



DAFNI

Data & Analytics Facility for National Infrastructure



Science and
Technology
Facilities Council



UKCRICTM

UK COLLABORATORIUM
FOR RESEARCH ON
INFRASTRUCTURE & CITIES



Engineering and
Physical Sciences
Research Council



DAFNI

Data & Analytics Facility
for National Infrastructure

DAFNI Sandpits 2024

IMproving flood-disruPted road networks resilience with dynAmic people-Centric digital Twins (IMPACT)



Science and
Technology
Facilities Council



UKCRICTM

UK COLLABORATORIUM
FOR RESEARCH ON
INFRASTRUCTURE & CITIES



Engineering and
Physical Sciences
Research Council



DAFNI

Data & Analytics Facility
for National Infrastructure

Project Team

Role	Name	Organisation	Division or Department
PI	Qiuchen Lu	University College London	Bartlett School of Sustainable Construction
Co-I	Tao Cheng	University College London	Dept of Civil, Environ & Geomatic Eng
Named Researcher	Xuhui Lin	University College London	Bartlett School of Sustainable Construction
Named Researcher	Xianghui Zhang	University College London	Dept of Civil, Environ & Geomatic Eng
Team Member	Tohid Erfani	University College London	Dept of Civil, Environ & Geomatic Eng
Team Member	Trung Hieu Tran	Cranfield University	Centre of Design Engineering



Science and
Technology
Facilities Council



UKCRICTM

UK COLLABORATORIUM
FOR RESEARCH ON
INFRASTRUCTURE & CITIES



Engineering and
Physical Sciences
Research Council



DAFNI

Data & Analytics Facility
for National Infrastructure

Current Facts

- In the UK, escalating flood increasingly affect people and property, intensifying pressure on national road networks [1].
- The A303 has been closed for **days** after heavy rainfall-induced flooding since Storm Ciarán in November 2023.
- Approximately **6,600 kilometres** of UK roads are within regions prone to flooding, and this is anticipated to increase by up to 160% by the 2080s if adaptation measures are not implemented [2].

Traffic congestion is the most common risk to the road network, which is an important part of assessing road network service capacity and demonstrating road network resilience [3].



[1] Climate Change Committee (2021). Advice to Government for the UK's third Climate Change Risk Assessment. <https://www.theccc.org.uk/wp-content/uploads/2021/07/Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf> (Latest accessed 18/09/2023)

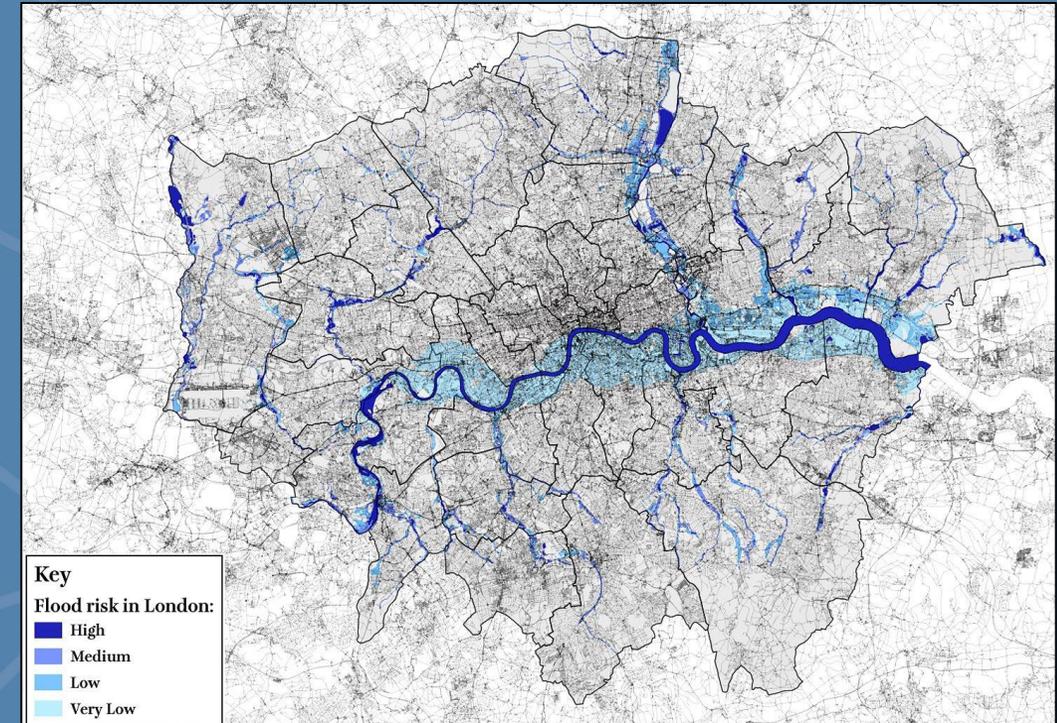
[2] Begum, S., Fisher, R. S., Ferranti, E. J., and Quinn, A. D. (2022). Evaluation of Climate Change Resilience of Urban Road Network Strategies. *Infrastructures*, 7(11), 146.

[3] Chen, H., Zhou, R., Chen, H., & Lau, A. (2022). A resilience-oriented evaluation and identification of critical thresholds for traffic congestion diffusion. *Physica A: Statistical Mechanics and its Applications*, 600, 127592.

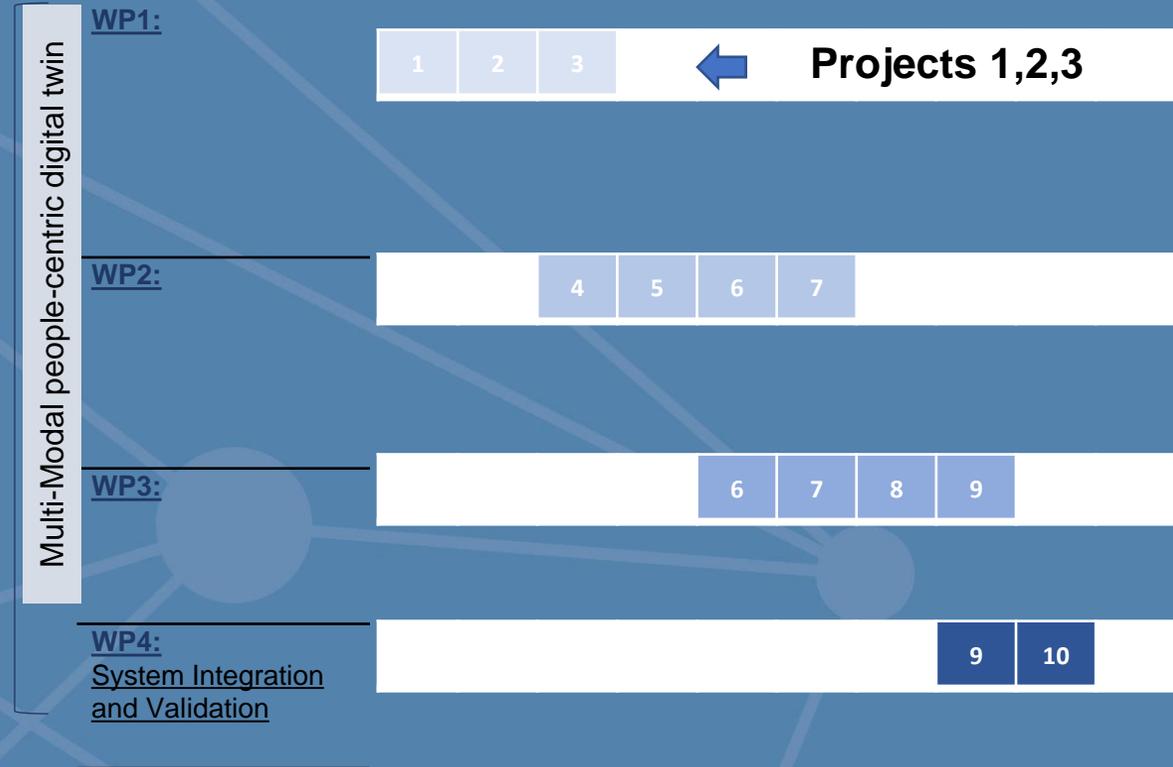
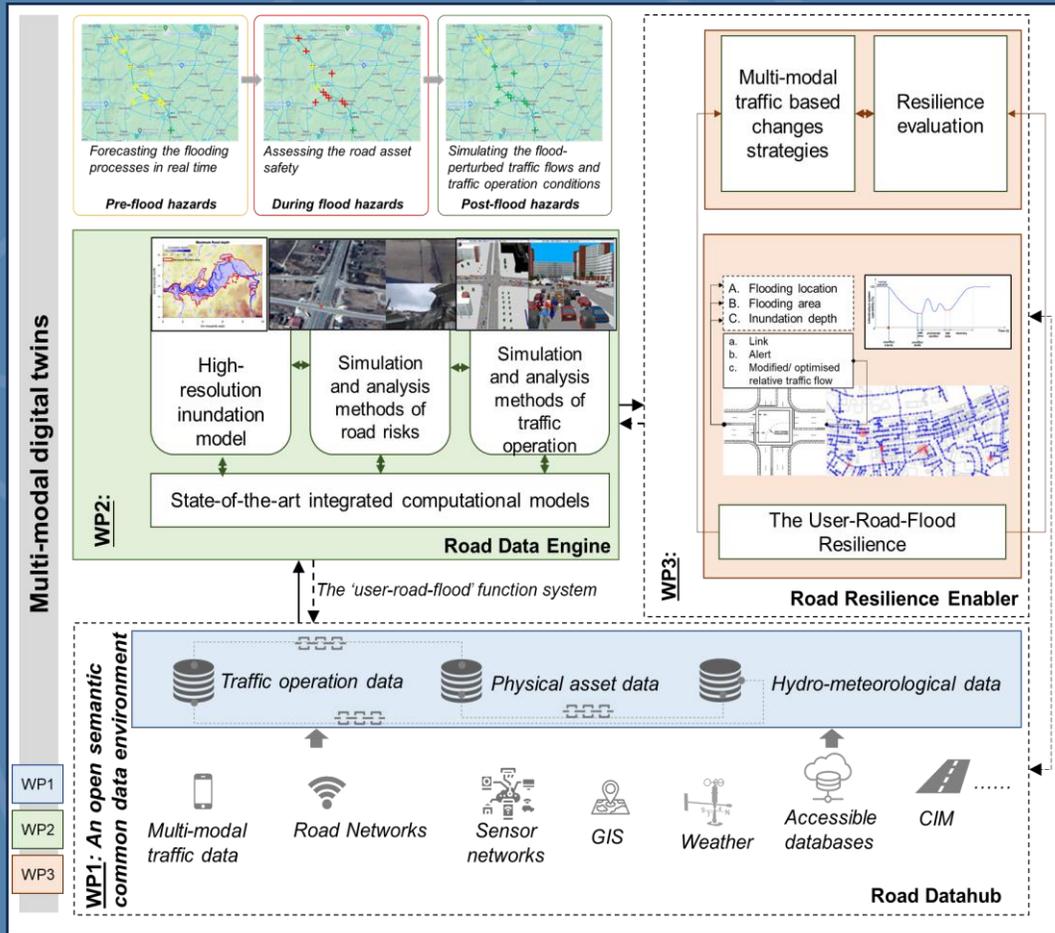
Research Challenge

This project will address three key challenges of UK road networks that will be:

- (1) Dynamic – Static:** sensitive to sudden changes in true conditions (assessing congestion risk in flood is however hindered by interaction complexity and dynamic nature of ‘user-road-flood’ cross-domain system);
- (2) Cross-domain Integration:** informative on flooding events (current approaches ignore the integrated flood-road-user characteristics);
- (3) Multimodal Nature:** capable of performing human-centric assessments and multimodal data sharing.



The goal is to assess and improve the resilience of road networks in fast-changing flood through the multimodal data – based **dynamic people-centric digital twin**.



Outputs on DAFNI and BSRW & DSIT aims

1. The dynamic people-centric digital twin; including three modules.

- (1) a web platform demonstrator based on DAFNI and (2) a trial platform with the London case study.

2. The novel 'user-road-flood' data-sharing strategies for multi-scale and multi-modal traffic data to meet the DSIT 'Challenges and solutions to data sharing' strategy.

- (1) large-scale multimodal datasets for the London area as a live implementation of DAFNI, (2) mechanisms and strategies for data querying, sharing and communicating.

Who can apply	What we're looking for	What We Will Fund	What we will not fund	How To Apply	Assessment Process
<p>A total fund of £240,000 is available across the two sandpit events. We are interested in proposals looking at Infrastructure Resilience in the following two areas, Transport and Energy.</p> <p>The DAFNI Programme and it's Centre of Excellence is seeking to support feasibility studies. We will fund projects which develop and explore scenarios in response to a particular short-term or long-term shock and develop appropriate solutions which demonstrate an aspect of resilience. Of particular interest are scenarios which can be transferred from one geographic region to another, can be scaled up to a national scale, or explore the interactions between different infrastructure systems and with environmental and societal features in a multidisciplinary approach.</p> <p>Projects should include how to access, use, and combine data and computational models to evaluate and measure the impact of shocks, and propose appropriate responses and adaptations to further resist, absorb and recover from the shock event.</p> <p>Here are some examples of areas we would seek to fund:</p> <p>Transport:</p> <ul style="list-style-type: none">• Modelling of transport systems to identify pinch points which cause transport systems failures and explore mitigation strategies.• Digital twin of a transport system or operational systems to consider impact of failures and potential approaches to mitigation.• Simulating the impact of natural and human derived shocks onto transport systems and explore adaptation and mitigation strategies					

• **Dynamic People-Centric** ← Challenge 1

• **'User-Road-Flood'** ← Challenge 2

• **Multimodal and Multi-resources Data** (bicycle, bus car on roads) ← Challenge 3

Accelerating and improving delivery of road enhancements
 ↓ Up to **33%** reduction in the cost of construction.

Reducing road **maintenance and construction** costs; Improving efficiency

Civil Infrastructure (Transportation)

Pre-emptive operations and automated incident detection and response
zero Injuries or deaths on the SRN by 2040.

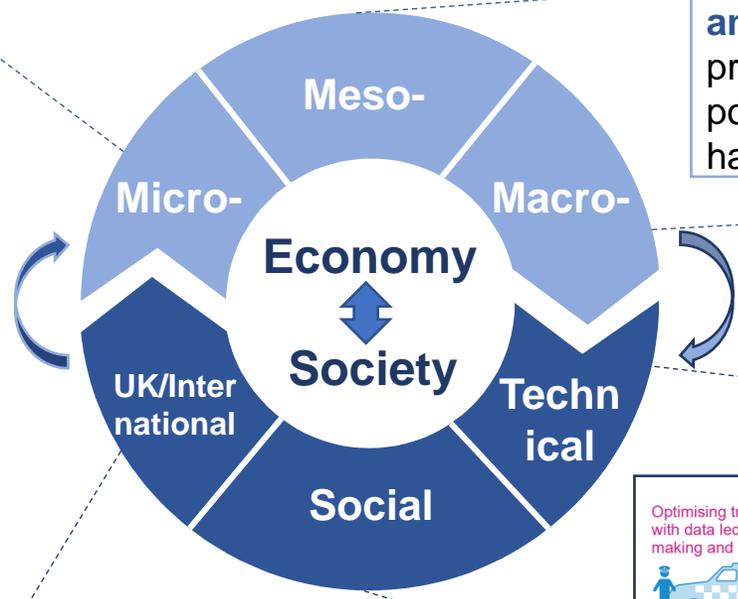
Minimising **rescue costs and hazards loss** by providing early alerts of potential destructive climate hazards

Surroundings/Built Environments

Growing the economy **£7bn** pa of benefits of the UK infrastructure sector from developing a National Digital Twin.

Bringing in **economic benefits** and **new markets** for the UK; Delivering the world leading road infrastructure

UK International



Increasing **public awareness** of climate changes; Creating the **policy/agreement** of climate changes in the built environments

UK International

Optimising traffic flow with data led decision making and automation
 ↓ Up to **10%** Potential reduction in traffic delays due to the benefits of full 5G connectivity.³

Ensuring **users' journeys** are predicable, reliable, safe, smoother and open-data; Saving **lives and costs** during environmental hazards

Society

Accurate and real-time information available to customers and seamlessly integrating with third party partners and wider transport network
 ↑ **40%** Improvement in customer satisfaction with the accuracy of the roadwork information between 2018 and 2019.³

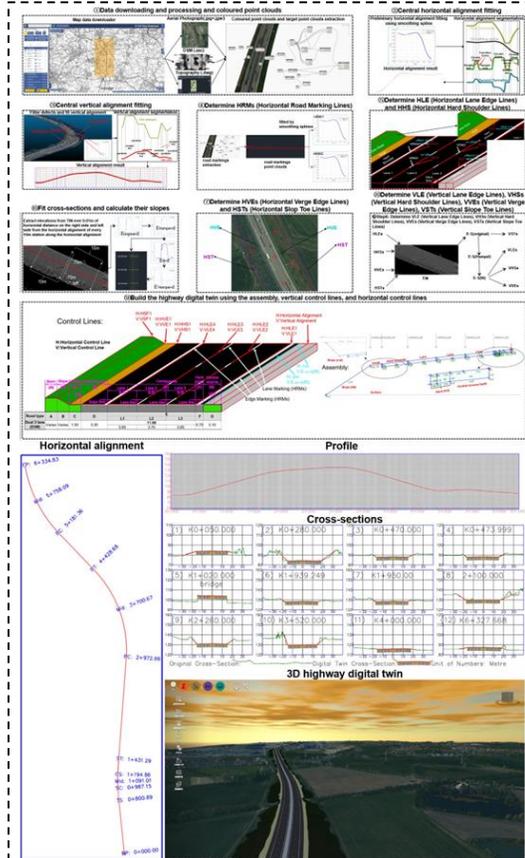
Increasing **employment rate** and opportunities; Achieving digital transformation and creating **new industries**

Technology

<https://nationalhighways.co.uk/media/2chotw13/introducing-digital-roads.pdf>
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/596812/climate-adrep-highways-england.pdf



Research Project Foundations



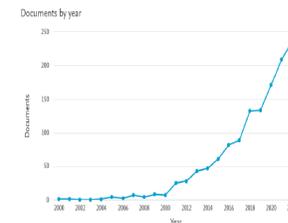
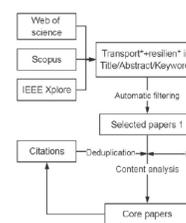
ICE R&D Enabling Fund, 'SeeCarbon: Revealing and Reducing Infrastructure's Carbon Footprint In A Digitally Open Socio-technical Way'

- Knowledge of road networks;
- Knowledge of human travel behaviours.

Data Resources

Sector	Name	Data format	Usage	
Basic Geometry	London Street Data	geojson, shp	base	
	London DEM Data	geoTiff, *	base	
Inundation	Flood Map	Dynamic	flood propagation	
		Static	flood propagation	
Residents	Land Use	geojson, shp	generate OD matrix	
	Age Structure	csv, *	generate trips	
	Education Level	csv, *	generate trips	
	Transportaion Mode	csv, *	generate trips	
Sector	Name	Data format	Usage	
Transportation	Public Transportation Data	station and link	geojson, shp, GTFS	generate trips
		timetable	csv, GTFS	generate trips
		dimension and seats	csv, GTFS	generate trips
	Traffic Flow	geojson, shp, csv*	validation	
	Traffic Status	geojson, shp, csv*	validation	
Management	Maintenance Process	*	generate plans	
	Maintenance Cost	*	generate plans	

Literature Review(1,294 results)



Preliminary Study



Science and Technology Facilities Council



UKCRIC™
UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES



Engineering and Physical Sciences Research Council



DAFNI

Data & Analytics Facility for National Infrastructure

Thank you so much and Q&A

Qiuchen LU MPhil Ph.D. MCIQB A.M.ASCE

Associate Professor in Digital Built Asset and Facility Management, The Bartlett School of Sustainable Construction, University College London, UK

Email: qiuchen.lu@ucl.ac.uk



Science and
Technology
Facilities Council



UKCRIC™

UK COLLABORATORIUM
FOR RESEARCH ON
INFRASTRUCTURE & CITIES



Engineering and
Physical Sciences
Research Council



DAFNI

Data & Analytics Facility
for National Infrastructure