Photo Credit

Disruptive Technology Opportunities

Download Chatbot

On this page: *Disruptive technologies have the potential to integrate material, machine, and digital technologies across the infrastructure life cycle. Often referred to as InfraTech, they impact the development, delivery and ongoing operation of infrastructure, and create new opportunities for infrastructure service delivery that can benefit users, providers and societies alike.*

The emerging technologies outlined in Examples of Disruptive Technologies that Could Transform Infrastructure and Appendix A have the potential to integrate material, machine, and digital technologies across the infrastructure life cycle. Often referred to as InfraTech, they impact the development, delivery and ongoing operation of infrastructure, and create new opportunities for infrastructure service delivery that can benefit users, providers and societies alike.[1] Against this background, the InfraTech Agenda explicitly aims to accelerate the adoption of new technologies in infrastructure to support economic recovery and growth.[2]

New technologies are expected to increase efficiencies in the development, delivery and operation of assets; reduce costs for construction, and operation and maintenance; extend the life of assets; ensure greater engagement of stakeholders and users; and allow for the development of new models for infrastructure financing and asset optimization. The trend in disruptive innovation for all sectors is to enhance the interconnection of people and services around the world efficiently, reliably, and sustainably. These innovations are causing value chains to be increasingly decentralized and globalized.[3]

From a policy perspective, it is important to make a distinction between (i) technologies used in infrastructure design, planning, delivery and management versus (ii) the integration of technologies into the structures themselves, which changes the nature of infrastructure assets from simple inanimate objects to dynamic information systems.[4]

(a) Disruptive technology is changing the way we design, build, and manage infrastructure throughout the project cycle. InfraTech applications can be adopted across the PPP project life cycle. These can include the following categories:

- **Development and planning:** The use of disruptive innovation - such as improved analytical functions, big data, artificial intelligence (AI), and the mobile internet - is already leading to material cost savings in the infrastructure preparation stage. It will likely also lead to faster and more informed decision-making because disruptive technology allows all team members to connect with real time visual data. One example where disruptive technology is already used for infrastructure development and planning is AI-enabled prediction and demand forecasting. Advanced analytics for planning also includes the use of complex city models with synthetic populations living in digital twins,[5] which are estimated to result in a 10 percent improvement in construction business effectiveness and more than 20 percent gains in productivity.[6]

- **Design:** Big data and improved analytics will influence how we design infrastructure. There has been an exponential increase in data sources helpful to the design process, including from satellite imagery, mobility records, social media, logistics, and transaction records. The cost of gathering data is also decreasing exponentially, with drones or crowd-sourcing techniques proving to be highly cost effective, and advanced analytical modeling techniques, such as building information modeling (BIM),

are already being used for 3D modeling in the design phase. Further innovations in technology will also provide insights into how a project will perform throughout its life cycle, allowing a view into a project's future risk profile.[7] In transport, for example, whole-of-system network models are used to rethink rail asset operations and renewals, allowing operators to manage operations risk and maintenance interdependencies more efficiently.[8]

- **Procurement:** InfraTech is increasingly used in public procurement globally. Big data and data analytics can, for example, be used to optimize procurement. In order to prepare and analyze big data sets, AI and machine learning (ML) may be required. The incorporation of blockchain technology into the bidding and contracting process ensures transparency and reduces the risk for corruption related to the procurement of infrastructure projects, and also has the potential to reduce transaction costs.[9]

- **Construction:** Disruptive technology enables infrastructure to be built more efficiently: 3D printing technologies and new materials together with AI-enabled robots and construction equipment make it possible to lower the costs for construction and to minimize waste and human labor.[10] AI, ML, IoT, big data and improved analytics are already able to collect and aggregate a much larger flow of data than has been historically possible. These new technologies allow for real-time analysis of project progress, identify actionable realities, and communicate among project team members. BIM technology enables developers to create data-based, digital 3D models of projects so that architects, engineers, and contractors can simultaneously collaborate.[11] This innovation in BIM allows those who design infrastructure to provide real-time support to those building it.[12] Augmented reality and virtual reality help to create immersive experiences that provide insight into potential design flaws, risks, and issues before and during construction, and sending mini-robots into buildings under construction can also help track work as it progresses.

- **Maintenance:** Going forward, better use of big data and other disruptive technologies can help reduce the costs of maintenance and extend the life of the asset. Data from a variety of new sources, including satellite imagery, unmanned aerial vehicles (UAVs, or drones) will enable remote supervision of infrastructure assets. IoT technology and sensors can make maintenance more efficient by providing real-time data related to the condition of the infrastructure asset and its components, anticipating future maintenance and optimizing equipment performance. Real-time reporting and visualization via smartphones can turn large amounts of sensor data into usable intelligence to support complex asset decisions. Remote and automated methods (e.g., drones, IoT, robots) can maintain or increase the frequency of physical inspections to ensure critical infrastructure services are not interrupted and allow for targeted intervention. Further, AR and VR together with AI can aid technicians in making repairs in real-time.

- **Operation:** The availability of vast amounts of data through IoT on cloud-based platforms and the speed at which the data can be delivered can improve the efficiency, costs, and transparency related to the management of infrastructure. For example, with regard to parking management, disruptive innovation can allow operators to collect and distribute real-time information about where parking is available. Thus, they can assist drivers in finding open spaces quickly, and encourage them to park in underused areas and garages through demand-responsive pricing.[13] Moreover, new user interfaces and platforms driven by advanced technologies, including payment mechanisms together with drone/satellite-based surveying, have the potential to radically change customer experience. Due to the new possibilities created by InfraTech, some large transit agencies are starting to reduce costs (for operation and ticket prices) while increasing satisfaction and service levels by focusing on self-service delivery and alternative business models.[14] Depending on the specific PPP infrastructure project, operation going forward may also be transformed by other InfraTech solutions, such as smart shipping containers that reduce the costs for lost or damaged cargo, battery improvements that allow renewable energy storage at off-peak hours, or AI-based deep-cleaning robots.

- **Management of PPP contracts:** Disruptive technologies can enable more collaborative and customer-centric projects. Blockchain and the different mechanisms it enables, such as smart contracts and the tokenization of infrastructure, may have the power to solve existing issues related to PPP projects that are derived from the lack of trust among parties, asymmetry of information, and lack of predictability and transparency. Collection and processing of real-time data through disruptive technologies can improve tracking and governance of projects.

(b) Disruptive innovation, such as robotics, AI, the internet of things, and other technologies can also be integrated in physical infrastructure systems or used with existing technology. This can make roads, urban transport systems, ports, wastewater treatment and power generation plants more efficient, more cost-effective, and more resilient towards outer shocks and stresses, and will change the way infrastructure is operated and used going forward.[15]

Examples:

- New electronics become available for fiber optic projects that make broadband internet traffic more efficient.
- Road, bridge and tunnel projects integrate sensing technology for autonomous vehicles.
- Road projects integrate new intelligent transportation systems (ITS) incorporating a variety of new technologies including Bluetooth, video, and other wireless systems to promote efficient traffic management, allow for toll tracking and billing, enhance emergency response times, and assist with law enforcement.
- Urban transport projects use trains that run on roads and rails, and use battery technology for electrification.
- Smart cities employ ICT infrastructure, namely high-speed wireless networks as well as other technologies, such as IoT and AI solutions, to manage and govern municipal water and waste management, electricity generation, and street lighting.

For additional examples, see Appendix A, which describes different disruptive technologies and how they are applied to infrastructure, and Appendixes B and C, which highlight trends related to disruptive innovation in the energy and transport sectors.

Footnote 1: Stocktake of InfraTech Use Cases by the Global Infrastructure Hub presents a collection of use cases demonstrating the application of InfraTech, with analysis of the sectors and technologies represented.

Footnote 2: G20 Infrastructure Working Group. 2020. "G20 Riyadh InfraTech Agenda, Background."

Footnote 3: For more details, see the World Bank Group's 2020 Infratech Policy Toolkit and its 2020 Infratech Value Drivers.

Footnote 4: G20 Infrastructure Working Group. 2020. "G20 Riyadh InfraTech Agenda, Background."

Footnote 5: Digital twins integrate data, including real-time sensor data, to better visualize and optimize assets, ensure continuity of services, and make well-informed new investment decisions (Global Infrastructure Hub and G20 Infrastructure Working Group. 2020. InfraTech Stock Take of Use Cases. Reference Note, June 2020.).

Footnote 6: 14 World Bank Group. 2020. Infratech Value Drivers.

Footnote 7: Pellen, Adrian. 2017. "Disruptive Technology Brings Risk and Opportunity to Infrastructure Projects." Marsh McLennan BRINK, August 14, 2017.

Footnote 8: World Bank Group. 2020. Infratech Value Drivers.

Footnote 9: For more details, see the Deloitte 2020 Study on Uptake of Emerging Technologies in Public Procurement.

Footnote 10: World Bank Group. 2020. Infratech Value Drivers.

Footnote 11: A recent German highway project (Biebelried intersection and the Fürth/Erlangen intersection in the German state of Bavaria) uses, for example, cloud-based and fully integrated iTWO 4.0 technology based on 5D building information modelling (BIM) with AI integration. The use of cutting-edge technology allows stakeholders to upload and share vast quantities of data, including three-dimensional design applications, transparently and accurately throughout the entire project life cycle, thereby enabling faster and more efficient decision-making. WEF (World Economic Forum). 2021. Why the world needs a fresh take on smart and sustainable infrastructure; Verfügbarkeitsmodell A3 AK Biebelried – AK Fürth/Erlangen, Nordbayern GmbH & Co. KG. (Last visited September 13, 2022.)

Footnote 12: Pellen, Adrian. 2017. "Disruptive Technology Brings Risk and Opportunity to Infrastructure Projects." Marsh McLennan BRINK. August 14, 2017.

Footnote 13: SFPark Pilot Project.(Last visited: September 13, 2022.)

Footnote 14: World Bank Group. 2020. Infratech Value Drivers.

Footnote 15: Examples of disruptive innovation that have occurred or are anticipated to occur specifically in the energy, transport, and information and communications technology sectors are explained in more detail in Appendix B.

Related Content

- **PPP Contracts in An Age of Disruption (Download PDF version)**

The Disruption and PPPs section is based on the Report "PPP Contracts in An Age of Disruption" and will be reviewed at regular intervals.

For feedback on the content of this section of the website or suggestions for links or materials that could be included, please contact the Public-Private Partnership Resource Center at ppp@worldbank.org.

Disclaimer: *The resources on this site is usually managed by third party websites. The World Bank does not take responsibility for the accuracy, completeness, or quality of the information provided, or for any broken links or moved resources. Any changes in the underlying website or link may result in changes to the analysis and recommendations set forth on the* Public-Private Partnership Resource Center. *The inclusion of documents on this website should not be construed as either a commitment to provide financing or an endorsement by the World Bank of the quality of the document or project. If you have any comments on any of the links provided on the* Public-Private Partnership Resource Center, *please get in touch here*