



Task Force 7
Infrastructure Investment and Financing

Policy brief

A NEW VISION FOR INFRASTRUCTURE: GOVERNANCE AND VALUE NETWORK INTEGRATION THROUGH FEDERATED DATA SPACES AND ADVANCED INFRASTRUCTURE SERVICES FOR A RESILIENT AND SUSTAINABLE FUTURE

SEPTEMBER 2021

Michael Bühler Konstanz University of Applied Sciences (Lead author)
Thorsten Jelinek Taihe Institute (Core team)
Konrad Nübel Technical University Munich (Core team)
Norman Anderson CG/LA Infrastructure
Glenn Ballard UC Berkeley
Mark Bew PCSG Limited
David Bowcott Aon Risk Solutions
Kai Broek Capgemini Invent
Gerd Buziek Esri Deutschland GmbH
Isabel Cane OECD
Raffaele Della Croce OECD
Harry Dimitriou University College London
Dale Evans Project13
Jeff Herriman Ascentage Group, LLC
Volker Kefer Verein Deutscher Ingenieure
Isidora Kosta World Economic Forum
Thomas Maier G20 Global Infrastructure Hub
Ibrahim Odeh Columbia University
Rafael Sacks Technion Israel Institute of Technology
Thomas Schmid Bavarian Construction Industry Association
Hajnalka Vaagen Norwegian University of Technology

T20 NATIONAL COORDINATOR AND CHAIR



T20 CO-CHAIR



T20 SUMMIT CO-CHAIR



Università
Bocconi
MILANO





ABSTRACT

Twenty-first century infrastructure needs to respond to changing demographics, becoming climate neutral, resilient and economically affordable, while remaining a driver for development and shared prosperity. However, the infrastructure sector remains one of the least innovative and digitalised, plagued by delays, cost overruns and benefit shortfalls (Cantarelli et al. 2008; Flyvbjerg, 2007; Flyvbjerg et al., 2003; Flyvbjerg et al., 2004). The root cause is the prevailing fragmentation of the infrastructure sector (Fellows and Liu, 2012). To help overcome these challenges, integration of the value chain is needed. This could be achieved through a use-case-based creation of federated ecosystems connecting open and trusted data spaces and advanced services applied to infrastructure projects. Such digital platforms enable full-lifecycle participation and responsible governance guided by a shared infrastructure vision. Digital federation enables secure and sovereign data exchange and thus collaboration across the silos within the infrastructure sector and between industries as well as within and between countries. Such an approach to infrastructure technology policy would not rely on technological solutionism but proposes the development of open and trusted data alliances. Federated data spaces provide access to the emerging data economy, especially for SMEs, and can foster the innovation of new digital services. Such responsible digital governance can help make the infrastructure sector more resilient, efficient and aligned with the realisation of ambitious decarbonisation and environmental protection targets. The European Union and the United States have already developed architectures for sovereign and secure data exchange.¹



CHALLENGE

Infrastructure is a priority for the G20 and has led to the establishment of the Global Infrastructure Hub, the Global Infrastructure Connectivity Alliance, G20 Principles for Quality Infrastructure Investment and the G20 InfraTech agenda. The uptake and large-scale implementation of recommendations of these initiatives by G20 member states can still be improved. The G20's focus on investment finance needs to be complemented by an engineering design and delivery focus. Implementation visions and bankable infrastructure pipelines that bridge political cycles and are not prone to political risk are inadequate or lacking. In the absence of flow-efficiency, common infrastructure practices are still determined by sequential planning and discipline silos.

As the process of infrastructure development and delivery is very complex, the best practice approach is to decompose the overall task into smaller components which are understandable and manageable. This approach, certainly, is a basic principle in our economy, based on division of labour. The process of infrastructure development and delivery in most countries is therefore a stepwise phase process, where the next phase begins as soon as the preceding phase is closed. The level of granularity of planning increases with each phase until it is brought to a constructible planning state. Such linear consecutive processes are called “*waterfall models*” (Benington, 1983).

Each phase is executed independently and has its particular composition of stakeholders. Often, project leadership also changes across different phases. The process is so segregated that a common understanding of the entire process does not exist among the majority of relevant stakeholders, and the process itself regularly loses sight of the desired outcomes. As a result, problems in the process are usually addressed in a specific phase or even within a sub-phase, while the entire process model is hardly questioned. This approach is seen as a common way of avoiding change.

Consequently, such complex multi-stakeholder processes tend to lead to a multi-dimensional principal-agent dilemma in which asymmetric information policies predominantly increase local efficiencies in the functional silos of the project. However, the optimisation of the benefits of the overall system – or even more, the interests, needs and requirements of the infrastructure asset users – move entirely out of sight.

To understand the root causes, problems must first be addressed and related to the specific phase or component of infrastructure development and delivery. It is then necessary, but not sufficient, to develop recommendations at the level of the specific problem; it is not sufficient since the overall problem of asymmetric information cannot be solved at the specific level of granularity. Moreover, the problem of slow planning processes or administrative hurdles will not be solved simply by accelerating the planning processes nor merely by reducing administrative hurdles. Instead, a system change is required.

In other industry sectors, we see that value creation evolves through trusted networks of collaboration, so-called *value networks* (Allee, 2009). The underlying multistakeholder and multidisciplinary ecosystems increasingly become the backbone of our digitalised world,



mobilising specialised actors that share values, governance principles and common goals. *Value networks* are interactive, integrative and agile, and focus on people's needs. In infrastructure development and delivery, however, such value chain integration is lacking (Ochieng et al., 2017).

We can conclude that the *global infrastructure gap* (Moser, 2016) cannot be eliminated by taking only the financial aspects into account; the whole value chain of development and delivery has to be transformed into an integrated system, a *value network*, focused on end user needs and requirements as well as a much broader approach to value creation. The root cause is the existing fragmentation and lack of cooperation within the infrastructure value chain. Sequential (waterfall) planning and resource-efficiency (focusing on silos) are still common practice, compared to the necessary flow-efficiency and agility (across the *value network*), preventing a more impactful realisation of broader goals.



PROPOSAL

Traditionally, value is created within the boundaries of an enterprise or a value chain. In contrast, digital platforms challenge incumbents by changing how a value network consumes and provides products and advanced services. Digital platforms, which utilise an ecosystem of autonomous agents to co-create value, have the potential to overcome the existing fragmentation of the infrastructure value chain (Hein et al., 2020). The sharing and reusing of data and pioneering technologies – such as cloud/edge computing, artificial intelligence, digital twins, Internet of Things (IoT)/smart sensors, 5/5.5G and distributed ledgers – can help to integrate the value chain and thereby enhance infrastructure productivity, efficiency, and affordability. Such platform-driven integration can also spur innovation through ecosystem participation and accelerate the achievement of the broader objectives of decarbonisation, resilience (OECD, 2021) and human-centred infrastructure (Samans and Davis, 2017).

The digital transformation of the infrastructure sector will increase investment efficiency and sustainability, since in general, the digital transformation positively impacts the localisation and achievement of the UN Sustainable Development Goals (ElMassah and Mohieldin, 2020). Moreover, digital transformation will enable transparent criteria for ESG (environmental, social and corporate governance) investment, which will be a driving force in the future. The advantages and progress of state-of-the-art cyber-physical systems in infrastructure, including advancements in sustainability and decarbonisation, is well documented (Anumba and Roofigari-Esfahan, 2020). However, despite significant progress – e.g., by applying Building Information Model (BIM), a decision-making instrument that already leverages various digitalisation tools and applications – major challenges remain for the actors involved in infrastructure projects (Hetemi et al., 2020). Therefore, this federated platform proposal has the potential to function as a transformative marketplace between the public and private sector, in particular for SMEs.

This policy brief proposes digital platforms for infrastructure as *mobilisation* and *learning platforms* to address and overcome the limitations of the existing platform economy (Hagel, 2015, 2008). *Mobilisation platforms* bring existing expertise together to create shared outcomes. They enable and make multistakeholder co-creation processes more effective throughout the entire infrastructure lifecycle. Mobilisation is needed not only to integrate the various silos of infrastructure delivery into a single process and project, but also to create entire infrastructure ecosystems that are open to outside parties who can build complementary products and advanced services. Mobilisation platforms can and should evolve into *learning platforms*. Learning platforms provide the level of *agility*, *resilience* and *antifragility* that is needed for continuous improvement, innovation and adaptation to a rapidly changing environment (cf. Passos et al., 2018; Taleb, 2014). Modelling digital platforms as *learning platforms* will help to coordinate and accelerate the digitalisation of infrastructure and the transformation of infrastructure production and delivery methods (Sawhney et al., 2020).

Utilising the concept of *mobilisation* and *learning platform* as an underlying value and structure of digital platforms, the potential upside of infrastructure digitalisation can be



tremendous. Digital platforms for infrastructure can help to take holistic perspectives on infrastructure development (Figure 1). For the classification, a holistic model (Wilber, 2018) is used. Importantly, digital platforms can enable the transformation towards *Infrastructure 4.0*, but they won't intrinsically realise those benefits or resolve the challenges associated with traditional infrastructure. Considering their dual-use and disruptive character, advanced technologies can even be part of or worsen humanity's challenges (Jelinek, 2021; Jelinek et al., 2020). This is why governments introduce new laws and regulations that aim to make advanced technologies and digitalisation secure and safe while serving the needs of society. Hence, this policy brief is premised on the assumption that governance and therefore some degree of coordination and regulation are crucial for a successful transition toward *Infrastructure 4.0*.

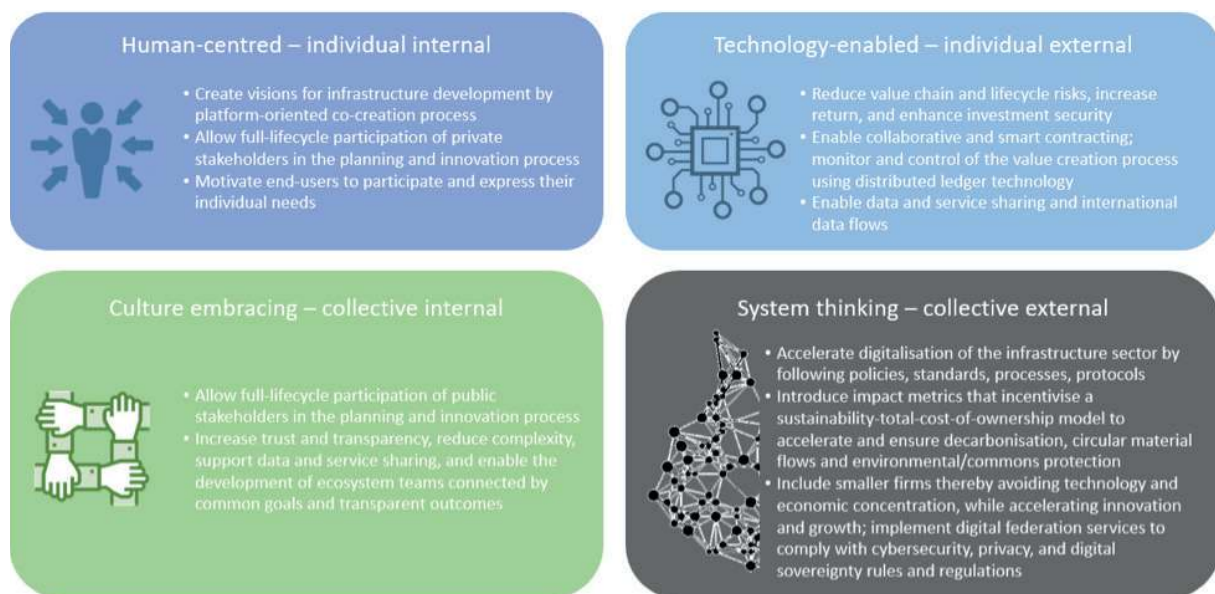


Figure 1: Holistic perspectives on infrastructure development

MOBILISATION AND LEARNING PLATFORMS FOR INFRASTRUCTURE

The path of working towards the creation of a digital platform for the design, construction and operations of built environment assets creates a tremendous opportunity. The development process could not only improve the symmetry of knowledge amongst the stakeholders, but also lead to the convergence of existing systems within the value chain into a *mobilisation and learning platform*. Platform creators and participants should take into consideration five dimensions of this iterative process of “systems convergence and platform emergence” to harness the benefits of such transformation process, as illustrated in Figure 2: governance, design, protocols, implementation and use cases. Each dimension is presented in detail in the subsections below.

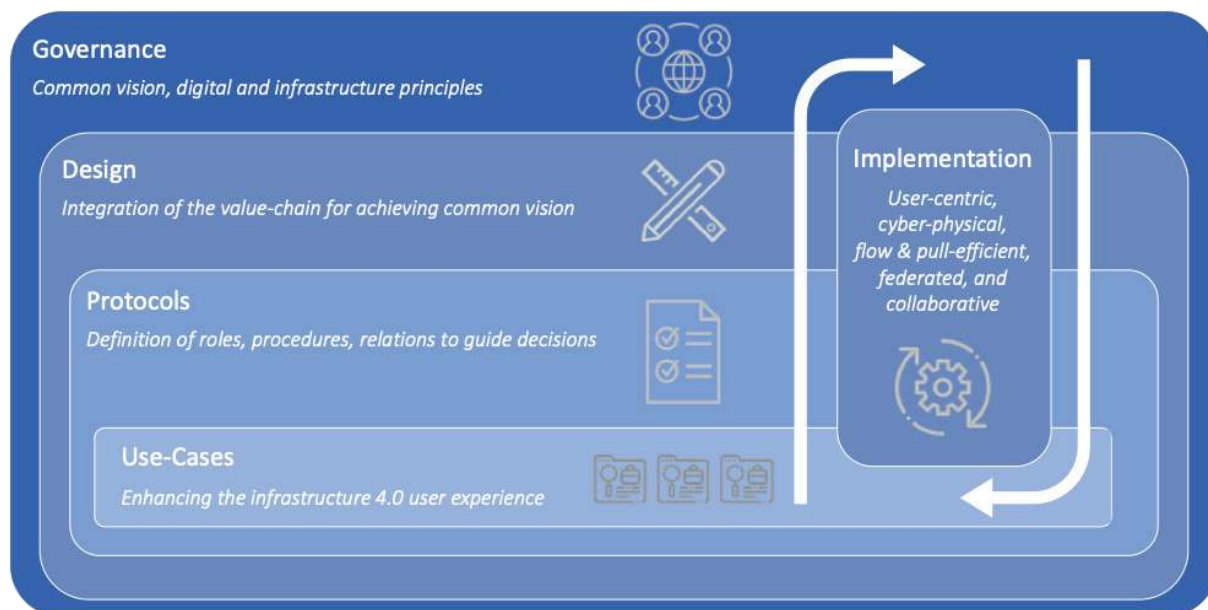


Figure 2: Five dimensions of implementing a mobilisation and learning platform

Governance

As indicated above, technology itself won't solve the limitations of traditional infrastructure. On the contrary, the OECD (2017) identifies infrastructure mainly as a governance challenge. However, a digital platform doesn't simply operate without governance but already emulates a governance structure that determines rules as well as facilitates and regulates the interaction of participants and the sharing of data and data services (cf. Hagel, 2015). This is why governance is the most crucial dimension of planning, developing and operating a digital platform for infrastructure. If governance can be construed as the possibility for collaboration directed by common principles as well as a space that limits human autonomy, a platform provides the opportunity to restrict unwanted behaviour and enable or incentivise desirable behaviour for the purpose of reaching common goals (WEF, 2020).

The OECD (2017) lists a set of infrastructure governance challenges that need to be addressed to avoid the existing *infrastructure governance gap* (Kenny, 2007) merely being replicated through a poorly designed *digital governance structure*. According to the OECD, a sound infrastructure governance framework requires (1) a shared strategic vision for advanced infrastructure service needs; (2) a strategy for mitigating integrity risks; (3) a common method of infrastructure delivery that balances political, societal, economic and strategic interests; (4) a sound regulatory design and approach; (5) a consultation process to meet the demands of the general public; (6) policy coordination across the different levels of government; (7) a long-term infrastructure strategy that ensures both affordability and assets performance; (8) data for fact-based decision-making; and (9) infrastructure systems that are resilient and adapt to new circumstances. In addition, infrastructure governance should also incentivise and reinforce environmental and social sustainability standards.

For the purpose of developing a digital platform, those overarching governance requirements, which are mainly targeted at governments, need to be translated into more specific



rules across three different domains of hard and soft governance, including (1) the digital infrastructure and data governance domain, (2) the infrastructure project life cycle domain, and the (3) legal, regulatory and industrial standards domain. From a platform design perspective, *digital federation services* (Anan et al., 2003) function as the specific technological and digital representation of those different governance requirements and manifest as *digital platform protocols* (Silva et al., 2019). The term federation emphasises the governance aspect of *mobilisation* and *learning platforms*. Based on the design and specification of those protocols, a platform can therefore enforce a desired degree of value chain integration through information transparency and the possibility of collaboration based on shared data spaces and data services. Platform governance can therefore represent the aspects of *integrated project delivery* (Fischer et al., 2017).

Importantly for the development and operations of such a federated digital platform, the policy brief recommends mapping the core regulations, standards and processes of infrastructure delivery as well as the regulatory requirements concerning cybersecurity, privacy and data sovereignty (see Figure 3). Both sets of *federation services* – one for infrastructure, the other for the digital infrastructure and data ecosystem – constitute the core governance framework of an emerging digital platform for infrastructure delivery. While cloud providers and hyperscalers² will naturally focus on *federation services* regarding the trustworthiness of the digital infrastructure and data ecosystem, the *federation services* concerning the virtualisation of the development, design, construction and operations processes for the built environment assets still need to be developed.

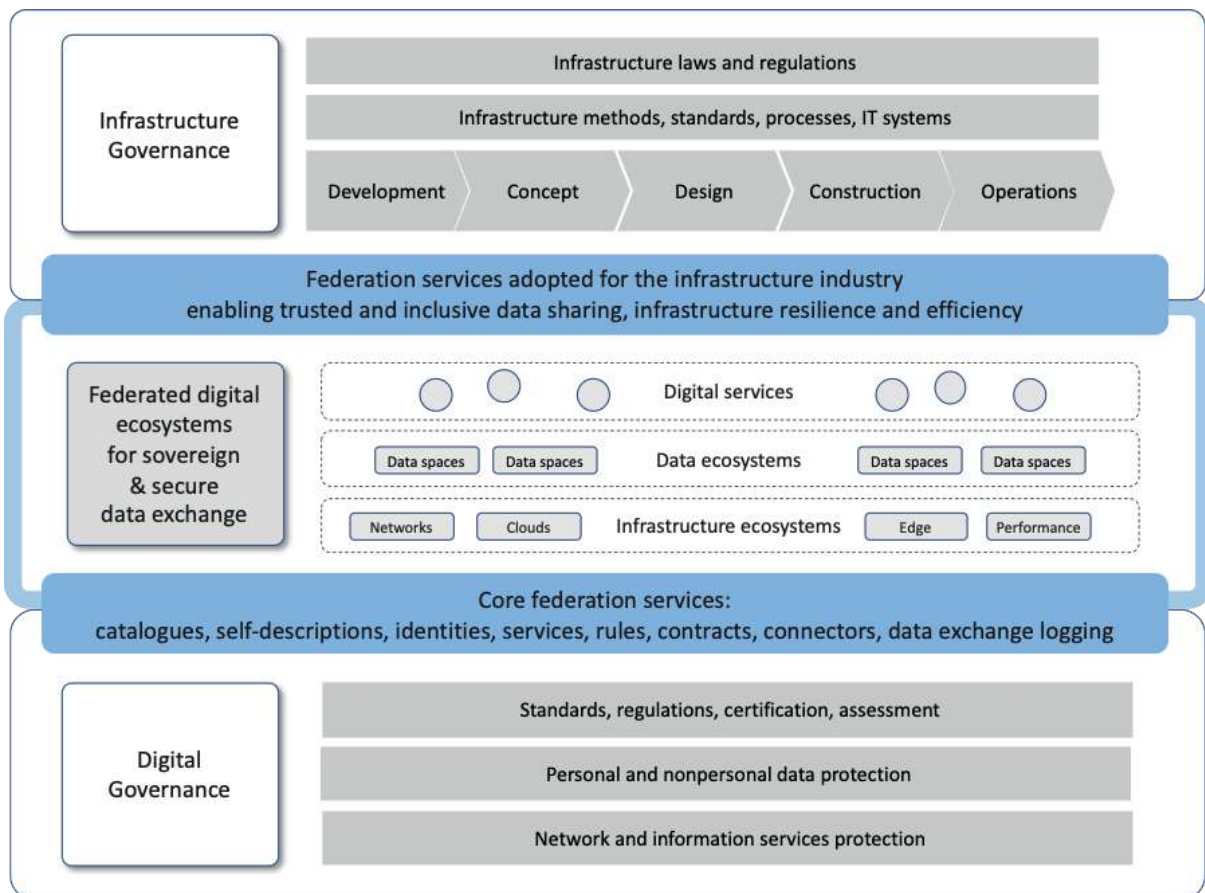


Figure 3: Governance structure of the federated digital platform for infrastructure



The risks associated with technological dependency on global hyperscalers are among those that will be addressed by federated platforms (e.g., the US's NIST Cloud Federation Reference Architecture and the EU's Gaia-X Federation Services), and the implementation of these platforms will affect all dependent technological areas including sustainable infrastructure. The following objectives regarding digital sovereignty will enable novel business models and incentivise inclusive development by fostering an equitable platform ecosystem for infrastructure:

1. Avoid “lock-in” to a particular technology, with resulting technological and commercial dependency on the provider;
2. Reduce the risk of services being modified or terminated in an uncoordinated manner by the provider;
3. Share selected data and digital services to different ecosystems, while ensuring ownership, data and privacy protection;
4. Gain access to open and trusted data spaces to maintain control over the development of new digital services within an interoperable and trustworthy digital and data infrastructure.

As presented in the following, such a governance structure is not realised through a traditional top-down systems integration approach. On the contrary, this comprehensive platform is realised in a flexible, bottom-up approach by focusing on scalable and marketable use cases that eventually become part of an infrastructure ecosystem.

Design

The design of an infrastructure platform starts with developing the governance framework outlined above by taking into consideration hard and soft governance requirements. Hard governance relates to existing laws and regulations that tend to determine design choices. Soft governance requirements mainly relate to standards, processes and legacy systems. Their manifestation within the new platform is an iterative process evolving over time. Hence, to manage the platform development in an agile way, the platform design should be centred around the development of use cases, which also leaves space for exploration and experimentation.

A platform tends to grow along its most effective use cases first and then gets shaped by the ecosystem that surrounds it. Therefore, prioritised use cases have to be identified, developed and implemented. Use cases should be (or must have the potential to become) business cases, since only competitive and marketable concepts will foster their adaptation and scalability. The platform develops with the development and adaptation of its best business cases (Raj and Raman, 2017). The scalability of use cases is achieved by structuring, standardising, modularising and connecting with existing solutions. Promising business models could already be created using existing data and employing exponential technologies. Design decisions have been made concerning the degree of intelligent automation, data sharing and collaboration across organisational boundaries. Such a design approach allows for relocating innovation to an emerging ecosystem and a huge network of outside firms. However, use cases must be identifiable within the infrastructure process and life cycle.



Furthermore, to overcome the value chain fragmentation and lack of collaboration within the infrastructure industry on public-sector projects, a multi-stakeholder as well as a multi-phase perspective must be taken and an integrated project team including the project owner must be formed (Zhang et al., 2013). The learnings from the UK's National Digital Twin initiative (West, 2021), two decades of building information modelling (Smith, 2014) and experience of other industry sectors should be considered, including procurement of hospitals and highways using the *integrated project delivery* approach (Kent and Becerik-Gerber, 2010).

While the platform's digital architecture should be based on the principles of *security and privacy by design/default* to ensure trustworthiness, the infrastructure use case architecture should be based on the principles of *collaboration and flow-efficiency by design*. The collaborative framework must include the early involvement of all stakeholders and needs to be outcomes-based. It must measure metrics of operational results to validate success or failure of outcomes, including traditional metrics such as output performance in term of cost, time, scope and quality but also other indicators such as resilience, environmental standards and social impact. The collaboration framework needs to include an effective dispute resolution mechanism as well as pain, gain and risk sharing (Lloyd-Walker et al., 2014).

Although the focus of this policy brief is on public infrastructure, including public-private partnerships, the policy brief considers any infrastructure as being part of the commons (Ostrom, 1990). The benefits of infrastructure investments could be more evenly distributed by closing the digital divide (Siddarth, 2021) and by applying, for instance, more inclusive COVID-19 recovery policies (Kroner et al., 2021) enabled through open public consultation and participation processes in the early stage of infrastructure development (Bricout et al., 2021). Such premise fundamentally influences the design of the platform. This is not to say that market dynamics are neglected. On the contrary, the platform design is premised on the profit ideal. Social and environmental sustainability standards no longer stand in opposition to market and profit considerations, yet conflicting goals need to be addressed. Thus, the core design principle should remain premised on the triple bottom line: people, planet and prosperity (Elkington, 2004). Value creation has to be incentivised and should be derived from the shared infrastructure vision and governance principles.

Protocols

Protocols, which are agreed-upon or accepted sets of rules or standards for procedures, constitute a more granular level of platform design. Defining platform protocols helps to translate governance and design requirements into concrete procedures and source code (cf. Mukhopadhyay and Bouwman, 2019). They represent the specific roles of platform participants and their tasks, relations and decisions associated within each domain and between the domains of governance. They guide decisions towards achieving shared values and objectives. Protocols function as a common language for stakeholders to develop the platform without the need to become too technical. Low- and no-code environments increase the adaptability of the platform and the integration of use cases (Soto et al., 2015).

As indicated in Figure 3, a set of protocols constitutes the federative services that enable trusted collaboration and data sharing across an ecosystem. Their definition allows for mir-



roring, optimising and streamlining infrastructure processes alongside the value chain, in relation to virtual and physical assets, and facilitating a seamless information exchange between stakeholders. Protocols can make pain points related to non-synchronised delivery processes or low-quality problems transparent and help to monitor the development and delivery process of infrastructure projects (WEF, 2016).

Protocol metrics should be implemented to track the realisation of common objectives. Legitimate protocols cannot be developed without stating the vision and objectives as already outlined by the governance and design frameworks. In contrast, existing metrics can be realigned with the broader goals and strategy to make them meaningful. In essence, protocols directly address the governance gap and the myriad of challenges associated with traditional infrastructure delivery. However, protocols are never final but need to adapt to a constantly changing environment and increasing complexity (Paruchuri, 2006).

Implementation

To respond to an increasingly complex and changing environment, which is marked by constant crises, requires an effective combination and application of implementation values and methods that support *agility*, *resilience* and *antifragility*. Agility is a form of adhocracy and emphasises flows and iterations. Resilience promotes self-organisation and robustness through rapid adaptation, while antifragility suggests that improvement occurs even in the face of shocks (Gritsenko and Wood, 2020; Taleb, 2014). Such project and work flexibility are required to manage digital technologies that are themselves disruptive. Today's dynamic development is supposed to intensify in the future, as the world is further changing towards an era of ubiquitous digitalisation, heightened cyber-physical risks and structural instabilities (cf. Jelinek, 2020).

While those methods are applied within the ICT industry, they rarely find application within the infrastructure and public sector. Thus, setting up a dynamic governance structure and developing a digital platform for use-case-based infrastructure development can create tension between technology, infrastructure and public-sector participants. However, the infrastructure industry has developed its own set of innovative planning and delivery methods that should be considered and combined with those of the ICT industry.

Accordingly, those infrastructure methods are user-centric and flow- and pull-efficient, emphasise value generation, seek to reduce waste, and pursue perfection. In particular, *lean construction* requires the adaptation of lean principles originating from the *Toyota Production System* to the construction sector. *Lean thinking* is the antidote to waste (Howell et al., 2017). *Target Value Delivery* is a management practice that drives the design and construction to deliver customer value within project constraints (Ballard, 2008). The *Last Planner System* is a collaborative production management system (Ballard and Tommelein, 2021). *Integrated Project Delivery* is a construction project delivery method that seeks efficiency and involvement of all participants (people, systems, business structures and practices) through all phases of design, fabrication, and construction (Kent and Becerik-Gerber, 2010). Promoting the digital platform to the infrastructure sector is an opportunity for those methods to become the new *modus operandi* and help to realise the broader goals (Sawhney et al., 2020).



USE CASES

Use cases are at the centre of transformation towards a future era of infrastructure planning and delivery that is cyber-physical, user-centric, flow- and pull-efficient, and carbon-neutral. *Infrastructure 4.0* also suggests the emergence of new business models and incentives for innovation and inclusive development (Klostermeier et al., 2019). During this transition, use cases should increasingly represent a dynamic cyber-physical world that functions as a domain of smart and automated planning, construction and operations. The underlying digital infrastructure and data ecosystems are distributed, interoperable and interconnected, and ensure cybersecurity, privacy and data sovereignty (see Figure 3).

The development of use cases can start with individual applications and existing data. In the course of platform implementation, a growing number of use cases increasingly constitute an ecosystem of trusted and open data spaces with links to other industries and regions. However, it is important that use cases are embedded from the outset within the digital and infrastructure governance and process frameworks in order to set the basis for overcoming the existing fragmentation of the value chain.

For governments to kick-start the development of *mobilisation* and *learning platforms*, an inventory of micro and macro use cases should be identified, compiled and prioritised using examples from industry (e.g., interoperability standards for BIM data exchange³), national government initiatives (e.g., the UK's Infrastructure Client Group's Project 13⁴), G20 initiatives (e.g., InfraTech stock take of use cases⁵) and the latest supra-governmental initiatives (e.g., Gaia-X federated digital platform⁶) as well as examples of digital *mobilisation* and *learning platforms* from other sectors, which will provide transferable knowledge. The promotion of use cases and the development of platforms can be accelerated through government funding and market mechanisms. Existing cloud platform systems and hyperscalers, such as Amazon, Google and Microsoft, need to increase their trustworthiness through enhancing cybersecurity, privacy and sovereign data exchange. *Smart infrastructure development and management* could offer a compelling set of transformative use cases.

OUTLOOK

Governments should promote the introduction of federated platforms for infrastructure planning and delivery, and mandate multi-stakeholder and multidisciplinary teams to design and implement the most promising use cases to accelerate the transition towards *Infrastructure 4.0*.

However, as already stressed above, technology and digitalisation alone will not resolve the governance and strategic gap of the infrastructure industry. Thus, to complement the implementation of platforms, governments should establish *National Infrastructure Councils* to develop visions, realise long-term strategic planning, and develop and implement new participative models of sustainable and resilient infrastructure development. With the creation of national infrastructure councils, governments can make an extraordinary contribution to new and more vision-oriented, sustainable and participatory planning and infrastructure delivery. Thus, infrastructure councils should not solely focus on a sectoral approach, e.g.,



transportation only, but also foster comprehensive approaches for infrastructure development and transformation, such as the necessary decarbonisation. They can provide and generate evidence-based proposals for action and act as a knowledge centre and independent think tank, putting infrastructure development back at the centre of societal attention. National infrastructure councils should govern local infrastructure councils, which are local/metropolitan agencies that plan, procure and manage assets using the infrastructure platform model. In addition, a global network of national infrastructure councils and agencies could establish a fertile ecosystem of international experts bringing together global knowledge and research in this field.

The blueprint is already available: Infrastructure Victoria,⁷ an Australian infrastructure agency, develops infrastructure based on visions and public demand rather than on biased cost-benefit analysis, aiming to establish a stable institutional context that thinks beyond short-cycled politics. Similar agencies or councils have recently been established in the UK,⁸ France and elsewhere.

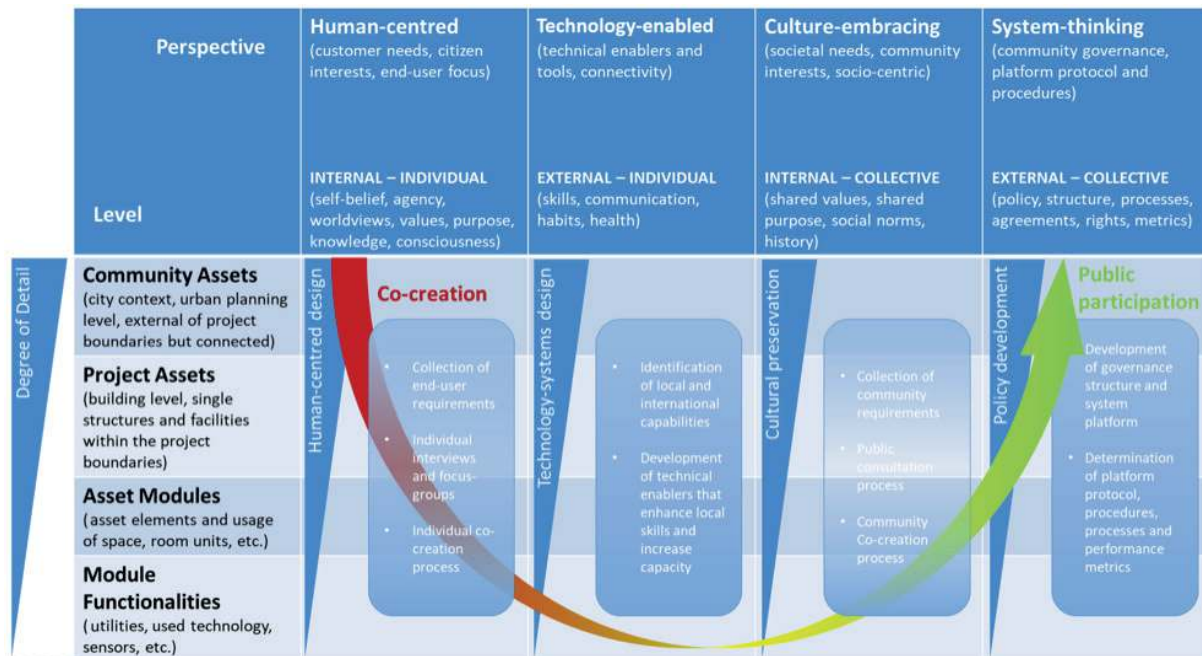


Figure 4: Holistic model of infrastructure development

As the basis for strategic discussions and decision-making concerning the future of infrastructure and the implementation of a learning platform, this policy brief does not propose specific technologies, but a holistic model of infrastructure development, as depicted above (Figure 4), that helps to embark from linear waterfall models that have lasted over decades.



APPENDIX

The policy brief contributes to the T20 “*Task Force 7: Infrastructure Investment and Financing*” and the policy areas “*digital infrastructure*”, “*infrastructure governance*” and “*technological advances*”, and builds upon the “G20 Principles for Quality Infrastructure Investment” by enhancing the “*G20 InfraTech Agenda*”.

Our proposal provides a holistic framework that could become the platform testbed for an otherwise fragmented *G20 InfraTech agenda* by acknowledging a human-centred value network approach. We see an opportunity not only with providing financial resources but also with enabling the integration of project delivery and stable value chain stakeholder networks. Thus, our brief constitutes a future design of the digital economy and infrastructure recommended to the G20. The policy brief also contributes to the G20 Infrastructure Working Group (policy areas preparation and management) and supports the UN SDGs 9, 11, 13 and 17. This policy brief is based on research and numerous expert interviews carried out since July 2020. An international workshop to finalise the policy brief was held in Munich on 2 April 2021.

The policy brief addresses the following policy areas: exploiting technological advances for infrastructure development; strengthening infrastructure governance: openness, transparency and inclusion of local communities; new initiatives and mechanisms to support digital infrastructures; and integrating environmental criteria into infrastructure investment.



NOTES

¹ The US's NIST Cloud Federation Reference Architecture: <https://www.nist.gov/publications/nist-cloud-federation-reference-architecture> and the EU's Gaia-X Federation Services: https://www.gaia-x.eu/sites/default/files/2021-05/Gaia-X_Architecture_Document_2103.pdf; also cf. The International Data Spaces Association (IDSA): <https://internationaldataspaces.org>.

² Typically, at their most basic level, hyperscalers provide cloud, networking and internet services at scale by offering organisations access to infrastructure via an IaaS model. Examples of hyperscalers today include Google, Microsoft, Facebook, Alibaba and Amazon.

³ <https://www.buildingsmart.org/about/openbim/>.

⁴ <https://www.project13.info>.

⁵ <https://www.gihub.org/infrastructure-technology-use-cases/>.

⁶ <https://www.bmwi.de/Redaktion/EN/Artikel/Digital-World/GAIA-X-Use-Cases/smart-infrastructure-management.html>.

⁷ <https://www.infrastructurevictoria.com.au/about-us/>.

⁸ <https://nic.org.uk/about/the-commission/>.



REFERENCES

- Allee, V. (2009), *The Future of Knowledge*, Taylor & Francis, <https://books.google.de/books?id=38-pTkfr8mwC>
- Anan, H.; J. Tang; K. Maly; M. Nelson; M. Zubair; and Z. Yang (2003), *Challenges in Building Federation Services over Harvested Metadata*, International Conference on Asian Digital Libraries
- Anumba, C. J.; and N. Roofigari-Esfahan (2020), *Cyber-Physical Systems in the Built Environment*, Springer
- Ballard, G. (2008), "The Lean Project Delivery System: An Update", in *Lean Construction Journal*
- Ballard, G.; and I. Tommelein (2021), *2020 Current Process Benchmark for the Last Planner (R) System of Project Planning and Control*
- Benington, H. D. (1983), "Production of Large Computer Programs", in *Annals of the History of Computing*, Vol. 5, No. 4, pp. 350-361
- Bricout, J.; P. M. Baker; N. W. Moon; and B. Sharma (2021), "Exploring the Smart Future of Participation: Community, Inclusivity, and People with Disabilities", in *International Journal of E-Planning Research (IJEPR)*, Vol. 10, No. 2, pp. 94-108
- Cantarelli, C. C.; B. Flyvbjerg; B. Van Wee; and E. J. F. Molin (2008), *Cost Overruns in Large-Scale Transportation Infrastructure Projects: Which Explanations Can Be Given?*
- Elkington, J. (2004), "Enter the Triple Bottom Line", in *The Triple Bottom Line: Does It All Add Up*, pp. 1-16
- ElMassah, S.; and M. Mohieldin (2020), "Digital Transformation and Localizing the Sustainable Development Goals (SDGs)", in *Ecological Economics*, Vol. 169, p. 106490
- Fellows, R.; and A. M. Liu (2012), "Managing Organizational Interfaces in Engineering Construction Projects: Addressing Fragmentation and Boundary Issues across Multiple Interfaces", in *Construction Management and Economics*, Vol. 30, No. 8, pp. 653-671
- Fischer, M.; H. W. Ashcraft; D. Reed; and A. Khanzode (2017), *Integrating Project Delivery*. John Wiley & Sons
- Flyvbjerg, B. (2007), "Policy and Planning for Large-Infrastructure Projects: Problems, Causes, Cures", in *Environment and Planning B: Planning and Design*, Vol. 34, No. 4, pp. 578-597, <https://journals.sagepub.com/doi/10.1068/b32111>
- Flyvbjerg, B.; N. Bruzelius; and W. Rothengatter (2003), *Megaprojects and Risk: An Anatomy of Ambition*, Cambridge University Press
- Flyvbjerg, B.; M. K. Skamris Holm; and S. L. Buhl (2004), "What Causes Cost Overrun in Transport Infrastructure Projects?", in *Transport Reviews*, Vol. 24, No. 1, pp. 3-18
- Gritsenko, D.; and M. Wood (2020), "Algorithmic Governance: A Modes of Governance Approach", in *Regulation & Governance*
- Hagel, J. (2015), *The Power of Platforms: Part of the Business Trends Series*, Deloitte University Press, 15 April
- Hagel, J.; and J. S. Brown (2008), "From Push to Pull: Emerging Models for Mobilizing Resources", in *Journal of Service Sci-*



ence (JSS), Vol. 1, No. 1, pp. 93-110, <https://clutejournals.com/index.php/JSS/article/view/4305>

Hein, A.; M. Schrieck; T. Riasanow; D. S. Setzke; M. Wiesche; M. Böhm; and H. Krcmar (2020), "Digital Platform Ecosystems", in *Electronic Markets*, Vol. 30, No. 1, pp. 87-98, <https://link.springer.com/article/10.1007%2Fs12525-019-00377-4>

Hetemi, E.; J. Ordieres-Meré; and C. Nuur (2020), An Institutional Approach to Digitalization in Sustainability-Oriented Infrastructure Projects: The Limits of the Building Information Model", in *Sustainability*, Vol. 12, No. 9, pp. 3893, <https://www.mdpi.com/2071-1050/12/9/3893>

Howell, G.; G. Ballard; and S. Demirkesen (2017), "Why Lean Projects Are Safer" in *Proceedings of the 25th Annual Conference of the International Group for Lean Construction*, Heraklion, Greece

Jelinek, T. (2020), "The Future Rulers? On Artificial Intelligence Ethics and Governance", in W. Billows and S. Körber (eds), *Reset Europe: Time for Culture to Give Europe New Momentum*, Institut für Auslandsbeziehungen, pp. 244-252

Jelinek, T. (2021), "The Artificial Intelligence Governance Gap", in O. Inderwildi and M. Kraft (eds), *Intelligent Decarbonisation: Can Artificial Intelligence and Cyber-Physical Systems Foster the Achievement of Climate Mitigation Targets?*, Springer Nature

Jelinek, T.; W. Wallach; and D. Kerimi (2020), "Policy Brief: The Creation of a G20 Coordinating Committee for the Governance of Artificial Intelligence", in *AI and Ethics*, <https://link.springer.com/article/10.1007%2Fs43681-020-00019-y>

Kenny, C. (2007), *Infrastructure Governance and Corruption: Where Next?*, Vol. 4331, World Bank Publications

Kent, D. C.; and B. Becerik-Gerber (2010). "Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery", in *Journal of Construction Engineering and Management*, Vol. 136, No. 8, pp. 815-825

Klostermeier, R.; S. Haag; and A. Benlian (2019), *Geschäftsmodelle digitaler Zwillinge: HMD Best Paper Award 2018*, Springer Fachmedien Wiesbaden, <https://books.google.de/books?id=nEa9DwAAQBAJ>

Kroner, R. G.; E. B. Barbier; O. Chassot; S. Chaudhary; L. Cordova Jr; A. Cruz-Trinidad; T. Cumming; J. Howard; C. K. Said; Z. Kun et al. (2021), "COVID-Era Policies and Economic Recovery Plans: Are Governments Building Back Better for Protected and Conserved Areas?", in *Parks*, Vol. 27 (Special Issue)

Lloyd-Walker, B. M.; A. J. Mills; and D. H. Walker (2014), "Enabling Construction Innovation: The Role of a No-Blame Culture as a Collaboration Behavioural Driver in Project Alliances", in *Construction Management and Economics*, Vol. 32, No. 3, pp. 229-245

Moser, H. (2016), *Barriers to Bankable Infrastructure: Incentivizing Private Investment to Fill the Global Infrastructure Gap*, Rowman & Littlefield

Mukhopadhyay, S.; and H. Bouwman (2019), "Orchestration and Governance in Digital Platform Ecosystems: A Literature Review and Trends", in *Digital Policy, Regulation and Governance*

Ochieng, E.; A. Price; and D. Moore (2017), *Major Infrastructure Projects: Planning for Delivery*, <https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=6234514>

OECD (2017), "Getting Infrastructure Right: The Ten Key Governance Chal-



lenges and Policy Options”, in *The OECD Framework for the Governance of Infrastructure*, <https://www.oecd.org/gov/getting-infrastructure-right.pdf>

OECD (2021 forthcoming), *Building Resilience: New Strategies for Strengthening Infrastructure Resilience and Maintenance* (report for the G20 Italian presidency 2021), Paris, OECD Publishing

Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press

Paruchuri, V. K. (2006), *Adaptive Scalable Protocols for Heterogeneous Wireless Networks*

Passos, D. S. dos; H. Coelho; and F. M. Sarti (2018), *From Resilience to the Design of Antifragility*, PESARO 2018: The Eighth International Conference on Performance, Safety and Robustness in Complex Systems and Applications, Athens, Greece

Raj, P.; and A. C. Raman (2017), *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, CRC Press

Samans, R.; and N. Davis (2017), *Advancing Human-Centred Economic Progress in the Fourth Industrial Revolution A Leadership Agenda for G20 Governments*

Sawhney, A.; M. Riley; and J. Irizarry (2020), *Construction 4.0: An Innovation Platform for the Built Environment*. Routledge

Siddarth, D. E. G. W. (2021), *The Case for the Digital Commons*, 2 June, <https://www.weforum.org/agenda/2021/06/the-case-for-the-digital-commons/>

Silva, J. d. C.; J. J. Rodrigues; J. Al-Muhtadi; R. A. Rabêlo; and V. Furtado (2019), “Management Platforms and Protocols for Internet of Things: A Survey”, in *Sensors*, Vol. 19, No. 3, p. 676

Smith, P. (2014), “BIM Implementation – Global Strategies”, in *Procedia Engineering*, Vol. 85, pp. 482-492, <https://www.sciencedirect.com/science/article/pii/S1877705814019419?via%3Dihub>

Soto, J. A. C.; O. Werner-Kytölä; M. Jahn; J. Pullmann; D. Bonino; C. Pastrone; and M. Spirito (2015), “Towards a Federation of Smart City Services”, in *International Conference on Recent Advances in Computer Systems*

Taleb, N. N. (2014), *Antifragile: Things That Gain from Disorder*, Random House

WEF (2016), “Shaping the Future of Construction: A Breakthrough in Mindset and Technology”, in *World Economic Forum*

WEF (2020), *Agile Regulation for the Fourth Industrial Revolution: A Toolkit for Regulators*, <https://www.weforum.org/pages/agile-regulation-for-the-fourth-industrial-revolution-a-toolkit-for-regulators>

West, M. e. a. (2021), *The Approach to Develop the Foundation Data Model for the Information Management Framework*, National Digital Twin Programme

Wilber, K. (2018), *Integral Politics: Its Essential Ingredients*, Integral Life

Zhang, L.; J. He; and S. Zhou (2013), “Sharing Tacit Knowledge for Integrated Project Team Flexibility: Case Study of Integrated Project Delivery”, in *Journal of Construction Engineering and Management*, Vol. 139, No. 7, pp. 795-804



ABOUT THE AUTHORS



Michael Bühler Konstanz University of Applied Sciences (Lead author)

Michael is a Member of the T20/G20 Task Force TF7 Infrastructure Investment & Financing, Member of the G20 Global Infrastructure Hub Academic Advisory Panel, Member of the OECD Executive Consultation Group of the Blue Dot Network, Accredited Member EU Gaia-X platform development team focusing on Smart Infrastructure Management as well as Member of the Association of German Engineers (VDI) Advisory Council on Civil Engineering.



Thorsten Jelinek Taihe Institute (Core team)

Dr. Thorsten Jelinek is the Europe director of the Taihe Institute and the managing director of DPG Digital Platform Governance based in Berlin. He is also an affiliated researcher at the University of Cambridge and a member of the advisory board of the OECD's Trust in Business initiative. Dr. Jelinek focuses on governance and regulatory questions concerning artificial intelligence, digitalization, cybersecurity, and privacy. As a member of Germany's Gaia-X domain on geoinformation, he also focusses on digital sovereignty and the development of international data alliances



Konrad Nübel Technical University Munich (Core team)

The focus of research of Konrad Nübel is the construction process management, which considers the complete value chain of construction. Construction process management is a discipline of management and organization combined with the utilized production technology. Prof. Nübel studied civil engineering at the University of Karlsruhe (now KIT) and at the University of Waterloo (Canada). He earned his PhD in geotechnical engineering at KIT. As a scientific assistant he was invited for research stays in Graz, Innsbruck, Prague, Gdansk, Tokyo, and Baton Rouge, in his research area of numerical modelling of granular material behavior. Then he took over several Management positions both in the operative construction industry as well consulting and accompanied construction projects worldwide at the companies Züblin, Bilfinger, Smolczyk & Partner Consulting as well BAUER Special Foundations. In 2019 he joined TUM as a full professor in Construction Process Management. Prof. Nübel is in the board of the TUM Leonhard Obermeyer Center, which research focus is on the digitalization in the area of built environment, board member of the TUM real estate cluster, Academic Director of the Venture Labs Built Environment, a member of the Construction Committee of the Association of German Engineers (VDI), and an accredited member EU Gaia-X platform development team focusing on Smart Infrastructure Management.



Norman Anderson CG/LA Infrastructure

Norman F. Anderson is Chairman & CEO of CG/LA Infrastructure. He oversees the four pillars of CG/LA's business: Blueprint 2025 2X; the Leadership Forum platform, which operates in the U.S., Latin America and Eurasia; GlobalViP, an algorithm-driven tool for infrastructure project owners; and Strategic Advisory, including M&A and both brownfield and greenfield investment opportunities. Mr. Anderson is, or has been, a member of various World Economic Forum groups, including the Global Advisory Council on Infrastructure, the Strategic Infrastructure Initiative, and the Advisory Committee on Building Foundations for Transparency. He has taught an Engineering & Entrepreneurship course at Columbia University in New York City. He is a partner in CAMG, a pan-Atlantic infrastructure fund.



Glenn Ballard UC Berkeley

An accomplished educator, author and public speaker, Dr. Ballard is currently a member of the construction engineering and management program faculty at UC Berkeley. His teaching focuses on improving, as opposed to controlling, project performance. His principle research interest is adapting lean production theory from manufacturing to construction management practice. Toward that end, he has developed a model for lean delivery of capital facility projects, the Lean Project Delivery System™. Dr. Ballard is also a founding member of the International Group of Lean Construction, which is dedicated to the development and application of production control concepts and techniques in the construction industry. He is frequently asked to share his research and experience with audiences at conferences and private organizations around the world. He has worked as a manager, trainer and consultant with a myriad of organizations ranging from construction and engineering firms to public utilities to international oil and gas manufacturers. These organizations include: Ford Motor Co., Brown & Root, Bechtel Corp., Jacobs Engineering, Petroleos de Venezuela, Pacific Gas & Electric, Caltrans and the Department of Defense.



Mark Bew PCSG Limited

Mark is a recognised authority in the field of building information modelling (BIM) and digital technology systems, whose advice is sought by businesses and Governments around the globe. He has industry-leading expertise in this field and uses his deep understanding of how digital information can be optimised to realise value and improve financial, social and environmental outcomes for all. Following his work for UK Government to develop the Level 2 BIM Strategy in 2012 he was awarded the MBE for services to construction. He has since led the implementation of this strategy and also the development of the Level 3 BIM Strategy, now called Digital Built Britain, which was mandated in 2016.



David Bowcott Aon Risk Solutions

David oversees growth strategy for Aon GCIG worldwide. To fuel global growth David has been given jurisdiction over generating innovations and insights for Aon clients using the market-leading volume of business Aon transacts within the construction and infrastructure sector. Through the implementation of innovative solutions David has successfully helped clients reduce project risk and operational risk. Solutions are housed within the following categories: i) contractual advisory, ii) operational advisory, iii) technology advisory, and iv) risk finance advisory and brokerage. In technology, David was named to Builtworld's Adoption Leaders 50, is advisor to several infratech firms, and is infratech thought leader.



Kai Broek Capgemini Invent

Kai is an expert and senior manager in data strategy and business transformation at Capgemini Invent. At Capgemini, he advises his clients in innovative ways to automate and optimize their internal processes with AI powered solutions. Before that he was managing partner and founder of AI Rocketeers which supported companies in their digitization and automation journey including the implementation of platform business models. Before, he founded multiple companies and held several managing director positions in Malaysia where he successfully delivered strategies, MVPs, Centers of Excellence for AI, service and operating models and large scale transformation initiatives for insights driven enterprises. His professional journey throughout his career was in data science, predictive analytics and conversational agents with a strong focus in platform models, data strategy, data sharing economy, intelligent automation and AI applications. Kai has extensive experience in building up large scale organizations, multi stakeholder management on C-Level, extensive experience in automotive, public sector, machine building and mobility. Kai holds a master in International Business from the University of Applied Sciences in Constance, Germany.



Gerd Buziek Esri Deutschland GmbH

Prof. Dr.-Ing. Gerd Buziek is Esri Deutschland's director of communications and public affairs since 2011. He started his career in the private sector in 2000 at SICAD Geomatics, a SIEMENS company, Munich. From 2002 to 2004 he served as managing director at CeGI, Center for Geoinformation GmbH, Dortmund, to develop the Spatial Data Initiative in Northrhine-Westfalia. Buziek's academic background is in surveying, geomatics, visualization, and communication. He serves as honorary professor at University of Hannover, Germany, since 2009. Furthermore, he is currently member of the advisory board of Jade University for Applied Sciences in Wilhelmshaven/Oldenburg, Germany, member of the program commission on Earth Observation of the German Aerospace Center (DLR), first Vice President of the German Umbrella Organization of Geoinformation (DDGI), and he contributes as to the German National IT-Summit.



Isabel Cane OECD

Dr. Isabel Cane leads the Trust in Business initiative at the OECD. She works to strengthen public-private cooperation to inform policy and improve implementation in the areas of Anti-Corruption, responsible business conduct and corporate governance. Isabel has more than 15 years of experience advising national and international policy platforms, previously working at the World Economic Forum's Partnering Against Corruption initiative, the Australian Department of Foreign Affairs and Trade, and the World Bank. Isabel worked extensively on Environment Social and Governance issues in the extractives industry (Mongolia and Latin America) where she advised multi-nationals on responsible minerals development. She has a PhD from the University of Queensland's Sustainable Minerals Institute, Australia, where she currently holds the position as Industry Fellow.



Raffaele Della Croce OECD

Raffaele Della Croce is a Senior Economist at the OECD and Senior Fellow at Collegio Carlo Alberto in Turin. He has been Senior Fellow at Imperial College in 2019/2020 at the Centre for Climate Finance and Investment in London. He is responsible for producing research and analysis on sustainable investment, low carbon infrastructure financing, impact of innovation and infratech for resilience. Recent work includes ESG Investment in infrastructure part of the OECD Business and Finance Outlook published in October 2020. At the OECD he has launched the "Institutional Investors and Long-term Investment" project gathering major pension funds, insurance companies, and sovereign wealth funds across the world. As coordinator of the G20/OECD Taskforce on Long Term Investment he has been contributing to policy discussions at the level of G20, Asian Pacific Economic Cooperation (APEC) and the European Commission. This work was developed in close collaboration with major organizations such as the World Bank, IMF, EIB and Asian Development Bank. Invited regularly to investor's conferences to present, moderate and chair sessions. Represented the OECD to G20, APEC, Financial Stability Board and UN meetings. Raffaele earned a doctorate degree from the Smith School of Enterprise and the Environment, University of Oxford; he holds a master's degree in Economic Policy Management from Columbia University, City of New York and a graduate degree in economics and business administration from Sapienza university of Rome.



Harry Dimitriou University College London

Harry Dimitriou is Bartlett Professor of Planning Studies at University College London (UCL) and sometime Head of the Bartlett School of Planning. He is Director of the OMEGA Centre at UCL – an international centre of excellence for the study of mega infrastructure and development funded by the Volvo Research and Education Foundations (VREF) undertaking international research into decision-making in the planning, appraisal, delivery of mega urban transport projects in Europe, USA and the Asia Pacific. Professor Dimitriou holds a Ph.D. in Transport and Urban Development from the University of Wales (1990). He was a member of the Transport Working Group for the Intergovernmental Panel on Climate Change (IPCC) and the Foresight Built Environment and Transport Panel of the Office of Science and Technology (OST) of the UK Government. He is member of several committees of the US Transportation Research Board (TRB) of US National Research Council (NRC) and is currently advisor to UN-Habitat.



Dale Evans Project13

Dale has over thirty years' experience in infrastructure delivery, asset management, operational management and change management. He is the Chair of the Infrastructure Client Group (ICG), leading the development of a progressive approach and work programme. Dale heads the Executive Steering Group for Project 13; a New Delivery Model for Infrastructure. As ICG member, he led a number of influential work streams, including Alliancing Best Practice (2014) and Alliancing Code of Practice (2015). Dale was responsible for the overall leadership and management of the @one Alliance, a progressive and collaborative model for delivery of the Anglian Water investment programme. In his positions, Dale was leading all aspects of Alliance strategy and operation. He consistently delivers significant efficiency savings, out-performing all financial, service and sustainability targets and providing positive returns for Alliance partners with turnover £750m pa., 5.8 million customers. Management of a £1.7bn 5-year investment programme over 15 years.



Jeff Herriman Ascentage Group, LLC

Jeff joined Ascentage in 2019 to provide business strategy and corporate development support to players in the emerging construction technology space. Jeff has over 30 years of international experience in starting, developing, buying/selling and turning around companies and senior management teams as a strategist, deal-maker and “company doctor.” He was responsible for strategy, mergers & acquisitions and information technology at Turner Construction in the early 2000s and had the same roles with W.S. Atkins engineering until 2017. In both cases, he was responsible for incubating new technology enabled ventures and partnering with software, hardware and solution providers, from start-ups to Autodesk and SAP. Jeff has completed over 50 transactions on buy- and sell-side in the US, Europe, Middle East, Africa and Asia. Over the years, he has built a strong network of relationships with private equity, investment banking, legal and accounting firms. Earlier in his career, Jeff was a strategy consultant and part of a start-up management team. He holds an MBA from Harvard Business School. He is also a registered representative of Madison Park Group, a member of FINRA and SIPC.



Volker Kefer Verein Deutscher Ingenieure

Dr Volker Kefer has been President of the Association of German Engineers (VDI) since 2018. Dr Kefer was awarded the Grashof-Denk-Münze at the German Engineers' Day in May 2017. Since 2017, he has been Managing Director of Kefer Invest GmbH and Chairman of the Supervisory Board at Vossloh AG. From 2006 to 2016, he worked for Deutsche Bahn AG, including from 2013 to 2016 as Group Board Member responsible for Infrastructure, Services and Technology, and additionally from 2015 as Deputy Chairman of the Management Board of DB AG. From 2009 to 2013, he was the Group Board Member responsible for Technology and Infrastructure and from 2006 to 2009, he was Chairman of the Management Board of DB Netz AG. Particular successes were the concept development, tendering and awarding of the ICx, the connection generation of today's ICE and IC fleet, as well as the representation of the “Stuttgart 21” project in public with a positive outcome of the referendum in November 2011.



Isidora Kosta World Economic Forum

Isidora has 17 years of experience in the field of infrastructure and urban development. Currently, Isidora leads the Infrastructure Industry at the World Economic Forum bringing together leaders from industry, government, and academia and building communities of purpose between private and public sector in the space of infrastructure and urban development. Before the WEF, she was working as project finance senior manager in the infrastructure advisory practice of Ernst & Young and assistant advisor on project finance for Grant Thornton. In these positions, Isidora deepened her expertise in public private partnerships focusing on capacity building towards equitable risk allocation in infrastructure projects. Isidora is a passionate advocate of systems' leadership as the only possible way to address complexity in modern world's challenges. Isidora holds an MBA with specialization in finance and investments from Baruch College as well as a master in public administration and international relations from Ethnikon, Athens, Greece.



Thomas Maier G20 Global Infrastructure Hub

Thomas is currently Senior Advisor to the G20 Infrastructure Hub. Before that, he was the Managing Director, Infrastructure at the European Bank for Reconstruction and Development. As such he oversaw the Bank's operations in the Municipal and Environmental Infrastructure and Transport sectors. Mr Maier joined the EBRD as Senior Project Manager in August 1993 and later worked as Senior Banker in the Romania, Moldova, Croatia and Ukraine country team. In 1999 he moved to the Municipal and Environmental Infrastructure team as Deputy Director and became Team Director in October 2001. During his time at EBRD, Thomas was board member in various investee companies of EBRD and was the Chairman of the Global Agenda Council for Infrastructure of the World Economic Forum. Before EBRD, he was at NatWest Markets where he worked on acquisitions, management buy-outs and highly leveraged transactions in the UK and Western Europe. Thomas is a German national and holds a degree in Public Management and an MA in Development Economics.



Ibrahim Odeh Columbia University

Ibrahim S. Odeh focuses his studies and research on assisting construction firms with strategic management assignments in areas related to: strategy and business development; infrastructure and construction market analysis; market entry strategy; and trends affecting the future of the construction market. Odeh also joined the World Economic Forum (WEF) as an official Industry Expert in Engineering and Construction in 2017. He also managed to work on several research and consulting projects and market studies with leading firms and institutions such as the World Economic Forum, Boston Consulting Group, Skanska, AECOM, Turner, Dentons, HAKS, and STV. Moreover, Odeh is actively working since 2015 as an advisory committee member on a multi-year project that is focused on studying “The Future of Construction” with the WEF. Odeh received his Ph.D. in Civil Engineering with a focus on Construction Management from University of Illinois at Urbana-Champaign. He also holds an MBA degree with an emphasis on Finance from Minnesota, USA.



Rafael Sacks Technion Israel Institute of Technology

Prof. Sacks earned his doctorate in 1998 from the Technion in Civil Engineering. He has worked as a structural engineer, CAD software developer, and construction project manager, and was a consultant to major industry and government clients. He joined the Technion as a member of faculty in 2000 and served as Head of Structural Engineering and Construction Management in the Faculty of Civil and Environmental Engineering from 2012-2015. He established the BIM and Virtual Construction Laboratories at the Technion’s National Building Research Institute



Thomas Schmid Bavarian Construction Industry Association

Thomas has been Chief Executive of the Bavarian Construction Industry Association since 2014. He was First Mayor of Garmisch-Partenkirchen from 2002 to May 2014. Before that, he worked in the Foreign Service of the Federal Republic of Germany for over a decade, most recently as Head of the Legal and Consular Section of the German Embassy in Ottawa. Thomas studied political science at the University of Munich. This was followed by postgraduate studies at the College of Europe in Bruges, Belgium, from which he graduated with a Master of European Studies.



Hajnalka Vaagen Norwegian University of Technology

Since 2016, Hajna is Associate Professor at the Faculty of Engineering Science, Department of Ocean Operations and Civil Engineering, Norwegian University of Science and Technology (NTNU) in Ålesund, Norway. Before, she held several positions in academia including senior researcher at SINTEF Applied Economics and Operations Research, Trondheim, Norway; associate professor in logistics at Molde University College, Norway as well as industry at Hajni D Design and Møbler, Molde, Norway, production department leader at Øran-produkter, Åndalsnes, Norway and product development manager at Eurotex Ltd in Hungary. Hajna hold a PhD in quantitative logistics as well as a Master of Science in logistics from Molde University College, Department of Logistics.