Front. Eng. Manag. 2018, 5(3): 407–410
https://doi.org/10.15302/J-FEM-2018204

COMMENTS

Peter E.D. LOVE, Lavagnon A. IKA, Giorgio LOCATELLI, Dominic D. AHIAGA-DAGBUI

Future-proofing 'Next Generation' infrastructure assets

© The Author(s) 2018. Published by Higher Education Press. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0)

Infrastructure remains the backbone of an economy. The G20s Global Infrastructure Hub forecasts a need of more than US $ 4 trillion for infrastructure funding in the world by 2040 (Jessop, 2017). Yet, paradoxically, the poor performance of infrastructure projects and their lack of resilience and adaptability seem to have become the norm. The reasons for such a record of poor performance on infrastructure projects are numerous. Changes in scope that occur during the construction of assets because of complexity, uncertainty and mismanagement are some of the usual culprits. These changes of scope, for example, may not only result in an increase or decrease in capital expenditure (CAPEX) (Love et al., 2017; Invernizzi et al., 2018), but also influence the ability to provide added-value during operations and maintenance. Increases or decreases in CAPEX, adversely impact an asset owner's ability to provide effective and efficient goods and services as well as taxpayers, contractors and their supply chains' profitability. As a result, this hinders an asset owners' ability to secure infrastructure that is both resilient to unexpected events and adaptable to changing needs, uses or capacities (Love et al., 2017).

There have been countless reports and studies undertaken to espouse the need to 'future proof' the delivery and cost-effectiveness of infrastructure assets. For example, the United Nations has set the making of cities and human settlements inclusive, safe, resilient and sustainable as one of its Sustainable Development Goals for developing countries. Future-proofing is the critical process of anticipating future events, changes, needs or uses to prepare appropriately, minimize impact and capitalise on opportunities (Masood et al., 2015). While such work has been used to support the establishment of much needed public policy and provide direction to acquire the benefits of enacting a 'future-proofing' strategy, a fundamental question remains unanswered once the decision-to-build has been made: 'How can asset owners deliver their new infrastructure assets cost-effectively and ensure they are robust, resilient and adaptable? ' This question is the focus of this commentary.

Prevailing evidence indicates that current strategies, processes, methods and technologies used to deliver, maintain and operate infrastructure assets in Australia are not able to guarantee cost-effective 'future-proofed' assets. With calls for a commensurate need to shift toward the digitisation of built environment's practice being made, an urgency to re-examine the actual activity, events, and the nature of work and its context is needed so that the issue of 'how' to leverage effective new tools, techniques, and frameworks can be undertaken. Put simply, infrastructure assets are still being delivered and managed under the auspices of a 20th Century paradigm and an urgent shift is required to operate in the 'digital era' to accommodate the changing nature of work, demographic patterns, markets, sustainability and climate change. Thus, there is a need for more symbiosis between the digital and the physical backbones of infrastructure.

By some estimates, the cost of non-resilience in Australia is too high: The economic cost of unmitigated climate change represents 0.5% of GDP by 2020, rising to 1.2% in 2050 (Garnuat, 2011). A significant proportion of Australian infrastructure assets are privately owned or operated on a commercial basis by the private sector. Thus,

Received May 25, 2018

Peter E.D. LOVE (✉)
School of Civil and Mechanical Engineering, Curtin University, Perth, Western Australia 6845, Australia
E-mail: p.love@curtin.edu.au

Lavagnon A. IKA
Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, Ontario KIN 6N5, Canada

Giorgio LOCATELLI
School of Civil Engineering, University of Leeds, Leeds LS2 9JT, Yorkshire, United Kingdom

Dominic D. AHIAGA-DAGBUI
School of Architecture and Built Environment, Deakin University, Geelong, Victoria 3220, Australia

in supporting national security, economic prosperity and community well-being, it is imperative that the public and private sector infrastructure providers work collaboratively and cooperatively to ensure that the 'Next Generation' of infrastructure is deisgn and constructed in a timely manner and at minimum expense. In addition, a project's life cycle, and its ability to be of value into the future for human-kind needs to be considered. Underpinning the next wave of infrastructure investment is the availability of the finance to fund projects; thus, financial and non-financial incentives and risk sharing will need to be re-examined, particularly project delivery methods as they will need to support newly digitised processes. There is need to engender and enact changes to existing policies and practice toward infrastructure development in Australia in order to become competitive in world markets.

The 'Next Generation' of infrastructure assets will be subjected to increasing degrees of complexity, extreme competition and uncertainty with respect to the outcomes of climate change, availability of resources and the emerging *disruptive* nature of digitisation. Regardless of their origin, these factors indirectly stimulate an unprecedented rate of change, which asset owners and built-environment professionals need to be prepared to embrace. An inability to engage and embrace such change will further inhibit their ability to deliver infrastructure assets on budget, to schedule, to their specified quality and safety. Despite public policy identifying 'what' needs to be undertaken to ensure infrastructure resilience, a disconnect exists between 'what' and 'how' assets can be 'future-proofed.' Fundamentally, there has been a paucity of research that has examined how processes should be re-engineered to accommodate 'future-proofing' as part of an assets life-cycle performance improvement. Yet the research that has been undertaken has tended to develop new policies and frameworks that have been simply superimposed on top of existing processes that are unable to cope with the complexities and nuances needed to provide resilient and adaptive assets. The upshot in this instance is that there is an increasingly likelihood for infrastructure assets to be delivered unsuccessfully, as cost and schedule growth are experienced which may also lead to safety and environmental issues occurring (Love et al., 2016), not to speak of benefit shortfalls.

The performance and productivity of infrastructure asset delivery is a vexing problem for asset owners in Australia, as it has been observed that, on average, 48% of them fail to meet their baseline time, cost and quality objectives (Carvel Group, 2013). Well-known Australian projects that have attracted the attention of the popular press due to cost overruns include the Melbourne's Southern Cross Railway Station, Sydney Cross City Tunnel, Brisbane's RiverCity Motorway and the M7 Clem Jones Tunnel.

Australia is becoming uncompetitive in the design and delivery of its infrastructure projects; its hospitals are 62% and its schools 26% more expensive to build than in other countries that form part of the Organization for Economic Co-operation and Development (OECD) (Bowditch, 2013; Davies, 2014). In Sydney, the cost of the 33 km-long WestConnex Motorway, which includes a 13-km tunnel has come under the spotlight, as it has been estimated that it will cost a staggering $350 million per kilometre. Yet in Paris, the 'Duplex A86', which is a 10-km road tunnel, cost a mere $226 million per kilometre to construct. A plethora of reasons have been put forward explaining 'why' Australia is more expensive than other OECD countries in its delivery of infrastructure projects, which include (Regan et al., 2015):

- prescriptive tendering processes, which require financing to be secured prior to the submission of bids for construction;
- multifarious subcontracting that creates unnecessary layers of management;
- over-specification, or redundant performance, which inhibits a contractor's ability to provide innovative alternatives;
- ineffective scoping of projects (scope creep) and low adoption of digital engineering, which can contribute to an excessive number of 'changes orders' being experienced during construction; and
- an unjustified increase in salary levels in jobs that have not experienced an increase in productivity, in response to rising salaries in related professions that have undergone growth in labor productivity. This scenario has been the subject of intense debate, as the construction industry is deemed to be a laggard when compared to other industrial sectors of the economy.

The aforementioned issues are the 'tip of the iceberg,' as the Australian construction industry's ailments are deeply embedded in a change-averse culture, with established power structures and relationships that impede learning and innovation being adopted. Despite intense periods of introspection and several 'Royal Commissions into the Building Industry', which have called for reforms to be undertaken (Gyles, 1992; Cole, 2002), performance and productivity improvements have been, at the best, marginal and generally confined to Occupational Health and Safety improvements. The emergence of the digital era and the call to adopt *Building Information Modeling* (BIM) and smart technologies are disruptive enablers to improve the performance of an asset over its life-cycle. However, the absence of integrated structures and technology receptive processes and an inability to respond to the change required to effectively implement them has hindered their potential to deliver the performance improvements that have been widely espoused. If the 'Next Generation' of infrastructure assets are to be 'future-proofed,' then powerful transformational change is needed in the processes of delivery and management.

Such change was recommended by Egan (1998) in the UK almost 20 years ago and stipulated that the construction industry needed to adopt lean production techniques and set a number of targets for cutting costs, improving predictability and eradicating defects. The absence of incentives, collaborative working practices, and public clients focusing on lowest price rather than value for money has failed to make the change required to revolutionize the UK construction industry (McMeekan, 2008). In attempting to address their performance woes, an array of Australian companies have mimicked their UK counterparts and implemented lean techniques and its variants. Pockets of excellence can be found in Australia, but on the whole lean techniques have not been widely embraced or been significantly successful (Heaton, 2015). While the lean philosophy has merits, it has been applied in a piecemeal manner by organisations without understanding the underlying dynamics that have contributed to causing the problem they seek to address. Its adoption simply adds another unproductive layer to the problems that the construction industry has to deal with (Green, 2011).

The absence of a theory, for example, that explains 'Why' and 'How' infrastructure projects experience cost overruns has contributed to thwarting the construction industry's adeptness to change (Love et al., 2016). There has been an overreliance in explaining the cause of cost overruns as 'independent' rather than 'interdependent' causal influences and as such the views of those participants involved in the chain of events that lead to their occurrence are generally limited to specific issues at certain points in time. Thus, the determination of causation is narrowly and superficially defined, which potentially leads to innate bias being reported. Furthermore, there has been a tendency to pinpoint a single 'root cause' for a cost overrun and then suggest that an intervention will change and/or prevent its occurrence. However 'the root cause' often represents the place at a point in time where a researcher decided to complete their investigation. The use of singular, independent-cause identification approaches has led to inappropriate risk assessments being developed throughout the delivery process; the interdependency between causal variables has still not been effectively considered.

Cost overruns seldom occur as a result of a stand-alone cause (Love et al., 2016). Even though they may superficially appear to be different, the causes of poor performance in infrastructure projects are interwoven and form a complex network. The same goes for over-simplification of complexity in the identification of the causes of cost overruns. There is, therefore, a need to move beyond simply developing lists or ranks of independent factors to understand dynamic connections between various causal factors and how they materialise during the course of a project's life. Failure to adequately understand and accommodate this inherent interdependency can lead to the development of sub-optimal solutions for 'future proofing'. Ultimately, the cost to construct an infrastructure asset influences the extent of 'future proofing' that can be undertaken. Thus, there is a need to challenge contemporary thinking that surrounds cost overrun causation by ensuring explanations are grounded in situated practice so emergent theory reflects reality. Instead of reducing complexity, let us embrace complexity for more infrastructure resilience and adaptability!

Acknowledgements The authors would like to acknowledge the financial support provided by the Australian Research Council (DP160102882). In addition, the authors would like to thank the Editors of Frontiers of Engineering Management (FEM) and reviewers for their constructive and insightful comments, which have helped improve the quality of this manuscript. We would also like to thank Professor Hanbin Luo and his colleagues at Huazhong University of Science and Technology and the Editorial staff, in particular, Mrs Yong Li, of FEM for their wonderful support.

References

Bowditch G (2013). Australia's infrastructure cost conundrum. http://theconversation.com/australias-infrastructure-cost-conundrum-19037, 2018–5-18

Caraval Group (2013). A review of project governance effectiveness in Australia. http://www.infrastructureaustralia.gov.au, 2018–5-18

Cole J T (2002). Productivity and Performance in the Building and Construction Industry. Royal Commission into the Building and Construction Industry, Melbourne, Victoria, Australia

Davies A (2014). Why is infrastructure so bloody expensive? Crikey. https://blogs.crikey.com.au/theurbanist/2012/02/16/why-is-infrastructure-so-bloody-expensive/, 2018–5-18

Egan J (1998). Report of the Construction Task Force. London: HMSO

Garnuat (2011). Garnuat Climate Review.http://www.garnautreview.org.au/update-2011/garnaut-review-2011.html, 2018–5-21

Green S D (2011). Making Sense of Construction Improvement. Oxford: Wiley-Blackwell

Gyles R V (1992). Royal Commission into Productivity in the Building Industry. Final Report, Volumes 1–10, Sydney, New South Wales, Australia

Heaton (2015). Is Australia missing out on lean construction? Construction News. https://sourceable.net/australia-missing-lean-construction/, 2018–5-18

Invernizzi D C, Locatelli G, Brookes N J (2018). The need to improve communication about scope changes: Frustration as an indicator of operational inefficiencies. Production Planning and Control: 1–14

Jessop S (2017). The G20's Global Infrastructure Hub forecasts a need of more than US $ 4 trillion for infrastructure funding in the world by 2040. https://www.reuters.com/article/us-global-infrastructure-report/world-needs-94-trillion-spent-on-infrastructure-by-2040-report-idUSKBN1AA1A3, 2018–5-21

Love P E D, Ahiaga-Dagbui D D, Irani Z (2016). Cost overruns in transportation infrastructure projects: Sowing the seeds for a probabilistic theory of causation. Transportation A. Policy & Practice, 92: 184–194

Love P E D, IraniZ, Smith J, Regan M, Liu J (2017). Cost performance of public infrastructure projects: The nemesis and nirvana of change-

orders. Production Planning and Control, 28(13): 1081–1092
Masood T, McFarlane D, Parlikad A, Dora J, Ellis A, Schooling J (2015). Toward future proofing of UK infrastructure. In: Proceedings of ICE, Infrastructure Asset Management. 3(1): 26–41
McMeekan R (2008). Egan 10 years on. www.building.co.uk, 2018–5-18
Regan M, Smith J, Love P E D (2015). Better infrastructure procurement for public private partnerships: An Australian perspective. In: Proceedings of 5th International/11th Construction Specialty Conference June. Vancouver