

Urban Systems Modelling

A systems approach for Hazard and Resilience



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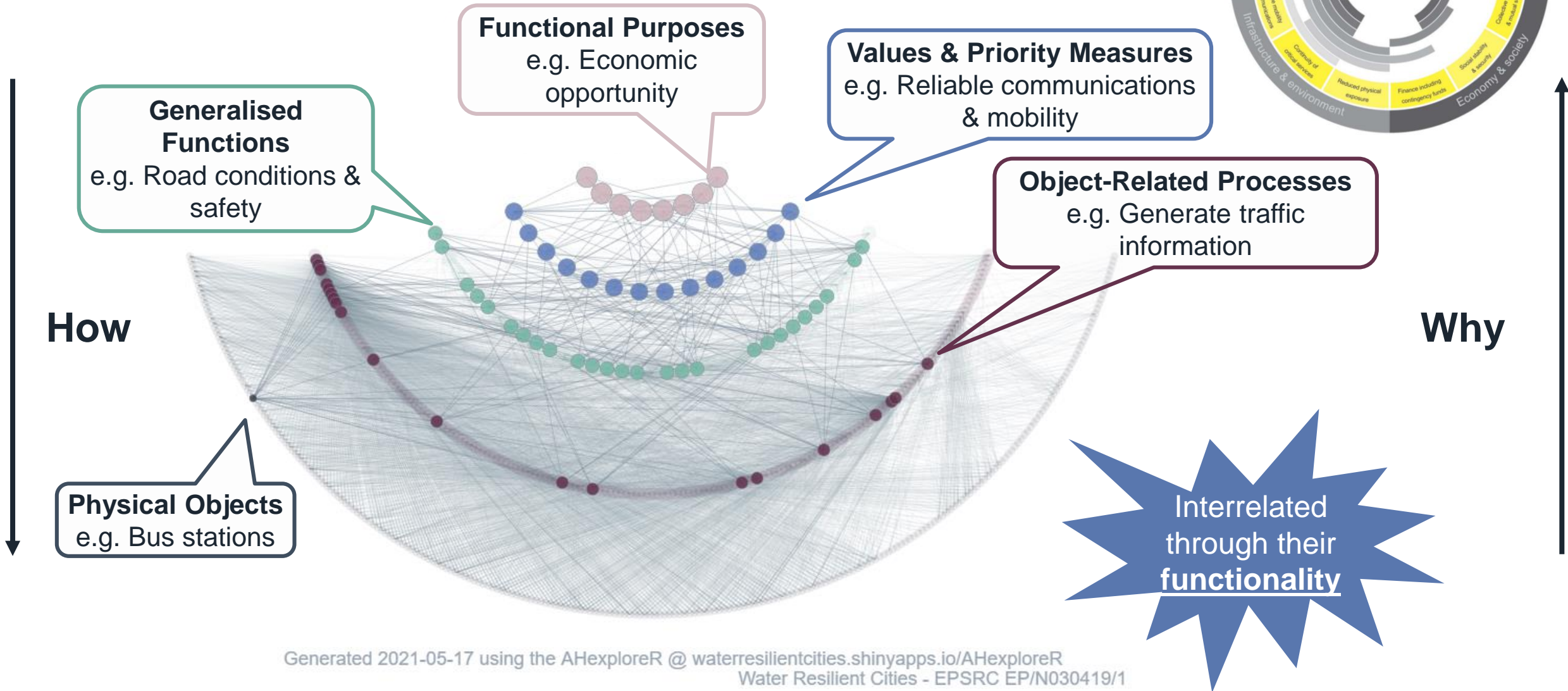
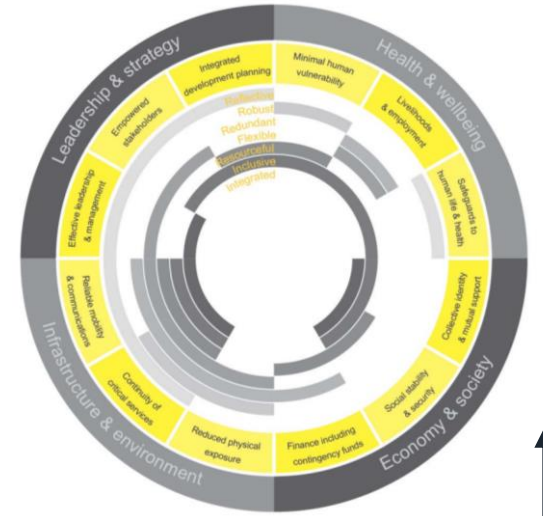
Prof L Beevers, Dr M Bedinger, Dr A Visser-Quinn, Ms Kerri McClymont, Mr David Morrison and Mr G Aitken

Urban Resilience: Systems thinking

- Cities: tightly coupled systems
- Interconnected sectors: e.g. healthcare, transport, education, economy.
- Impacts of hazards e.g. floods or global pandemic
 - Short-term emergency response and longer-term outcomes
- Resilience: track against high level outcomes

Urban Systems Abstraction Hierarchy

Arup (2015) 'City Resilience Framework'. Available at: <https://www.rockefellerfoundation.org/report/city-resilience-framework/>.



Urban System Abstraction Hierarchy

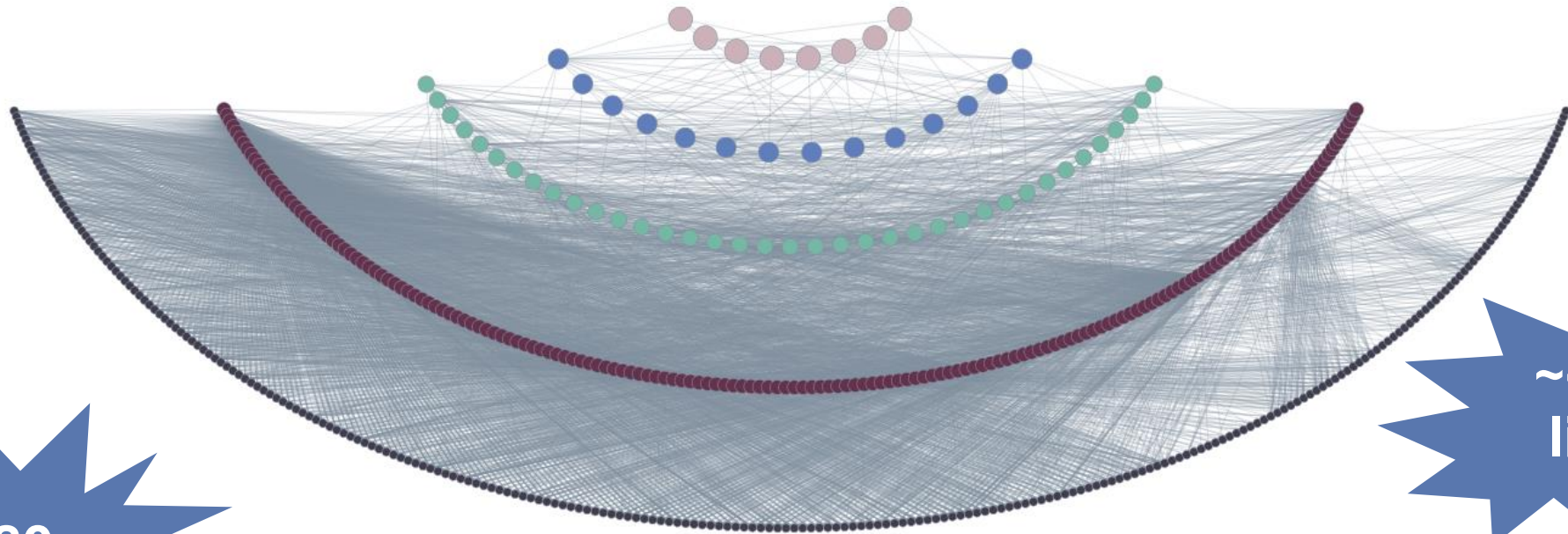
1 – Functional purposes

2 – Values and priority measures

3 – Generalised functions

4 – Object-related processes

5 – Physical objects



~480 nodes

~4500 links

Navigating the USAH network

- Quantify the interdependencies through network metrics

$$\lambda C_E = AC_E$$

- Eigenvector centrality identifies the most influential nodes in the network at each level based on the importance of its neighbours

Adjusting for location 1

- OSMtidy + manual checks used to find object types present in a city

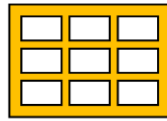


Adjusting for location 2

- AHgen used to filter the USAH template and remove Physical Objects not located within a specific city e.g. Edinburgh



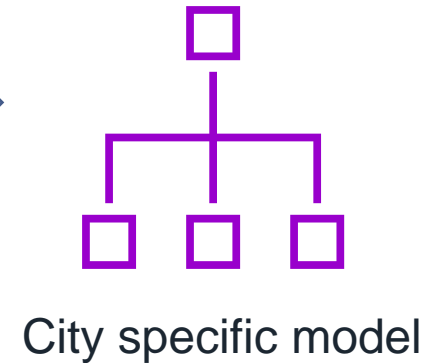
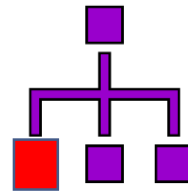
1. Input



2. Match

id	name	geometry
96	Outdoors and natural environment, Shrub land	list:(75.772515180574, 75.772515180574, 75.772515180574, 75.772515180574)
97	Outdoors and natural environment, Shrub land	list:(75.7803892, 75.7803892, 75.7803892, 75.7803892)
98	Exhibition centres, Stadiums and arenas	list:(75.802188, 75.802188, 75.802188, 75.802188)
99	Food production and horticulture, Agriculture	list:(75.833822, 75.833822, 75.833822, 75.833822)
100	Outdoors and natural environment, Grass land	list:(75.8247491, 75.8247491, 75.8247491, 75.8247491)
101	Sports and games, Outdoor playground	list:(75.803053, 75.803053, 75.803053, 75.803053)
102	Sports and games, Outdoor solid facility	list:(75.8001898, 75.8001898, 75.8001898, 75.8001898)
103	Sports and games, Outdoor solid facility	list:(75.773647, 75.7737117, 75.7737117, 75.773647)
104	Buildings, Caravans	list:(75.792249, 75.792249, 75.792249, 75.792249)
105	Water, Lentic water bodies	list:(75.8552857, 75.8552857, 75.8552857, 75.8552857)
106	Water, Rivers and burns	list:(75.803951, 75.803951, 75.803951, 75.803951)
107	Water, Rivers and burns	list:(75.837284767921, 75.837284767921, 75.837284767921, 75.837284767921)
108	Water, Rivers and burns	list:(75.8428898158, 75.8428898158, 75.8428898158, 75.8428898158)
109	Water, Reservoir	list:(75.8454878, 75.8454878, 75.8454878, 75.8454878)
110	University	list:(75.8536, 75.8536, 75.8536, 75.8536)
111	Religious sites and buildings, Place of worship	list:(75.8536, 75.8536, 75.8536, 75.8536)
112	Religious sites and buildings, Place of worship	list:(75.85425922532, 75.85425922532, 75.85425922532, 75.85425922532)
113	Religious sites and buildings, Place of worship	list:(75.854, 75.8536, 75.8536, 75.854)
114	Retail, Shopping centre	list:(75.82897, 75.82878, 75.82878, 75.82897)
115	Attractions, Historic	list:(75.7972, 75.7968, 75.7968, 75.7972)
116	Attractions, Historic	list:(75.8158, 75.81546, 75.81546, 75.8158)
117	Attractions, Historic	list:(75.8448, 75.84452, 75.84452, 75.8448)
118	Attractions, Historic	list:(75.8449, 75.8446, 75.8446, 75.8449)
119	Attractions, Historic	list:(75.84916, 75.84926, 75.84926, 75.84916)
120	University	list:(75.8164, 75.81644, 75.81644, 75.8164)

3. Filter



City specific model

- Download AHgen @ <https://github.com/avisserquinn/AHgen>

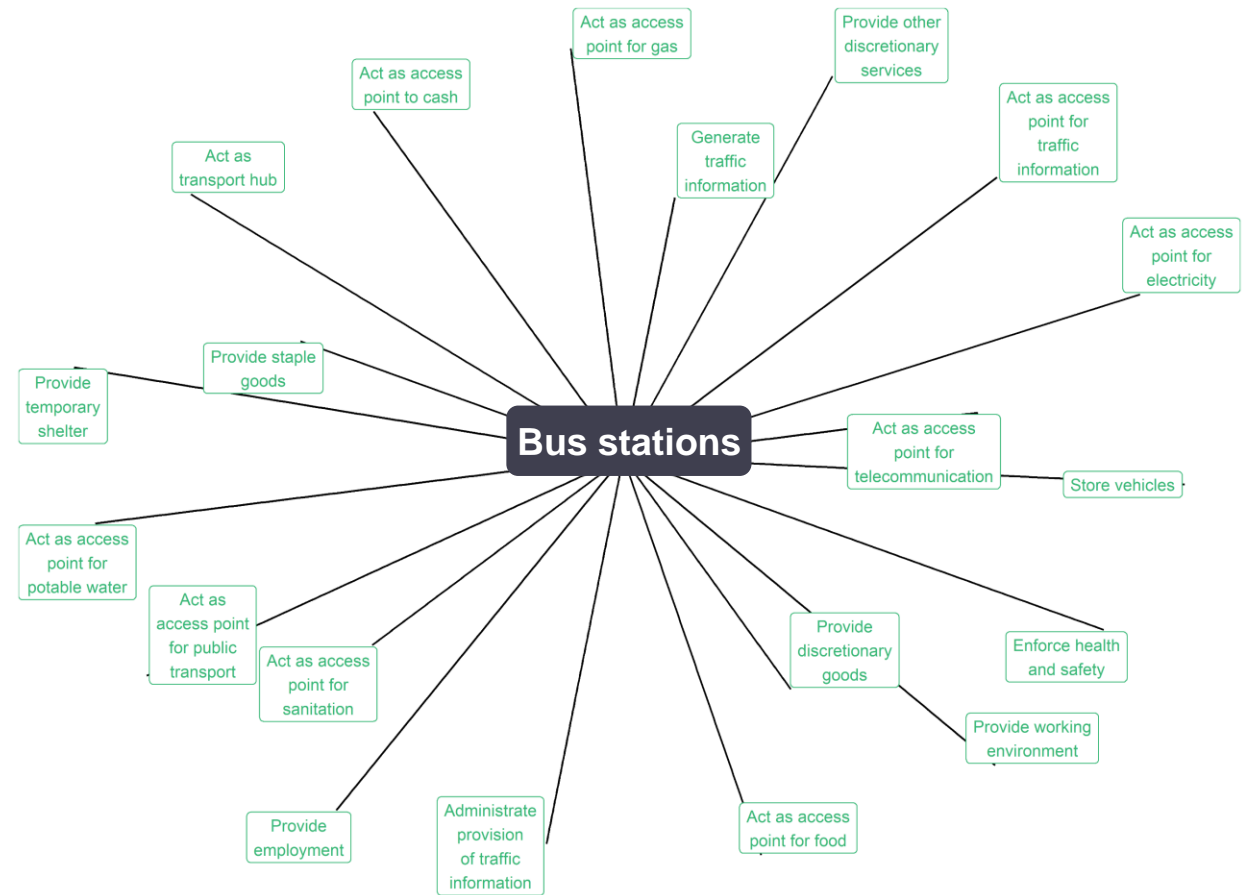
Case Studies: Cities

- Created:

- **Belfast** [Core City] (approx. 1.5 weeks)
- **Bristol** [Core City] (approx. 1.5 weeks)
- **Edinburgh**
- **Glasgow** [Core City] (approx. 2 weeks)
- **London** (approx. 4 weeks)
- **Manchester** [Core City]

Adjusting for a hazard

- Introduce hazard at Physical Object to Processes layer (tangible exposure)
- ~3550 potential edges to be weighted depending on hazard type
- Track change in baseline to hazard scenario using **eigenvector centrality**



Case studies: Hazard

COVID-19

- Weighted by edges
- Reflect the capacity of nodes to fulfil certain processes
- ~56% of potential edges in the PO-ORP layer are weighted during lockdown scenario
- Track change in intangible exposure

Flood hazard

- Weighted by node
- Reflect exposure of nodes that are no-longer functional
- ~20% of potential edges in the PO-ORP layer are weighted during flood hazard scenario
- Track change in intangible exposure

Summary

- Urban model – developed for 6 UK cities
- Track hazards from tangible exposure through to intangible outcome
- Examine change – explore HOW to strengthen physical objects and their processes to improve outcomes
- Links to DAFNI: house models/improve availability/upgrade analysis metrics
- Model available:
 - <https://doi.org/10.5281/zenodo.4756676>



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