UKCRIC

UK COLLABORATORIUM FOR RESEARCH ON INFRASTRUCTURE & CITIES

Building the future through collaborative innovation

Annual Report 2020-2021

Credit: Ryoji Iwata/Unsplash

UKCRIC

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Credit: Christian Wiediger/Unsplash

Who we are and what we do

UKCRIC was created in 2015 to design, lead and support the development and growth of a coordinated and coherent, world-class, UK-based national infrastructure and cities research community. With considerable support from EPSRC, UKCRIC has built a national network of facilities including research laboratories; urban observatories; and data analytics, simulation and visualisation capabilities (DAFNI).

UKCRIC provides the transdisciplinary, systems-based research for the transformation of infrastructure and urban systems, generating economic opportunities for the UK. We recognise that governments struggle to think about infrastructure in a joined-up way and we were founded to address the impacts that siloed thinking and planning can have on current and future infrastructure.

UKCRIC's integrated research capability underpins the renewal, sustainment and improvement of infrastructure and cities in the UK and elsewhere. By engaging government, industry, academia and end users, UKCRIC is de-risking, helping to prioritise, and providing evidence, analysis and innovation for future national infrastructure and urban investments to deliver a safer, more resilient and more sustainable future.

UKCRIC is working to benefit society by encouraging disparate areas of infrastructure to work collaboratively with each other; areas such as water, waste, transport, energy, and telecoms. We engage with stakeholders to better understand and address complex urban and infrastructure challenges through collaborative research, and we are always looking for opportunities to help improve situations.

As UKCRIC transitions into its operational phase, it remains committed to enabling a step change in the performance of the UK's cities and its infrastructure systems, creating generational impacts by planning toward realising the full potential of the original capital investment.

Foreword

Setting one's sights very high can be a risky business. It requires courage, determination, grit, and a great deal of gumption, and perhaps even a little hubris for rising above the inevitable hurdles. In this, its first phase, UKCRIC set its sights very high indeed. It comprises a once-in-a-generation investment in infrastructure research capability, necessary not only to fill the gap that had emerged in recent decades, but also to strengthen the nation's and indeed the world's capacity to face the challenges ahead.

Planning for, designing, constructing, operating, and decommissioning infrastructure is an increasingly complex undertaking. Appropriately, UKCRIC seeks to mirror and engage with that complexity through structuring itself around three distinct components: very large-scale physical facilities accompanied by cutting edge modelling capabilities in digital twins alongside real-world urban observatories, all spread across the length and breadth of the country's regions, cities, and universities.

The UKCRIC team are therefore to be heartily congratulated for having achieved a plethora of milestones this year across all three realms: the opening of three world-class facilities, the birth and success of DAFNI, and the proven success of the city observatories.

As Inaugural Chair of UKCRIC's International Advisory Board, it has been both a pleasure and a privilege to bring together some of the world's foremost infrastructure thinkers and practitioners to help guide this coming-into-being of an entity with great global potential. As I step down from this role, I want firstly to thank the UKCRIC leadership team for the opportunity to chair the Board, secondly to congratulate the entire UKCRIC team on what they have already achieved, and thirdly to wish the leadership team plenty more courage, grit, and gumption as they transition into UKCRIC's operational phase.

Cynthia Mitchell
Emeritus Distinguished Professor, Institute for Sustainable Futures,
(University of Technology Sydney, Australia)

A letter from the Convenor

For most of the period covered by this Review (September 2019 to March 2021), the world has been operating under severe restrictions on movement and activity. The Covid pandemic and its consequences have undoubtedly also impacted on UKCRIC.

September 2019 saw the opening of the National Research Facility for Infrastructure Sensing at Cambridge (by the then President of the Institution of Civil Engineers, Andrew Wyllie CBE) and the National Infrastructure Laboratory at Southampton (by the Chief Executive of Network Rail, Andrew Haines OBE). Edinburgh and Heriot Watt Universities formally joined UKCRIC as Partners in October, and the Urban Observatories were formally launched in November. Since the first lockdown, society has cautiously and with some setbacks edged our way back towards at least some aspects of what was regarded as "normal". When it became clear that lockdown would be with us for a while, UKCRIC organised a series of online meetings that led to the development of 'Rethinking infrastructure and cities for a Covid-19 world: A UKCRIC prospectus'. As events this summer continue to remind us, it is essential that we do not allow the need to rebuild economies distract us from the necessity to prevent further climate change and loss of biodiversity, adapt to the consequences of the climate change that is already inevitable, and build a more equitable society. These aims are core to UKCRIC's Scientific Missions, which also support UK Government priorities for a net zero greenhouse gas future and levelling up; and the National Engineering Policy Centre's five foundations for a net-zero recovery. Covid restrictions notwithstanding, our facilities have seen considerable use, especially by the host institutions.

Our Urban Observatories have made crucial contributions to local and national government and policy throughout the pandemic in terms of guiding the safe use of our infrastructure, social innovation and mitigating environmental impacts. In February 2021, DAFNI became part of a new £10M UK centre for climate and environmental risk for the financial industry.

This Review marks the end of Phase 1 of UKCRIC, which focused on the delivery of the new facilities and cementing the place of DAFNI and the Observatories in the infrastructure and cities landscape. The challenge as we move into Phase 2 will be to ensure that UKCRIC partners work collaboratively and collectively with each other, the wider research community, industry and government, and the public to realise the huge benefit that well-planned and well-realised infrastructure and cities bring to society and the environment. We are also developing proposals for different categories of membership of UKCRIC, to enable a wide range of academic and user stakeholders to become formally involved, and are looking to establish a presence in Wales and Northern Ireland so that UKCRIC represents every region of Great Britain.

In every respect, we have challenges ahead. But together, we can turn these challenges into opportunities, and through our research and engagement with policy help the UK and indeed the world move rapidly towards a more sustainable, resilient and equitable future. If you would like to join us on this exciting journey, please do get in touch.

Professor William Powrie, UKCRIC Convenor

UKCRIC in numbers

£196M of **PUBLIC FUNDING INVESTED**
(exc. primary funding for facilities)

£40M of **RESEARCH FUNDING ATTRACTED** from **commercial sources**

£7.6M **RESEARCH FUNDS LEVERAGED** from **non-UK** sources

15 **PARTNER ACADEMIC INSTITUTIONS** across the UK

88 **SMEs** involved in **PROJECTS** and **ACTIVITIES** related to the **FACILITIES**

23 **INTERNATIONAL ACADEMICS** visiting the **UKCRIC FACILITIES** to conduct research

35 **MEDIA ARTICLES** about UKCRIC

24 **FELLOWSHIPS AWARDED** based on access to facilities

1 **PATENT**

1 **SPIN-OUT COMPANY**

85 **UKCRIC EVENTS** in 2021

These figures cover the time period from the commissioning of the facilities until March 2021.

78 

RESEARCH AWARDS
secured by **UKCRIC MEMBERS** utilising the **FACILITIES**

88 

NON-ACADEMIC INSITUTIONS using **UKCRIC FACILITIES**

406 

POST-GRADUATE RESEARCHERS using or being trained on the **UKCRIC FACILITIES**

149 

PEER-REVIEWED PUBLICATIONS in **105 JOURNALS** with an average **IMPACT FACTOR** of **5.7**

90 

RESEARCH DEGREES AWARDED to students who have used the **UKCRIC FACILITIES**

34 

CONFERENCE PRESENTATIONS

2 

KTPs AWARDED based on **UKCRIC FACILITY** use

4 

RESEARCH PRIZES

52% 

of publications involving **INTERNATIONAL AUTHORSHIP**

21 

publications involving **INDUSTRY AUTHORS**

8.3 

AVERAGE CITATIONS per publication

Our Scientific Missions

UKCRIC is driven by four Scientific Missions, each working to develop and deliver breakthrough research for the benefit of society. They are designed to facilitate the delivery of interconnected, integrated and transdisciplinary research programmes and projects.

Cross cutting themes within each Scientific Mission, alongside links with UKCRIC's facilities and industry, are central to achieving UKCRIC's vision.

The four Missions are:

INFRASTRUCTURE AND URBAN SYSTEMS FOR ONE PLANET LIVING

Accelerating sustainability through substantial advances in responsible consumption, resource efficiency and sustainable growth and helping the UK meet its carbon targets.

OWNERSHIP, GOVERNANCE AND BUSINESS MODELS FOR INFRASTRUCTURE AND URBAN SYSTEMS

Developing innovative models for coping with greater system interdependencies, changing patterns of use and new, disruptive technologies while at the same time delivering social justice and affordability.

TRANSFORMATIONAL INFRASTRUCTURE AND RESILIENT URBAN SYSTEMS FOR A CHANGING WORLD

Pioneering methods in infrastructure and urban systems design to meet the challenges of climate change, changing patterns of use, societal expectations and emergent technologies.

INFRASTRUCTURE AND URBAN SYSTEMS AS DRIVERS OF EQUITY, INCLUSION AND SOCIAL JUSTICE

Providing the underpinning, transdisciplinary research platforms for forging healthy, happy and productive lives for all through urban design, planning, policy and infrastructure.

Research Routemaps

Research Routemaps aligned to the Scientific Missions focus on complex societal challenges whose solutions require many different disciplines and sectors to interact. A focus on problems, rather than on disciplines or sectors, means that solutions can be applied to the multiple challenges faced by society.

Our Missions bring into focus problem-specific societal challenges that require many different sectors to interact to find a solution. This focus on problems, rather than on sectors, means that solutions can be applied to multiple challenges faced by society. UKCRIC's Missions, and the way that we use them, continue to evolve through discussion and workshops and in response to shifting societal needs.

UKCRIC's initial eight Research Routemaps are:

1 LOW-CARBON MATERIALS

2 LEAN INFRASTRUCTURE

Mission: Infrastructure and urban systems for one planet living

5 BALANCING RISKS AND RESPONSIBILITIES

6 RESPONSIVENESS TO INNOVATION AND CHANGE

Mission: Ownership, governance and business models for infrastructure and urban systems

3 DIGITAL TWIN AND SMART INFRASTRUCTURE

4 RESILIENCE – SOIL AND WATER

Mission: Transformational infrastructure and resilient urban systems for a changing world

7 ACCESSIBLE, AFFORDABLE URBAN MOBILITY

8 SOCIALLY JUST UTILITY SERVICE PROVISION

Mission: Infrastructure and urban systems as drivers of equity, inclusion and social justice

UKCRIC's Facilities

We develop and invest in research on infrastructure systems and cities; offering new ways of coping with the grand challenges of the 21st century such as climate and demographic change, resource scarcity and social justice.

UKCRIC is composed of three strands: infrastructure laboratories, Urban Observatories, and the Data & Analytics Facility for National Infrastructure (DAFNI).

The **infrastructure laboratories** are a collection of facilities conducting research on the basic science, technology and engineering that underpins the infrastructure sectors and delivers innovative solutions which meet sustainability and resilience criteria. While some of the laboratories are complete and operational, others are shortly to come online.

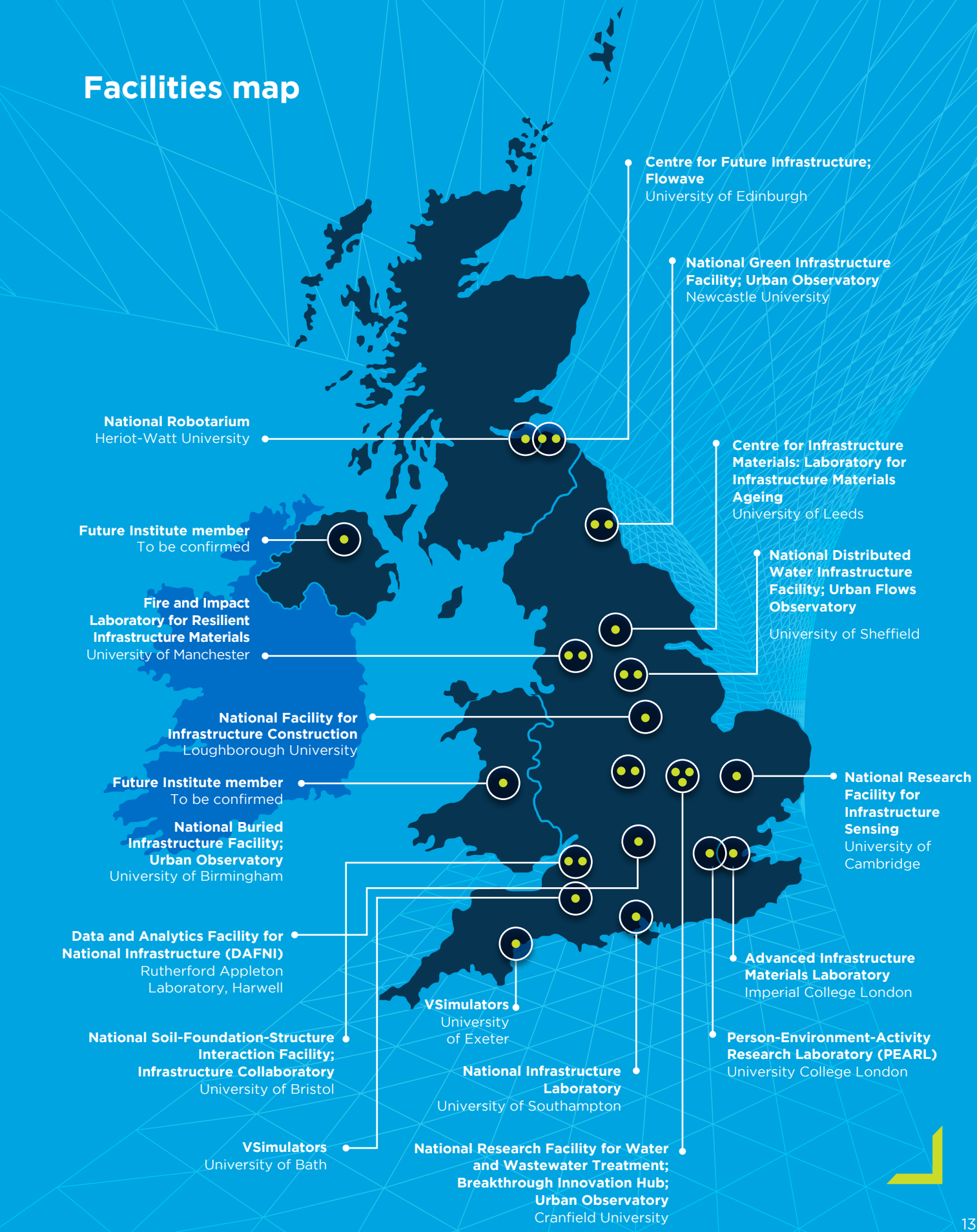
The **Urban Observatories** are a network of UK institutions collecting real-time environmental data – on everything from air quality to noise pollution – to build a picture of each city and the environment it creates. Each of the six observatories is linked to a university and the data collected is openly available. They are based in Newcastle, Bristol, Sheffield, Cranfield, Manchester and Birmingham, with the joint aim of developing a new understanding of cities.

DAFNI, the **Data & Analytics Facility for National Infrastructure**, is the National Platform to satisfy the computational needs in support of data analysis, infrastructure research, and strategic thinking for the UK's long-term infrastructure and cities planning and investment needs.

A **Coordination Node** provides governance and coordination on behalf of UKCRIC as a whole to ensure that the collective impact of the investments and research is achieved and communicated across and between sectors and communities.

Full information is available at **www.ukcric.com/facilities.**

Facilities map



National Research Facility for Water and Wastewater Treatment
Cranfield University

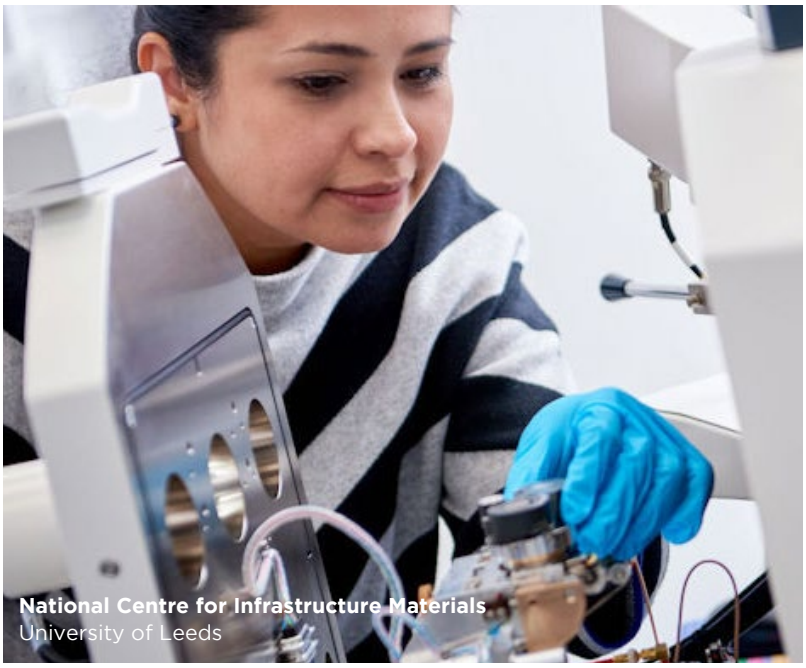
National Buried Infrastructure Facility
University of Birmingham

Soil Foundation Struture interaction Laboratory
University of Bristol

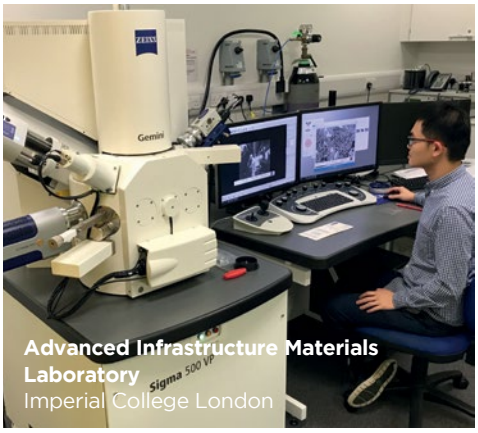
National Research Facility for Infrastructure Sensing
University of Cambridge

Caption: Testing the visibility differentiator system at PEARL. This can change visibility from completely clear to a maximum visible distance of 60cm.

Person-Environment-Activity Research Laboratory
UCL, London



National Centre for Infrastructure Materials
University of Leeds



Advanced Infrastructure Materials Laboratory
Imperial College London

A world-class suite of infrastructure laboratories

UKCRIC's network of infrastructure laboratories is available for use by researchers and industry alike. The network comprises a series of bespoke, dedicated laboratories for research into the many aspects of infrastructure design and development.

- **National Distributed Water Infrastructure Facility (NDWIF)** at the **University of Sheffield** provides a unique laboratory for research into the performance of distributed urban water infrastructure.
- **National Research Facility for Water and Wastewater Treatment** at **Cranfield University** supports research on the inter-dependencies between treatment and distribution processes, condition monitoring and performance of technologies.
- **National Green Infrastructure Facility** at **Newcastle University** is a 'living laboratory', underpinning research into Sustainable Drainage Systems, Green Infrastructure approaches, and making urban centres more resilient and sustainable for future generations.
- **National Infrastructure Laboratory (NIL)** at the **University of Southampton** aims to find new and innovative ways to improve the efficiency of maintaining and upgrading existing infrastructure as well as developing more cost-effective ways of designing and constructing new infrastructure.
- **National Centre for Infrastructure Materials: Laboratory for Infrastructure Materials Ageing** at the **University of Leeds** aims to provide a networked suite of facilities to research the ageing and deterioration of a whole suite of infrastructure materials.
- **Advanced Infrastructure Materials Laboratory** at **Imperial College London** has state of the art equipment to undertake fundamental analysis, processing, imaging and testing of infrastructure materials.
- **Fire and Impact Laboratory for Resilient Infrastructure Materials** at the **University of Manchester** consists of two facilities to enable investigations of the mechanical properties of materials exposed to extreme loading conditions caused by fire, impact and blast.
- **Person-Environment-Activity Research Laboratory (PEARL)** at **University College London** is based in East London. PEARL is designed to enable fundamental and applied research on the ways in which people interact with infrastructure and cities.
- **Soil-Foundation-Structure Interaction Laboratory** at the **University of Bristol** aims to integrate structural and geotechnical engineering for soil structure testing.
- **National Research Facility for Infrastructure Sensing (NRFIS)** at the **University of Cambridge** focuses on the research and application of advanced sensor technologies for infrastructure monitoring and assessment.
- **National Buried Infrastructure Facility** at the **University of Birmingham** is a 'one of its kind' facility for research, education and training in buried infrastructure-ground interaction.
- **Centre for Future Infrastructure** at the **University of Edinburgh** is an intellectual hub for ideas, and a workshop for forging those ideas into practical opportunities and applications, bringing together stakeholders from across the university sector, industry, government and beyond.
- **National Facility for Infrastructure Construction at Loughborough University,** which supports research and enterprise on novel approaches for delivery and maintenance of assets underpinned by automation and digital technologies.
- **National Robotarium at Heriot-Watt University,** a world-leading centre for Robotics and Artificial Intelligence, that creates innovative solutions to global challenges.
- **VSimulators** at the **University of Bath,** a building sway motion and environment simulator.
- **VSimulators** at the **University of Exeter,** which supports fundamental and applied research in human motion tolerance and performance in the built environment.

While some of the laboratories are still under construction, there are many up and running. Visit www.ukcric.com/facilities for full details.

Consolidating data on national infrastructure and a focus on growth

The DAFNI vision is to allow researchers to use state-of-the-art modelling, simulation and visualisation to better inform and develop strategic thinking. DAFNI has been developed so researchers can run models on a common computing system with a central repository of data. Using cutting edge computers, models and simulations can be scaled to greater coverage and resolution. Collaborators are not only able to use the platform as a shared workspace to integrate models and data from different sectors, but are also provided with a suite of tools and capability to reduce many of the interoperability issues researchers face when accessing information from disparate sources.

In this third year of its development, the DAFNI team has started to explore how the platform can begin to support the National Digital Twin agenda, an opportunity to transform the efficiency and reliability of national infrastructure. In a digital twin, data from real systems are fed into a running computer simulation to predict outcomes that can then be fed back to the real system to steer its course. DAFNI provides a platform to support infrastructure digital twins, coupling diverse simulation models that together contribute to digital twins that are national in scope.

In 2020 DAFNI provided an extensive programme of user interaction in the form of DAFNI Roadshow demonstrator events, demonstrator videos and the development of help guides to support users to fully engage with the platform and develop their research. DAFNI has also been involved in several new projects which have meant working more closely with Government departments such as Defra, Climate Change Committee, Environment Agency, Office of National Statics and England's Economic Heartland as well as extending to academic researchers beyond DAFNI's originating partners.

DAFNI's community is steadily growing and now has more than 100 users. This number rises steadily with each interaction the DAFNI team has with the research community. This growth has been boosted by DAFNI Champions. Their involvement has not only supported the development of the DAFNI platform but is extending and stretching its capability within a growing community of users. This extensive work demonstrates the demand for the platform and provides a significant stepping stone to launch the platform operationally in 2021. DAFNI Champions are spearheading projects in several priority areas, such as demonstrating collaborations using advanced technological capabilities, developing digital twins with a UKCRIC Urban Observatory, investigating new data ontologies to support research and using the DAFNI platform to help predict the spread of Covid-19 and other pandemics through populations.

UKCRIC's Urban Observatories: monitoring the UK's cities

The Urban Observatories network is a pioneering initiative which is capturing over 50 different types of data via a growing network of sensors located throughout the UK. As the UK's largest set of publicly available real time urban data, it represents the often invisible elements impacting our everyday lives. The network, comprising sites overseen by the Universities of Newcastle, Sheffield, Bristol, Manchester, Birmingham and Cranfield, has witnessed the largest sensor deployment in the UK to create the largest set of open environmental monitoring data in the world.

The Urban Observatories are collecting environmental data – on everything from air quality to noise pollution – to build a picture of each city and the environment it creates, measuring over 60 environmental indicators from air quality and flooding to urban biodiversity. This benefits not only the individual cities, but the UK as a whole, as the data enables researchers to identify trends and patterns that underpin infrastructure investment and operational decisions.

The Observatories are capturing data that in many cases has never been previously recorded. The UK's first live pollen count is now publicly available through the Manchester-i open access data streaming platform. This UK first was achieved by the Manchester Urban Observatory using a real-time biological aerosol spectrometer which has now been deployed at the Fallowfield Manchester Environmental Research Institute air quality supersite for routine monitoring.

Visit **www.ukcric.com/facilities** for further details.

The UKCRIC Urban Observatories were shortlisted for STEM Research Project of the Year as part of the 2019 THE (Times Higher Education) Awards. The Manchester Urban Observatory team was awarded Outstanding Contribution to Social Innovation and Environmental Impact in May 2021.

Supporting UKCRIC's Postdocs

The Centre for Postdoctoral Development in Infrastructure, Cities and Energy (C-DICE) was launched earlier this year to address two pressing and interlinked challenges facing the UK: (1) the development of a talent pipeline focusing on highly skilled postdoctoral leaders in academia or industry and (2) the progress towards net-zero through research and innovation, delivered by those leaders. The programme is funded by Research England and is led by the Universities of Loughborough, Birmingham and Cranfield. C-DICE encompasses the full breadth of the UKCRIC and Energy Research Accelerator (ERA, see www.era.ac.uk) partnerships comprising an extensive network of 18 leading Higher Education Institutions (HEIs) as well as additional partners including industry, research institutes, and organisations responsible for researcher development. This gives C-DICE access to an enormous breadth and depth of multidisciplinary expertise in infrastructure, cities and energy research, and importantly will connect postdoctoral researchers to a vast network of organisations and individuals.

If you would like to hear more about, or explore how you can engage with, C-DICE, please visit our website (www.cdice.ac.uk) and sign up for regular newsletter updates.

C-DICE has an ambitious programme filled with opportunities for postdoctoral researchers, HEIs, industry and other organisations to join and benefit from: The C-DICE annual conference, taking place on the 27th of October 2021; a peer-2-peer training programme; funded and part-funded placement and secondment calls for HEIs and for industry to host postdocs; two calls for sandpits, each with seed-corn funding attached; and, an online platform that will allow individuals to access opportunities and record their participation and progress. These are just the first events in a series that will grow in the next year to include innovative opportunities such as a suite of training interventions, dragon's dens, hackathons, funded fellowships and policy showcase events.

UKCRIC Funding Call 2021

In March 2021, UKCRIC launched its first call for research projects. 26 applications were received from across UKCRIC's members. With a focus upon infrastructure and cities and demonstrating a contribution to establishing UKCRIC as *the* institute for infrastructure, five projects were awarded funding:

1. **Accelerating UKCRIC Mission 3: Ownership, governance, and business models for infrastructure and urban systems(AM3).**
2. **Suburban-fringe 'on-demand' algorithm based shared transport**
3. **UKCRIC transition decision support**
4. **PLEXUS PLUS: multi-scale soil scanning for evaluating abutment-soil interaction in Integral Abutment Bridges**
5. **Establishing a Competencies Framework for Infrastructure Policy Professionals**

Partners

Cranfield University

Heriot-Watt University

Imperial College London

Loughborough University

The University of Manchester

Newcastle University

UCL
CIVIL, ENVIRONMENTAL & GEOMATIC ENGINEERING

University of Birmingham

University of Bristol

University of Cambridge

The University of Edinburgh

University of Leeds

University of Oxford

The University Of Sheffield.

University of Southampton

Governance and structure

Management Board

Julie Alexander (Chair), Places for People
Prof. William Powrie, Convenor, University of Southampton
Prof. Gordon Masterton, Deputy Convenor, University of Edinburgh
Prof. Liz Varga, Principal Investigator, University College London
Prof. Lindsay Beevers, Heriot Watt University
Prof. Leon Black, University of Leeds
Prof. Nick Buenfeld, Imperial College London
Prof. Sergio Cavalaro, Loughborough University
Prof. Richard Dawson, Newcastle University
Prof. Phil James, Newcastle University
Prof. Jim Hall, University of Oxford
Prof. Paul Jeffrey, Cranfield University
Prof. David Richards, University of Southampton
Prof. Chris Rogers, University of Birmingham
Prof. Anastasios Sextos, University of Bristol
Prof. Jennifer Schooling, University of Cambridge
Prof. Sean Smith, University of Edinburgh
Prof. Simon Tait, University of Sheffield
Prof. Nick Tyler, University College London
Prof. Giulia Viggiani, University of Cambridge
Prof. Yong Wang, University of Manchester

Coordination Node

Prof. William Powrie, Convenor, University of Southampton
Prof. Gordon Masterton, Deputy Convenor, University of Edinburgh
Prof. Liz Varga, Principal Investigator, University College London
Rod Anderson, University of Southampton
Dr. Tom Dolan, University College London
Prof. Jordan Giddings, University College London
Prof. Paul Jeffrey, Cranfield University
Kasia Ladds, University College London
Dr. Joanne Leach, University of Birmingham
Dr. Barbara Pizzileo, University College London
Prof. David Richards, University of Southampton
Prof. Chris Rogers, University of Birmingham
Dr. Anne Stringfellow, University of Southampton

Advisory Board

Prof. Cynthia Mitchell (Chair), Professor Emerita, University of Technology Sydney; Founder, The Good Ancestor
Prof. Lord Robert Mair, University of Cambridge
Prof. William Powrie, Convenor, UKCRIC
Prof. Brian Collins, Ambassador at Large, UKCRIC
Prof. Stephen Flynn, Founding Director, Global Resilience Institute, Northeastern University
Peter Ho, Chairman, Urban Redevelopment Authority of Singapore
Prof. Thomas D. O'Rourke, Professor, Cornell University
Prof. Pascal Perez, Director, SMART Infrastructure Facility, University of Wollongong
Bridget Rosewell, Commissioner, National Infrastructure Commission
Madalina Ursu, Formerly Head of Infrastructure, Greater London Authority

Work with us

We are actively seeking collaborative partners from the research community, industry, government, the third sector, finance, commerce and investment communities to work with us to solve the complex problems relating to infrastructure, cities and systems.

Furthermore, if your organisation's research and innovation priorities are related to our Scientific Missions why not consider becoming a member of UKCRIC?

Contact us at hello@ukcric.com.

UKCRIC

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UK Research and Innovation

EPSRC
Engineering and Physical Sciences Research Council