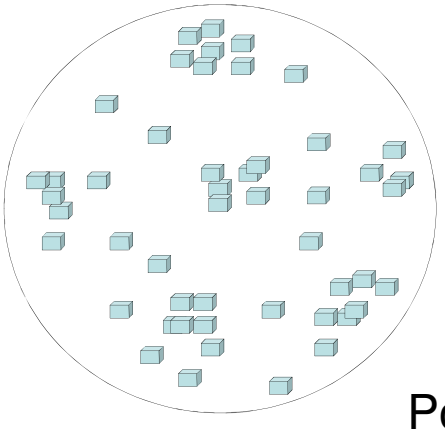
City Spatial Structure –
Policy, Management, Land & Energy Consumption



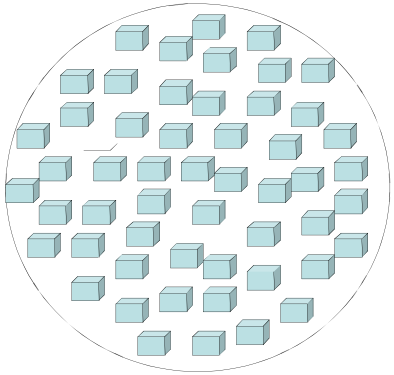
Monocentric



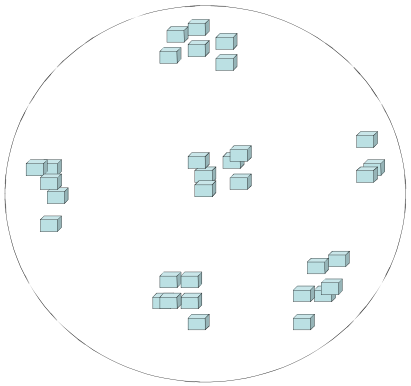
Sprawling



Polycentric

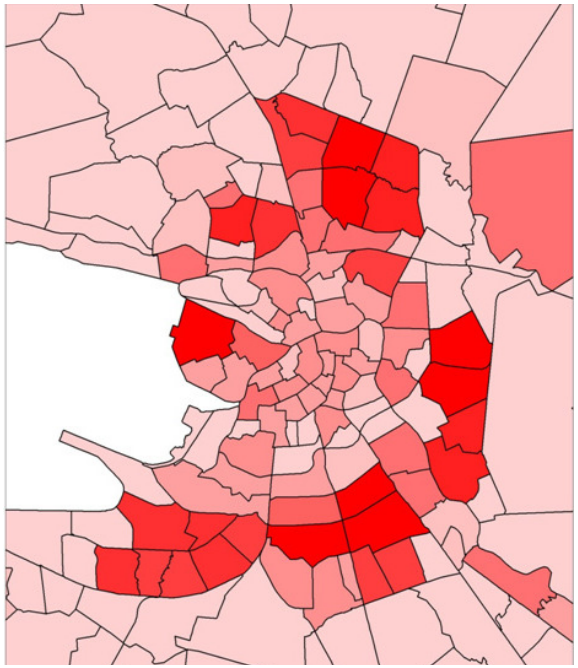


Compact

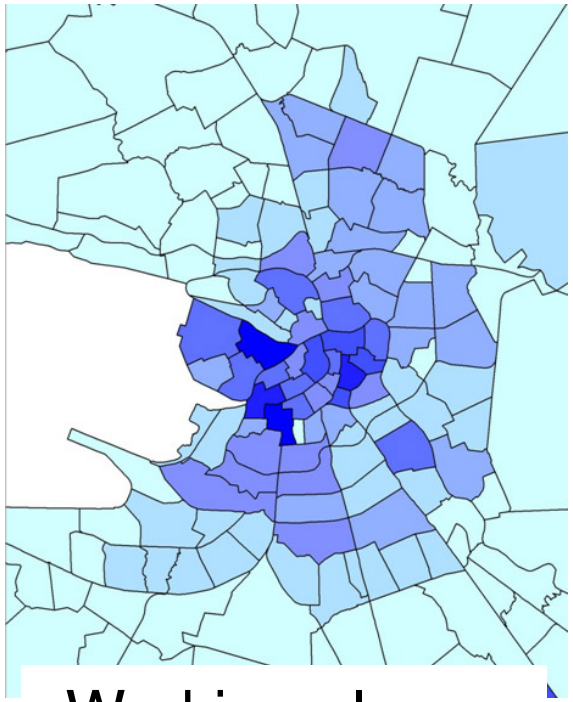


Combination of activity centers

Images: Nikolai Bobylev



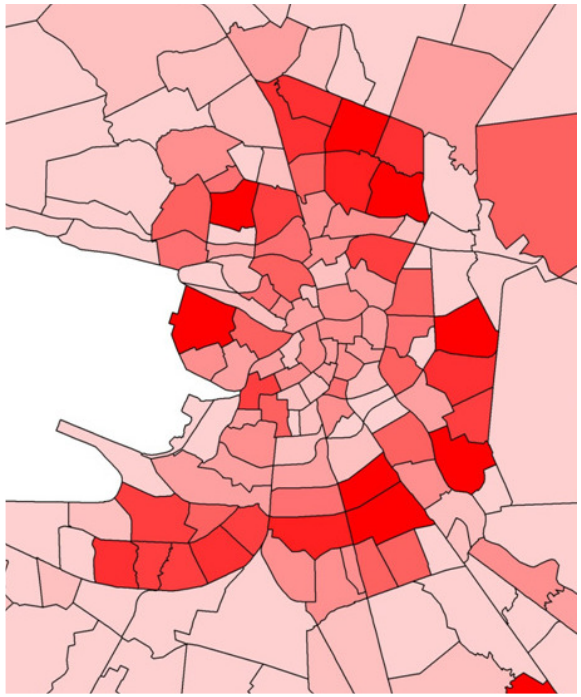
2005



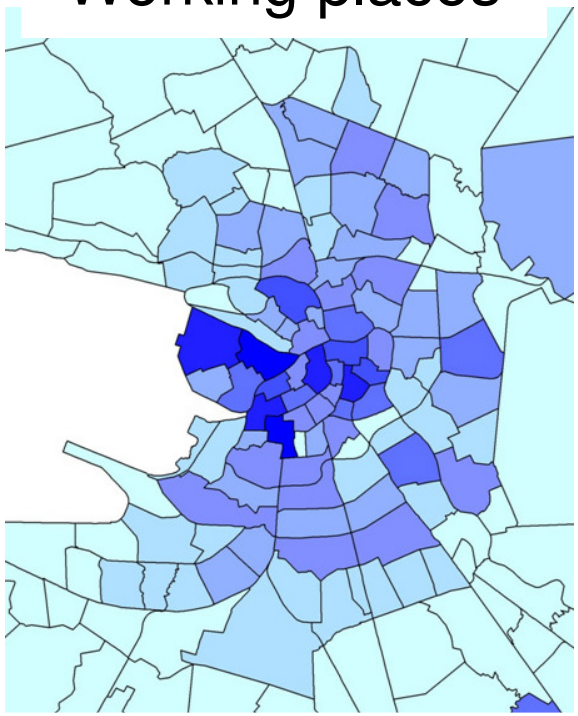
Saint Petersburg: population densities and working places (calculated in transport districts)

Population densities

Working places



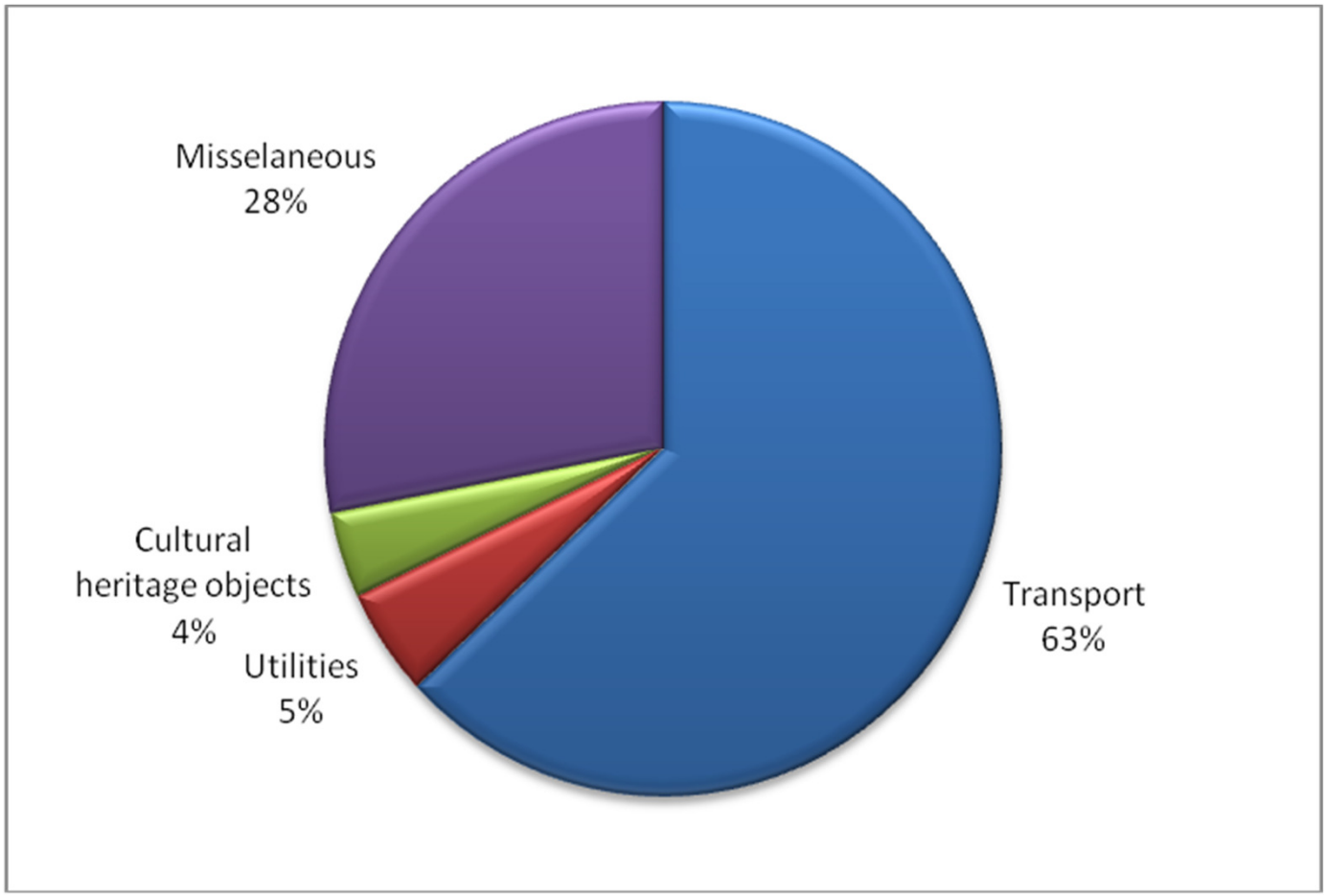
2015



Source: Leonid Losin, Concept of Saint Petersburg Master Plan

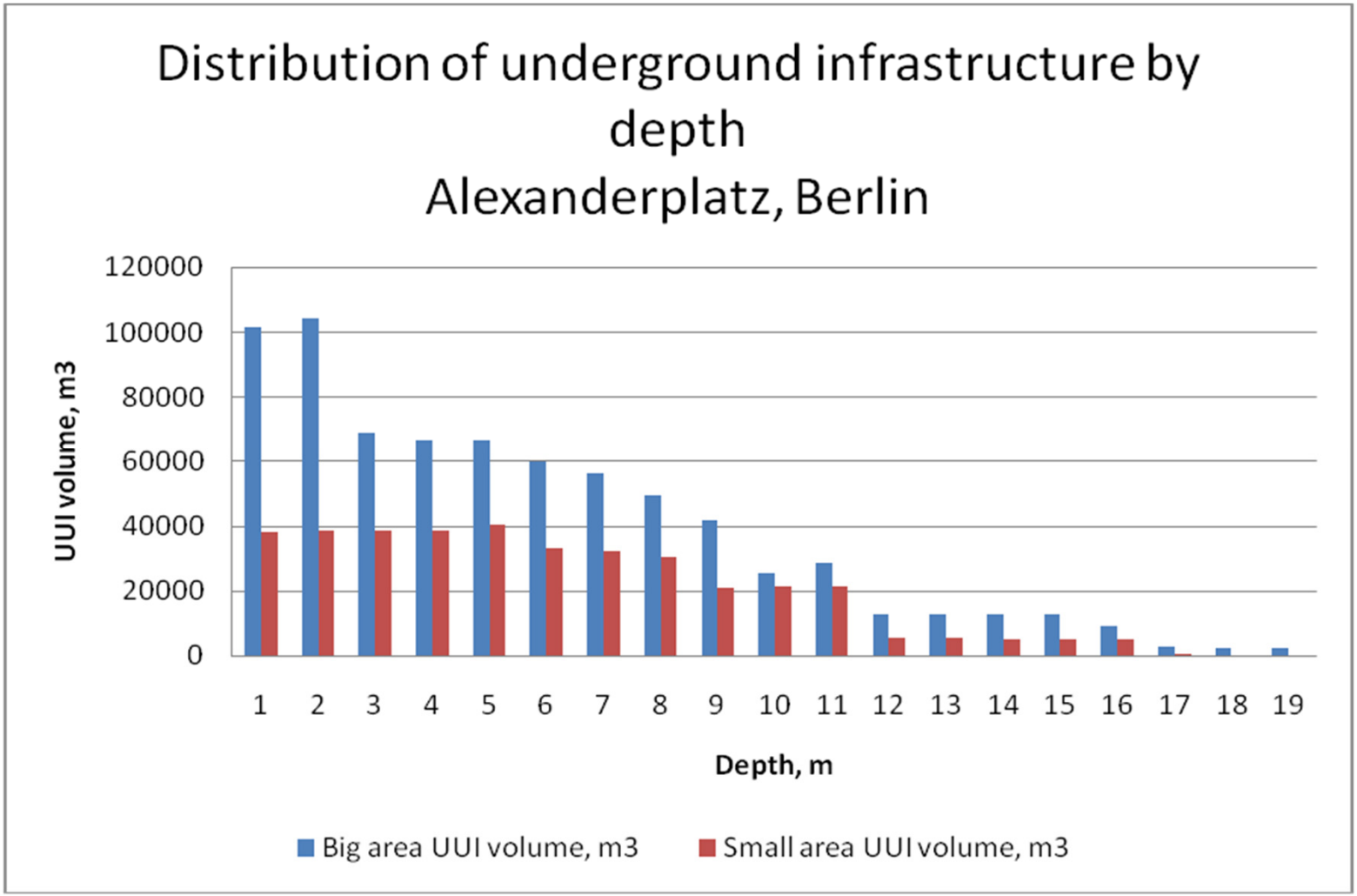
Urban Underground Infrastructure & its services (mobility&t)

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



Source: Bobylev, Nikolai (2010) Underground Space Use in the Alexanderplatz Area, Berlin: research into the quantification of Urban Underground Space use. Tunnelling and Underground Space Technology, Volume 25, Issue 5, September 2010, Pages 495-507. Elsevier, doi:10.1016/j.tust.2010.02.013

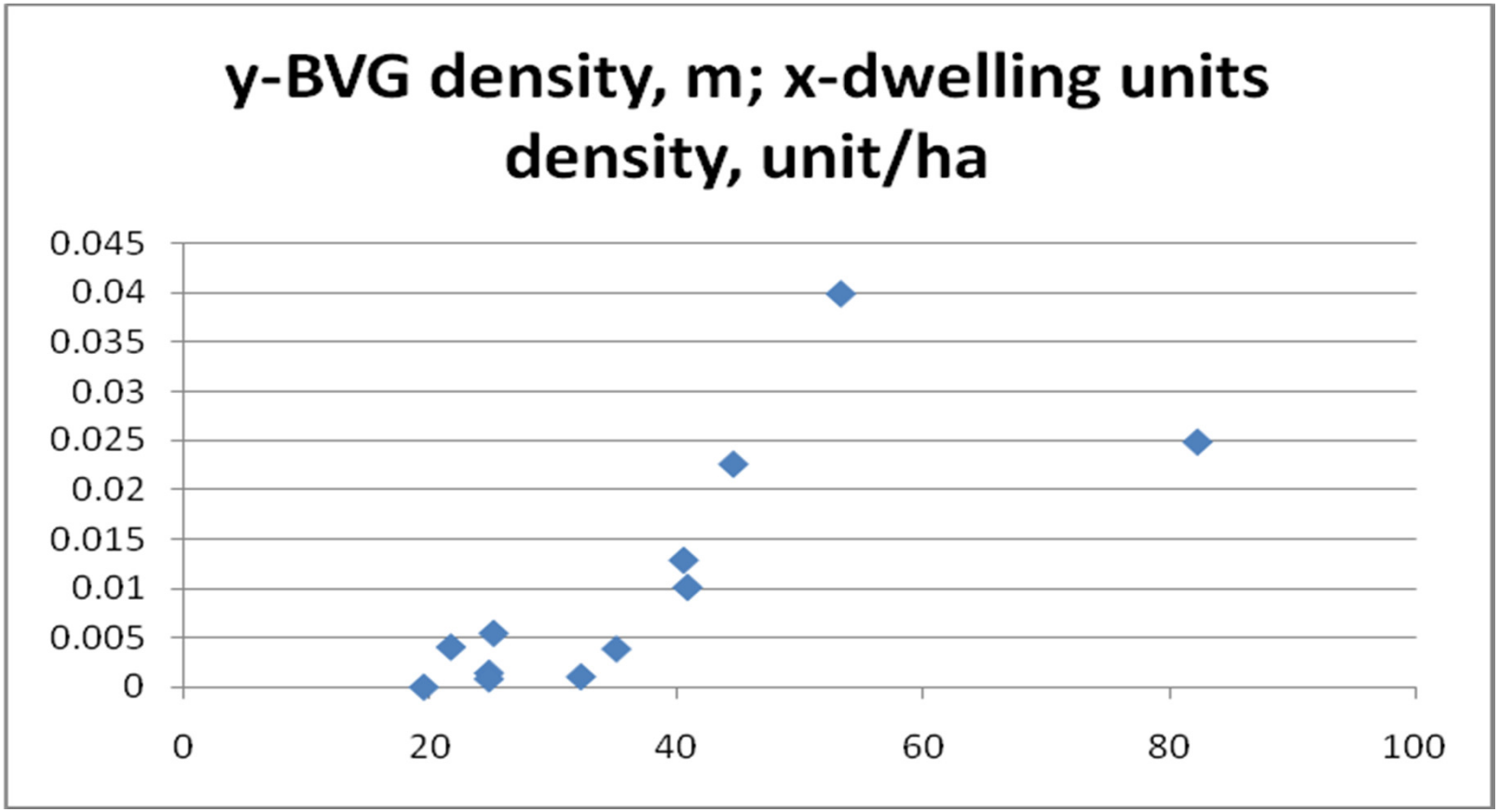
Quantification & statistics on UUI



Source: Bobylev, Nikolai (2010) Underground Space Use in the Alexanderplatz Area, Berlin: research into the quantification of Urban Underground Space use. Tunnelling and Underground Space Technology, Volume 25, Issue 5, September 2010, Pages 495-507. Elsevier, doi:10.1016/j.tust.2010.02.013

Quantification & statistics on UUI

Correlation between dwelling units density and UUI public transport infrastructure



Source: Bobylev N, Hunt DVL, Jefferson I, Rogers CDF, (2013) Sustainable Infrastructure for Resilient Urban Environments. In: Advances in Underground Space Development – Zhou, Cai & Sterling (eds), Copyright 2013 by The Society for Rock Mechanics & Engineering Geology (Singapore). Published by Research Publishing. pp. 906 – 917. ISBN: 978-981-07-3757-3; doi:10.3850/978-981-07-3757-3 RP-107-P219

UUI 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 UUI:

(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

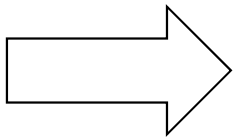
UUI Governance

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

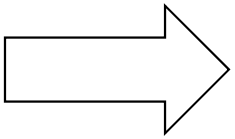
Example: lack of emergency response infrastructure in London and Saint Petersburg

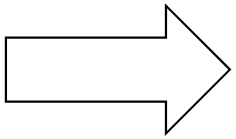
Photo: Nikolai Bobylev

UUI Governance

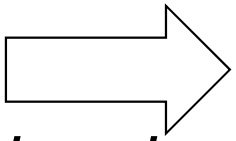
(1) City needs 

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*

UUI Governance

UPI interaction with urban development:

Reactive - UPI is implemented as a response to city needs.

Proactive - urban development follows UPI.

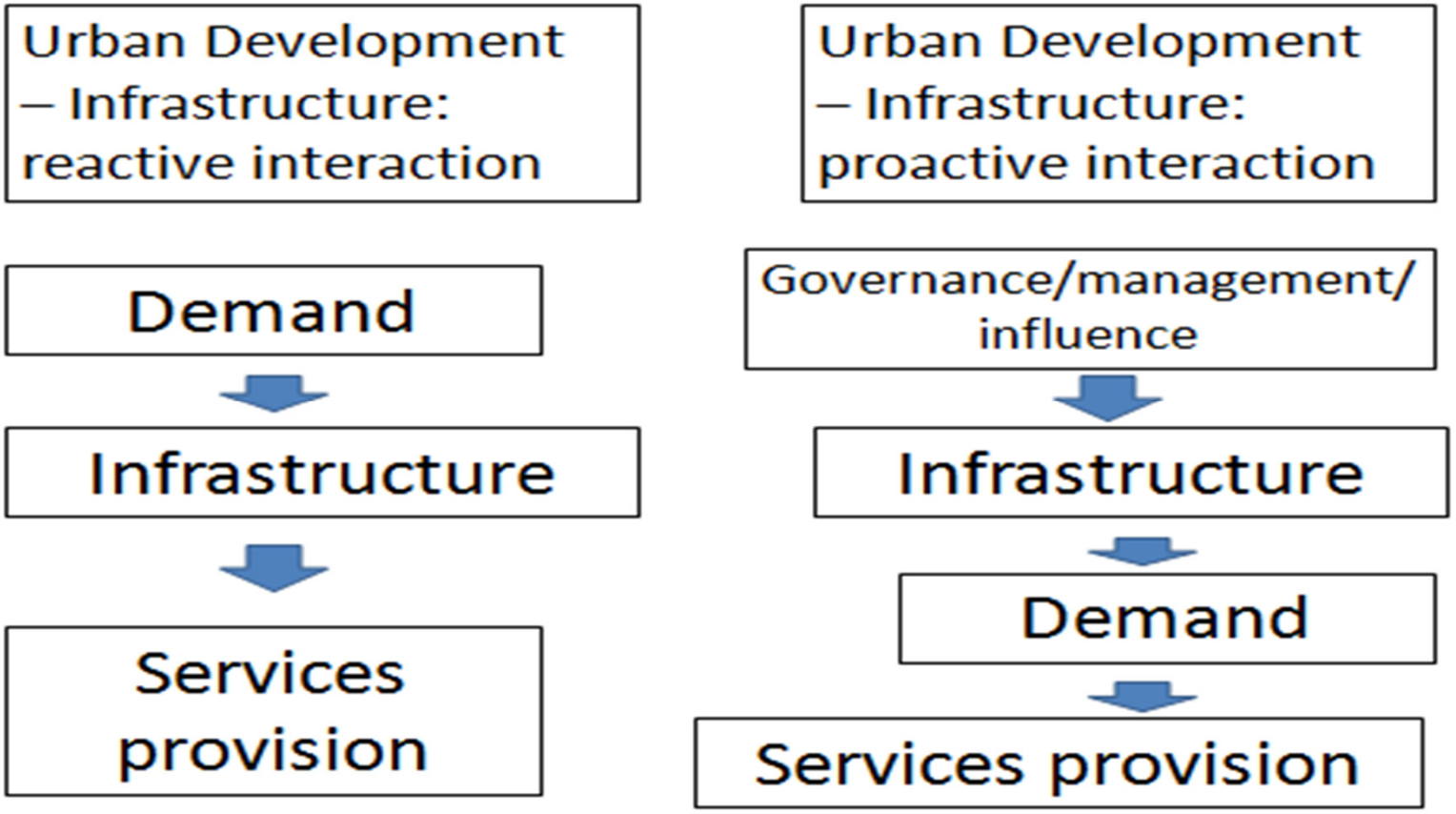


Diagram: Nikolai Bobylev

UUI Governance

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 a policy instruments

UUI Governance

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.

Background papers

Sterling, R., Admiraal, H., Bobylev, N., Parker, H., Godard, J.P., Vähäaho, I., Rogers, C.D.F., Shi, X., Hanamura T. (2012) Sustainability Issues for Underground Space in Urban Areas. *Proceedings of the ICE - Urban Design and Planning*, 32p. DOI: 10.1680/udap.10.00020

Bobylev, Nikolai (2010) Underground Space Use in the Alexanderplatz Area, Berlin: research into the quantification of Urban Underground Space use. Tunnelling and Underground Space Technology, Volume 25, Issue 5, September 2010, Pages 495-507. Elsevier, doi:10.1016/j.tust.2010.02.013

Bobylev, Nikolai (2011) Comparative analysis of environmental impacts of selected underground construction technologies using analytic network process. Automation in Construction, Elsevier. Volume 20, Issue 8, December 2011, Pages 1030-1040. doi:10.1016/j.autcon.2011.04.004

Bobylev, Nikolai (2009) Mainstreaming Sustainable Development into a City's Master Plan: a Case of Urban Underground Space Use. Land Use Policy, Volume 26, Issue 4, October 2009, Pages 1128-1137. Elsevier. doi:10.1016/j.landusepol.2009.02.003.