In the digital world, digital twins (DTs) have replaced physical models. They help researchers, urban planners, and other professionals improve processes and products and troubleshoot problems to achieve efficiencies, realize cost savings, and create new business opportunities. Digital twins are being used in manufacturing, health care, automotive, smart cities, natural resources, and others. For example, to move to zero carbon emissions, Las Vegas is partnering with Cityzenith, a digital twin technology developer, to gather and use data from buildings. The digital twin will enable monitoring and optimization of data to improve air quality, water management, and carbon emissions produced from major buildings. Researchers at Cambridge University have devised a way to use artificial intelligence (AI) to create “digital twins” of patients. The researchers posit that this technique can be used to predict individuals’ health issues over time and allow early intervention with personalized preventive care. These are just two recent examples of how digital twins are being used in different sectors.

In their article, “The Digital Twin Opportunity,” Pushkar P. Apte and Costas J. Spanos define a digital twin as “a dynamic model of a physical system that enables fast and creative experimentation at very low cost and risk.” The authors describe how digital twins are advancing; explain where digital twins can help target strategic priorities in sustainability, smart innovation, and health and safety; and offer best practices for implementing digital twins. They write, “DTs are particularly useful in exploring strategic cross-disciplinary opportunities, where it is risky to experiment on the real thing, whether it is a building, an earthmover, or a person. Especially exciting is the potential to use DTs to create business value while also meeting sustainability targets and improving people’s lives.”

In his Forbes article “Four Ways Digital Twins Can Drive Industrial Innovation,” Colin Parris defines a digital twin as a “digital copy, usually made in software, of a physical asset, manufacturing process or even entire network such as an electricity grid.” He notes that increasingly digital twins form part of companies’ asset performance management strategies. “Growing the digital twin ecosystem ultimately will help us reduce risks, while allowing industrial companies to realize the full benefits of digital transformation,” he concludes. Parris recommends companies join the Digital Twin Consortium, a global ecosystem founded to “accelerate the development, interoperability, and security of digital twins and enabling technologies.” The Digital Twin Consortium has working groups, publishes whitepapers, and hosts events, webinars, and meetings.

“How Digital Twins Are Reinventing Innovation,” a 2020 article published in MIT Sloan Management Review, explores how digital replicas are changing innovation. Mark Purdy and his coauthors explain that a digital twin is being used to restore Notre Dame Cathedral in Paris, which was partially ruined by a fire in 2019. The cathedral’s digital twin, they write, is “far more detailed and interactive than any blueprint—which allowed them [architects and engineers] to stay true to the original structure while also incorporating new innovations in design and materials.” The authors suggest digital twins will change innovation by enabling three critical drivers: continuous evaluation; faster, cheaper prototyping; and “innovating at the limits.” Digital twins enable a product to be evaluated in real time rather than only once or twice in its lifetime. They can lessen the need for expensive tests and physical prototypes, driving down the cost and increasing the speed of innovation. The authors write, “Much of the value associated with digital twins arises from a digital thread, a connecting infrastructure that allows digital twins to share information with one another and connect traditionally siloed functional perspectives.” They discuss collaboration among digital twins and the multiplier effect.

Randall S. Wright highlights digital twins as one of four technologies creating opportunities and challenges in his recent Research-Technology Management column “Storm Warning: Four Technology Movements Are Creating Opportunities and Imposing Perils for Your Business . . . Right Now!” Wright mentions a mathematical model that could enable the creation of predictive digital twins at various scales and for various situations. Wright explains that the mathematical model “naturally integrates data, predictive models, and decision-making to enable the creation of a structural digital twin” that can replan its mission dynamically in response to structural damage that occurs in-flight. “Their development expands the use of digital twins from

In this space, we offer a series of summaries on key topics, with pointers to important resources, to keep you informed of new developments and help you expand your repertoire of tools and ideas. We welcome your contributions, in the form of suggestions for topics and of column submissions.

DOI: 10.1080/08956308.2022.1999637
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need to explore and understand the interaction of humans with digital twins. “A Probabilistic Graphical Model Foundation for Enabling Predictive Digital Twins at Scale,” by Michael G. Kapteyn, Jacob V. R. Pretorius, and Karen E. Willcox, describes the mathematical model in detail.

“Digital Twins: Bridging the Physical and Digital” by Aaron Parrott, Lane Warshaw, and Brian Umbenhauer discusses how realizing the full promise of digital twins requires integrating systems and data across organizational ecosystems. They write, “The digital twins trend is gaining momentum thanks to rapidly evolving simulation and modeling capabilities, better interoperability and IoT sensors, and more availability of tools and computing infrastructure.” The authors outline the value digital twins offer, what’s new, the costs versus benefits, and modeling the digital future. They also offer lessons from Airservices Australia, Bridgestone, and Takeda.

In “Digital Twin: Current Scenario and a Case Study on a Manufacturing Process,” the authors provide a state-of-the-art review of different digital twins and how they are applied. The article includes a case study of a digital twin model developed for an advanced manufacturing process and proposes a model for implementing a digital twin in a factory. “Digital Twin Providing New Opportunities for Value Co-Creation through Supporting Decision-Making” by Shaun West, Oliver Stoll, Jürg Meierhofer, and Simon Züst explore value co-creation and decision-making. The authors describe how firms can design, develop, and commercialize digital-twin-enabled value propositions. They also present eight managerial issues companies must consider when developing digital twins to support multi-stakeholder decision-making that leads to value co-creation.

Çağlayan Arkan identifies product-as-a-service, factory-as-a-service, and supply chain-as-a-service as three business models that digital twins enable in his article, “How To Get Started With Three Innovative Business Models Enabled By Digital Twins.” For product-as-a-service, Arkan says manufacturers can monitor their assets (by serial number) in real time to “see how and where their products are being used, predict maintenance issues, optimize spare part inventories and understand what to keep investing in.” He suggests enhanced simulation capabilities are an important product-as-a-service–related opportunity because digital twins will need to incorporate uncertainty into digital twin simulations at the outset, the need for digital twins to be accessible across the entire enterprise, and the one-of-a-kind applications to many different ones involving multiple assets, like guiding fleets of satellites, for example,” he writes. Wright also shares three key challenges identified by Professor Karen Willcox, a co-creator of the model: the need to incorporate uncertainty into digital twin simulations at the outset, the need for digital twins to be accessible across the entire enterprise, and the
enable companies to validate their designs digitally without expensive prototypes and reduce cycles. For factory-as-a-service, digital twins enable the service provider “to monitor and maintain equipment through real-time access to manufacturing data, quality and energy data to optimize production lines and keep equipment performing smoothly. . . . to enable mass customization, where certain equipment can be moved around, accessorized or modified as needed by the customer.” Regarding supply chain-as-a-service, Arkan explains that digital twins across the supply chain can track individual assets and shipments. “The data powers predictive insights around inventory, demand, and efficiency. Digital twins can also monitor for damage and contamination in transit or conditions such as temperature or humidity,” he writes. They can layer weather data or other third-party data sources, predict and avoid disruptions and be able to locate their goods faster in case of a disaster.” Arkan advises businesses to do the following: identify the outcomes they’re aiming to achieve, start small (for example, one user case, one product, one factory), and learn from the data, then repeat and expand. Digital twins, he argues, offer “a way of empowering people, amplifying value and transforming ‘what if’ into ‘what could be.’”

In their article, “Twin-Driven and AI-Enabled Is the Future of Product Development,” Teresa Tung, Marc Carrel-Billiard, Matthew Thomas, and Sarat Maitin suggest digital twins will increase efficiencies, speed up development, deliver better design options, and create new streams of revenue. The authors argue that digital twins must be deployed with artificial intelligence (AI) to enable companies to “reimagine how they develop products,” make “the simplest ‘static’ products become ‘living’ products,” and “deliver an evolving experience for their customers.”

We will continue to learn about new and exciting ways digital twins are applied in different industries. Companies will continue to explore, experiment, and tweak how they use digital twins to innovate processes, products, and business models. As the technology matures, it may play a pivotal role in resolving climate change, creating smarter cities, and improving health outcomes, to name but a few.

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**Research-Technology Management seeks submissions**

**CALL FOR PAPERS: Special Issue: How Digital Transformation is Reshaping Innovation and R&D**

Submission Due Date: February 15, 2022  
Review Process: On a rolling basis from November 2021 to April 2022  
Possible Publication: July or September 2022

The digital transformation of organizations continues at a frenetic pace. While some companies are achieving trailblazer status, others are finding it difficult to change. Advances in digital technologies such as cloud computing, internet of things (IoT), machine learning (ML), artificial intelligence (AI), and big data architectures have disrupted the routines and work practices underlying R&D. Companies are taking steps to digitize their innovation management and product development processes, and some are using digital tools to transform from a product-centric to a service-centric business model (i.e., servitization).

No person, or even an organization, can expect to have all the resources needed to develop new, compelling digital solutions; particularly at the pace being set by the leaders. Much knowledge can be gleaned from the R&D teams that have adapted their innovation processes—and maybe their R&D structures—to lead digital transformation.

**RTM** is actively seeking papers on the following topics:

- Digital tools are shaping the future of open innovation. How are organizations using these tools to develop collaborative and more nimble development environments?
- R&D teams are engaging external partners to develop digital ecosystems. What effect has this had on product/service offerings?
- Have the goals of R&D been changed to address emerging macroeconomic themes, like sustainable development goals and achieving net zero targets? What are the implications of these changes on firm-level capabilities—i.e., business model, routines, and processes?
- How have digital tools powered this change?
- How has digital changed the way companies develop new products? How are firms rethinking and reinventing their idea to launch gating systems? How has Agile process and cloud-based product lifecycle management (PLM) enhanced product development and new product introduction?
- Has the organization developed a new set of leading R&D indicators to guide and measure its digital progress?
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- How is digital transformation impacting the innovation processes of small- and medium-sized companies? Are these benefiting from the availability of digital tools and open innovation? Has digital leveled the playing field?
- How do development teams use big data technologies (ML, AI, digital twins, etc.) to enhance product design, quality, and serviceability?
- What role do leaders of digital transformation play in carrying out successful digital transformation in R&D and innovation management? What are the success factors?
- How has digital changed the agenda of the research organization? What analytics tools do they use to give the organization better headlights?
- Submissions are by no means limited to these topics. The special issue is also open to submissions that provide further insights into R&D innovation in the context of digital transformation.

Papers and case studies should highlight specific, firsthand examples of how companies are adapting their workforce, their workplace culture, and their R&D and innovations processes. Submissions should include data on the practices, companies’ experience with them, adaptations to make them successful, and managerial lessons learned/practical implications.

**RTM** articles are concise and practice oriented. Ideal submissions offer concrete examples and data to support theories about invention and innovation, the management of technology and capabilities to support innovation, or the process of portfolio selection and management. Successful submissions will offer readers practical information they can put to work immediately.

We prefer submissions at around 4,000–4,500 words, although we will occasionally publish truly groundbreaking pieces as long as 5,000 words. Articles should be submitted via our Editorial Manager system at [http://www.editorialmanager.com/rtm/](http://www.editorialmanager.com/rtm/). For submission requirements and author’s guidelines, visit us at [www.tandfonline.com/urtm](http://www.tandfonline.com/urtm). For more information about this call or to join our email list to receive notification when calls for papers are released, please email RTM’s managing editor, Tammy McCausland, at mccausland@iriweb.org.