The role of ‘urban living labs’ in ‘real-world testing’ robotics and autonomous systems.

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***Abstract*—As the world rapidly becomes more urban, alongside opportunities to enhance social life, cities face pressing challenges in terms of; congestion, air pollution, food production, provision of care services, infrastructural upgrades, and increased demands for energy, water and mineral resources. Concurrently, technological advances are beginning to extend robotics and autonomous systems technologies (RAS) outside of controlled laboratory environments. In response to these trends, new collaborations are emerging in the form of RAS urban living labs (RAS-ULL) – sites devised to design, test and learn from social and technical RAS innovation in real time. In the U.K., and internationally, there is growing policy advocacy for governments to support development of these experimental spaces to refine and de-risk RAS applications, but this goal is challenging for urban governance bodies and regulators protecting the public realm. This paper analyses RAS-ULLs from three emblematic national-urban contexts leading in urban robotic experimentation – the U.K., U.S.A. and Japan – adopting a focus on delivery robots, service robots and maintenance robots. Developing a comparative analytical framework, we demonstrate the significant potential to learn from international RAS-ULL exemplars to enable extended field experiments in U.K. cities and build strategic capacity around a proactive policy landscape for responsible urban robotic experimentation.**

Keywords— Urban living labs, experiments, field robotics, regulation, human-robot interactions, social acceptability.

I. Introduction

In the context of contemporary urbanism, there is mounting interest amongst researchers, technologists and policymakers in re-shaping city infrastructures, services and aspects of social life through advances in robotics and autonomous systems (RAS) [1–7]. The possibilities for RAS restructuring of the city reflect significant developments in materials engineering, communications, artificial intelligence and machine learning, entwined with data analytics and socio-technical platforms that use robotics to augment and re-bundle service infrastructures [8]. This potential is reflected in national economic strategies, for example Japan’s Robot Revolution Initiative, which seeks ‘to make Japan the world’s most advanced robot showcase and achieve a society in which robots are utilised more than anywhere in the world’ [9], and in proposals for a new generation of utopian city projects – such as the proposed mega-city of Neom in Saudi Arabia [10], or Toyota’s plans for a smaller-scale Woven City in Japan [11]. Alongside these flagship visions and initiatives, there is growing pressure for existing cities to open up public spaces for new RAS experiments and applications, as emerging technologies reach the point of potential real-world application. Set against existing policy and regulatory frameworks, experimental RAS Urban Living Labs (RAS-ULL) are being advanced as an explicit form of intervention to trial, de-risk and improve new technologies, build public support, and appraise the possibilities, realities and implications of this new phase of urban restructuring.

To date, RAS systems have been primarily developed in tightly regulated contexts such as research laboratories [4]. As recognised by the U.K. Government Office for Science White Paper ‘Technology and Innovation Futures’, there is a need to support RAS, and particularly robotic, applications outside of these controlled environments and ‘establishing further ‘test beds’ to experiment with emerging technologies in carefully supervised real-world systems, like cities’ [13]. Creating living laboratories ‘provide[s] a sharp focus to aim developments from basic RAS scientific research into first prototype demonstrators’ [12] because urban test beds are ‘more open and complex, less predictable, and… where [human-machinic interactions] are less controlled’ [3]. However, creating these spaces and conditions raises critical challenges for urban decision-makers [3, 12]. RAS infrastructures are expensive, and there are technical, trust, safety and ethical challenges in bringing emerging technologies into complex and dynamic urban spaces alongside humans. Decisions will need to be made about the granting of licences to R&D organisations and selective changes in regulation. New collaborations between universities, private companies and public agencies will be needed to undertake and learn from experiments. The wider public will need to be actively involved in understanding the purposes and potential of testing in their local communities, as well as how experimental findings will be used [3].

Urban living labs (ULL) are sites devised to design, test and learn about the wider issues involved in the application of new technologies in real world conditions [14]. While the notion of ULL is broad, at its core is the idea that urban sites can provide a learning arena within which the co-creation of innovation can be pursued between research organisations, public institutions, private sector and community actors [15]. ULL have 3 key characteristics:

1. *Experimentation*: The testing of new technologies, solutions and policies in real world conditions, often in highly visible ways.
2. *Participation and user involvement*: Co-designing, collaboration and engagement with many stakeholders is often central to the experimental approach.
3. *Evaluation of actions and impact*: Systemic processes of evaluation underpins the ability of ULL to facilitate formalised learning and upscaling of applications.

For leading practitioners and advocates, ULL are seen not only as a means through which to gain experience, demonstrate and test technologies, but also as a step towards developing responses that have the potential to be scaled up across different domains, in order to support more systemic change. Notwithstanding the current Japanese service-industry context, real-world experiments in autonomous vehicles (AVs) and unmanned aerial vehicles (UAVs underway in a number of U.S. states, and trials of delivery 'bots' in the U.K. city of Milton Keynes, there remains relatively little analysis of what types of ULL might be needed for different aspects of RAS applications. Most ULL have to date been focussed on innovations in digital technologies, smart cities and urban infrastructure. Consequently, there is an urgent need to consider how such robotic-ULLs might address key deficits and challenges in the UK to accelerate the application of RAS, and review how international experience might provide lessons for effective urban experimentation and application domestically [3].

II. METHODOLOGY

To develop the evidence base that can support RAS-ULLs as a means for 'responsible urban innovation' [4], a systematic and comparative analysis of their rationales and interests, operations, outcomes and challenges is required. To contribute to this agenda, this article adopts an internationally comparative analytical approach to examine; (i) the design and enabling conditions for RAS-ULLs, (ii) the processes through which RAS-ULLs are implemented, and (iii) the effectiveness with which, and learnings from how, these interventions reshape and augment city infrastructures and services, societal practices, and urban governance. We develop a robust framework for analysing these three dimensions comparatively across three global contexts that are leading in robotic urban experimentation – Japan, U.S.A. and U.K. The research focuses on ULL that are experimenting with (i) service robots, (ii) delivery robots, and (iii) maintenance robots. We have selected these RAS innovations on the basis that they; are already being trialled in semi-public and public realms, seek to reshape and augment the delivery of urban services and operation of city infrastructures, challenge existing urban policy frameworks and regulation, and will involve interaction with citizens when deployed in cities. The case studies were researched through a combination of documentary review, and approximately 50 one-hour long semi-structured interviews conducted with policymakers, robotics firms, and professionals working with and/or employing robots in these locations. These data were subsequently coded and thematically analysed.

III. ANTICIPATED OUTCOMES & IMPLICATIONS

Whilst this research is ongoing, we anticipate that this project will highlight how robots are being materialised in specific 'early mover' cities, and that their processes and effects will be uneven. We seek to appraise the extent to which these RAS innovations become 'embedded' into, shaped by, and themselves shape infrastructures and urban services, social relations and policy arrangements [16] in order to inform future research priorities. To date, these initiatives are limited in material extent, with a focus on visions more than application, and discrete trials rather than holistic urban robotic restructuring [7]. This research will highlight; (i) how different social, technical and political contexts create conditions for, limit, and lead to contestations around urban robotic experimentation, (ii) the necessary coevolution of spatial planning, urban regulation, urban design and human-robotic interaction in the future 'infrastructuralisation' of robotically augmented cities, and (iii) the need to link national innovation priorities for future cities and industrial strategy to pressing urban issues, to responsibly create a social context for RAS applications in contemporary cities.

REFERENCES

[1] V. Del Casino Jr., "Social geographies II: robots," Progress in Human Geography, vol 40(6), pp.846-855, 2016.

[2] R. Macrorie, S. Marvin and A. While, "Robotics and automation in the city: a research agenda", Urban Geography, DOI:10.1080/02723638.2019.1698868, 2019.

[3] S. Marvin, A. While, M. Kovacic, A. Lockhart, R. Macrorie, "Urban robotics and automation: Critical challenges, international experiments and transferable lessons for the U.K.", UK-RAS Network White Paper, 2018.

[4] M. Nagenborg, "Urban robotics and responsible urban innovation", Ethics and Information Technology, 2018, DOI:10.1007/s10676-018-9446-8.

[5] L. Royakkers and R. van Est Just Ordinary Robots: Automation from love to war, London: CRC Press, 2015.

[6] I. Tiddi, E. Bastianelli, E. Daga., M. d'Aquin, E. Motta "Robot-city interaction: mapping the research landscape – a survey of the interactions between robots and modern cities," International Journal of Social Robotics, DOI:10.1007/s12369-019-00534-x

[7] A. While, S. Marvin and M. Kovacic, "Urban robotic experimentation: San Francisco, Tokyo and Dubai" (in press).

[8] M.R. Frank, L. Sun, M. Cebrian, H. Youn, I. Rahwan, "Small cities face greater impact from automation," Journal of the Royal Society Interface 15: 20170946. DOI:10.1098/rsif.2017.0946, 2018.

[9] Robot Revolution Realization Council, "The Prime Minister in Action", retrieved from http://japan.kantei.go.jp/97_abe/actions/201501/23article3.html, January 2015.

[10] O. Hassan, "Artificial intelligence: Neom and Saudi Arabia's economic diversification from oil and gas," The Political Quarterly. DOI:10.1111/1467-923X.12794, 2020.

[11] J. McCurry, "Toyota unveils plan to build 'city of the future' near Mount Fuji", The Guardian, 7 January 2020.

[12] Lloyd's Register Foundation, "Foresight review of robotics and autonomous systems: Serving a safer world", Report Series No. 2016.1, October 2016.

[13] Government Office for Science (2017) p.10 "Technology & Innovation Futures 2017", London: Government Office for Science, p.10.

[14] S. Marvin, H. Bulkeley, L. Mai, K. McCormick, Y. Voytenko Palgan, (Eds) Urban living labs: Experimenting with city futures, New York: Routledge, 2018.

[15] C. Liedtke, M.J. Welfens, H. Rohn, and J. Nordmann, "Living lab: user-driven innovation for sustainability," International Journal of Sustainability in Higher Education 13(2), pp.102-118, 2012.

[16] S.L. Star, "The ethnography of infrastructure" American Behavioral Scientist, 43(3), pp.377-391, 1999.