Sustainable Urbanisation in the Context of Economic Transformation and Climate Change:
Sustainable and Liveable Cities and Urban Areas
Europe-China Joint Call for Proposals

Full Proposal: Consortium, General and Financial Information

1. Project Overview

Project Short Title/Acronym: **SIMETRI**
Project Full Title: **S**usta**I**nable **M**obility and **E**quality in mega-ci**T**y **R**eg**I**ons: patterns, mechanisms and governance
Project Coordinator/Main Applicant: Professor Michael Batty
Topics: (tick the relevant topic(s)) ☐ Topic 1. Climate change and new urban economies ☐ Topic 2. Transformation of energy systems and strengthen urban circular economies ☒ Topic 3. Urban public administration and services innovation ☒ Topic 4. Integrated urban data management
Keywords (max. 5): Mega-City Regions, Human Mobility, Inequality, Big Data Analytics, Participatory Governance
Overall project type: (mark the relevant category/categories with X [for weaker dominance] or XX [for higher dominance])

X	XX	X
Fundamental research	Applied research	Innovation and implementation

Total Project Costs in EUR:	**975,984**	Requested funds in EUR:	**889,227**
Duration of the Project in months (max. between 36 and 48 months)[1]:	36 months	Expected start:	03.2019
Total Effort in Person Months:	192	Expected end:	03.2022

[1] Please check page 16 of the Call Text, and Annex A of your funding agency to see which maximum duration applies.

2. Abstract

The 21st century will be dominated by very large urban agglomerations, qualitatively different from those big cities that our contemporary analytical understanding and models of governance are able to handle. The growth of these mega-city regions is heavily influenced by the fusion of existing cities as well as by rapid continental scale migration. This growth is generating severe problems of social segregation, connectivity, mobility, and income inequalities that require new and powerful methods of analytical understanding such as those being developed using real-time 'big' data sources and new information technologies. We propose to develop a platform for prediction and urban governance using the Pearl River Delta 'Greater Bay Area' mega-city region as a demonstrator, bringing sustainability indicators and simulation models from the Greater London and urban Holland (the Randstad) regions to inform the development of an urban data and simulation platform relevant to designing and testing scenarios for new modes of transport and the alleviation of socio-economic inequalities in the Bay Area. These problems, we believe, will be key to mega-city regions during the rest of this century. The project will: (1) integrate already developed **L**and **U**se **T**ransportation **I**nteraction (LUTI) models for London and the Randstad with ongoing cellular development and transport models for the Greater Bay Area, (2) develop new indicators for measuring spatial efficiency and equity, (3) develop analytics to inform innovative policy analysis and governance, and (4) demonstrate these tools in association with planning agencies and government across the region.

3. Summary for the general public

We will develop a world-class science platform relevant to political decision-makers responsible for housing, transport, employment and urban development in the world's biggest mega-city region, the Pearl River Delta Greater Bay Area. This platform integrates work on inequality indicators and predicting future land use and transport developed in western Europe in London and the Randstad with related work in Shenzhen and Guangzhou, producing a system that will use state-of-the-art simulation models, big data from routine transport, and new ways of using information technology for participatory governance. We argue that such a platform is essential for the very largest cities which are qualitatively different from smaller cities. The platform developed here would be a world first.

4. Project Consortium

	Organisation	Type of organisation[2]	Country	Coordinator Europe / China[3]	Contact Person (first name and family name)
Project Coordinator/Main Applicant	University College London (**UCL**)	RO	United Kingdom	X	Michael Batty
Project Partner 2	Birkbeck University of London (**BBK**)	RO	United Kingdom		Joana Barros

[2] Type of organisations: SE = small enterprise; ME = medium-sized enterprise; LE = large enterprise; RO = research organisation, OTH = other type of organization. With regard to the size of companies, the current definitions of SMEs given in the EU competition law are applied (definition of small and medium-sized enterprises and of independent businesses in accordance with recommendation 2003/361/EC of the Commission dated 6 May 2003, [ABl. L 124 of 20.5.2003, pp. 36-41]; cf. http://ec.europa.eu/DocsRoom/documents/15582).

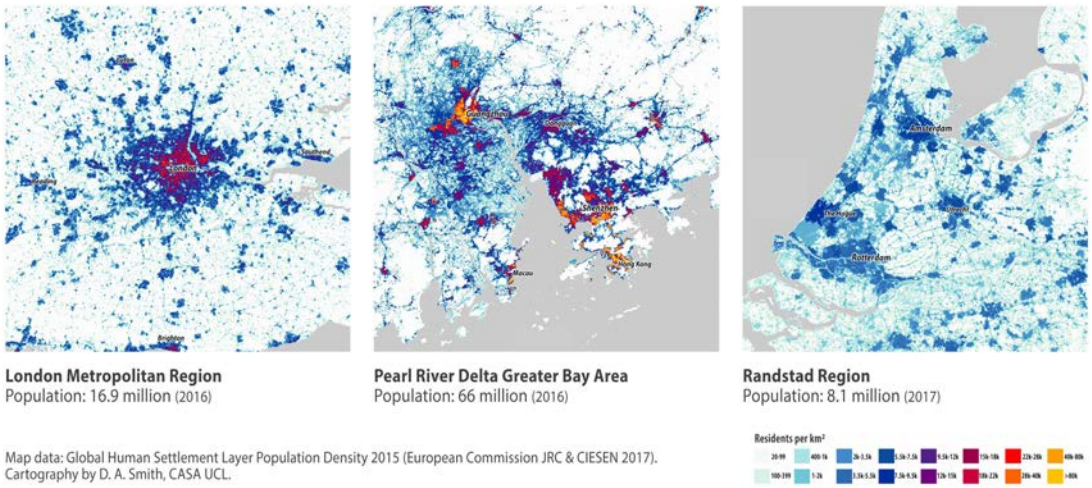
[3] Mark the respective organisation with X.

Project Partner 3	King's College London (**KCL**)	RO	United Kingdom		Chen Zhong
Project Partner 4	School of Business and Economics, Vrije Universiteit Amsterdam (**VUA**)	RO	The Netherlands		Eric Koomen
Project Partner 5	Shenzhen University (**SZU**)	RO	China	X	Qingquan Li
Project Partner 6	Shenzhen Institute of Research and Innovation, The University of Hong Kong (**HKU-SIRI**)	RO	China		Anthony G.O. Yeh
Project Partner 7	Sun Yat-sen University (**SYSU**)	RO	China		Suhong Zhou

5. Quality of Work, Project Objectives and Targets

5.1 Project objectives and targets

The general aim of the project is to develop a platform for both understanding and predicting future development in mega-city regions, which, we argue, are intrinsically different from the biggest cities that have developed so far. Mega-city regions of the order of 15 million persons or more have only emerged during the last 25 years; they are much more complex and qualitatively different from smaller cities. They are invariably better developed and more diverse with respect to the embedding of information technologies into public transit systems, housing markets, and different modes of mobility. The three regions we have chosen admirably illustrate the challenge as we show below



Our project thus aims to develop these complexities into analytical models that inform those mandated to develop future policies for their urban development. It is geared to meet the following objectives:

- To define and build a platform for managing urban data at different spatial and temporal scales based on conventional geo-demographic data and data pertaining to the real-time city
- To implement a platform for the Greater Bay Area in Shenzhen University with strong comparative analysis of similar data platforms in London (at UCL-KCL-BBK) and the Randstad (at Vrije Universiteit Amsterdam: VUA)
- To develop existing and new models of land-use-transport as outlined in the work packages building on expertise in LUTI models at UCL and VUA, and agent-based (ABM) and cellular automata (CA) models at Shenzhen, HKU-SIRI, and SYSU linked to the urban data platform
- To demonstrate these new tools with respect to mobility, accessibility and segregation for the Greater Bay Area incorporating new methods of model development based on state of the art multivariate analysis reflecting machine learning and related models such as ANN and RFA.
- To examine issues pertaining to how the spatial mismatch between demand for facilities in mega-city regions and their supply generates segregation and inequalities in and between cities and urban areas, and how such mismatches can be understood better and resolved using new types of dynamic data, much of it crowdsourced and or captured in real time.
- To collect and synthesize new forms of urban data that pertain to mobility such as mobile phone data, IC/RFID card data of public transportation, GPS floating car data, social media, and volunteered geographic information, integrating these with more conventional data sources from less frequent census archives

- To develop a diverse set of key performance indicators associated with scenarios for spatial development in the Greater Bay Area using new simulation tools. These will incorporate new indicators of sustainable development reflecting work done at UCL-KCL-BBK on accessibility and segregation
- To develop the data and simulation platform to embrace new forms of information for governance and policy analysis for use in exploring 'what if' scenarios for transport, mobility, and economic development in the Bay Area
- To impress the experience that such a platform has limitations, it is simply a pilot and a demonstrator of how issues pertaining to mobility, transit, segregation and housing might be embraced in policies that lie at the basis of public-private decision-making.

There are five key innovations that we consider define this project. First, we are dealing with a new kind of city, one which will dominate much of the urban future in this century. Mega-city regions that are much more complex than smaller cities, have different land use and travel patterns than smaller cities, and are fast evolving deep structures using new information technologies. No one group of people can deal with such complexity and therefore our approach brings together key modelling and simulation groups in Western Europe and China to effect progress in this area. Second, we consider new models will emerge from this cooperation and the experience of China and Europe will lead to new ways of thinking about how to compare and develop policy in mega-city regions. Third, we believe a new class of urban indicators is needed to identify key problems in mega-city regions, namely those that pertain to how transit and transport interact with social and economic locations generating inequalities and segregation that is different from much of what we observe in contemporary cities. Combined with different speeds of development, we believe our comparative approach is key to understanding how we can address the problems of really big cities. Fourth, the concept of a data-informed urban planning and evaluation approach will be implemented (for the first time anywhere) in the form of an urban analytical platform which will be validated in urban planning practice in the Greater Bay Area. Last but not least, we consider that the grouping of partners put together is one of the best there is. The London group has pioneered the development of urban models for many years, focused on CASA, while work at SZU and HKU-SIRI on cellular models has been at the forefront of this style of modelling since the 1990s. The Dutch group have been in the vanguard of developments in integrated environmental and land use transport models. The SYSU group are key to new developments in mobility and transport while all the groups are immersed in using real-time streamed data to inform their analytical work. The contributions of each group are listed below in their outlines and biographies.

The final deliverable from this work will be a platform which will provide a springboard for further development, will be useful to decision makers, and will provide a template for future research into the planning of mega-city regions. A specific focus of the project will be on mobility which we will use as a lens to see other aspects of the city in terms of its urban structure, form, function and development. In short, one very key feature of our approach will ***not*** be to cover everything necessary to thinking about future mega-city regions but to use key data-rich sectors and elements such as mobility as a focus through which to look at key problems of segregation, accessibility and (in)equality.

5.2 Overall project type

We consider our project to be comprehensive in that it cuts across the three substantive themes identified by the programme but is most centrally focused on *Topic 4: Integrated urban data management* and *Topic 3* which embraces *Urban public administration and services innovation* which we take to include transport and **M**obility **a**s **a** **S**ervice (MaaS). Mobility also reflects issues in *Topic 2* with respect to freight, waste, and, of course, the notion of the low carbon future which we consider mega-city regions are more likely to embrace than smaller cities. In fact, it is already clear that bigger

cities tend to be greener than smaller ones while their transport systems are likely to be much less dependent on individual usage of fossil fuels as in cities which contain vast swathes of suburbia. Such greenhouse gas impacts also provide a link to *Topic 1* on climate change. Our focus is the fundamental to the innovation and implementation spectrum in so far as it can be construed as a spectrum across the board, from theory to practice but applied research defines our set of tasks best. In fact, in our field, theoretical research is closely tied to practical applications and we do not distinguish one from the other, on the presumption as Kurt Lewin, the eminent psychologist said many years, ago that: " … there is nothing so practical as a good theory".

5.3 Results from other projects

See Table 5.1 below

Table 5.1: Existing results and deliverables obtained from publicly funded projects which provide the basis of or feed into the proposed project

Funding provider	Project number	Title	Description of results already obtained and relevant deliverables (verifiable results / products of R&D work) in terms of the basis for / differentiation from the proposed project	Location and type of documentation (e.g. link to homepage, publication, conference proceedings, interim report, final report, …)
European Research Council ERC-2009-AdG	249393	MECHANICITY Morphology, Energy and Climate Change in the City 2010-2016	The project endeavoured to answer the most fundamental questions of how urban morphology is affected by the energy and income of their populations. The project extended theories of urban morphology based on fractals, scaling and allometry to incorporate energetics in analogy to transport and network processes and linked these to statistical thermodynamics in spatial interaction and location modelling where energy, entropy, and accessibility are central. The urban theories and applicable computation models generated from this project is fundemental to the proposal and will be adapted to the Greater Bay Area mega-city region.	https://erc.europa.eu/projects-figures/erc-funded-projects/results?search_api_views_fulltext=&page=64&items_per_page=20&f%5B0%5D=funding_scheme%3AAdvanced%20Grant%20%28AdG%29 Final Reporting: https://cordis.europa.eu/project/rcn/94571_en.html Key Publication: Batty, M. (2013) **The New Science of Cities** (The MIT Press, Cambridge, MA)

FAPESP-ESRC-NWO-Joint Call	ES/N011449/1	RESOLUTION: REsilient Systems fOr Land Use TransportatION Award Reference 2015-2018	This project explored the impact of transportation on social segregation in São Paulo and London, comparable world cities in terms of their population, area and density at both municipal and metropolitan levels. These two cities provided us with examples of segregation enabling us to use the findings in one city to 'probe' the other; The project was built on the extensive experience in these systems acquired by CASA (see www.maptube.org; www.datashine.org.uk), transferring these ideas to São Paulo, building on their own systems (www.fflch.usp.br/centrodametropole/en/). The data systems, urban indicators and simulation models we built offer prospects for practical testing of alternative transport scenarios on new spatial structure devised by urban policy makers.	https://app.researchfish.com/awards/viewdetails/0?gorderby=organisation&filter=ESRC-ES/N011449/1 Key Publication: Barros, J., & Feitosa, F. F. (2018). Uneven geographies: Exploring the sensitivity of spatial indices of residential segregation. **Environment and Planning B: Urban Analytics and City Science**, 2399808318760572.
NSFC	41371377	Social network spatiotemporal data model and hot events evolution analysis	This project developed a unified spatiotemporal framework to represent, analyse and mine social network topology and dynamic event information on the social network, for example, Weibo and QQ. This project, therefore, demonstrated a way of supporting decision-making by understanding SNS users' responses and assessing the impact of online events. This framework can be used as a basis for the proposed urban analytical platform. The big volumes of urban data collected during this project will be re-used for the proposed platform.	http://spatial.szu.edu.cn/projects_details?id=21 Key Publication: Tu W., Cao R., Yue Y., Zhou B.D, Li Q.P., Li Q.Q. (2018) Spatial variations in urban public ridership derived from GPS trajectories and smart card data. **Journal of Transport Geography**, **69**, 45-57.
NWO-VERDUS/URD	438-11-014	Analysing and Exploring Sustainable Urban Strategies	This project provided new insights in urban development processes and the changing role of spatial planning in the Netherlands. These insights were combined in a new urban development model that was developed in cooperation with the Netherlands Environmental Assessment Agency PBL. The model is applied to simulate potential	http://urd.verdus.nl/aesus https://spinlab.vu.nl/research/spatial-analysis-modelling/spatial-planning/sustainable-urban-development/

		(AESUS: 2012-2014)	future developments and evaluate possible impacts of alternative development strategies.	Key Publication: Koomen, E. and Borsboom-van Beurden, J. (Editors) **Land-Use Modelling in Planning Practice**, Springer, Berlin
Central Policy Unit, HKSAR Government	S2017.A8.007.17S Strategic Public Policy Research (SPPR) Funding Scheme	In Search of New Economic Cooperation Models Between Hong Kong and the Big Bay Area (2018-21)	There is an urgent need to search for a new economic development model for the PRD as well as a new cooperation model between Hong Kong and the PRD. The study will identify opportunities and barriers of economic development and cooperation so as to formulate public policies and regional development plans to foster such new synergies between Hong Kong and the PRD in this new Chinese and global economic environment.	http://www.pico.gov.hk/en/research_report/report1718.html Key Publication Chen, Z., and Yeh, A. G. O. (2018) Accessibility Inequality and Income Disparity in Urban China: **Annals of American Association of Geographers**,

6. Key activities (work programme)

i) The overall strategy

The overall strategy for the work plan is based on five workpackages (WPs) shown in the figure below. The lead partners in Europe and China (UCL and SZU) will be responsible for WP1 – project management which encompasses project coordination, scientific coordination and dissemination.

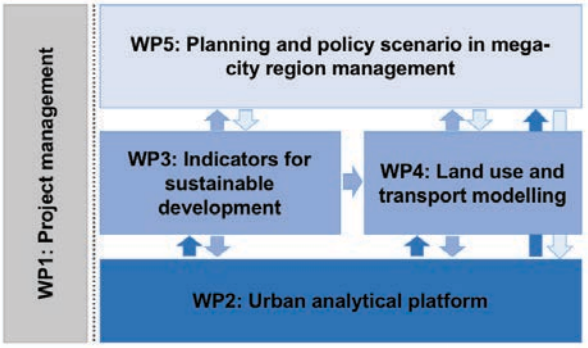


Figure 1. Overall structure of work plan

Research activities will be carried out in the four WPs (2-5) which **balance the leadership and encourage maximum interactions and collaboration between partners.** The leadership of each WP is based on the expertise and strength of individual partners which is further detailed in sections 11.2 and 11.3. The relationships between the WPs are noted below:

- WP2 will be led by SZU – the lead partner in China. The urban analytical platform serves as a technical foundation for the entire project. Based on this platform, innovative data processing methods will be developed for **cross-border, cross-sector and multi-source mega-city region data**. Processed datasets will be used in WP3, 4, and 5. At different stages of the project, analytical methods and models developed in other WPs will be integrated to the platform
- WP3 will be led by UCL – the lead partner in the UK, with tasks carried out by KCL and BBK. This package will develop **indices for evaluating different aspects of social inclusion and inequality**. Innovations will be made to new spatial analytical methods using emerging human mobility datasets. The indices will be integrated into WP4 urban models and applied in scenarios defined in WP5
- WP4 will be led by VUA – the EU partner from the Netherlands. The package will develop advanced **urban (LUTI) simulation models**. A methodological innovation is to advance the state-of-the-art urban models by adding socioeconomic indicators developed in WP3 and to include new data sets which are organized and managed using the platform developed in WP2
- WP5 will be led by SYSU. **Three planning and policy scenarios** will be defined and implemented addressing most critical issues **in mega-city region management,** namely, **cross-border flows, the spatial mismatch of jobs-housing,** and **the locational choice of urban regeneration sites** using indicators and models developed in WP3 and WP4.

In addition, the consortium will intensely interact with local stakeholders, sharing insights on planning strategy and policy implications, in return, closing the loops from feedback between them.

ii) The timing of the different WPs and their components) **Q – Quarter – three months, the project last for 36 months – 12 Quarters**

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	leading partner
WP1 Project management													**UCL, SZU**
1.1 Projection coordination													**UCL, SZU**
1.2 scientific coordination													**UCL, SZU**
1.3 Dissemination and exploitation													**UCL, SZU**
WP2 Urban analytical platform													**SZU**
2.1 Urban platform implementation													SZU
2.2 Participatory sensing data collection													SZU
2.3 Multi-source data fusion and inferring													HKU-SIRI
2.4 Interactive data visualization													SZU
WP3 Indicators for sustainable development													**UCL**
3.1 Indicators of spatio-social segregation													KCL
3.2 Indicators for mobility patterns													KCL
3.3 Indicators for social inequality													BBK
3.4 Comparative analysis of spatial inequality													BBK
WP4 Land use and transport modelling													**VUA**
4.1 Model development													VUA, HKU-SIRI
4.2 Incorporating socio-economic dynamics													VUA
4.3 Scenario simulation implementation													VUA
WP5 Planning and policy scenarios and governance													**SYSU**
5.1 Planning and policy comparison and scenarios													SYSU
5.2 Participatory urban planning and policy formulation													SYSU
5.3 New model of megacity region governance													HKU-SIRI

iii) Provide a detailed work description broken down into work packages:

- *Work package list (please use table 6.1)*
- *Deliverables list (please use table 6.2)*
- *List of milestones (please use table 6.3)*
- *Description of each work package (please use table 6.4, max. 1 page per work package)*

Table 6.1: Work package list

Work package No	Work package title	Lead project partner No	Lead project partner short name	Person-months	Start month	End month
WP1	Project management	1	CASA	13	1	36
WP2	Urban analytical platform	5	SZU	51	1	36
WP3	Indicators for sustainable development	1	CASA	40	7	30
WP4	Land use and transport modelling	4	VUA	43	1	36
WP5	Planning, policy scenarios and governance	7	SYSU	45	1	36
			TOTAL	192		

Table 6.2: Deliverables List

Del. no.	Deliverable name	WP no.	Delivery date
D1.1.	Consortium agreement	1	M0
D1.2.	Project report to ESRC	1	M36
D1.3.	Project annual report to NSFC	1	M12,M24,M36
D1.4.	Project report to NWO	1	M36
D2.1.	Urban Big Data Platform Demo	2	M8
D2.2.	Participatory Sensing Data Collection Component	2	M12
D2.3	Multi-source Urban Big Data Fusion Component	2	M24
D2.4	Initial Indicators and Model Integration with D2.1-D2.3	2	M24

D2.5	Urban Big Data Visualization Results	2	M36
D2.6	Final Integration of Sustainability Indictors in LUTI Models Embedded in the Urban Platform	2	M36
D2.7	Scenarios Tests for the Bay Area Using Platform	2	M36
D3.1.	Paper summarising the definitions, equations, and potential applied application.	3	M24
D3.2.	Open source code for indicator computing in Python to the published online and to be integrated in WP1.	3	M24
D3.3.	Paper on detecting mobility patterns using merging human mobility data.	3	M24
D3.4.	Report on a comparative study of urban inequality in three mega-city regions.	3	M30
D4.1	Initial model version simulating urban land-use change	4	M12
D4.2	Second model version including spatial distribution residents and employment density	4	M24
D4.3	Socio-economic dynamics module	4	M30
D4.4	Maps depicting basic socio-economic scenarios	4	M16
D4.5	Maps depicting policy alternatives	4	M30
D4.6	Paper describing recent land-use dynamics in the Greater Bay area and projected future changes	4	M16
D4.7	Paper describing modelling framework to simulate density changes	4	M28
D4.8	Paper describing simulation of socio-economic dynamics in in the Greater Bay area	4	M36
D5.1	Paper on planning and policy scenarios and comparison	5	M18
D5.2	Paper on dynamic system framework of sustainable development indicators for urban planning and policy formulation	5	M24
D5.3	Paper on new model of mega-city region governance	5	M30

Table 6.3: List of milestones

Milestone number	Milestone name	Work package(s) involved	Expected date

M1.1	Consortium agreement signed	WP1	M0
M1.2	Interim project workshop in China	WP1	M12
M1.3	Project workshop in the Netherlands	WP1	M24
M1.4	Final Project workshop in the UK	WP1	M36
M2.1	First version of urban analytical platform prototype is complete	WP2	M8
M2.3	Urban analytical platform for the Bay Area is complete	WP2	M36
M3.1	Open source code for economic-social indicators is complete	WP3	M24
M3.2	Comparative analysis of social inequality is completed	WP3	M30
M4.1	Initial simulation model is complete	WP4	M12
M4.2	Second model version is complete	WP4	M24
M4.3	Urban model applications for the Great Bay Area	WP4	M30
M5.1	Definition of planning and policy scenarios and comparison is complete	WP5	M18
M5.2	Urban planning and policy scenarios is complete	WP5	M24
M5.3	The new model of mega-city region governance is complete	WP5	M30

iv) Describe any significant risks, and associated contingency plans

There are two key risks that we might face: first involving the data sources that pertain to the entire mega-city region, and second the problems of coordination between the partners where software and ideas have to be pooled and discussed in tandem. First then, because such city regions are composed of many municipalities, there is no guarantee that we will be able to acquire uniform and comprehensive data sets for layers across all places that compose the Greater Bay Area in this case. Some data sets will certainly not be comprehensive and in such case we will focus on specific sample areas of the mega-city region where such data does exist. We believe the generality of the theories and models we propose are sufficiently robust to be applicable across the region. Nevertheless, to avoid problems, we need to select our sample areas carefully. Second, the pooling of ideas, tools and software will inevitably pose problems of coordination. But in computational modelling, there are no agreed standards world wide for data or software and in this sense, it is very hard to compare models and/or data in one region with another. However, we will make an effort to standardise where we can because ultimately we want this to be a project that produces theory and applications and tools for the planning of mega-city in general, globally.

Table 6.4: Work package description

Work package number	1	**Start date or starting event:**		M1		
Work package title	**Project management**					
Project partner number	1	2	3	4	5	6	7
Project partner short name	UCL	BBK	KCL	VUA	SZU	HKU-SIRI-SIRI	SYSU
Person-months per applicant:	**3**	1	1	3	**3**	1	1

Objectives. The aim of this WP is to manage the project to successful completion and to achieve its objectives, within the agreed schedule and budget, and with results that meet pre-agreed high-quality standards. Specific objectives include establishing and monitoring procedures for overall project coordination and innovation management. This WP will ensure the close coordination and cooperation of all partners.

Description of work

Task 1.1. Project coordination (UCL & SZU, other partners**)**

This task is responsible for the overall project coordination and decision-making. CASA as the main applicant will take the overall lead and the lead on the EU side. SZU will act as the leader on the China side. The task is to manage the relationship among partners in the consortium; and to monitor, organise, report research and disseminate activities during the project. The lead partner will manage the consortium agreement, which includes a consensus on **data management and IPR**. The lead and co-leader will also take responsibility for organising annually the project meeting and workshops in the UK and China.

Task 1.2 Scientific coordination (UCL & SZU, other partners**)**

This task is focussed on assessing the quality of scientific work in the project. It will manage and validate the overall project work plan, and it will help to solve issues arising in and between WPs. The coordinators will ensure high-quality deliverables of WPs, a smooth collaboration, and close interactions among partners.

Task 1.3 Dissemination and exploitation (UCL & SZU, other partners**)**

All partners will take part in disseminating the results of the project through relevant channels. This includes the academic community which we plan to reach primarily through publications in high-impact conferences, journals, and workshops. More important is to engage with local stakeholders, including urban planners, transport planners, policymakers, and public institutions, during the period of the project and beyond, by means of workshop, routine meetings, providing training and consultancy based on materials generated in the project. The project will enable stakeholders to be involved from its very inception so that maximum impact of the project can be achieved and useful feedback on research outputs gained.

Deliverables (brief description and month of delivery)

D1.1. Consortium agreement before the start of the project (M 0)

D1.2. Project report to ESRC (M36)

D1.3. Annual project report to NSFC (M12, M24, M36)

D1.4. Project report to NWO (M36)

Work package number	2	Start date or starting event:		M1			
Work package title	**Urban big data integration and the analytical platform**						
Project partner number	1	2	3	4	5	6	7
Project partner short name	UCL	BBK	KCL	VUA	SZU	HKU-SIRI	SYSU
Person-months per applicant:	1	1	1	4	**30**	9	5

Objectives. This WP aims to develop an urban big data platform that integrates the capabilities of multi-source data processing and interactive visualisation. The data challenges (i.e. data scarcity, data in low resolution) often encountered in large scale urban analysis will be tackled in this package. This platform will build on most advanced big data techniques but go beyond the state of the art data sharing platform, by integrating indicators (from WP3), models (WP4) and scenarios (WP5) as key decision-support tools.

Description of work

Task 2.1 Urban big data platform implementation. (SZU)

The Urban Big Data Platform integrates several urban datasets, services and applications into a single solution. This platform consists of big data models, storage, servers, databases, indices, management, and other big data pre-processing utilities. The platform is supported by distributed computing services including Hadoop, MapReduce, cloud computing platforms, and commercial computing services.

Task 2.2 Participatory sensing data collection. (SZU, SYSU**)**

This task aims to use the power of the crowd to collect urban dig datasets that are too vast, heterogeneous, and/or expensive to be collected by other types of sensors. It includes developments in crowdsourcing data (e.g. social media data, mobile phone data) collection technologies and components including distributed urban data crowdsourcing, heterogeneous data cleaning, and crowdsourcing data quality evaluations.

Task 2.3 Multi-source urban big data fusion. (SZU, HKU-SIRI, UCL, KCL, BBK**)**

This task is to prepare data for scenario simulation in WPs 4 & 5 and comparative analysis in WP3. The challenges here are to infer transport data (i.e. O-D matrices) and population data (e.g. distribution of home and work locations) at fine spatio-temporal scale, in particular, for the Greater Bay Area. The team will develop urban computing methods for human activity recognition, spatial distribution pattern mining, and transportation network analysis, built on the progress made in several relevant projects across the entire consortium. Particular attention will be paid to data variability across different municipalities in the Bay Area.

Task 2.4 Interactive data visualization (SZU, HKU-SIRI, UCL, VUA, SYSU**):** This task aims to provide essential access for users to comprehend urban big data and to gain insights which are crucial for decision makers, politicians, as well as for the general informed public. This task includes a variety of data visualizations including spatial distributions of sustainable indicators, the processes of land use-transportation-individual simulation, and the results of urban plan and policy scenarios.

Deliverables: D2.1 Urban big data platform demo (M8); **D2.2** Participatory sensing data collection component (M12); **D2.3** Multi-Source Urban Big Data Fusion Component (M24); **D2.4** Initial indicators and model integration with D3.1-d3.2 (M24); **D2.5** Urban Big Data Visualization Results (M36); **D 2.6** Final Integration of Sustainability Indictors in LUTI Models Embedded in the Urban Platform (M36); **D2.7** Scenarios Tests for the Bay Area Using Platform (M36)

Work package number	3	Start date or starting event:				M7
Work package title	**Indicators for sustainable mega-city region development**					
Project partner number	1	2	3	4	5	6	7
Project partner short name	UCL	BBK	KCL	VUA	SZU	HKU-SIRI	SYSU
Person-months per applicant:	**1**	**10**	**10**	4	3	6	6

Objectives This WP will develop sustainable development indicators, with a strong focus on measuring spatial and social inequalities. This WP will build on state-of-the-art indicators developed by partners in previous projects (in particular CASA-BBK-KCL's **RESOLUTION** project) and further develop them into combined indices of inequality for mega-city regions. This WP will also operate as a comparative study across regions (Greater Bay Area, London and Randstad regions) and test the robustness of the concepts and measurements of inequality across different cultural and planning contexts as well as how these indicators relate to the various urban simulation models.

Description of work

T3.1. Indicators of spatio-social segregation (KCL, BBK, SZU**):**

Exploratory analysis of inequalities will be carried out to classify social groups, Spatial segregation levels will be measured for different groups and their spatial patterns analysed using multiscalar spatial indices. Those indices will be combined with traditional inequality indicators, e.g. Gini coefficients, and crossed-over with indicators for mobility and relocation., developed in T3.2 as part of T3.3.

T3.2. Indicators for measuring mobility and relocation patterns (KCL, SZU, SYSU**):**

This task will apply multi-level spatiotemporal analysis to understand the dynamics of movement in the Bay Area. For short-term mobility, we will look at daily travel patterns at the individual level and collective mobility patterns which display urban spatial structure. A particular focus will be on inter-city trips. For long-term migration and relocation, data mining building on state-of-the-art work associated with the existing work of the partners will be developed for emerging mobility data,

T3.3. Indicators for measuring social inequality (BBK, KCL, UCL, VUA**):** Combining results from T3.1 – most influential attributes for social segregation, and T3.2 – mobility and relocation patterns, this task will measure the spatial and social inequality with access to opportunities, especially, transport-related e.g. housing, jobs, and basic services. Advanced accessibility indices developed in RESOLUTION will be adapted.

T3.4. Comparative analysis of inequality on 3 mega-city regions (BBK, UCL, KCL, SYSU, HKU-SIRI**)**

This task develops a comparative analysis of inequality across the three mega-city regions based on the results obtained by the application of the above-mentioned indicators for the three case studies within the context of existing policies and development strategies in the three mega-city regions. The objective of the analysis is to grasp the impact of different types of planning strategies at mega-city scale.

Deliverables: D3.1. Paper summarising the definitions, equations, and potential applied application (M24); **D3.2.** Source code for indicators calculated in Python to be published online and to be integrated in WP4 (M24); **D3.3.** Paper on detecting mobility patterns using merged human mobility data (M24); **D3.4.** Paper on a comparative study of urban inequality in the three mega-city regions (M30).

Work package number	4	Start date or starting event:		M1			
Work package title	Land use and transport modelling						
Project partner number	1	2	3	4	5	6	7
Project partner short name	UCL	BBK	KCL	VUA	SZU	HKU-SIRI	SYSU
Person-months per applicant:	0	2	1	**20**	6	10	4

Objectives Building on recent experience with of state-of-the-art land-use models applied in the Dutch planning context, this WP develops an advanced urban model that addresses contemporary planning issues: urban extension-densification; spatial distribution of residents-employment; and inclusiveness and equity issues.

Description of work

T4.1 Model development (VUA, HKU-SIRI): The initial version of the model will focus on understanding and simulating dynamics in urban extension and densification, addressing the land-use implications of socio-economic and demographic scenarios in relation to (changes in) accessibility and spatial planning alternatives. A second version will incorporate a density module that addresses local dynamics in residents and employees. This module will apply a utility-based framework to estimate the local costs and benefits of locating in specific sites under the overall constraints of regional demands for housing and employment. This model development work builds on recent advances progressed by VU in cooperation with others from European Commission-Joint Research Centre. In this WP, the issue of market forces in western mega-cities and in China will be addressed particularly with respect to residential location and housing.

T4.2 Incorporating socio-economic dynamics (VUA, BBK, KCL**)**: Future socio-economic dynamics (e.g. geo-demography, inequity) will be simulated by the model using a novel module that incorporates indicators developed in WP2 and links these to the simulation of population dynamics pursued in Task 4.1. Together with London group, the VUA PhD student will develop a spatial simulation approach that combines the current spatial distribution of demographic and socio-economic groups, expected changes in their location preferences, the competition for space between these groups and government interventions in relation to, for example, changes in the transport infrastructure. This novel simulation approach will allow the answering of questions such as: which groups are likely to be displaced as a result of urbanisation processes.

4.3 Scenario simulation (VUA, SZU, SYSU, BBK**)**: Together with other partners, socio-economic scenarios and planning alternatives will be designed to sketch possible future developments (WP4) using data processed in WP1. The VU-PhD will implement these simulation alternatives in the urban model. Two sets of simulation results are foreseen: socio-economic scenarios and implications of transport and housing policies.

Deliverables: D4.1 Initial model version simulating urban land-use change (M12); **D4.2** Second model version including density of residents and employment (M24); **D4.3** Socio-economic dynamics module (M30); **D4.4** Maps depicting basic socio-economic scenarios (M16); **D4.5** Maps depicting policy alternatives (M30); **D4.6** Paper describing recent land-use dynamics in the Great Bay Area and projected future changes (M16); **D4.7** Paper describing modelling framework to simulate density changes (M28); **D4.8** paper describing simulation of socio-economic dynamics in the Greater Bay Area (M36)

Work package number	5	Start date or starting event:				M1	
Work package title	**Planning and policy scenarios and new model of governance in megacity region**						
Project partner number	1	2	3	4	5	6	7
Project partner short name	UCL	BBK	KCL	VUA	SZU	HKU-SIRI	SYSU
Person-months per applicant:	1	1	2	5	6	10	**20**

Objectives This aim of this WP is to compare urban planning strategies and policy making process in the three megacity regions, along with measured indicators from WP3, to define scenarios to be simulated using models from WP4. Engaging with stakeholders will be a crucial task in this WP to maximize the impact of the proposed research in real-world practice. Ultimately, the aim of this WP is to formulate a new model of multi-stakeholder participatory governance for mega-city regions.

Description of work

T5.1 Planning and policy comparison and scenarios (SYSU, HKU-SIRI, KCL, BBK, VUA, UCL**):** The task will first conduct a comparative study on urban planning strategies and policy making process in three megacity regions. The goal of the comparison is to evaluate different types of policies with respect to social segregation, daily mobility, relocation, and spatial inequalities. Secondly, combining the results from WP3, scenarios around spatial mismatch of jobs-housing, cross-border flows, and urban regeneration will be defined in respect to the correlated planning ad policy strategies, mechanism and expected results. The defined scenario will then be implemented using the models developed in WP4 with data from WP2.

T5.2 Multi-stakeholders' participatory urban planning and policy formulation (SYSU, HKU-SIRI**):** The scenario simulation and the analysis of results will be carried out in an iterative mode collecting several rounds of feedbacks from stakeholders. This task will further analyse the main tasks and barriers of sustainable development in megacity regions. A dynamic system framework considering both bottom-up factors of individual and companies' preferences in housing, transport, etc. and top-down factors such as governments' regulations of land use control and environmental protection will be setup. Based on these, essential planning strategies in both short and long term will be provided concerning cross-border traffic planning, industrial and residential configuration and the locational choices of urban regeneration sites.

T5.3 New model of megacity region governance (HKU-SIRI, SYSU**,** SZU**):** This task will formulate a new model of multi-stakeholder's participatory governance based on the lessons learned in Task 5.2. This new model is essential to this project, because it establishes a way of governance that engaging public, private and third sectors via big data approach and direct dialogues. The planning and policy would then be optimized considering multi-stakeholders' opinions. To be specific, the task will come out with specific measures, such as encouraging information sharing, building up incentive mechanisms, updating volunteered geographic information and applying these to planning practice using the platform in WP2.

Deliverables: **D5.1** Paper on planning and policy scenarios and comparison (M18)**; D5.2** Paper on dynamic system framework of sustainable development indicators for urban planning and policy formulation (M24); **D5.3** Paper on new model of mega-city region governance (M30)

7. Ethical and regulatory considerations

The project will use secondary data from public and private agency sources while ensuring that this data is appropriately anonymized: for example, taxi data, social media and related sources are controlled by the providers and thus the team will not have access to any individual profile data from which the secondary data is aggregated. Thus there are no direct ethical considerations with respect to the collection and compilation of data on populations in the Greater Bay Area as individual questionnaires will not be administered in compiling any of this data. However, in terms of the dissemination of the data platform and the simulation tools, various stakeholders will be involved and in this sense, there will be discussions concerning the applicability of the data and modelling platform for generating and testing urban development scenarios in the region. This will involve some crowdsourcing in that stakeholders will be invited to respond to various interfaces and the suitability of different tools but these discussions will be administered in a way that does not elicit any confidential information relating to these individuals and the agencies that they represent. Finally, some of the data that will be collected is 'open' in the sense used in the UK & US – that is, openly made available under creative commons licenses or through the public domain and this does not involve any questions of confidentiality or privacy in that that data has already been organized so that public norms, standards and regulations will have been met.

8. Added value of international co-operation

Each of the seven partners have worked on urban data, the construction and applications of new tools for planning, namely simulation models and scenario generators, and have strong track records in developing world class research and applications in the domain of urban data management and applied urban policy making. The impact of their work is indicated below in the scope of their published work as measured by their impact factors. What has barely been attempted as yet is to develop comparative research which explores the differences and similarities between urban data in different cultural and economic contexts as well as ways of using these tools for the future planning of urban development in very different kinds of city.

The seven different partners have a wide range of projects which form the background to this proposal. SZU and SYSU have a strong tradition in modelling transport within the wider context of space-time modelling and both have worked on phone call data, social media, and RFID card data. Expertise in big data is key to their work on the proposed data modelling platform. The London group led by CASA with key input from KCL and Birkbeck College has a long tradition of land use transport (LUTI) modelling and this is reflected in their science of cities work has been recently funded by a European Research Council AdG. Their work on real-time transport models complements the SZU and SYSU work. The work from HKU-SIRI in Shenzhen has been involved with new methods of GIS and also real-time streamed data focused on transport while their work on cellular automata modelling of the entire Pearl River Delta is part of a long tradition with this kind of modelling beginning in the early 1990s. VUA has been at the forefront of linking LUTI to environmental models, exploring the impact of low carbon futures.

The only comparable work in urban simulation so far has been in Europe, Australia and the United States in the International Study Group on Land Use Transportation Interaction (ISGLUTI) which was accomplished in the 1980s. It was followed by the SPARTACUS and PROPOLIS projects which compared urban simulations tools for different European cities but there has been nothing that compares western with east Asian cities. Our proposal would be one of the first of its kind in taking tools developed from Western Europe and blending these with those from China, thus enabling the best of both worlds to be captured. In particular, new kinds of analysis are already emerging from big data in Chinese cities which are leading to new models that have relevance to other parts of the world, particularly western European and American mega-city regions.

Besides this comparative work which in and of itself is both new and innovative, the focus of the project is on the largest urban agglomerations in the form of mega-city regions which will constitute the cutting edge of urbanization during the rest of this century. The three cities chosen represent a fusion of large and small cities in what has been called for over a century megalopolis. The fusion and continuing growth of our three cities poses important challenges for developing new ways for their understanding and planning and the tools that we are already bringing to bear on these cities need to be extended and compared. In this sense, the project will take state-of-the-art models from London, Randstad and the Greater Bay Area and fashion these so that they are integrated within the data platform that will be built in Shenzhen.

This will provide a unique collaboration that is only possible now because of the longevity of our working relationships which have matured to the point where we can attempt this. Batty and Yeh have worked together for many years (Batty, M., Yeh, A.G.O, Guest Editorial: The Promise of Expert Systems for Urban Planning, **Computers, Environments and Urban Systems**, **15**, 101-108, 1991). Our links with Shenzhen and SYSU have developed more recently through the project with Chen Zhong noted below in her bio, and there are important longer term links with Wuhan through GI science and geomatics linking London and the Netherlands. The three partners in central London – UCL, KCL, and BBK – are all colleges of the University of London and located within the extended Bloomsbury campus. The links between VUA, BBK and UCL have been in place since the late 1980s. Last but not least, the various researchers in the wider team all publish in similar journals and are well aware of each others expertise and focus and this bodes well for this collaboration.

One of the key elements to the project will be the development of big data and associated urban simulation models of location and traffic for the planning of mega-city regions and the expertise of the wider group will synthesize high-frequency, massive, and complex types of big data which require the support of key technologies such as visual analysis, data mining, and simulation and prediction. The team members are highly interdisciplinary with their focus on urban planning, geography and computer science making them highly complementary. The project has the potential to break through the limitations of the application of big data analysis making full use of big data for urban modelling, urban environmental perception, facility evaluation, and data visualization. Finally, the implementation of the project will enhance academic exchange which is already in motion.

9. Relevance – Contribution of the project to the goals of the call

To address sustainable urbanization in mega-city regions, systematic and formal tools are required to support the transition to such the kind of sustainable future that meets the range of sustainable development goals (SDGs) that have been widely agreed by various international forums. We consider that our grouping of European and Chinese partners is one that can deliver these tools and demonstrate how that can be used in many European and Chinese cities. The comparative analysis we are proposing takes key ideas about how to understand and address key problems in mega-city regions in the UK, the Netherlands (Randstad) and China, fashion a platform that synthesizes these tools for supporting forecasting and planning using the example of the Greater Bay Area and produces a platform that is applicable to many other cities which are growing rapidly to mega-city status. Our demonstrator is thus a kind of template for developing powerful tools to explore the problems of a much wider range of cities than the ones that we have chosen as exemplars. In this was we will build capacity in Europe and China.

In one sense, what we are suggesting is that our collaboration will establish a roadmap for the future planning of mega-city regions not only in Europe and China but globally. As we have been at pains to point out in this proposal, we are quite selective in the urban problems of mega-city regions that we will address: namely focusing on the planning of services and their implementation that focus on sustainable

housing, transportation and basic retail and governmental services, embracing an inclusive and integrated policies for moving towards sustainable cities with very large and varied populations. In this sense, our focus is on *Topic 3: Urban public administration and services innovation* through the development of *Topic 4: Integrated urban data management* which will provide the data and tools strong and robust enough to deal with the problems of mobility, income and social inequalities and accessibility that we see as central to a feasible planning support. The platform will operate in real time, embracing continually changing data requirements and sources, much of which will be big data from remote and personal sensors, built on the basis of less frequently collected data from conventional census sources.

In terms of innovation, the call asks for ways of integrating 'models and planning approaches to tackle disparities in and between cities and urban areas' and we consider that the approach we advocate is the only one that can achieve this kind of integrated thinking. Our platform which is extensible to many sectors of the city system and is able to embrace different geographical representations of the many administrative divisions in mega-city regions is an effective way of addressing the sustainable development goals associated with mega-city regions during an era when it is essential to enable not only administrations to coordinate but also the tools and methods that we use for designing the future to be integrated in a seamless manner.

10. Impact of the project

10.1 Expected impacts

Our project is firmly embedded in the various governments that comprise the Greater Bay Area where SYSU, SZU and HK-SIRI have long standing links to agencies including Urban Planning Land & Resource Commission of Shenzhen Municipality, Housing and Construction Bureau of Shenzhen Municipality, Transport Commission of Shenzhen Municipality, Guangzhou Land Resources and Planning Commission, Guangzhou City Planning Kance Design & Research Institute that have responsibility for future urban development in the region. The urban data platform will comprise the core set of tools that will be used to generate a series of planning scenarios that will be defined with respect to these agencies once the platform has been constructed. These agencies will advise on the extent to which various sustainable development goals might be achieved in the region and identify the problems of making this happen. Although the European partners do not have detailed knowledge of the Bay Area agencies, they do have their own experiences in relating this kind of data and simulation work to key issues of climate change. Batty has been involved in the Tyndall Centre for Climate Change *Cities Project* which was an integrated assessment of the impact of sea level rise in the London region using various models while Koomen ran the AESUS project examining similar issues in the Netherlands. (Batty was an advisor to this project: see below section 11). At the time of writing Yeh has been awarded a grant by the HK SAR to research "Economic development between Hong-Kong and the Big Bay Area" which will be key to enabling the whole region to aim towards greater economic and social sustainability.

We consider the various web sites and online tools as well as access to online data that the urban platform will develop to be strong outlets for integrating this research with local stakeholders and for communicating the results of the project to a range of stakeholders from working scientists involved on other aspects of the region's development to political decision-makers as well as to an informed public. The deployment of the platform will be paralleled by various research into the most appropriate ways of engaging citizen participation and the delivery of related services. In this sense we consider that this research will have a major impact on the planning of the entire region.

We also consider that publicizing our tools beyond the domain of planning and the public sector is important. Many of the tools we are developing are relevant to private concerns involving transport,

housing, land development and land regulation as well as waste, water and related physical-natural elements of the built environment. We will take very opportunity to progress these ideas across all sectors and we consider such extensions to be key elements in any future development of this project, after the funding for which we are now seeking, ends.

Last but not least as we have indicated, the applicability of our platform goes well beyond the Greater Bay Area because we envisage it having relevance to many world mega-city regions, in other parts of Europe and Asia Pacific as well as the Americas and Australasia. We are conscious that although the tools we proposed have relevance to mega-city regions in the Global South, the platform would require adaptations if it were to be applied to mega-city regions in less developing countries

10.2 Dissemination and/or exploitation of project results, and management of intellectual property

The immediate impact of our work will be achieved through publications. The usual outlets in terms of books and learned journals will be used (as reflecting the track records of the investigators shown in section 11). Our researchers publish in high impact journals with an eye to citation as this is the way the field has and will continue to develop. Our web presence and the various meetings with stakeholders involving data acquisition, the use of online and desktop models and related tools, as well as the construction of scenarios will all impress the impact of this work on the wider world outside of academia.

The group is versed in using social media and web news to get its message across; for example, the UCL-KCL-BBK Resolution project noted below has used BBC media to publicize the research (see Barros, J., Batty, M. (2016) (with Joana Barros) Acessível para quem? Como o transporte divide ricos e pobres na cidade brasileira, Especial para a BBC Brasil, http://www.bbc.com/portuguese/brasil-37572962); what is equivalent to BBC is CCTV media in China, the Chinese partner SYSU has been interviewed for their relevant research on policy and regulations for bike sharing schemes (see interviews on http://tv.cctv.com/2017/06/05/VIDEbW8m7gPMNzPOctPQa69G170605.shtml) The usual presentation of material at national and international conferences will form a key component of the dissemination.

Many PIs and Co-I on the consortium are acting as advisors for local government and provide consultancy and training service to the government, which will be an important and effective channel for disseminating impacts to policy makers. For instance, Li from SZU is deputy to the National People's Congress. Yeh from HKU-SIRI has been a member of Transport Advisory Committee, Town Planning Appeal Board. Zhou from SYSY has been advisory consultant on major administrative decision-making committee Guangdong Province.

In terms of IPR, all rights to software pertaining to the tools developed will be vested in the developers on behalf of the institutions represented. We will follow normal practice defined by the institutions (RO) to which the researchers belong to. The tools will be made available to the stakeholders involved in their development as will be the data. Local licenses and practices pertaining to proprietary and open data will be observed.

11. Project consortium and management, multi-actor and trans-disciplinary collaboration, co-creation

11.1 Management structure and procedures

The organization of the project with respect to management is complicated in that we have expertise in seven different partnerships that will be coordinated through the four substantive workpackages. Our collaboration however is based on long term relationships between the partners. The Centre for Advanced Spatial Analysis (CASA) at UCL is heavily linked with KCL and Birkbeck in that the two CoIs – Zhong and Barros – developed their research there with Batty and have been heavily involved in the ESRC Resolution project which deals with simulating segregation and accessibility in London and Sao Paulo. The UCL-KCL-Birkbeck grouping is thus an extension of CASA, and the three colleges are part of the University of London system. UCL and Birkbeck also have strong links with VUA in terms of land use transport modelling with Batty acting as adviser to Koomen's AESUS project which focussed on integrating LUTI type models with other decision support for urban planning in the Netherlands. Batty has good links with HKU-SIRI and SYSU going back to the 1980s through the network established by Yeh. More recently strong links have been forged with SZU by Batty and Zhong and there are indirect links with Wuhan University with respect to their common interests in GI science. These links also pertain to joint research in mobility between SYSU, SZU and HKU-SIRI.

In essence, the project takes our individual and collective experiences with different styles of modelling, and different varieties of data (from conventional to 'big') developed in London, Amsterdam, Hong Kong in Shenzhen, Guangzhou and Shenzhen itself, and integrates these through a platform for urban analytics that will fuse spatial models with geographic data. This will require very close management where the post-doctoral research fellows who will be based in these four locations will require tight coordination in terms of the timing of different stages of the project. Although we will build the platform and demonstrate this for the Greater Bay Area, our experience with applying similar models to metropolitan London and the Randstad, particularly with respect to model coupling and integration, is essential to the success of the demonstrator. As part of the generic context of this project, comparative analysis of how these models work on the different urban forms of the three mega-city regions raises issues relating to how they need to be tuned to local contexts and thus part of the project will be focused on comparative issues between mega-city regions in Europe and in South East China.

Substantial cooperation between the partners will be required necessitating a strict timetable of visits between the Bay Area and London-Amsterdam, as well as structuring our work flows so that we can share data, codes and of course key ideas. These will be coordinated with various conferences in the two regions and specific project meetings timed to meet the sequence of milestones and deliverables indicated in a previous section.

We consider that the number of partners, their diverse but closely linked expertise in new information technologies, big data, urban simulation and planning support systems, and their geographical disposition are essential to researching the development of robust and applicable tools for the planning of mega-city regions across all scales.

11.2 Individual project partners

Partner 1: University College London (UCL)
Role in the project: Leading partner of the project, leading WP1&3, mainly participating in WP5

University College London is ranked in the top 5 universities in the UK and in the top 20 in the world. CASA is an interdisciplinary research centre within UCL, where expertise is drawn from architecture, cartography, computer science, environmental science, transport, geomatics, geography and planning. There is now a focus on complexity theory as the underlying logic to underpin much of the work on modelling and simulation. The most recent simulation research (http://quant.casa.ucl.ac.uk/) is related to the development of a land use transport model for England and Wales for exploring the impact of large infrastructure projects e.g. high-speed rail and residential development. CASA's mission to develop a science of cities was pump-primed by an ERC Advanced Grant Mechanicity, which developed many tools relevant to this proposal and many of CASAs researchers into the centre.

Professor Michael Batty (PI) is currently Bartlett Professor of Planning at University College London where he is Chair of the Centre for Advanced Spatial Analysis (CASA). He pioneered the development of land use transport interaction (LUTI) models in his early career as presented in his book **Urban Modelling: Algorithms Calibrations, Predictions** (CUP, 1976). He has also initiated the use of fractals in the study of urban form and function and this led to his work in cellular automata and agent based models, all of which are relevant to the simulations proposed in this project. His books **Cities and Complexity** (MIT Press, 2005) and **The New Science of Cities** (MIT Press, 2013) both won the Alonso Prize of the Regional Science Association in 2011 and in 2018. His most recent book **Inventing Future Cities** will be published by MIT Press in late 2018. His blogs www.complexcity.info cover the science underpinning the technology of cities and his posts and lectures on big data and smart cities are at www.spatialcomplexity.info. Prior to his current position, he was Professor of City Planning and Dean at the University of Wales at Cardiff and then Director of the National Center for Geographic Information and Analysis at the State University of New York at Buffalo. He is a Fellow of the British Academy (FBA) and the Royal Society (FRS), was awarded the CBE in the Queen's Birthday Honours in 2004 and the 2013 recipient of the Lauréat Prix International de Géographie Vautrin Lud. In 2015 he received the Gold Medal of the Royal Geographical Society. In 2016, he received the Senior Scholar Award of the Complex Systems Society and the Gold Medal of the Royal Town Planning Institute. **His H index is 88**.

Dr. Duncan Smith (CoI) is Lecturer in Urban Analytics at CASA. From 2014-2015, he was a Research Fellow on the ERC Advanced Grant MECHANICITY where he was researching various aspects of city performance in relation to city scale, dynamics and urban form. Before 2014, he was Urban Data & Visualisation Research Officer at LSE Cities in the London School of Economics. From 2010 during the final stages of his PhD, he was Research Associated in the EPSRC ARCADIA Adaptation and Resilience in Cities in CASA and from August 2009 until August 2010 he held the post of the Greater London Authority Economics Research Fellow at CASA. Examples of his work are viewable at his research blog https://citygeographics.org/. His research work uses detailed survey and census data to analyse and map how the changing economic geography of the global city-region London is having dramatic impacts on travel patterns and transport sustainability. **His H index is 10**.

Selected recent Publications: **Smith, D.A.** (2016) Online interactive thematic mapping: Applications and techniques for socio-economic research, **Computers, Environment and Urban Systems**, **57**, 106-117; Reades, J. and **Smith, D. A.** (2014). Mapping the 'Space of Flows': the geography of global business telecommunications and employment specialisation in the London Mega-City Region, **Regional Studies, 48**(1), 105-126; Jenkins, K., Hall, J., Glenis, V., Kilsby, C., McCarthy, M., Goodess, C., **Smith, D.** & Birkin, M. (2014) Probabilistic spatial risk assessment of heat impacts and adaptations for London, **Climatic Change**, **124**, 1-13;

Partner 2: Birkbeck University of London (BBK)

Role in the project: Leading tasks 3.3 and 3.4, mainly participating WP4 and WP5

Birkbeck, University of London is a world-class research and teaching institution, a vibrant centre of academic engagement and excellence and London's only specialist provider of evening higher education. Its Department of Geography offers a vibrant and supportive research environment with staff working across the breadth of the discipline, from areas of critical contemporary theory and policy including Cities, International Development, Culture, Identity and Inequality, to empirical, policy-relevant research in Climate and Environmental Change and Human-Environment Relations and Governance on timescales from the Quaternary to Futures, and Geo-analytics and Modelling. In terms of this project, its expertise in forging links with those outside the academy is central.

Dr Joana Barros (CoI) has been a lecturer at Birkbeck, University of London since 2005. Prior to that, she was a Postdoctoral Researcher at the Brazilian National Institute for Spatial Research (INPE), Brazil, and before that in the last year of her PhD study at UCL, she was a Research Assistant at the Centre for Advanced Spatial Analysis (CASA), University College London. Her areas of expertise lie in urban planning and modelling, more specifically agent-based and cellular automata models applied to urban systems and urbanisation in developing countries (with a focus on Latin America). Her research has focused on the dynamics of urban growth and inner-city transformation in Latin American cities, with emphasis on the socio-economic composition of the urban society in these countries and its impacts on urban space, and vice-versa. She has explored in depth urban morphology, spatial patterns, locational dynamics, transportation and social issues in these cities with a focus on computational models and quantitative techniques that support a better understanding of urban and environmental spatial processes. She brings expertise in segregation and inequalities in large cities to the project. As co-PI of the RESOLUTION project (Resilient Systems for Land Use and Transportation-- http://www.urbantransformations.ox.ac.uk/project/resolution-resilient-systems-for-land-use-transportation/), she developed partnerships with the University of São Paulo (USP), the Federal University of ABC (UFABC) and the Brazilian National Institute for Space Research (INPE), involving quantitative comparisons of spatial and social segregation with a strong focus on transport accessibility. Her past research projects include: SIMURBAN2 (Análisis y simulación prospectiva mediante TIG del crecimiento urbano actual), in partnership with the University of Alcalá, Spain; GEOMA (Development of Methods, Models and Geo-information for Environmental Management) at INPE, Brazil; and the ESRC NEXUS (Multi-Agent Approaches to Urban Development Dynamics) at CASA, UCL. **Her H index is 10.**

Selected Publications: **Barros, J.** and Feitosa, F. (2018) Uneven Geographies: Exploring the sensitivity of spatial indices of residential segregation. **Environment and Planning B: Urban Analytics and City Science**. DOI: 10.1177/2399808318760572; Barros, J. (2004) Simulating Urban Dynamics in Latin American Cities, in Atkinson, P. M., et al. (Eds) **Geodynamics**, CRC Press, New York; **Barros, J.** (2012) Exploring Urban Dynamics in Latin American cities using an agent-based simulation approach. In: **Agent-based Models of Geographical Systems**, Heppenstall, A. J., Crooks, A. T., See, L. M., Batty, M. (Eds) Springer, Heidelberg, DE; **Barros, J.** & Alves Jr., S. (2003), Simulating Rapid Urbanisation in Latin American Cities, in Longley, P. and Batty, M. (Eds) **Advanced Spatial Analysis**, ESRI Press, London; Barreira-González P. and **Barros J.** (2017) Configuring the neighbourhood effect in irregular cellular automata based models. **International Journal of Geographical Information Science, 31** (3) 617-636. doi: 10.1080/13658816.2016.1219035; Batty, M., **Barros, J.** & Alves Jr, S. (2006) Cities: continuity, transformation and emergence, in E. Garnsey and J. McGlade (Eds) **Complexity and Co-Evolution: Continuity and Change in Socio-Economic Systems**, Edward Elgar, Cheltenham, UK;

Partner 3: King's College London (KCL)

Role in the project: leading task 3.1 and 3.2. mainly participating WP2, WP5

King's College London (KCL) is a public research university located in London, UK. It is ranked as 7th in the UK and is 23rd in the world rankings. It has produced many important discoveries from the work of Maxwell in the 19th century to the development of DNA in the 1950s. It has an emerging thrust in urban informatics which the CoI is involved in, and is the London branch of the Centre for Urban Science and Progress (CUSP). She holds an academic position at the Department of Geography, working in the Geocomputation research domain. The Geography department produces world-leading and internationally excellent critical research in the geographical disciplines, research which both challenges and supports academic theory, public policy and social practice. The Geocomputation Research Domain, in particular, supports the development of a robust and replicable approach to analysis, one that builds on and improves existing computational methods and tools to investigate geographical patterns and underlying processes.

Dr Chen Zhong (CoI) is Lecturer in Spatial Analysis at the Department of Geography, KCL. Her doctorate was in spatial modelling and big data analysis for transit in Singapore where she worked in the ETH Zurich Future Cities Lab. Her research interests include spatial data mining, spatiotemporal visualization, complex network analysis, and the use of such analytical techniques for urban and transport planning. She is particularly interested in urban mobility analysis and modelling, looking into various urban contexts. She runs an ongoing collaborative project (No. K-17014-01) entitled "Evaluating urban plan implementation based on mobility data: a case study of Shenzhen" together with the Chinese leading partner – Shenzhen University, supported by the Institute for China Sustainable Urbanization, Tsinghua University open fund. The collaboration between KCL and SZU is built on a mature EU-China partnership that guarantees a stable consortium for the proposed project. Other related projects include her PhD research project on detecting functional urban changes from urban movement patterns in Singapore using emerging urban mobility datasets; postdoctoral research (at CASA UCL – the EU leading partner) on travel behaviour analysis and modelling using Oyster card data in London; and comparative studies of regularities in London and Beijing. She has been involved in a FAPASP-ESRC funded project – RESOLUTION: REsilient Systems fOr Land Use TransportatION (led by CASA UCL and BBK), originally as a researcher and later as an advisor after moving to KCL, particularly working on advanced accessibility and segregation measures. **Her H index is 10.**

Selected publications: Zhong, C., Luan, ZL., Tu, W., Shen, Y., Li, XM. (2017). **"**Profiling Rapid Urban Transformation through Urban Mobility Data in Shenzhen" **Seeing China's Transformations through Big Data: The Geography of Mobility, Wellbeing and Development**, Routledge. in review**. Zhong, C.,** Batty, M., Manley, E., Wang, J., Wang, Z., Chen, F., & Schmitt, G. (2016). Variability in Regularity: Mining Temporal Mobility Patterns in London, Singapore and Beijing Using Smart-Card Data. **Plos one, 11**(2), e0149222. Reades, J., **Zhong, C.,** Manley, E. D., Milton, R., & Batty, M. (2016). Finding Pearls in London's Oysters. **Built Environment, 42**(3), 365-381. **Zhong, C.,** Schläpfer, M., Arisona, S. M., Batty, M., Ratti, C., & Schmitt, G. (2015). Revealing Centrality in the Spatial Structure of Cities from Human Activity Patterns. **Urban Studies**, 0042098015601599.; Manley, E., **Zhong, C.,** & Batty, M. (2016). Spatiotemporal Variation in Travel Regularity through Transit User Profiling. **Transportation**, 1-30. doi: 10.1007/s11116-016-9747-x **Zhong, C.,** Arisona, S. M., Huang, X., Batty, M., & Schmitt, G. (2014). Detecting the Dynamics of Urban Structure through Spatial Network Analysis. **International Journal of Geographical Information Science***, 28*(11), 2178-2199.

Partner 4: School of Business and Economics, Vrije Universiteit Amsterdam (VUA)

Role in the project: Leading WP4, **mainly participating in WP2, WP5**

Vrije Universiteit Amsterdam (VUA) is an independent academic institution focused on high quality, fundamental, innovative and socially oriented education and research. Its Department of Spatial Economics is a world player in the domains of Spatial, Transport and Environmental Economics. Within the department, the SPINlab carries out research and education in the domains of geo-information science and spatial data management. The lab applies a wide range of spatial analysis methods and techniques in relation to many different scientific and societal topics. SPINlab carries out methodological and applied research in support of various societal challenges including the energy transition, sustainable urban management and climate adaptation.

Dr. Eric Koomen (CoI) is associate professor in the Department of Spatial Economics. His research interests include land-use change analysis, spatial modelling and policy support with a special focus on urban development processes, impact assessment, climate adaptation and policy evaluation. He has managed many research projects related to these topics in various countries around the world developing, for example land-use models to support spatial planning. Currently, he coordinates courses on 'Land-use change' and 'Imaging and assessing landscapes' at VUA and he is responsible for the 'Urban Environment Lab' at Amsterdam University College and 'GIS and Environmental Impact Assessment' in the UNIGIS MSc programme. He supervises BSc, MSc and PhD research, has edited and co-authored three books and published over 70 papers in scientific and applied journals and books. In his research and teaching, he focusses on the causes and consequences of urban development relying on data retrieved from novel data sources (LIDAR, luminosity, mobile phone data etc.), spatial analysis using GIS and econometric techniques and the application of advanced modelling tools to simulate future conditions. He is active in applying his knowledge in more practice oriented consultancy projects for regional authorities, national research institutes, the World Bank, Asian Development Bank, European Commission, and OECD. Application domains include simulating urban development scenarios, assessing impacts of such developments and analysing effects of spatial planning. **His H index is 27.**

Key publications: Engelfriet, L., **Koomen, E.** (2018) The impact of urban form on commuting in Chinese mega-city regions. **Transportation**. DOI: 10.1007/s11116-017-9762-6. (forthcoming); Zhou, T., **Koomen, E.,** Van Leeuwen, E. (2018) Residents' preferences for cultural services of the landscape along the urban–rural gradient. **Urban Forestry & Urban Greening 29**:131-141; **Koomen, E**., Diogo, V. (2017) Assessing potential future urban heat island patterns following climate scenarios, socio-economic developments and spatial planning strategies. **Mitigation and Adaptation Strategies for Global Change 22** (2): 287-306; Jacobs-Crisioni, C.G.W., **Koomen, E.** (2017) Population growth, accessibility spillovers and persistent borders: **Journal of Transport Geography 62**: 80-91; Broitman, D., **Koomen, E**. (2015) Residential density change: Densification and urban expansion. **Computers, Environment and Urban Systems 54**: 32-46; Jacobs-Crisioni, C.G.W., Rietveld, P., **Koomen, E**., Tranos, E. (2014) Evaluating the impact of land-use density and mix on spatiotemporal urban activity patterns: an exploratory study using mobile phone data. **Environment and Planning A 46** (11): 2769 – 2785; Batista e Silva, F., **Koomen, E.,** Diogo, V., Lavalle, C. (2014) Estimating demand for industrial and commercial land use given economic forecasts. **PLoS ONE 9** (3): e91991. DOI: 10.1371/journal.pone.0091991; **Koomen, E** and Borsboom-van Beurden, J. (2011) **Land-use modelling in planning practice**. GeoJournal Library Vol. 101, Springer, Dordrecht; Mubareka, S., **Koomen, E.,** Estreguil, C. and Lavalle, C. (2011) Development of a composite index of urban compactness for land use modelling applications. **Landscape & Urban Planning 103**: 303-17。

Partner 5: Shenzhen University (SZU: Key Laboratories: Spatial Smart Sensing and Services, Smart Cities, Geo-environment Monitoring)

Role in the project: Lead partner in China, leading WP1&2, mainly participating in WP 3 and 5

Shenzhen University (SZU) is a full-time comprehensive university, in line with the aim of China's Ministry of Education (MOE) to further develop the critical infrastructure in the Special Economic Zone of Shenzhen. Its laboratories, **the Shenzhen Key Laboratory of Spatial Smart Sensing and Services, the Research Institute of Smart Cities,** and **the Key Laboratory for Geo-environment Monitoring of Coastal Zone of the National Administration of Surveying**, Mapping and Geoinformation, contribute to the acquisition, management, analysis and application of geographic data in cities and costal zones. The team members from SZU have led many research projects, including the "973 Program" and the "863 Program" from the Ministry of Science and Technology (MST), scientific projects from NSFC, e.g. "Mining the Human Mobility Laws and Modelling Travel Dynamics Based on Heterogeneous Spatial-Temporal Big Data", "Social Network Spatiotemporal Data Models and Hot Events Evolution analysis", and "Data-driven Based Spatial Choice Behaviour Analysis". The laboratories are extremely well equipped with MODIS station, dual-band laser radar, UAV, computing clusters, and network systems. These systems generate multi-source geographical and human trace data covering the Guangzhou-Shenzhen-Hong Kong Bay Area, which includes mobile phone location data, Sina Weibo data, vehicle GPS trajectories, and smart card data. These are all central to the urban platform that SZU will build.

Prof. Qingquan Li (PI China) is the President of Shenzhen University. He is Eurasian Academician, and Chief Scientist of National Program on Key Basic Research Project of China (973 Program), Deputy Director for Faulty Geosciences and Environment Resources in the Science and Technology Commission of the MOE, and Founding Chairman of ACM SIGSPATIAL China Branch. He has long been engaged in teaching and research in GIS, urban informatics, intelligent transportation, and the integration of 3S technologies. He has hosted and completed more than 30 research projects, including the "863 Program", NSFC Key Program, and NSFC General Program. He is the Awardee of the 9th National Award for Youth in Science and Technology, the National Prize for Science and Technology Progress, the National Prize for Technological Invention, and the Science and Technology Progress Award of the Ministry of Education. Qingquan has edited and co-authored three books and published over 400 papers in scientific journals and books. His **H index is 46**.

Dr. Wei Tu is Senior Associate Research Fellow in Shenzhen University and a Visiting Scholar of Department of Urban Studies and Planning at MIT, working in the Senseable Cities Lab with Prof.Carlo Ratti. His main research interest focuses on the big urban data driven human behaviour and urban studies. He is the PI of several national science and technology programs. He has published more than 30 articles and his **H index is 8**. **Prof. Zhen Dong Huang** is a professor and certified urban planner with his **H index at 14**. He is the executive director of Research Institute for Smart Cities at Shenzhen University. He got the PhD from Utrecht University, The Netherlands. Dr. Huang was the PI of two National Natural Science Foundation of China (NSFC) projects and a national high-tech development (863) program. His major research areas include urban public transport, land use and transport integration, GIS for urban planning, and urban spatial analysis. **Prof. Yang Yue** is a Professor of Laboratory of Spatial Smart Sensing and Services, Shenzhen University. She obtained the Ph.D degree in urban planning and GIS from the University of Hong Kong, supervised by Prof.Yeh. She has hosted several national science and technology projects. Her research interests include urban big data management, data mining, and travel behavior analysis, etc**. Her H index is 13.**

Key publications: LI Q.Q (2017) From Geomatics to Urban Informatics. **Geomatics and Information Science of Wuhan University**, 42(1): 1-6; **Tu W**., Cao J Z, Yue Y, Shaw S L., Zhou M, Wang Z.S.,

Chang X M, Xu Y, **Li Q Q** (2017) Coupling mobile phone and social media data: a new approach to understanding urban functions and diurnal patterns. **International Journal of Geographical Information Science 31**(12), 2331-2358; **Tu W**, Cao R., Yue Y, Zhou B D, Li Q P, **Li Q.Q**. (2018) Spatial variations in urban public ridership derived from GPS trajectories and smart card data. **Journal of Transport Geography, 69**, 45-57; Tu W., Hu Z.W, Li L F., Cao J Z, Jiang J C, Li Q P., **Li Q Q**. (2018) Portraying Urban Functional Zones by Coupling Remote Sensing Imagery and Human Sensing Data **Remote Sensing. 10**(1), 141; **Yue Y**., Lan T., Yeh A.G.O., **Li Q.Q** (2014) Zooming into individuals to understand the collective: A review of trajectory-based travel behaviour studies. **Travel Behaviour and Society. 1**(2), 719-723; **Yue Y**, Zhuang Y., Yeh G. O. A (2016) Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. **International Journal of Geographical Information Science**. 31(4): 658-675. Zhou M., **Yue Y.**, **Li Q.Q**, Wang D.G. Portraying Temporal Dynamics of Urban Spatial Divisions with Mobile Phone Positioning Data: A Complex Network Approach (2016) **ISPRS International Journal of Geo-Information**, 5; Huang W., **Huang Z**, Lin M. (2017) A Decision Support System for Plant Optimization in Urban Areas with Diversified Solar Radiation. **Sustainability, 9**(2): 215; **Huang Z**, Liu X. (2014) A Hierarchical Approach to Optimizing Bus Stop Distribution in Large and Fast Developing Cities. **ISPRS International Journal of Geo-Information, 3**(2):554-564; **Huang Z**, Zhang M, Liu X. (2017) Estimating light-rail transit peak-hour boarding based on accessibility at station and route levels in Wuhan, China. **Transportation Planning & Technology**, 40.

Partner 6: Shenzhen Institute of Research and Innovation, The University of Hong Kong

Role in the project: leading task 5.3, mainly participating WP2

The University of Hong Kong Shenzhen Institute of Research and Innovation (HKU-SIRI) incorporated in March 2011 with the support of the Shenzhen Municipal Government, is an integral part and an extension into mainland China of research conducted by the University of Hong Kong (HKU), The Institute also plays an important role in transferring science and technology from HKU to the Mainland, China, especially in the Pearl River Delta area. It promotes hi-tech, knowledge transfer, industry incubation, the introduction of key laboratories and research centres, training of talent for interdisciplinary research, and focuses on strengthening the partnerships between HKU, Shenzhen, the Pearl River Delta and Chinese industry.

Anthony G.O. Yeh (CoI) is Chan To-Hann Professor in Urban Planning and Design and Chair Professor of Department of Urban Planning and Design and Director of GIS Research Centre. He is former Dean of Graduate School, Director of the Centre of Urban Studies and Urban Planning, Institute of Transport Studies, and Head of the Department of Urban Planning and Design at the University of Hong Kong. He is an Academician of the Chinese Academy of Sciences and of the Academy of Social Sciences in the UK, a Fellow of TWAS (The Academy of Sciences for the Developing World), the Hong Kong Institute of Planners, the Royal Town Planning Institute, the Planning Institute of Australia, the Royal Institution of Chartered Surveyors, and the Chartered Institute of Logistics and Transport. His main areas of specialisation are in urban development and planning in Hong Kong, China, and South East Asia and the applications of GIS as planning support systems. He received the UN-HABITAT Lecture Award in 2008 for his outstanding and sustained contribution to research, thinking and practice in the human settlements field and the 2012 Dr. Gill-Chin Lim Global Award in the 2012 Annual Conference of the Association of Collegiate Schools of Planning in recognition of his global commitment and leadership as a scholar and an educator in humanistic globalization. He is a recipient of HKU's Distinguished Research Achievement Award in 2016, the highest honour and award for excellence in research bestowed by HKU to one of its staff every two to four years. He has been Founding Secretary-General of the *Asian Planning Schools Assoc* and *Asia GIS Assoc*, Chairman of the *Hong Kong Geographical Association*, Vice President of the *Commonwealth Assoc of Planners*, and Chairman of the *Geographic Information Science Commission of the International Geographic Union (IGU)*. **His H index is 54. Xingjian Liu** is an Assistant Professor in the Department of Urban Planning and Design at the University of Hong Kong. His research uses new urban data and analytics to explore the association between urban form and city performance. He is an associate director of the Globalization and World Cities (GaWC) research network. Xingjian has received Regional Studies Association Early Career Researcher Award (2015), Royal Town Planning Institute Early Career Researcher Award (commended; 2017), Austrian Academy of Science Young GIS researcher award (2017), AAG-Regional Planning and Development Emerging Scholar Award (2014), and HKU Research Output Prize (2016). **His H index is 19.**

Selected key publications: Professor Yeh has published extensively on simulating development, transportation and economic activity in the Pearl River Delta. Recent publications include "Interjurisdictional Cooperation through Bargaining: The Case of the Guangzhou–Zhuhai Railway in the Pearl River Delta, China" (2013), **The China Quarterly, 213**, pp. 130-151. (Jiang Xu and **A.G.O.Yeh**); "A Commuting Spectrum Analysis of Jobs–housing Balance and Self-Containment of Employment with Mobile Phone Location Data" (2018) **Environment and Planning B: Urban Analytics and City Science**, **Vol. 45**(3) 434–451 (Joseph X.G. Zhou, A.G.O. Yeh, Weifeng Li and Yang Yue); "Accessibility Inequality and Income Disparity in Urban China: Case Study of Guangzhou" (forthcoming), **Annals of American Association of Geographers**, (Zifeng Chen, A.G.O. Yeh).

Partner 7: Sun Yat-sen University (SYSU)

Role in the project: Leading WP5, mainly participating in WP2, WP3

Sun Yat-sen University is a comprehensive multi-disciplinary university founded by Dr. Sun Yat-sen and with an educational tradition spanning over 90 years. It is a preeminent research, academic and cultural centre and the premier location for talent development in China. The School of Geography and Planning has been authorized as an International School by the Ministry of Education and by the State Bureau of Foreign Experts Affairs in 2015.The Guangdong Key Laboratory for Urbanization and Geo-simulation mainly focuses on urban geography, urban transportation, urban policy, geographic information system and their interdisciplinary application. The members of the laboratory have engaged in important research projects such as National Key Technology R&D Programs Subjects (863) "Spatiotemporal Process Simulation and Real-Time GIS" and "Urban Spatial Information Intelligent Processing and Analyzing System" Key Program, the Excellent Young Scientist Program and General Research Program of NSFC. The laboratory has already accumulated large volumes of urban data, which will support this project.

Suhong Zhou (CoI) is a professor the School of Geography and Planning at SYSU. She is Vice Director of Centre of Integrated Geographic Information Analysis, School of Geography and Planning, Sun Yat-sen University, and Former Vice Dean of School of Geography and Planning, Sun Yat-sen University. She is currently a member of the China Society for Urban Planning Council; vice chairman of the Big Data Specialized Committee, Urban China Research Council; executive member of Geography Society of Guangdong Province, China; expert in major administrative decision-making consultation in Guangdong Province, China. She is also editorial board member of the journal of **Tropical Geography** (Chinese). She was awarded "Youth Geographic Science and Technology Award" of China Geography Society, and the National Natural Science Foundation of China's Excellent Young Scientist Programme (of which only four people in the field of human geography in China have received the award). She has been engaged in interdisciplinary research focussed on spatial-temporal of daily activities, and urban policy and applied geographic information science. She is PI of four National Natural Science Foundation of China (NSFC) and more than 30 provincial and local research and consultation projects. She has published 2 books and more than 150 academic papers. She has also applied for four national invention patents and three software copyrights. She also guided students to participate in the national competition winning more than 10 awards. **Her H index is 18.** Others members on the project include Prof Qiuping Li, Wen Ping, Liao Liao, Prof Yutian Liang and Dr. Zhong Zheng.

Key publications: Zhao, P., Kwan, M. P., & **Zhou, S**. *(2018). The uncertain geographic context problem in the analysis of the relationships between obesity and the built environment in Guangzhou. **International Journal of Environmental Research and Public Health, 15**(2), 308; Zheng, Z., & **Zhou, S**.* (2017). Scaling laws of spatial visitation frequency: applications for trip frequency prediction. **Computers Environment & Urban Systems, 64**, 332-343; Nong Y., **Zhou S.*,** Liu L., Li Q., Peng Y., Hao X. (2017). Structural cities: Delimiting commercial centre boundaries and their hierarchical characteristics in urban China based on taxis' GPS trajectory data. **Journal of Planning Education and Research,** DOI: 10.1177/0739456X17741964; **Zhou, S.*,** Liu, Y., & Kwan, M. P. (2016). Spatial mismatch in post-reform urban china: a case study of a relocated state-owned enterprise in Guangzhou. **Habitat International, 58**, 1-11; **Zhou, S.*,** Xie, M., & Kwan, M. P. (2015). Ageing in place and ageing with migration in the transitional context of urban china: a case study of ageing communities in Guangzhou. **Habitat International, 49**(15), 177-186; Li, Q., Tu, W., & Zhuo, L. (2018). Reliable rescue routing optimization for urban emergency logistics under travel time uncertainty. **International Journal of Geo-Information, 7**(3), 77; Zheng, Z., Rasouli, S., & Timmermans, H. (2016). Two‐regime Pattern in Human Mobility: Evidence from GPS Taxi Trajectory Data. **Geographical Analysis, 48**(2),157-175.

11.3 Consortium as a whole

The consortium of seven partners includes the disciplines that determine systematic research and applications into the building of land use and transport models and the measurement of economic and social segregation and inequalities, namely urban studies and geographic information science, geomatic engineering, spatial economics (primarily at VUA), planning, transportation and computer science. These are all essential to the project and there is critical mass in Europe (London and Amsterdam) and in the Greater Bay Area to make the project workable. The seven partners have several colleagues (indicated above) trained in cognate areas such as physics and mathematics as well as mainstream economics, geography and planning who have informally agreed to be involved in supporting the project in diverse ways. The project is based on four well-founded scientific laboratories – UCL-KCL-BBK, SZU with HKU-SIRI, SYSU and VUA – which provides this critical mass.

With so many partners which we argue is essential to mirror the requisite variety needed to deal with mega-city regions, there is a danger of the project becoming imbalanced and divergent but this is avoided by our focus on SZU where the platform will be built and where we will establish the collaborative context to be explored and utilised. SYSU and HKU-ISIS will feed into SZU while VUA and UCL are already cooperating and both will link strongly with SZU where all the expertise will come together. The resources in the Bay Area are greater than in Europe and thus the focus on this location makes sense.

Although the three mega-city locations are somewhat different with the Randstad being about half the size of the London region which is about half the size of the Bay Area (10m<20m<40m pop), when one looks at the even wider regions, they become more comparable. For example, the urban Netherlands merges directly into urban Belgium and northern-eastern France while the hinterland of London for many years has embraced Birmingham and the Midlands as well as the near north-west based on Manchester and Liverpool. Our models have been developed for these wider constellations and we feel that the kind of comparability we seek is quite well established through this choice of cities. We cannot build the platform for all three cities separately but as we intend the Greater Bay Area project to be demonstrator for other mega-city regions, we consider this choice to be optimal. Moreover, the key problems in these cities are similar – mobility, public transit, housing inequalities and increasingly social and economic polarisation.

The philosophy of the project team and the individual research units is pluralistic in that none of us believe that one single approach can ever be taken to problems as complex as those facing a mega-city region. Different models need to be considered and this is inevitable. Although the seven partners are working with fairly similar data and simulations, there are both local and cultural differences that determine how different tools and methods can be used in different places by different groups. This we are well aware and will provide an important basis for our comparative development of models in the Bay Area. We ascribe to the notion that this kind of scientific knowledge is social constructed and that we are the agents involved in this construction as indeed is the wider context in which this takes place.

Last but not least our demonstrator is designed to interface with stakeholders who we see as being local and regional government in its widest sense. We will liaise as we are already doing with various stakeholders where the Shenzhen context is important to the initial development of the platform. We believe that the transfer of these kinds of tools to policy and practice is much, much wider than a project like this and enormous resources are required for this. However, we will design the platform from scratch with stakeholders in mind ranging from data providers to policy analysts. In a project such as this, where we are producing a demonstrator that is applicable to mega-city regions more generally, we need to be very clear about the kinds of stakeholders involved and we thus intend to develop the platform for a standard set of stakeholders and problems that are generic to the mega-city region. In this sense, we

will circumscribe the project in such a way to make our methods applicable to cities wider than those that provide our case studies here.

12. Data management

*A. What data sets of **long-term value** do you expect that the project will produce? "Long-term" means those data sets that, over time, will or may be of value to others within your research community and/or the wider research and innovation community. Data of long-term value should meet the FAIR principles; i.e. they should be findable, accessible, interoperable and reusable.*

New data sets will be produced from processing, aggregating and fusing existing datasets. The long-term value of the generated datasets relate to the following uses: (1) as sample data for demonstrating the usage of the indicators and simulation models developed in the project. (2) in relation to new indicators or tools developed in the future, the data sets can be used for benchmarking to compare the performance of the mega-city region with respect to future scenarios (3) for future comparative studies in the three-mega-city regions associated with consortium agreement (4) made available for other researchers working on similar problems in the Greater Bay Area, subject to appropriate licensing agreements

The consortium will follow a global policy of Open Research Data for most datasets, workloads, experiments, benchmarks, and results generated during this project. Therefore, the long-term value is not limited to researchers within the consortium but to the broader research community pursuing mobility and inequality related work.

*B. How do you intend to **manage these data** during the life of the project to ensure their long-term value is protected? For example, where will the data be held during the project, who will have access, and will a specialised data manager be part of the project team?*

The consortium has agreed a preliminary, simple but efficient management structure. Regarding data management, during the period of the project, data from three regions will be hosted and managed by partners located in the specific region (e.g. London team will manage the data in the UK, the Dutch team in the Netherlands, the Shenzhen team the data in the Greater Bay Area and so on). Nevertheless, access to the data will be granted to all members of the consortium. We will use various open source depositories to share data and code such as Github and related web storage sites.

A PI/Co-I from each party will take the role of data manager (Provisionally Dr. Tu Wei from SZU for China partners, Dr. Eric Koomen from VUA for the Netherlands and Dr. Chen Zhong from KCL for UK partners). A detailed agreement will be discussed and defined by these data managers; in particular, for some confidential datasets from China with respect to the level of aggregation associated with the new generated data sets. Data will also be managed strictly so that it meets the regulations posed by hosting university e.g. University Records and Data Retention Schedule.

*C. How will the data be **managed after the end of the project** to ensure their long-term availability? For example, will the data be published with a Digital Object Identifier (DOI) and/or placed in a recognised long-term repository or data centre, and when will this take place?*

Data will be managed according to national and university regulations after the end of the project. For instance, UK data will be managed following guidance for data archiving and preservation that provide a list of specific categories of records and how long they should be retained. Research data for long-term value will be archived and made publicly available where appropriate. We will review the research data generated during the project and ensure it is 'cleaned' and well structured for use. Data will also be stored in the UK data service (ESDS), as per the terms of ESRC funding. We will also advertise most

publishable data on the project website. Similar arrangements will pertain to the Dutch and Chinese data archiving.

D. *What **supporting documentation and other information** do you plan to make available to support this longer-term re-use of the data by others?*

Supporting documents such as metadata (in the form of readme text files) and the relevant documents including research papers and manuals for using data to compute urban indicators and simulation models (in PDF) will be produced. These will detail the meaning of the data and how to use it, as required by data archiving rules, for instance, in the UK, regulations posed by ESDS, that facilitate their use by other researchers.

E. Do you *envisage there being any **restrictions** on how the data can be accessed or reused? JPI Urban Europe's policy is that the data should be as open as possible, though with restricted or closed access/reuse where appropriate and necessary, for example if there are sensitive data involving human subjects, if the rules on protecting personal data are followed or if commercial or industrial exploitation is foreseen (e.g. patent application).*

No personal data will be used in the proposed research as we indicated in the section on ethical and regulatory considerations. The project does not envisage any such restrictions apart from one possible restriction posted on sharing confidential data from China; however, the final detail of data use and access will be addressed during the project, once the urban platform and its data is under construction.

F. *Will there be **other types of material** (e.g., samples, physical collections, software, curriculum materials) of long-term value produced? If so, what are your plans for ensuring these are also available for the long-term?*

*How have you accounted for the **costs** required to manage the data and other materials to ensure long-term availability? Please note that some funding agencies request applicants to include these costs in the budget request.*

Other types of materials include the urban platform itself, tools for urban indicator calculations, and the simulation models. The urban platform will be a web-based portal hosted in Shenzhen University in China that is publicly accessible. Tools for indicator calculations are open source and will be uploaded to Github. The relevant service is free. Simulation models need to be customised before they can be adapted to other cities and application and in this project we will indicate how this can be pursued. Manuals, in the form of research papers, will be provided and made open access. The project website will provide links to all these types of materials.

In addition, all consortium partners and the respective ROs have the required hardware and software resource, e.g. storage servers etc., to manage the data and the other materials. Therefore, there will be no costs incurred in managing the data and related materials.

13. Projected Costs (note: 1EUR=7.44RMB , 1GBP = 1.16 EUR)

Organisation	Country	Project type of partner contribution[4]	Costs (EUR; *including overhead costs according to the applicable funding agency's rules*) [5]						Cost share per partner (in %)	Total effort in person months per partner	Partner contribution in EUR	Requested funding in EUR	Funding rate requested (in %)
			Personnel	*R&D infra-structure use*	*Costs of materials*	*Third-party costs*	*Travel costs*	Total					
UCL	UK	A-F	101,071	0	580	0	5220	106,871	0.11	5.4~=6	21374	85497	80%
BBK	UK	A-F	148,943	0	3143	0	5800	157,886	0.16	14.7~=15	31577	126309	80%
KCL	UK	A-F	160,086	0	3143	0	5800	169,029	0.17	14.7~=15	33806	135223	80%
VUA	Netherlands	A-F	229,082	0	39,300	0	5,000	273,382	0.28	36	0	273382	100%
SZU	China	A-F	29570	26882	5376	13441	32258	107527	0.11	48	0	107527	100%
HKU-SIRI	China	A-F	34946	19489	0	6720	19489	80644	0.08	36	0	80644	100%
SYSU	China	A-F	27554	18817	0	7392	26882	80645	0.08	36	0	80645	100%
		TOTAL	**731252**	**65188**	**51542**	**27553**	**100449**	**975984**	**1**	**192**	**86757**	**889227**	

[4] I: Innovation / implementation; A: Applied research; F: Fundamental research; I-A: Innovation / implementation and applied research; I-A-F: Innovation / implementation, applied and fundamental research; I-F: Innovation / implementation and fundamental research; A-F: Applied and fundamental research

[5] For further information on the different cost categories see: → http://jpi-urbaneurope.eu/calls/sustainable-urbanisation-china-europe

14. Justification of resources

For ESRC – UCL – KCL – BBK: British universities cost their proposals with respect to indirectly incurred costs associated with investigators as a percentage of the full time equivalent (FTE) and directly incurred costs associated with PDRAs (Post Doctoral Research Assistants).

The **personnel cost:** The PI Batty is set at 7.5% FTE as are the three Co-Is Smith, Zhong and Barros at 7.5% FTE for 3 all years. Co-I Smith will be involved in visualization while Barros and Zhong will be involved in the development of indicators and data analytics respectively. Costs for directly incurred posts are for two full time one-year PDRAs to work on WP3. The first one-year post will be based at KCL and the second one-year post will be based at BBK. The PDRA will liaise frequently with researchers in CASA at UCL where there will be joint working. UCL-KCL-BBK are on the Bloomsbury campus in central London, all under the auspices of the University of London**. Travel costs** are required to facilitate exchange between London, the Greater Bay Area, and Randstad in the Netherlands. The planned travel includes trips to Shenzhen China for the project workshop budgeted at 2000 EUR/trip/person, trips to Amsterdam for project workshop at 500 EUR /trip/person, and 1 international conferences (e.g. CUPUM and AAG) budgeted at 2000EUR/trip/person and 2 domestic conferences budgeted at 1000EUR/trip/person. **Costs of materials** includes other directly incurred costs**.** A laptop as equipment is essential for the PDRA as this is an international collaborative project that s/he will be travelling between the countries. **Third party costs**: A two-day final project meeting will be held in London. Travel costs of international guests will be costed from partner's budget. The meeting will provide working lunches for 2 days budgeted at 17.5 EUR per person for 20 people from UCL Catering Menu. In total, 500 EUR is budgeted.

For NWO – VUA:

The **personnel costs** are comprised of a 3-year PhD-student (36 months full time) based on the prescribed NWO-salary table and include the standard bench fee for her or his travel costs.

Third party costs include: (1) network and consortium costs for organisation of a 2-day workshop in Amsterdam in 2020 (cost for venue, lunch and drinks for 20 participants for 2 days and dinner drinks for 1 day, total 1500 euro). For this workshop we will invite an external land-use modelling expert from the European Commission's Joint Research Centre to share experiences with a specific focus on the new global urban development model 2UP they are currently developing (budgeted at 800 euro).(2) Non-scientific personnel costs for PR work and setting up and maintaining a project website, writing blog texts and organising the 2-day workshop (budgeted at 6 days per year using the prescribed university salary table).(3) Other costs relate to the programming of the basis LUTI model for Shenzhen (20,000 euro) and updating it with additional features in the following two years (10,000 euro) by the Object Vision company.

Travel costs refer to those incurred by the VU-PI (Dr. Koomen) for travel to Shenzhen (1 week budgeted at 2000 euro), two international conferences (in 2020 and 2021, budgeted at 2400 euro) and final 2-day workshop in London (600 euro).

For NSFC – SZU – HKU-SIRI – SYSU:

The **personnel** cost in China does not include any overheads. That gives the Chinese partners more flexibility to arrange research staff on the project. Also because of different financial systems, none of the research staff are full time work for one project, therefore only part-time participating in the proposed project. The person-month in section 13 are therefore calculated as such:

SZU will have four academic staff members one the project including the PI- Li, Prof. Huang, Prof. Yue and Dr. Tu at 8.3%. Each will contribute 3 months on the project over three years. Tu will assistant the PI- LI for project management. All of them will responsible for supervising research staff. There will be one PDRA and two PhD students working as research staff on the project. Each of them will contribute 12 months on the project. In total, 29, 570 ERO are budgeted according to the salary scale in China. **SYSU** will have three academic staff involved in the project including the Co-I Prof. Zhou, Prof Li, and Prof. Liang, each contributing 3months on the project. Research staff include 1 18 months PDRA and 2 PhD students each contributing 6 months on the project. In total, 27,554 ERO are budgeted. **HKU-SIRI** has similar arrangement as that in SYSU, with total cost budgeted at 34,946 ERO.

R&D infrastructure use: including the purchase of 4 workstations and cloud service to store urban data, publish the scenario simulation service, support interactive visualization to the public.

Travel cost includes 15 domestic travels per year among partners which is quite reasonable as the three partners are in three different cities unlike the London team and there are many staff members involved in the project. International travels include 1 trip to London and 1 trip to Amsterdam for project workshop for leaders and main researchers. 19,489 ERO and 26,882 ERO were budgeted for HKU-SIRI and SYSU. SZU required slightly higher cost at 32,258 Euro because they act as project leader on China side and extra trips will be made.

Costs of materials includes the necessary printer, paper, and the associated design materials for the dissemination and the conclusion of this project.

Third-party costs include the subscription fee to the cooperated organizations public institutions and companies for necessary complimentary data API and expert consultancy service.

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