UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

URBAN & PUBLIC INFRASTRUCTURE RESEARCH INITIATIVE

Executive Summary

Digital & Polar Laboratory

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Introduction

The University of Cape Town is establishing laboratory facilities to support interdisciplinary research in the fileds of 1) Urban and public infrastructure and 2) the Southern Ocean and the Antarctic environments. The intersections between these two fields of study are **climate change, sustainable development and digital technologies**. Both programs seek to exploit digital technologies (big data analytics, digital twins, virtual reality, internet of things and sensing technologies, etc) to develop an in-depth understanding of climate change impacts on physical infrastructure and the cryosphere. In addition, this facility will become the hub for transformative teaching & learning for undergraduate and postgraduate levels and continuing professional development. The vision is to become an international centre of excellence on the African continent.

Brief summary

The World Economic Forum projects that the urban population in Africa will double by 2050.

> *Make no mistake - Africa's future is urban. But in the next two decades, African cities will need to do much more, with much less. While national governments will need to step up and implement regulations to raise public finance, African mayors, city residents and businesses cannot afford to wait. A new mindset is urgently required. But this first requires facing up to the scale of the challenge. (https://www.weforum.org/agenda/2018/06/Africa-urbanization-cities-double-population-2050-4%20ways-thrive/*

Our view is that urbanisation should not be viewed as a hindrance to economic growth and the goal of reducing carbon emissions. On the contrary, it should stimulate economic growth and support decarbonisation. While South Africa has sound economic policies and climate change adaptation strategies, its success remains stubbornly low, as reflected by increasing levels of **poverty and unemployment**. On the other hand, the **emergence of digital technologies** means that extraordinary **ideas and tools capable of changing the way we live** are now available. Digital Technologies and solutions tend to be disruptive and are prone to leapfrogging – they completely shift traditional approaches to problem-solving, often at scale. A unique feature of Digital Technologies is that, while there are vast differences in the levels of economic development between developed and developing countries, all stand to benefit from innovations that this era affords. In this context, the physical fabric of the conventional city or municipality – its infrastructure and economic development – is the nexus through which Digital Technologies transform how societies function and develop. Thus, shaping future urban areas must be **centred on local realities and needs**. In South Africa and Africa at large, **unemployment, poverty, inadequate housing, access to clean water and sanitation and poor educational facilities are some of the top urban challenges**. The reality of the impact of these challenges is reflected in the familiar sights of civil unrest, the vast majority of which are about inadequate physical infrastructure and unemployment. Any infrastructure solutions must therefore be **human-centred** in order to be effective.

This multifaceted nature of urban and public infrastructure, **bridging the divide of engineering, technology, finance, policy and the arts,** demands a sophisticated trans-disciplinary research capability. To this end, the University of Cape Town is establishing a state of the art facility for inter-, trans and multi-disciplinary research on key urban and public infrastructure challenges while **ethically exploiting**

developments in digital technologies and solutions. The ultimate purpose of this initiative is to improve and secure the quality of life in African urban and municipal environments.

The Southern Ocean and the Antarctic environments are essential dynamic regulators of the Earth and African climate. Thus, South African climate change projections and the resulting adaptation strategies are inextricably linked to the Southern Ocean and Antarctic environments and, by induction, the sustainable development and urban and public infrastructure. South Africa has recognised the importance of Polar research by establishing the South African Polar Research Infrastructure (SAPRI) initiative, championed by the Department of Science and Innovation (DSI) through the South African Research Infrastructure Roadmap (SARIR). This initiative not only responds to the importance of Polar research and climate change but also to the Blue Oceans initiatives. As part of the SAPRI framework, the University of Cape Town is establishing a National Polar Laboratory, with the approval and support of the DSI and participating Universities. This will be the first glaciology laboratory in the continent of Africa capable;e of conducting sub-zero temperature experiments. An integral part of the laboratory is the exploitation of digital technologies in Polar research and education. In particular, digital technologies will facilitate digital twinning, extended reality, visualisation and big data analytics. Thus, scientists and the public will have unprecedented access to Antarctica through digital technologies. This accidental intersection between Urban and public infrastructure research and Polar research provides unique opportunities to address climate change, sustainable development, resilient infrastructure human capital development under one roof.

Location

The University of Cape Town has established itself as a leading research institution attracting excellent students from the African continent and beyond. Located in the University of Cape Town's Upper Campus, which lies on the slopes of Table Mountain, the site of the Digital and Polar Laboratory is prime land. Upper Campus is a hive of activities. It hosts four of the University of Cape Town's six faculties (Science, Engineering and the Built Environment, Commerce, and Humanities), the Sarah Baartman Hall (for graduation ceremonies, major events and examinations), and two residence halls. Bounded by the New Engineering Building and Madiba Circle, the Digital and Polar Laboratory occupies an easy to access and prominent location.

Figure 1: Digital & Polar Laboratory Site

The labs

The Digital Lab will support a range of research activities related to physical infrastructure with the express intention to develop innovative data-driven solutions, including **1) artificial intelligence and connected infrastructure**. This research focuses on data analytics, sensors, visualisation, system integration for physical infrastructure design, operation and management, and building information management aimed at prevailing local conditions. **2) Resilient and sustainable infrastructure**. This research will study the role of resilient and sustainable infrastructure in the context of a fast-changing and urbanising African continent. Specifically, there will be a focus on the role of new technology to shape infrastructure in anticipation of or in response to climate change. **3) Engineering education.** The lab will provide a platform for enhancing teaching and learning. The information obtained from the data visualisation lab is expected to improve our understanding of how we learn, which may revolutionise how we teach engineering. A key feature of the Digital Laboratory is that it will be a living laboratory in which water services within the building will be used to develop technologies for water and sanitation and **digital twins** of selected infrastructure will be used to inform the development of human-centred infrastructure solutions. The Digital Lab will include the following; 1) **Extended reality laboratory**, 2) **Digital sensor interface laboratory,** 3) **Data analytics and visualisation laboratory**, 4) **Living laboratory** and 5) **Training facilities**. Such a facility focussed on physical infrastructure will be the first of its kind in Africa and arguably in the world.

The facility will support a whole host of **polar research activities across science and engineering disciplines**, including 1) the training of glaciologists and 2) offering services to external customers and research scientists nationally and internationally. The capabilities of the laboratory will include: 1) **Near-zero and sub-zero experiments with biological specimens** from the polar ocean, sub-Antarctic islands and the Antarctic continent; 2) **Artificial sea ice creation** in a wave tank and study of wave-ice-atmosphere-ocean interactions (one of the few facilities in the world to use seawater); 3) **Sub-zero testing and analysis of physical, mechanical and biogeochemical properties of artificial and natural ice** samples; 4) **Cold storage capacity of ice samples, biological cultures and geological samples** for full

exploitation of research potentials; 5) Development and testing of **digital autonomous observation platforms** for their suitability in extreme environments; 6) Calibration of acquired commercial instruments, including ocean gliders and other large autonomous devices, with considerable savings in maintenance costs; 7) **Digital laboratories to facilitate digital twinning of Antarctic and ocean platforms**, provide facilities for teaching and learning and provide access to information to national partners. DSI will partly fund the equipping of this facility.

The Digital and Polar Lab will become the knowledge hub for South African and African Infrastructure and Polar research, supporting 1) **the development of high-level human capital** 2) **informed decision making** for infrastructure development and the Southern Oceans. Human capital development will go beyond training the next generation of researchers to include technology transfer and the training of stakeholders.

Aims and anticipated outcomes

Production of scientific work with a clear impact

The key to successful infrastructure delivery and operation lies in human-centred and evidence-based research. The capabilities of digital technologies provide perfect conditions for developing a deeper understanding of the obstacles to infrastructure delivery and operation and its intersection with **socio-economic and socio-political challenges**. In South Africa and the African continent, coupled with poor infrastructure, is poverty and unemployment. Evidence-based research and innovation supported by the digital lab will provide solutions that would ensure the most relevant infrastructure solutions are implemented. Infrastructure projects are capable of creating employment, thereby alleviating the grand challenge of poverty in African cities. The COVID-19 pandemic has taught the world the importance of reliable scientific information. Without credible research and reliable data, the devastating effects of the pandemic could have been worse. The biggest threat to infrastructure is climate change and associated extreme events such as flooding. The impact of climate change on infrastructure is a major research theme supported by the Digital Lab.

Expansion and increased output of high-quality research

One of the most appealing features of the Digital and Polar Lab is that it will enable trans, cross and interdisciplinary research through data and digital platforms. This is critical as infrastructure and climate change related challenges are primarily affected by technical, social, economic, environmental and political issues. Currently, there is no common platform for interdisciplinary research into infrastructure. Exploiting this untapped potential will strengthen, expand and invariably result in increased and impactful research outputs.

Improved educational experience and understanding of science

One of the most exciting opportunities offered by the Digital and Polar Lab is the ability of students and researchers to engage with the grand challenges in infrastructure and polar research through virtual/augmented/extended reality, data visualisation, and remote measurements. This direct interaction will deepen the understanding of societal and environmental challenges associated with infrastructure and climate change and thus stimulate the development of relevant, innovative

solutions. In line with the University of Cape Town's vision 2030, the Digital and Polar Lab will provide space and facilities to "unleash potential".

Project timetable

Since the granting of financial support by the University and the endorsement of the project by the Department of Higher Education in mid-2020, significant progress has been made towards the project development. A full schedule of accommodation (all rooms and sizes) has been consolidated as a brief for the input of professional teams. A digital scan of the site and the identification of existing underground services (water, sewers, and electricity) has been completed. The geotechnical investigations to inform foundation requirements are underway.

It is anticipated that the appointment of the complete team of technical consultants will be completed by the end of April 2022. Construction is expected to start in the second half of 2023 and is anticipated to take 24-30 months. The appointment of consultants and contractors follows the University of Cape Town procurement processes, whose basis is competitive bidding.

Finance

The estimated costs of the project are; 1) R170million for the building 2) R50million for equipment 3) R9.18million for technical staff and R33million for an endowed chair. The University of Cape Town has committed R50million towards the building, while the Department of The Department of Science and Innovation has committed R25million for equipment.

The Department of Higher Education has committed to ring-fence funding for the Digital and Polar Lab in the next funding cycle of 2023/2024.

Item		Rands		Sterling
Construction	R	150 000 000.00	£	8 173 076.92
Professional fees	R	20 000 000.00	£	961 538.46
Equipment	R	50 000 000.00	£	2 403 846.15
Human resources (1 Chair, perpetual)	R	33 000 000.00	£	1 650 000.00
3 technical staff (3 years)	R	9 180 000.00	£	459 000.00
Total	**R**	**262 180 000.00**	**£**	**13 647 461.53**

Fund raising summary				
University of Cape Town	R	50 000 000.00	£	2 403 846.15
Department of Science & Innovation	R	25 000 000.00	£	1 201 923.08
Total	R	75 000 000.00	£	3 605 769.23
Shortfall	**R**	**187 180 000.00**		**£ 7 211 538.46**

Operational and maintenance costs

Research in the Digital and Polar Lab will be an extension of existing work within the research entities involved. However, due to the specialised nature of the facility, competent technicians will be hired. This will ensure that the digital infrastructure remains functional. Information technology will be supported by the University's IT department.

Conclusion

We are grateful for the opportunity to submit this proposal. We do believe this project will have a significant, positive impact on Africa's grand challenges namely, impacts of climate change, poverty and unemployment. The University of Cape Town has an excellent history of managing donor funds. We will provide a full report on the expenditure of funds.

The University of Cape Town has an excellent record of establishing successful cross-discipline research hubs. Examples of these world-class institutes are; African Climate and Development Initiative (ACDI), Future Water, the Institute for Communities and Wildlife in Africa, the Institute of Infectious Disease and Molecular Medicine (IDM), the Neuroscience Institute and the Poverty and Inequality Initiative (PII). The Digital and Polar Lab project draws on the wealth of experience gained from these projects.