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Creating a National Urban Research and Development Platform for Advancing Urban Experimentation

Peter Newton * and Niki Frantzeskaki

Centre for Urban Transitions, Swinburne University of Technology, Melbourne 3122, Australia; nfrantzeskaki@swin.edu.au

* Correspondence: pnewton@swin.edu.au

Abstract: Transformative changes are required for a 21st century sustainable urban development transition involving multiple interconnected domains of energy, water, transport, waste, and housing. This will necessitate a step change in performance goals and tangible solutions. Regenerative urban development has emerged as a major pathway, together with decarbonisation, climate adaptation involving new blue-green infrastructures, and transition to a new green, circular economy. These grand challenges are all unlikely to be realised with current urban planning and governance systems within a time frame that can mitigate environmental, economic, and social disruption. A new national platform for urban innovation has been envisaged and implemented in Australia that is capable of enabling engagement of multiple stakeholders across government, industry, and community as well as real time synchronous collaboration, visioning, research synthesis, experimentation, and decision-making. It targets large strategic metropolitan, mission-scale transition challenges as well as more tactical neighbourhood-scale projects. This paper introduces the *iHUB*: National Urban Research and Development Platform, its underlying concepts, and multiple layers of technical (IT/AV), software/analytical, data, and engagement, as envisioned and implemented in Australia's four largest capital cities and five collaborating foundation universities.

Keywords: innovation; experimentation; cities; urban transformation; sustainability transition; urban collaboratory; engagement

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1. Introduction

Urban decision-making in the 21st century has never been as challenging nor as consequential as it is now. The rapid growth of large cities is overtaking their capacity to successfully plan and manage increasingly complex and dynamic systems. A stocktake of the 'state of the cities' in recent urban literature in Australia and internationally has identified a constellation of challenges confronting cities in most developed and developing countries:

- ecological footprints two to three times the global average, linked to built environments and urban forms that are massive consumers of natural resources in construction and operation [1]. This reflects unsustainable systems of production and consumption. Urban footprints are increasing at a faster rate than population growth, which is linked to a dependence on fossil fuels, low-density urban forms, and little or no low carbon mobility infrastructure investments in place to provide alternatives to post-war car dependent suburban growth [2];
- climate change impacts manifest in increased urban damage from wildfires, flooding, urban heat, and more intense storms (hail, wind, coastal storm surges) that are putting urban infrastructure under stress and in need of adaptation and re-investment;
- economic inequality reflected in unequal access to urban jobs and services (health, education, and public transport) within cities is a result of the current operation of the labour (location of employment opportunities) and the housing markets that increases suburbanisation of social disadvantage [3], often combined with racial/ethnic inequalities;

- urban forms and sedentary lifestyles that predispose residents to higher levels of ill-health as a result of non-communicable diseases (e.g., diabetes type 2, cardiovascular disease, respiratory disease); a set of health challenges to city planners and designers that are not as yet clearly identified [4], and
- digitalisation as a major disruptor as well as transformer of cities and society, with noticeable digital divides evident in current urban populations [5].

To add to these pressures, the shock of COVID-19 as a worldwide pandemic has created unprecedented health and economic impacts in cities on all continents that were exacerbated by a lack of planned preparedness identified in earlier urban performance reviews [6,7]. It has magnified the inequalities inherent in today's cities and has unleashed a torrent of commentary about it representing a tipping point for the introduction of a transformative approach to city planning and design including modes of living, working, and learning that need to be part of the post-pandemic strategic thinking about cities.

Research momentum targeting a *transition* to more sustainable urban development has been slowly gathering pace over the past ten to twenty years internationally, especially in the European Union. At a global level, targets for transition are now embodied in the United Nation's Sustainable Development Goals, also adopted by the Australian Government, although there are significant lags in the progress of their adoption in cities and regions [8]. Prior to this, the national State of Environment reports on built environments and human settlements [9] had established a set of normative goals for city planning and development focused on achieving significant reductions in their consumption of natural resources, reductions in emissions and waste streams, enhancing urban environmental quality in both public and private realms, enhancing liveability and well-being of resident populations, increasing resilience to the growing array of exogenous and endogenous pressures facing cities and regions, and substituting smart urban systems and processes for those currently in use to achieve more effective and efficient economic, social, and environmental planning and management of cities. Subsequently, five key performance objectives have been nominated for the nation's cities: sustainable, liveable, inclusive, resilient, and productive, all of which now feature as aspirational goals in the metropolitan planning strategies of the large capital cities. Attempts to monitor progress across the settlement hierarchy via a National Cities Performance Framework [10], however, has identified key deficiencies and gaps in developing relevant indicators, datasets, and reports. It is also reflective of a planning deficit in Australian urban development policies and processes this century, whereby neo-liberal governments have become strongly developer-led in their strategic planning and project initiation activities, widening spatial inequalities within cities.

Transformative changes are required for a 21st century sustainable urban development transition involving multiple interconnected domains of energy, water, transport, waste, and housing. This will necessitate a step change in performance goals and tangible solutions. Regenerative urban development has emerged as a major pathway, together with decarbonisation, climate adaptation involving new blue-green infrastructures, and transition to a new green, circular economy. These grand challenges are all unlikely to be realised with current urban planning and governance systems within a time frame that can mitigate environmental, economic, and social disruption. A new national platform for urban innovation has been envisaged and implemented in Australia that is capable of enabling the engagement of multiple stakeholders across government, industry, and community as well as real time synchronous collaboration; a basis for enhancing and accelerating urban visioning, research synthesis, experimentation, policy-making, and decision-making. It targets large strategic metropolitan, mission-scale transition challenges as well as more tactical neighbourhood-scale projects. The aim of this paper is to introduce the *iHUB*: National Urban Research and Development Platform, its underlying justification, concepts, and multiple layers: technical (IT/AV), software/analytical, data, and engagement, as envisioned and implemented in Australia's four largest capital cities and five collaborating foundation universities. The paper then proceeds to outline the multiple applications and expected benefits of a nationally networked urban collaboration platform that is readily scalable.

2. Literature Review

The literature reviewed for this paper addressed two related fields central to the topic: the transition challenges confronting 21st century urban development that must be met within a window of opportunity that is rapidly closing under business-as-usual planning and governance practices; and opportunities that are emerging for harnessing rapidly developing digital technologies meshed with innovations in sustainable urban development thinking and practices across multiple scales (building, precinct and city/region) and stakeholder groups.

2.1. An Era of Transitions: A Future We Need to Prepare For

A response to 21st century urban challenges requires transformational change in multiple, connected domains, or as recent research on sustainability transitions points to, deep transitions to infrastructure systems [11]. In cities, institutional proximity makes transformative changes in one domain like urban mobility spill over and influence multiple interdependent domains. This makes transformation dynamics complex and pluriform as well as possible to trigger through different entry points [12]. Hence, there is value in elucidating transformative tipping points in the forms of multi-sectoral transitions that we discuss here.

Socio-ecological cities transitions or renaturing cities transitions: Transformative actions to deal with climate change can take many forms in cities through scaled up investments in green infrastructure and nature-based solutions [13]. Such interventions will increase the adaptive capacity of cities and their resilience to buffer climate change impacts. The IPCC and national agencies have been developing increasingly detailed and scaled down projections of climate change and strategies for its mitigation and adaptation that many jurisdictions are seeking to apply at metropolitan levels. Population attitudes and level of concern as well as the government's susceptibility to lobby group influence over climate change are influential factors in the rate and scale of response. Conforming innovations to urban regeneration include greening urban infill, re-planning for greening in-between spaces, and utilising abandoned spaces for micro-green urban amenities as well as reducing heat stress by experimenting with green facades and multifunctional green roofs have challenges to be overcome in planning and scaling up [14].

Energy transitions: Guided by the Paris agreement, a shift from fossil fuels to renewables and a radical transformation at socio-technical and socio-economic levels to net zero energy systems in cities need to be at the heart of a sustainable low carbon economy. The built environment as well as other key sectors of the economy all have roles to play, in addition to the energy sector. Decarbonising the built environment can occur with improving and benchmarking energy efficient housing and take-up of rooftop solar and battery storage, creating a capacity for future smart housing to be net zero energy. The mission of such an urban energy transition can be to have an energy producing city with many interconnected sectors to be on net zero [15]. Constraining factors relate to politically vested interests in the fossil industry and its lobbies, especially in countries like Australia that remain on the periphery of the Paris agreement and currently steer away from national political consensus for such a transition.

Urban mobility transitions: These represent one of the greatest sustainability challenges. Many disruptive and conforming innovations co-exist including the electrification of mobility/electric vehicles, energy efficient public transport (hydrogen buses, trains running on renewables), modular mobility planning as an approach already applied across the globe as well as sharing economy platforms for urban mobility for cars and bikes alike. However, these innovations need to find their application in a fast-changing urban fabric. Macro-level metropolitan plans calling for increased public transport provision in new greenfield suburbs (light rail, trackless trams) as well as retrofitting those suburbs that have failed to be connected in the post-war era of car dependent suburbs (in order to achieve 20-min neighbourhood and 30-min city aspirations) await realisation. Delivering '20-min neighbourhoods' in post-war suburbs that have not provided active transport access (walking, cycling, e-biking) to cafes, shops, services, and schools necessitates a faster paced urban mobility/urban fabric transition during as well as post pandemic. Re-localising the city to accommodate newfound home–work preferences and office and shopping space efficiencies are new, disruptive, and challenging to re-imagine and plan.

Digital economy transitions: These represent an outworking of the 5th (Kondratieff) long wave of innovation centred around digital computing and communications technologies that were emerging in the 1980s, enabling networked computing, the platform for the Internet and its manifest applications—the Internet of Things—which continue through to the present [5]. The national digital platform for urban planning and design that is a focus of this paper is a tangible realisation of this continuing wave of digitalisation.

2.2. Urban Innovation and Transformation through Experimentation

These transition tipping processes interconnect and put in motion feedback loops in urban systems and their functions and form the basis of the sixth long wave of societal transformation to a green economy [16] (Figure 1). In our era, we see the critical convergence between the digital transformation (5th wave) and the emerging 6th wave of societal sustainability transformation. Such a convergence of digital and sustainability technologies holds promise for accelerating the needed transitions to a smart sustainable urban future, but raises the question: how can it be mobilised, triggered, and overall, achieved?

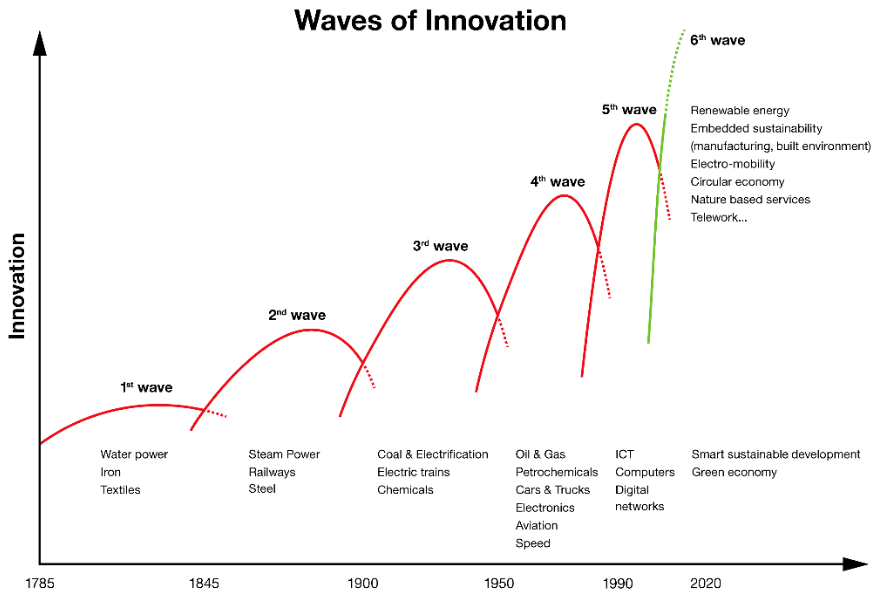

Figure 1. Long waves of technological and societal innovation: the 6th wave—smart sustainable development (Source: modified from [16] with permission).

Here, we see emerging areas of converging activity—pieces of the complex urban sustainability puzzle—coming together in multiple domains. At an applied research level, there is growing recognition of the criticality of assembling transdisciplinary teams from different disciplinary backgrounds relevant to investigating solutions to current and emerging urban problems. Achieving smart sustainable cities requires a shift from the siloed approach of much current scholarship in the built environment, social science, environmental science, and information science disciplines to integrated thinking and analysis. The emergence of the new field of urban transition studies over the past 15 years is establishing new theoretical and conceptual frameworks for tackling 'wicked' urban research challenges [11,12]. A key feature of this research has been the development of socio-technical frameworks for urban innovation projects that recognises that technological advances alone will rarely effect needed transformational change, given the barriers and regimes that exist in many populations, sectors of industry, and governments. Urban science also continues to advance as a multi-disciplinary field focused on creating a computational (and increasingly fully digital, e.g., visualisation, sensors, etc.) understanding of city systems in relation to how they function and change. New approaches to urban modelling are emerging that are geospatial and object-based, allowing a more realistic representation of built environment elements, ranging in scale from individual material products (and their attributes), to their assembly in buildings and infrastructures (physical and social), and situated within precincts, catchments, and wider metropolitan and natural resource regions. Building information models, precinct information models, and city information models (BIM, PIM, CIM) are characteristic of these powerful analytic and visualisation tools now being applied in urban planning and design. Increasingly, these evidence-based inputs to the future visioning, planning, and development of cities are pointing to the ecological and social limits to current trajectories of economic and urban development [17]. A change in thinking and models of governance is required in both public and private sectors if there is to be a transition to clean energy, and a transition to a green economy that encompasses and benefits all sectors of industry, within a time frame that mitigates major environmental, social, and economic disruption.

We argue that multi-scalar experimentation and stakeholder engagement is a mechanism to sustain and capitalise these critical convergences and ensure momentum of the needed transitions toward a large-system transformation. Experimentation is a way to engage and activate key stakeholders and lift the level of innovation in urban planning aligned to the UNSDGs and national city performance goals. Transitions studies have identified urban experimentation platforms and processes as instrumental for shaping new institutions, new relations, and generating safe spaces for driving urban innovation and devising ways to navigate barriers to innovation and change.

Urban experimentation as a process is situated either physically (in a field-site or in a place), or virtually (e.g., platforms and digital laboratories). The 'laboratory' and the 'field site' have been identified as principal locations where urban investigation and experimentation can occur. In cities, the dominant forms of urban experiments are place-based. Urban laboratories in the Built Environment and Design disciplines are less common than in STEM disciplines (where purpose-built laboratories have been at the heart of major advances in the physical, chemical, biological, materials, and medical sciences as well as engineering), but are emerging in the footsteps of leaders at MIT (Senseable City Lab, Media Lab, etc.), UCL (Urban Lab), and Singapore-ETH's Future Cities Lab. The core objectives of such laboratories include the investigation of current urban systems and processes and the creation of urban innovations capable of translation into the field. 'Field sites' extend beyond the laboratory to provide settings that are critical to many research disciplines such as ethnography, geography, ecology, and sociology as well as planning and design that study urban environments, but represent research and experimental settings that are more difficult to control in relation to boundaries and capacity to manipulate and measure influencing factors [18]. In place-based experimentations, 'City as Lab' [19] and Urban Living Labs (ULLs) [20] have emerged as a design (in terms of process, and organisation) and a setting for real-world trialling, 'stretching and conforming' of institutional spaces for new solutions, new relations, and co-creation of innovations that relate to the governance of urban sustainability transitions [21]. There are those who question whether urban experiments that seek pathways capable of urban transformation can emerge from a traditional laboratory setting: what we term 'urban experimentation *sensu stricto*' in the strict sense. The reasoning being that 'they need to take place in real-world settings that cannot be tightly controlled, involve societal actors in initiating and carrying out the experiments (necessitating co-creation or co-production, rather than only experts), and focus on learning about what the system ought to be and how to achieve such transformation' [22] (p. 212). Urban Living Labs have emerged in response to this—what we term 'urban experimentation *sensu lato*'—in the broad sense. The impact of urban living labs as governance mechanisms to urban transformations can be traced through the ways they generate planning ideas and alternatives that lead to the adaptation of plans and to social and policy learning by doing and testing at the setting of the urban living lab. Being 'protected spaces' where innovative ideas are safe to fail and safe to change and adapt also further empowers actors/stakeholders and their partnerships to mobilise ideas and to transfer concepts from ideation to implementation. As governance mechanisms, urban living labs are fruitful grounds for policy innovation and planning adaptation [23].

ULLs also have their weaknesses in relation to their role in driving urban innovation and especially in the way they lack a connection to urban policy and statutory planning. Many ULL experiments remain as iconic and stand-alone projects with no direct or implicit connection to urban agendas and urban programs, often making the case for experimentation to occur in the shadow of unsustainable or conventional urban planning and policy processes/programs. Specific weaknesses include an inability to substitute alternative (new) development options that encompass land use and building mixes, densities, streetscapes, mobilities, blue-green infrastructures, resident socio-demographics, etc. and assess differences in performance outcomes. ULLs are typically 'bespoke', where urban designs, fabrics, and technologies are tailored to a particular political and geographic context, where project boundaries are predefined, limiting examination of project scale issues and where opportunities for comparative spatial and temporal analysis are absent or problematic. This extends to issues of socio-technological experimentation, project governance, management, and levels of stakeholder engagement and roles (e.g., involving the extent of co-design and co-production). In a recent book that reviews ULLs, Marvin et al. [20] (p. iii) concluded that 'despite the experimentation taking place on the ground, we lack systematic learning and international comparison across urban and national contexts about their impacts and effectiveness. We have limited knowledge on how good practice can be scaled up to achieve the transformative change desired.'

The question this poses is whether it is possible to envisage smart processes and platforms capable of more realistically examining scenarios that represent a spectrum of potential future urban systems and living environment options, applicable in a sufficient variety of geographical (physical, climatological) landscapes/contexts, social, built forms, and urban fabric contexts that lend themselves to being subject to experimentation and comparative performance assessment?

3. Methodology

3.1. A National Ecology of Urban Innovation: Model Specification and Gap Analysis

Is it possible to envisage an experimentation platform relevant to urban systems at all scales that enables policy and governance innovation as well as socio-technical design innovation (e.g., evaluation of alternative urban development project options, infrastructure technologies, land use, and population mixes, etc.) that can be subject to quantitative and qualitative analysis and research synthesis, results from which hold the promise of more rapid evidence-based policy and implementation and transformational change? This is the challenge to which we now turn as we outline the concept and implementation of a unique national urban research and development platform developed in Australia, capable of significant scale-up locally and globally.

We have envisaged an ecology of innovation for transformative built environment research and development (R&D) capable of addressing a number of the weaknesses/deficiencies of individual urban labs and ULLs discussed above. We have identified a critical gap in the national ecology of urban innovation that inhibits a level of engagement, collaboration, research synthesis, experimentation, and trialling new models of governance necessary for accelerating change. That gap is a national urban research and development platform that links multiple leading urban labs into a network capable of synchronous collaboration on key transition projects that enables best practices, learnings, and approaches to be transferred and adopted quickly. This platform supports transdisciplinary R&D capable of tackling difficult and seemingly intractable urban 'projects' ranging from large scale strategic metropolitan planning to municipal precinct redevelopment where there is significant NIMBY push-back involving multiple stakeholder groups and across the project lifecycle (vision/concept, co-design, detailed design, co-production, management). This urban experimentation gap is highlighted in Figure 2.

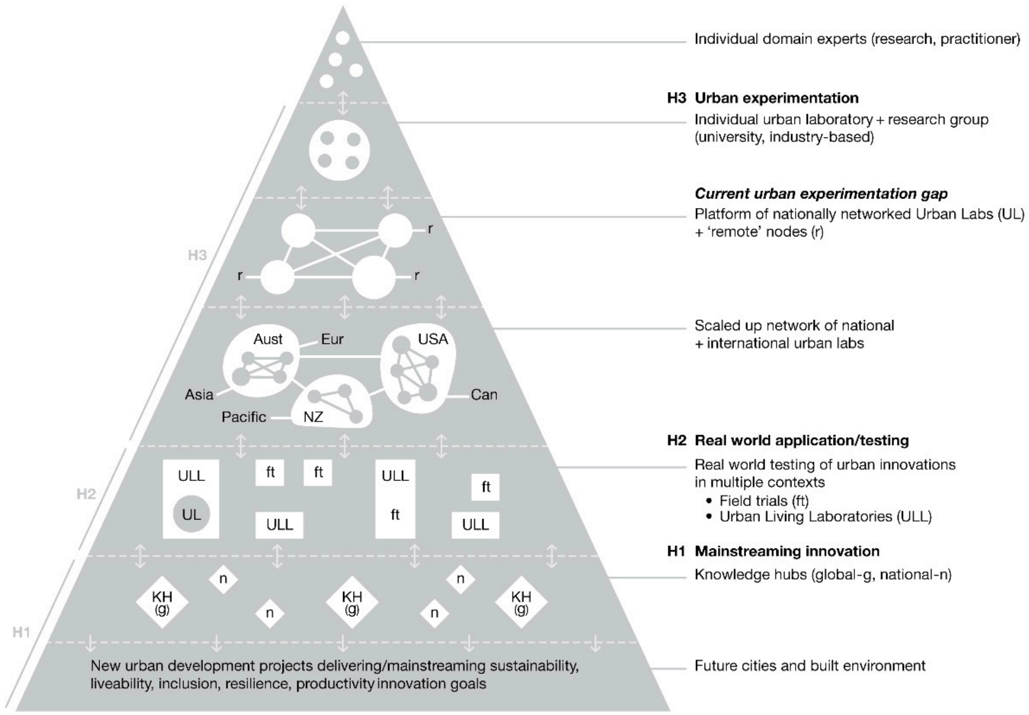

Figure 2. The role of urban experimentation in the innovation ecology of cities and the built environment and how *iHub* platform can facilitate and enable it.

Individuals with knowledge and expertise permeate the entire innovation ecology of advanced nations, from independent researchers to project team members to the overarching governance membership for a jurisdiction. Networks and collaborations are key to increasing speed and success in urban based projects—silos are not, yet the latter are characteristic of much strategic and applied research in built environment and design disciplines. Even the individual urban laboratories that are appearing in this field are predominantly siloed. As a recent review comments: 'Australia's labs rarely work across disciplinary, geographic and sectoral boundaries' [24] (p. 42). The identified collaboration gap in urban experimentation is capable of being addressed nationally (as well as internationally) via a networked platform of urban laboratories with the capacity of being able to collaborate seamlessly and synchronously on common, challenging problems or opportunities. Metcalf's Law [5] (p. 173) suggests that the value of networks increases exponentially in proportion to the number of contributing nodes. The rapid growth in computational, visualisation, and broadband technologies enables many of the collaborative and experimental engagement processes that are a feature of ULLs to be realised in a hybrid digital–human collaboratory ('collaborative-laboratory' [25]). What we have termed the *iHUB National Urban Research and Development Platform (iHUB)* is the focus of the section that follows. The justification of *iHUB* that has driven its development includes:

- assembling a critical mass of expertise nationally (and globally) to focus on a major urban project;
- enhancing inputs of new ideas across the project life cycle, especially early-stage strategic visioning, concept development, sketch planning, and preliminary performance assessment—a critical phase for innovation that is often foreshortened, resulting in

'business as usual' outcomes; supports information integration across the life cycle of a project; it flattens the curve in the time required to deliver more sustainable and actionable outcomes;
- enabling more extensive engagement across multiple stakeholder groups, blending top down and bottom approaches; and
- providing for more integrated systems thinking, synthesis, analysis, and visualisation of alternative future scenarios; utilising leading toolkits that enable multi-factor, cross-domain, and cross-scale spatial modelling as well as meshing qualitative and quantitative analyses.

With the onset and global spread of the COVID-19 pandemic, the capacity of *iHUB* to more productively and safely support new ways of collaborative working represents a major additional benefit of this digital platform.

3.2. iHUB Concept, Functionality, Specifications, and Implementation

Evidence from a recent OECD survey across research fields [26] shows that although digitalisation has become a pervasive activity, the transformation is uneven across disciplines and sectors, and is influenced by factors such as organisational practices, experience, skills and capacity, availability of data and analytical tools. The built environment and design (BED) disciplines do not feature among the 16 fields of research that were a focus of this global study, another indication that they are in 'catch-up' mode scientifically.

The *iHUB* concept had its genesis in an earlier digital era. The early 1980s saw the emergence and spread of microcomputers with ever increasing capacity across all sectors including planning [27]. The emergence of higher speed telecommunications in the early 1990s enabled the development of networked computing on dedicated wide area digital networks (WANs) capable of operating at speeds comparable to local area networks (LANs) of approximately 2 Mb/s (compared to typical public ISDN networks running at 64 Kb/s at that time [28]). A research collaboration between Telecom Research Laboratories and CSIRO (two of Australia's largest research organisations at that time) created the Centre of Expertise in Geographic Information Systems and Analysis, whose objective was to develop prototype applications for emerging high-speed networks capable of supporting distributed synchronous computing in the architecture, engineering, and construction sector. A product for enabling synchronous design (CAD) collaboration on a distributed virtual private 10 Mb/s network was first demonstrated in July 1993 between researchers and practitioners in design offices in Melbourne and Sydney, providing a platform for the creation of virtual project teams involving leading companies such as Lend Lease on major projects [29,30]. A new model for real time distributed collaboration in the BED field had been established, albeit narrowly focused at that time and requiring expensive equipment and highly specialist technical support.

Fast forward 25 years, and with the advent and widespread diffusion and falling costs of high-speed public Internet, high performance computing, high-capacity storage, high-definition computer graphics, and high-quality videoconferencing, the stage was set for the creation of a national platform of networked urban research laboratories—a national urban collaboratory: the *iHUB*. Over this period, there have been increasing calls for better urban governance [31,32] and better urban planning [33–35]. Both are linked, and both require mission-scaled urban innovation capacity that a national R&D facility can deliver (see [36]).

An AUD$1.8 million grant was provided by the Australian Research Council (ARC) in January 2019 to a consortium of five leading university urban research centres located in Australia's four largest capital cities (Swinburne University of Technology and Monash University, Melbourne; University of NSW, Sydney; University of Queensland, Brisbane; and Curtin University, Perth) to develop the *iHUB*: a nationally networked digital information platform for collaborative Built Environment and Design R&D. The ARC provides competitive funding for critical research infrastructure considered 'necessary to deliver high quality research and innovation outcomes, to improve national wellbeing and to enable Australian researchers to address key national and global challenges' [37]. Universities provide matching funds required for laboratory fit-outs necessary to accommodate the equipment and associated R&D activities (see Figure 3). The universities also provided the technical personnel (IT/AV, networking, software and security) and the research leadership required to specify, source, install, and test the equipment within each laboratory, but more critically across the national platform of laboratories to ensure synchronous operation. These activities occupied 18 months from 2019 to 2020.

Figure 3. Network of urban laboratories resident on the *iHUB* National Research and Development Platform (top left-to-right: Monash, Curtin Universities; bottom left-to-right: Swinburne, University of NSW).

The *iHUB* is a readily scalable state-of-the-art network of laboratories that comprise four integrated layers (Figure 4):

1. The *infrastructure layer* requires a commonality of computing, networking, visualisation, and audio-visual systems and software that delivers a platform for real time distributed collaboration across all labs in the network. The common technical specifications for the laboratories are given in Table 1. Each laboratory is connected by Australia's Academic and Research Network (AARNet), delivering speeds of 1 Gbps or higher, supporting high resolution visualisations and big data transmission.
2. The *data layer* initially established in the *iHUB* will operate as a distributed data system that draws on proprietary databases developed and managed within university partner organisations and their affiliated networks as well as those with open access managed by state governments, the federal government, and the Australian Urban Research Infrastructure Network (AURIN; https://aurin.org.au/). Established in 2010, AURIN provides researchers in urban studies with access to diverse sources of data, an ability to integrate data across subject areas and interrogate that data to answer their research questions. The surge in data acquisition, processing, and representation during the last decade, however, has not been adequately addressed by built environment and design (BED) professions insofar as the considerably improved data outputs are not routinely captured/accessed and converted to design inputs.
3. The *software layer* represents a significant repository of computer-based tools developed by the *iHUB* university partners who have all been involved in one or more

of the three national 'urban' Co-Operative Research Centres (CRCs including CRC Spatial Information, Low Carbon Living and Water Sensitive Cities), as well as those available as open source. Computer modelling of built environment performance has generally been undertaken in a piecemeal manner, as one-off grants to individual research groups or within CRCs, or consultancies working on (often domain- specific) projects, with the resultant tools rarely being applied to important urban planning and design issues and never integrated. They are extensive, but currently exist as separate tools, mostly new prototypes awaiting wider exposure on actual projects (e.g., via integrated assessment in research synthesis projects [38,39]). With subsequent hardening, and where strategically important, they have the prospect for being developed as integrated multi-factor models (see Figure 5). There is an opportunity here for the network partners to respond to repeated calls for creating a capacity for integrated urban systems analysis and modelling: a digital workbench containing analytical models that are interoperable.

4. The *engagement layer* requires a highly adaptable (laboratory) space capable of hosting up to 30 people in any configuration relevant to the engagement and decision-making processes that are in focus: 'break-out spaces' around four Pods for more exploratory discussions; 'lecture' mode and 'boardroom' mode, for more structured engagement and decision-making (see Figure 6). Each Pod is mobile, enabling different configurations of 'digital pin-up' spaces to be created for any combination of exhibition or interactive meeting spaces, hosting both presentations and real-time visualisations of urban analytics simultaneously. The engagement layer is where the major benefits of the *iHUB* network are delivered: imagine politicians, planners, developers, architects, engineers, social scientists, and citizens being able to gather in a room to make collective decisions based on real-time data analytics. In such a facility, key stakeholders, experts, and end-users could probe '*what if* . . . ' scenarios using 3D simulation to demonstrate the effects of competing urban development possibilities. The collected diverse disciplinary expertise and interests could debate alternative speculations around future cities together and consensually decide appropriate courses of action.

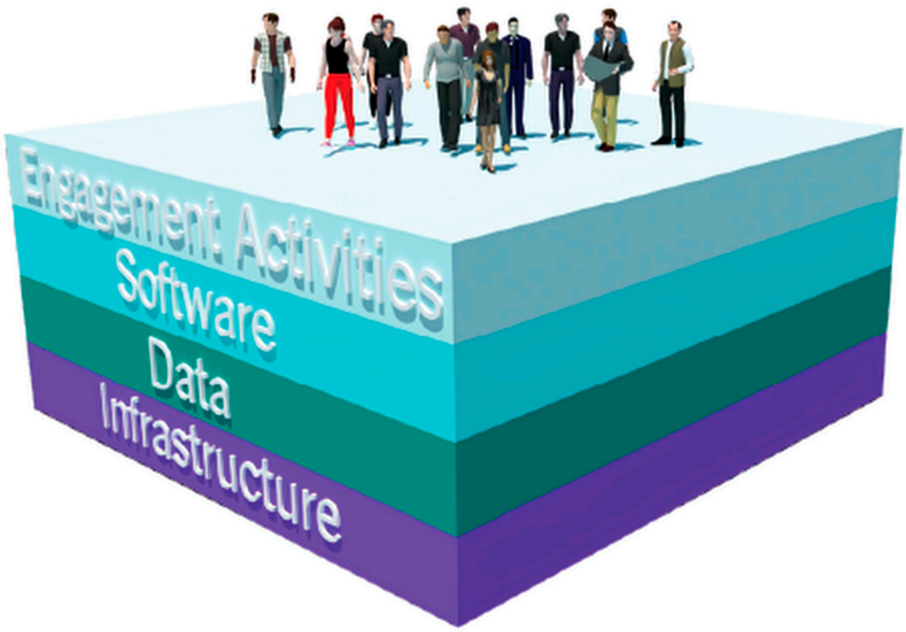

Figure 4. iHUB facility layers.

Table 1. Technical Specifications for *iHUB* Laboratories and National Platform.

iHUB Computer Units to Drive 4 Visualisation Display 'Pods' 4 × Dell Alienware Aurora R9 Desktop units 9th Gen Intel(R) Core (TM) i9 9900K 32 GB Dual Channel DDR4 at 2933 MHz 512 GB M.2 PCIe SSD (Boot) + 2 TB 7200 RPM SATA NVIDIA(R) GeForce(R) RTX 2080 SUPER(TM) 8 GB GDDR6
iHUB Research Computer Dell Alienware Aurora R9 Desktop 9th Gen Intel(R) Core (TM) i9 9900K 64 GB Dual Channel DDR4 at 2933 MHz 512 GB M.2 PCIe SSD (Boot) + 2 TB 7200 RPM SATA NVIDIA(R) GeForce(R) RTX 2080 SUPER(TM) 8 GB GDDR6
Display Cluster 4 × NEC C651Q 65″ Display (4K 3840 × 2160) Screens are set up in portrait mode with curved mount • Total resolution 8640 × 3840 • Total pixel 33 M
Video Conferencing Capability 4 × PolyCom Poly Studio USB video conferencing bar mounted on top of screen cluster (per pod) 120-degree FOV (field of view) UHD 2160p (4K) ultra-high definition resolution Automatic people framing & speaker tracking 5× zoom/EPTZ (electronic pan tilt and zoom) 2 × HuddleCamHD Tracking PTZ Camera whole facility video conference
Audio-Visual Control 10″ AV User Control to configure the different room modes Ceiling mounted PTZ (pan tilt zoom) camera's Ceiling mounted beamtracking microphones Banks of Display Screens (PODs) control
Electronic Whiteboard SMART Board®MX series 4K Ultra HD (3840 × 2160) resolution Silktouch™ frictionless surface 20 Simultaneous touch points & 2 pens
System for Remote Collaboration SAGE2 (http://sage2.sagecommons.org/project/introduction/)
Ultra High Speed Communication Network AARNet (https://www.aarnet.edu.au/)

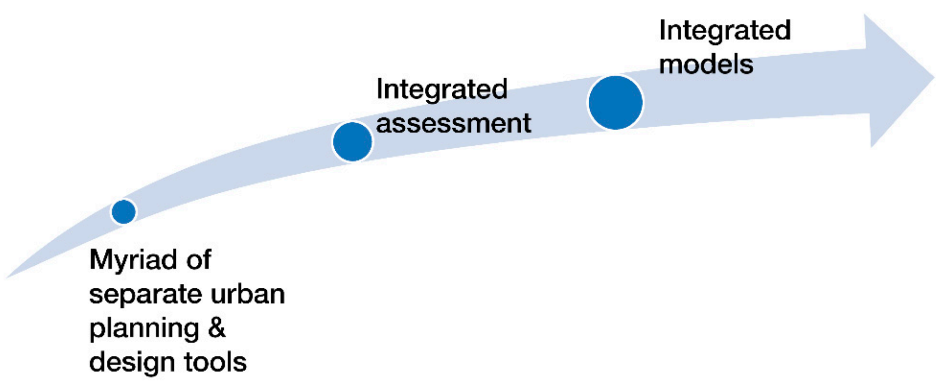

Figure 5. A trajectory for urban analytics.

Figure 6. Swinburne *iHUB* Urban Laboratory engagement configurations (left-to-right: breakout mode, boardroom mode, lecture mode) (Source: Rendered images by Awnili Shabnam (based on material supplied by Professor Marcus White, Professor Mark Burry, and Tianyi Yang, Swinburne University of Technology).

Overall, *iHUB* represents a new platform for future urban governance, linked to metropolitan policy making, plan-making, and place-making, albeit some distance from current practice. For the first time, future urban scenarios for any of the major capital cities can be tested for likely consequences in real-time. This enables all stakeholders to be present, sharing information and a wide assortment of insights with a fluency and timeliness only made possible by the confluence of rapidly improving computing technology and processes, and combining these with distributed urban analytics, design software, and facilitated engagement in an urban collaboratory.

4. Results and Discussions

The results and value of the *iHUB* platform lies in its many applications that can enable multiple forms of urban experimentation and decision-making capable of triggering and accelerating transformative change in cities. The *iHUB* website contains a video presentation of the national platform, highlighting its capacity to drive built environment innovation (https://www.swinburne.edu.au/research/facilities-equipment/ihub-network/).

What follows is a catalogue of 'use cases' envisaged for the platform once it is fully operational in 2021. For ease of presentation, they are arranged according to the target topic and leadership group best positioned to initiate and facilitate the multi-stakeholder, multi-disciplinary urban collaboratory.

Academic research on sustainable urban transitions. There are multiple challenges that urban research needs to address on this topic, as outlined in the Introduction. Following an extensive series of national workshops and synthesis, the Australian Academy of Science and Future Earth Australia [40] published an agenda for a 10-year strategy to enable urban transformations for the nation's cities, regions, and neighbourhoods. Its major objectives and recommendations are summarised in Table 2. To engage most effectively with these, *iHUB* provides a national engagement platform capable of assembling and connecting the trans-disciplinary expertise, data, and analytics required to deliver much of this agenda, especially the challenge of the integrated applied research necessary to help Australian industry and government deliver on the UNSDGs and Paris climate commitments.

It also provides an advanced collaboration and management platform currently lacking in national research organisations with geographically distributed partners (e.g., CSIRO, Co-operative Research Centres, National Environmental Science Programs); federal and state government agencies (e.g., Infrastructure Australia; Offices of State Government Architects); NGOs (Green Building Council of Australia); national professional associations (e.g., Planning Institute of Australia) and industry associations (e.g., Property Council of Australia), effectively a new 4-layered 'facility' that can be installed in any forward thinking, innovative multi-locational organisation. Its first application as a research management platform is in the recently announced National Environmental Science Program NESP2:

Sustainable Communities and Waste Hub (https://www.miragenews.com/149-million-commitment-to-environmental-science/), a seven-year collaborative research program involving *iHUB* partners across Australia, headquartered at the University of NSW in Sydney. It will be involved extensively in supporting stakeholder engagement, project initiation and management, and information dissemination; maximizing communication while minimizing the need for travel.

Table 2. Strategies and recommendations for urban systems transformation.

Vision for Action: Build coherent visions for our cities and regions to achieve SDGs
1. Enable a national framework and process to achieve the SDGs in cities and regions
2. Embed stakeholder and civil society participation in urban knowledge, policy and practice
Enable Innovation: grow a national urban innovation system to achieve sustainability visions
3. Create a national institutional framework to link urban and regional research, policy and practice communities
4. Establish a national network of innovation hubs to empower local urban and regional innovation across Australia
Connect Knowledge: invest in information and communication infrastructure to share urban and regional knowledge
5. Establish and sustain an integrated urban and regional knowledge platform for data analysis and exchange across the research, policy and practice communities
6. Support new capability to connect diverse knowledge across sectors, disciplines, and professions to achieve urban and regional visions
Build Capacity: train and employ a new cohort of urban and regional researchers and practitioners skilled in transdisciplinary visioning, knowledge and implementation
7. Establish a national program to expand researcher and practitioner capability for knowledge exchange across urban and regional research, policy and practice communities
8. Fund a national program to embed researchers and practitioners within relevant organisations linked to knowledge production and the SDGs

Source: Summarized from [40] with permission.

National settlement planning. In federal systems such as Australia, there are tensions concerning the role each tier of government has in national settlement planning. There have been increasing calls for a national vision and plan for Australia's future settlement system that focuses on the fast growing capital cities and their relationship with regional centres located within a 200–300 km radius of their CBDs [33,34]. As the Australian Academy of Science and Future Earth [40] (p. 13) have stated: 'Encouraging a productive balance of our national population between major centres and the regions has proven difficult (...) without a coherent national strategy to manage our population distribution and development of urban areas, we will be at a distinct competitive disadvantage'. *iHUB* could host such a national, mission-scale initiative/project. Similarly, *iHUB* and its stakeholder network could become a key platform for assembling the Australia State of Environment Report on Human Settlements and the Built Environment (https://soe.environment.gov.au/download/reports) that consistently highlights the lack of data and analytics capacity available for this important task that is undertaken every five years.

Metropolitan planning. Typically there are three levels of metropolitan planning and management: strategic direction setting (what should future cities look like in 30–50 years time?); metropolitan plan-making (how to plan now to produce better cities in 30–50 years time?); and how to successfully implement and adapt strategic plans at the municipal level? *iHUB* represents a catalyst for improving integration of planning concepts, strategies, and practices emerging at all levels, typically through the lenses of different ministries and departments (overcoming horizontal disconnects). This is of particular significance to future cities as climate change intensifies urban impacts (heat, flooding, sea level rise, extreme bushfires) necessitating better integration of land use and transport planning with 'blue-green' planning, often relegated to a second-tier role in plan-making [41]. Here, new urban analytic tools can demonstrate the clear benefits of alternative urban development scenarios adopting nature based solutions (https://watersensitivecities.org.au/solutions/water-sensitive-cities-scenario-tool/). There is often also a disconnect in vertical integration of city planning between state and municipal governments and local communities; linkages and dialogue readily forged via *iHUB* engagement, collaboration, and decision-making processes represent opportunities for evolution of new governance models for urban planning and development.

Precinct planning and design. Precincts are the building blocks of cities and a key scale for urban planning interventions in greenfield, brownfield, or greyfield contexts. At this scale, a greater level of engagement can be injected into the urban design and assessment processes for neighbourhood regeneration, given the significant levels of developer-led redevelopment occurring across established areas of cities. This involves both strategic and statutory planning processes as they relate to neighbourhood change, and where the urban transition challenge is from NIMBY to YIMBY. There is a growing list of precinct assessment tools capable of use in design charettes well suited to an iHUB environment involving the full range of stakeholder groups: local government planners, property developers, and community residents, delivering more rigorous and rapid project reviews [42]. Aligned to this is research synthesis, a process pioneered by Brown et al. [38] that assembles the relevant experts and practitioners together with their toolkits to address challenging next generation precinct planning projects (the results of which are clearly evident in envisioning sustainable infrastructure, and public realm for Australia's largest—240 hectare—brownfield redevelopment in Melbourne [39]). A process applicable nationally as well as internationally [43], but 'powered' by a 21st century digital platform such as *iHUB*.

The *iHUB* platform is also well suited to the more common and contentious smaller neighbourhood scale redevelopment projects occurring across the ageing but occupied greyfield suburbs of most fast growing cities. Whether urban renewal and retrofitting projects involve public sector housing [44,45] or clusters of private sector housing with high redevelopment potential [46], the planning, design, and community engagement processes are similar. Design-led projects are ideally highly iterative, and having the capacity to install a single ('remote') iHUB 'pod' on the project site with synchronous connection to a design 'lab' or 'studio' over high speed Internet can enhance and accelerate the engagement, design, and construction process significantly.

Sustainable building design and development. The building process is another interdisciplinary multi-party/stakeholder enterprise requiring teamwork and collaboration among geographically distributed parties. Building Information Modelling (BIM) enables integrated design across all stages of a building project: concept, sketch design, detailed design, construction/assembly, and delivery of a physical asset as well as a digital twin, which becomes the platform for facility management. *iHUB* can host all phases of this process, with the building project manager being the 'conductor' of a more effective team process, capable of introducing inputs from members of the 'orchestra' in a synchronous fashion, according to the 'script', or introducing improvisation as required (e.g., rapid assessment of a sketch design option; resolving 'clashes' in detailed design such as occurs between architectural and engineering layers; substitution of material products to reduce the environmental footprint; client 3D walk-throughs of interiors to inspect proposed fit-outs, fittings, finishes, and furnishings). In the residential building sector, there is uncertainty about consumer preferences when it comes to understanding trade-offs between dwelling typology, quality, urban location, and cost for different client groups. All elements that can be readily simulated in *iHUB* 'experiments' involving a range of socio-demographic/customer groups; creating knowledge critical to more informed housing supply decisions as well as to urban planners needing to better understand resident attitudes to different urban densities and future urban landscapes.

Community engagement. There has been extensive literature on public participation in urban planning over the past 50 years that traces its progress from being largely absent, to an essentially tokenistic ritual, to one where there are a number of levels of participation (from 'involvement' to 'collaboration' to 'empowerment and control' [47] (https://www.iap2.org.au/). Whether seeking engagement related to metropolitan or neighbourhood scale future plans or projects, there is an increasing palette of digital tools that can be used to enhance visioning, planning and design processes, and their outcomes [48,49]. Community engagement for collaborative decision-making is one of the prime applications envisaged for *iHUB*: promoting citizen-centric planning.

5. Conclusions

This paper has articulated the need for a national urban research and development collaborative platform and has developed an initial implementation linking urban research laboratories located in Australia's four largest capital cities. It is a network capable of rapid scale-up to other urban research labs in Australia as well as internationally, or to smaller 'remote' sites supported by a single *iHUB* 'Pod' (suited to smaller research groups, municipal planning departments, etc.).

The current innovation ecology for urban transition is necessary but not sufficient to drive a sustainable transformation of our cities in the 21st century, within a time frame that can minimise if not avoid the environmental, economic, and social threats now clearly evident. Progress is too fragmented/siloed, and slow. Smart sustainable development is needed, meshing advances in digitalisation with innovative sustainable planning, design, governance, and engagement processes.

A national ecology of urban innovation enabled and mediated by an *iHUB* platform benefits policy, planning, and governance in Australia in multiple ways:

- A capacity to support strategic as well as applied R&D; become a training ground for the next generation of urban researchers and practitioners; and a feeder for Living Laboratories and Knowledge Hubs as well as recipient of their outputs;
- An ability to stimulate and demonstrate the added value of experimentation and collaboration on mission-oriented challenges involving Built Environment and Design disciplines and the Architecture, Engineering and Construction sector in particular (e.g., enhancing quality of outputs, time to solution etc), although it has wider application to urban projects at all scales that seek to be transformative;
- Cost benefit and RoI compared to other national collaborative models for a similar sector of industry (e.g., UKCRIC, an AUD$500+ million UK Collaboratorium for research on infrastructure and cities; https://www.ukcric.com/);
- Potential for framing/scoping and applying new models of urban governance that can better demonstrate horizontal and vertical integration of all stakeholder groups that should be involved in charting the future of cities, their critical infrastructures, and their working and living environments. The emergence of alternative private sector 'smart city' business models for urban planning and development is a recognition that cities and their built environments are big business in the 21st century. Alphabet's Sidewalk Labs project on Toronto's waterfront redevelopment has been recently abandoned after three years in the face of significant public opposition [50,51]. A better model is needed for delivering urban innovation and transformation.

A national urban ecology for innovation activated by an *iHUB* collaborative platform can become a critical institutional space and enabling space for mission oriented urban research, providing the knowledge infrastructure needed for more strategic planning for the next generation of urban development in Australia and globally that must address the mounting set of challenges listed in the introduction to this paper. *iHUB* represents a perfect partner for mission-oriented projects, not only in an era of COVID-19, but beyond, as common practice.

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