

# **Spatial Design Network Analysis: improving design analytics for evidence-based planning and design nationally and internationally**

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# Summary of the Impact

- HKU FoA's next generation spatial network analysis software is directly contributing to **making urban spaces** more sustainable in some of **the world's most dynamic cities**:
  - In Hong Kong, Shenzhen, Shanghai, Paris, and London. We estimate that **sDNA-enabled projects** may have benefitted **up to 5 million residents** by offering **viable well-planned walkable alternatives** to car use
- allows for the first time, the standardised measurement of built environment variables in the field of public health analytics (**UKBiobank**).
  - the only national level cohort to have a wide range of **accurate measures covering all 4 pathways to impacts**

# Underpinning Research

- sDNA is a spatial design network analysis software (network science) used for comparing the relative efficacy of **2D/3D network layouts** for any type of movement, be it **pedestrian, cycle, road or urban rail**.
- A great deal of a city's **socio-economic performance** is down to **how people move around within the city**
- **Network layout impacts on accessibility distribution** that **sDNA analyses** is linked to urban socio-economic performance, be it density, land values, or health impacts distribution.
- **This allows urban, transport policies and design proposals to be predictively analysed for their performance**

# Underpinning Research

This falls into two categories:

- A. Research into the **underlying science** of the relationship between **network analysis** and **urban performance**, and
- B. **Computation and technical research** that implements models of urban network analysis **suitable for scientific and professional use.**



# Underpinning Research

## A.relationship between network analysis & urban performance

- i. FoA researchers have made a major contribution to establishing that a city's socio-economic performance, focusing particularly on '**wealth and health**', is strongly statistically associated with the configuration of urban road and pedestrian movement grids.
- ii. Our papers have used large-number studies (for statistical power) to show the associations between **network design characteristics** and performance outcomes such as **individual health, property prices, housing sub-market formation, street walkability, social and transactional opportunities, traffic externalities, 3-dimensional urban design performance, and the effectiveness of green spaces on walking choice and health.**
- iii. We have shown with **high levels of scientific confidence**, that the geometric and topological configurational information that **sDNA measures, can be used as a proxy for such urban socio-economic performance dimensions.**

# Underpinning Research

## B. urban network analysis suitable for scientific & professional use

- i. sDNA improves on the 3-decade old established market-leader, UCL's successful Space Syntax urban network software:
- ii. lacking transparency in its code, scientific credibility, industry-standard representation methods, advance geometric analysis features, suitability for 3D analysis and so on.



# Underpinning Research

## B. urban network analysis suitable for scientific & professional use

- iii. sDNA was built to address such issues and provide a brand new approach for urban design analytics while at the same time providing a scientifically credible tool to use in the fast growing interface between urban design and public health:
  - Native use of industry **standard data model** structures and representation – link geometry-node empirically tested in 2D
  - to make it **easy to use for designers**, a “true” **3D representation and analysis** was developed and empirically tested
  - a **unique hybrid network centrality** metric was designed, combining Euclidean & Geometric measures, which **outperformed previously used metrics empirically** which is **consistent with wayfinding theory**

# Underpinning Research

## B. urban network analysis suitable for scientific & professional use

### iii. Continued...

- Hong Kong detailed 2D/3D pedestrian mapping at city scale for the study of city-wide of connectivity, accessibility and walkability (2D is good enough for most cities, not Hong Kong) HKU team proofed and co-produced specifications with HK Government's Lands Department and adopted by them as the model used for active travel planning in HK.
- standardised spatial morphometrics in epidemiology. HKU team worked with Cambridge and Oxford Medical Schools.
- HKU & HKUST SPPR research grant 2017-20.A7.004. 17S HK\$ 3.5m for Strategies for Enhancing Walkability in Hong Kong via Smart Policies



# Underpinning Research

## Contextual information

- Research involved working with colleagues at:
  - Cambridge and Oxford University
  - University of Hong Kong (Medical School),
  - Tongji University in Shanghai
  - Shenzhen University,
  - Cardiff University

and with **planning and transport consultants** such as:

- WSP international, ARUP International and ARUP HK,

## **NGO**

- Civic Exchange (focused on promoting quality-built environment and walkability)

Hong Kong Government Departments

- Lands Department, Planning Department and Transport Department

# Underpinning Research

## Innovativeness of the knowledge

- We have shown with **high levels of scientific confidence**, that the geometric and topological configurational information that **sDNA measures**, can be used as a **proxy for urban socio-economic performance dimensions**.
- For the first time provides **at city scale quantitative and localised evidences** of the **strong interdependencies** of **at grade (2D) outdoor pedestrian network** and **multi-level (3D) outdoor and indoor pedestrian network**
- Provides at scale **representations** and **robust analytics** for **3D complex walking urban settings** used by **policy makers to planners and designers**



# Underpinning Research

## Significance

Significant not only to Urban Planning and design but also to **Urban rails and Transport Oriented Development (TOD)** is pursued **worldwide as backbone transportation policy forward** by city confronted with steep traffic demand, unbearable congestion and air pollution, enhancing **Hong Kong** recognition as the **world leading TOD city**.

- The research enable urban and transport and design policy maker to **understand from simple to very complex 2D/3D existing conditions** and simulate **predictively future conditions of TOD** that includes **3D vertical** and **2D horizontal integration**.
- Benchmarking what is probably the **most complex 3D urban settings in the world** – i.e. Hong Kong: Sheung Wan, Central, Admiralty, Wan Chai, provides **proofed analytics**

# Engagement

## Engagement process

- at **national and international** urban planning and transport practitioner **conferences**
- with large Chinese **Local Design Institute** through Tongji University and Shenzhen University,
- key note and presentation at **international and national Chinese planning conference** (IACP, UPSC)
- Presentations and KE with international **large and small planning, transport planning and design practices** (Atkins Global, Arup International & HK, WSP International, Benoy Global & HK, Lead8 (HK), Oval Partnership (HK), Wedderburn (UK), BRS (F).
- Presentations and KE with **Developer** (Swire, Global & HK) and **Place making economist** (Cistri, Global & HK)



# Impacts Achieved

## Beneficiaries

- **Local authorities**, urban policy makers that develop and deliver better urban policies (UK, France, China)
- **HK officials** in the relevant government bureaus and departments
  - Planning Department, Transport Department, Lands Department Development Bureau, Transport and Housing Bureau.
- **Urban professionals** and practitioners in HK, France, UK, China, urban and transport planners and designers

# Impacts Achieved

## Beneficiaries

- **General public**
  - General public who attended the conferences
  - General public **everyday life** that benefited from **better urban policy and designs** (UK, F, China).
  - General public **quality adjusted life year** that benefit from **better public health policy enabled by biobank complete 4 pathways to impacts** (UK)

# Impacts Achieved

## Nature and Extent of the Impact

- The research outcomes are used to establish **walkable BE policy standard, benchmark complex TOD** and **used globally as a tool for providing evidence-based policy walkability** design standard, and **decision making** in public and private urban planning and design and for public health scientific policy.
- HK LandsD adopted **FoA's mapping standard** by acquiring FoA's HK 3D pedestrian network map which is the **base of HK wide of walking policy making development** adopted by HKSAR Transport Department supported by the Planning Department
- sDNA analysis of FoA's HK 3D pedestrian network map in Central provides **1 of the prototypes** of the **HKSAR Built Environment Application Platform** of the **Common Spatial Data Infrastructure**



# Impacts Achieved

## Evidence

- Excerpt from testimony of Mr. Martin Wedderburn, Director of Wedderburn transport planning at human scale:

“Wedderburn regularly uses sDNA for both traditional planning/movement studies, as well as specialist pedestrian movement studies. In the past year, Wedderburn has employed sDNA for five projects in the UK, Middle East and Asia”.

e.g. 1: Wedderburn used the weighted analysis capabilities of **SDNA** to **prepare pedestrian demand forecasts** of the **Old Oak and Park Royal Development Corporation masterplan (650ha, 25,500 dwellings, 65,000 jobs)**. The methodology used inputs and outputs directly taken from the Transport for London strategic public transport modelling tool and created a local pedestrian flow forecast including transport interchange, access and egress trips of the stations, and walk-only trips using trip rates consistent with other modelling approaches.

e.g. 2: Wedderburn employed **SDNA** to assess the pedestrian connectivity impacts of the proposed Rotherhithe to Canary Wharf pedestrian/cycling bridge. Currently **Canary Wharf** has around **115,000 jobs** and they are set to increase to over 175,000 over the next 20 years. The proposal forms part of the Mayor's wider package of river crossings and new walking and cycling infrastructure in east London.

# Impacts Achieved

## Evidence

- Excerpt from testimony of Dr. Yu Zhuang, Shanghai TUP Design Institute Director of Urban Design Research Centre

“Before and since 2014 onward we have been using sDNA in many and a wide range of urban planning and design project. We have seen the benefit of engaging urban planner and designer in discussion enabled by the sDNA analysis in relationship to end users intended objectives. The decision making processed has been enriched and more certainty has been achieved between objectives and actual delivery on the ground”.

Example of projects:

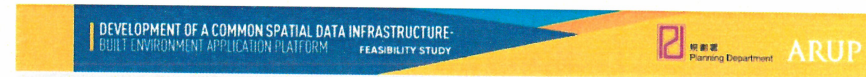
- **2016 Urban Design of Shanghai Xujiahui Sports Park** (Site area: 36 ha, 2017 Second-Grade Award of Shanghai excellent urban planning and Design)
- **2015 Urban Design for Shanghai Railway Station Area** (Site area: 46 ha).
- **2014 Urban Design of Shanghai Music Valley- Metro Line No.4 & Line No.10 Hailun Road Station area** (Site area: 55 ha; GFA: 1,238,000 m2).

# Impacts Achieved

## Evidence

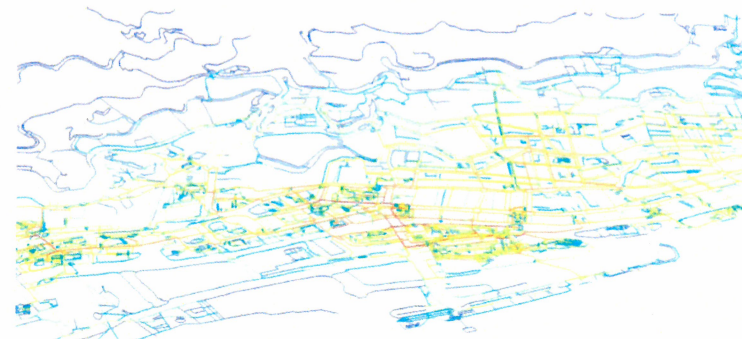
- **Excerpt from testimony of Bruce Chong, Associate Director, Arup HK**

“The Study comprises two study stages. Stage 1 is the study and formulation of a development framework and roadmap for BEAP [Built environment application platform], while Stage 2 is usability validation development of 10 prototypes/Beta test cases to demonstrate to Government Bureaux / Departments in Hong Kong.”



Current stage: [...] the HKU 3D pedestrian line and pedestrian path type categories (>20) model and sDNA are used as a base for the walkability analysis, and an integral part validating usability of an enhanced 3D Pedestrian Network Model and connectivity analysis

### 3D Pedestrian Map (Base Map from HKU)



© HKU FoA 2019 3D pedestrian network, pedestrian flow potential level processed with sDNA 2015

- Line diagram
- Effective width not available
- Basic street furniture included
- Pedestrian flow not included



# Impacts Achieved

## Evidence, its current acknowledged impossibility: proxies

Biological resource (UKBiobank) impact factor (BRIF), 500,000 cohort.

There is no standardised way of **quantifying impact for biological resource**. There is no standardized way **to quantify the degree to which a biobank is used and to link its use to the impact of the scientific discoveries that arise from it**.

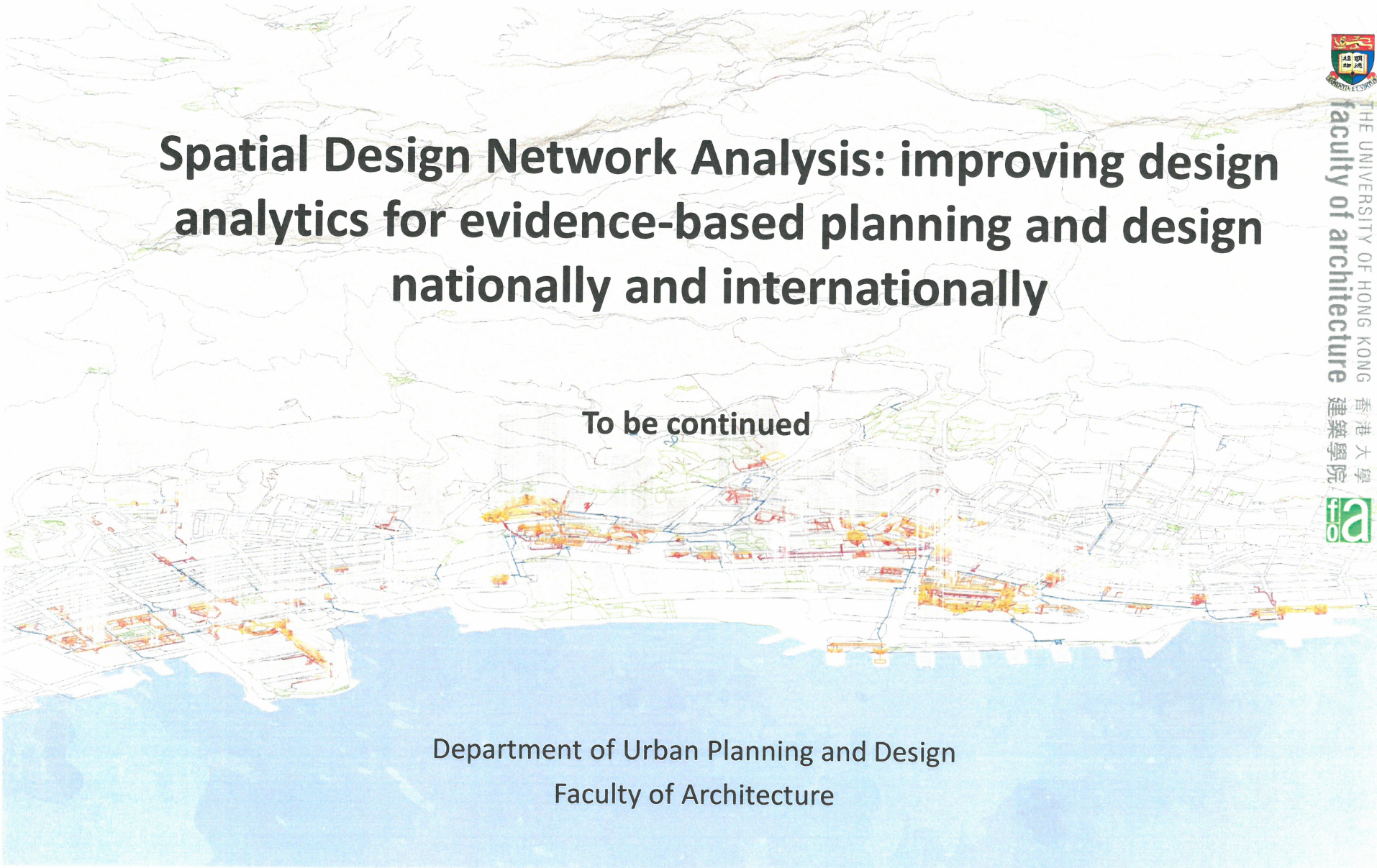
(Cambon-Thomsen, A., 2003. Assessing the impact of biobanks. *Nature genetics*, 34(1), p.25). <https://www-nature-com.eproxy.lib.hku.hk/articles/ng0503-25b>

- Rogers *et al.* 2011\*\* argue that **biobanks** could lead to significant financial impacts. E.g. if faster diagnosis and earlier treatment, by advances due to research of a biobank, would **reduce the annual life-year costs of only 2,000 patients of just one type of cancer by only \$5,000**, this in itself generate an **annual savings of \$ 10 million of the health care costs**.
- Considering the estimated value of a human life-year as \$ 50,000\* if the improvement of bio-specimen integrity resulted in more accurate diagnosis and better therapeutic management and **increased a patient's average life expectancy by just 0.5%**, it would mean an **increase in human life-year value of \$ 19,000 per patient or almost \$ 38 million/year for a cohort of as few as 2,000 patients**. This creates a huge impact on **National economic budgets, especially in countries like UK, as most of the population (66 m) is covered under NHS**.

\*international standard amount used by most government and private run health insurance firms

\*\*Rogers, J., Carolin, T., Vaught, J., Compton, C., 2011. Biobankonomics: a taxonomy for evaluating the economic benefits of standardized centralized human biobanking for translational research. *Journal of the National Cancer Institute Monographs*, 2011(42), pp.32-38.





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To be continued

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