

FORGING THE DIGITAL TWIN IN DISCRETE MANUFACTURING

.....
A Vision for Unity in the Virtual and Real Worlds

CONNECT:



Insresearch.com





FORGING THE DIGITAL TWIN IN DISCRETE MANUFACTURING

A Vision for Unity in the Virtual and Real Worlds

CONTENTS

EXECUTIVE OVERVIEW:	<u>3</u>
SECTION 1:	
Digital Twin State of Play	<u>5</u>
SECTION 2:	
Exploring Digital Twin Opportunities	<u>14</u>
SECTION 3:	
Digital Twin and Your Organization	<u>25</u>





Executive Overview

Defining Digital Twin

Today's era of change in manufacturing is faster than any seen in history. During the last decades, we progressed from simple electronic control to an environment of unlimited data and industrial transformation. Getting transformation right in today's competitive world is critical, and one key factor is the ability to manage and use data to achieve enterprise Strategic Objectives. A Digital Twin is often at the very heart of the metamorphosis.

While we see many definitions of "Digital Twin," LNS Research keeps it simple: A Digital Twin is an executable virtual model of a physical thing or system.

That "physical thing" can be anything from a manufactured object, like a car or aircraft, or even a pharmaceutical drug. Every single product has definable characteristics in the real world, and the Digital Twin combines and portrays the attributes virtually. In a perfect world, the Digital Twin would capture every single attribute of a product or system and its processes. In reality, the technology is still evolving to accomplish this vision and we're not there yet. That doesn't mean manufacturers can't proceed with and derive tremendous value from a simpler virtual model.

In fact, a few forward-thinking vendors of software for discrete manufacturing are already demonstrating the possibilities of the Digital Twin in the product development setting and in production environments. This explains the current state of Digital Twin offerings and the opportunities for the future. Since LNS Research already [covered similar ground for the process manufacturing sector](#), we'll focus on the value and possibilities of

Digital Twin for the discrete manufacturing enterprise.

This work arms the senior corporate executive with a straightforward understanding of:

- Results of the primary research on Digital Twin in manufacturing as a whole
- What is Digital Twin in context of discrete manufacturing
- How does a manufacturing enterprise capture value with Digital Twin
- Why the product Digital Twin and asset Digital Twin require distinct consideration
- Recommendations to develop and achieve value with a Digital Twin strategy





SECTION 1

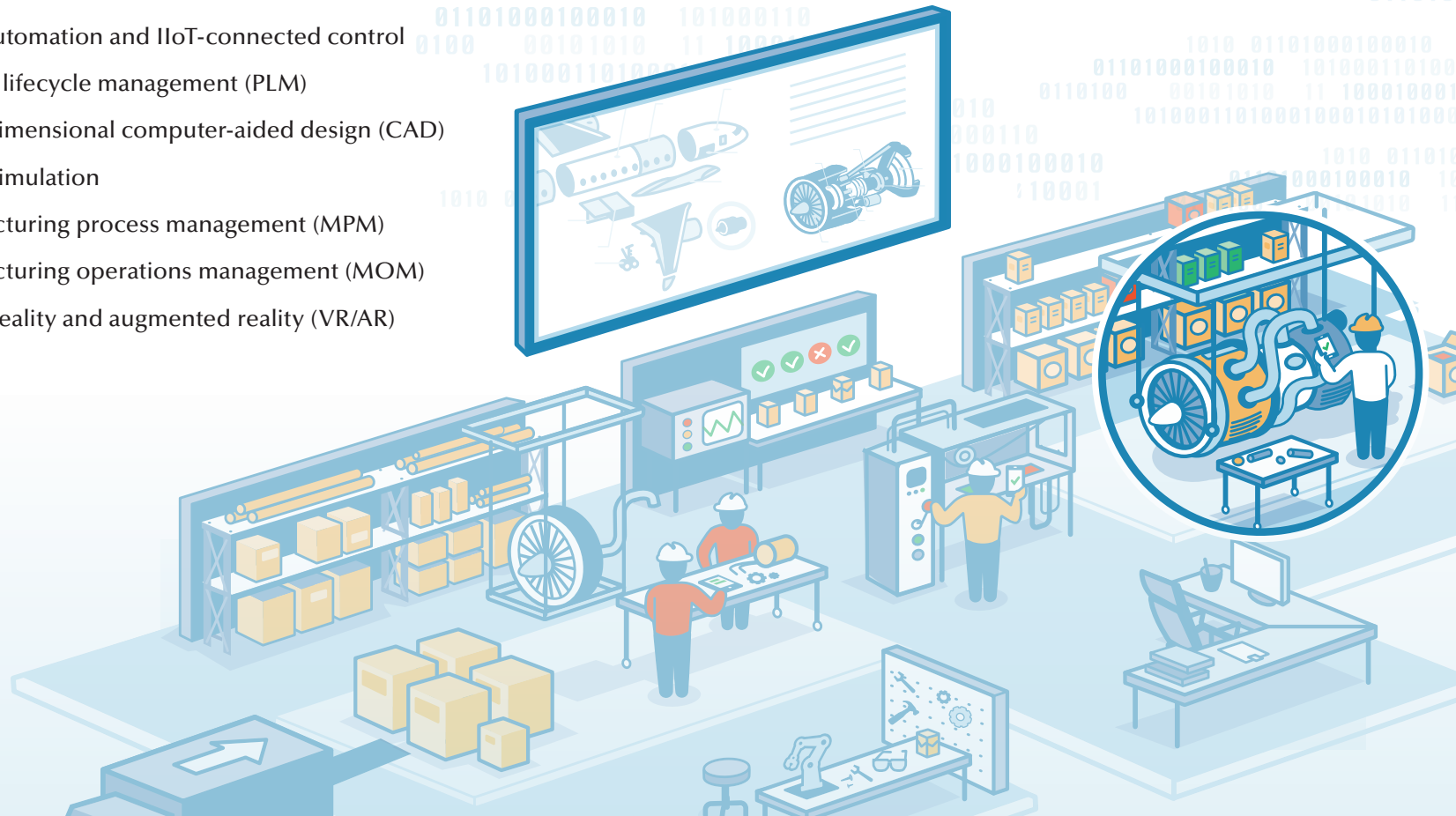
Digital Twin State of Play

Today's Possibilities

There's nothing new about the Digital Twins; we saw the first physical/virtual presentations as early as 2002. The concept wasn't an instant success due to complexity and the inability to handle the information required to deliver real value. Like many new concepts and approaches used in industry today, the Digital Twin has hugely benefited from the advent of the Industrial Internet of Things (IIoT), Industry 4.0, and, in general, the maturing of a plethora of other technologies around the same time. The Digital Twin relies on several leading technologies delivered by the IIoT: Big Data analytics, connectivity and application development, business process management, and on top of these, maturing technologies in the manufacturing world including:

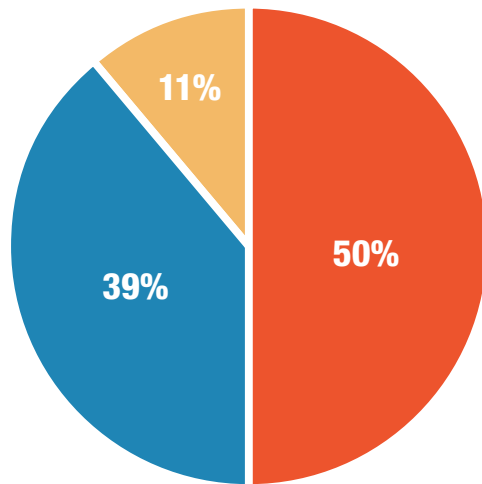
- Smart automation and IIoT-connected control
- Product lifecycle management (PLM)
- Three-dimensional computer-aided design (CAD)
- Digital simulation
- Manufacturing process management (MPM)
- Manufacturing operations management (MOM)
- Virtual reality and augmented reality (VR/AR)

These technologies combine in many different ways to support digital twins for discrete manufacturing — a product twin and a twin of the process used to make it. Although some of the related technologies have been around for a long time, the advent of more powerful computing and connectivity allows the Digital Twin to take on more fidelity and richness and become more like a virtual identical twin. An identical twin is like a Turing test in computer intelligence in that a human (or even a system) cannot distinguish between the twin and the real system. Today identical twins hardly exist and certainly not for complex systems of systems. As technology evolves, accuracy will tend towards the identical twin.



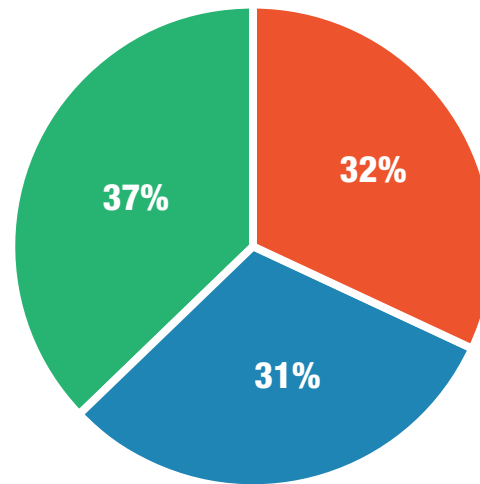
Demographics

LNS Research conducted primary research about the use of digital twins, how companies apply the technologies, and the benefits they expect or achieve. We surveyed over 300 executives from manufacturing companies across a wide range of industries, from semiconductor to oil and gas and many others. This report uses the results from the entire data set and the discrete sector as a subset, which is about one-half of the respondents.



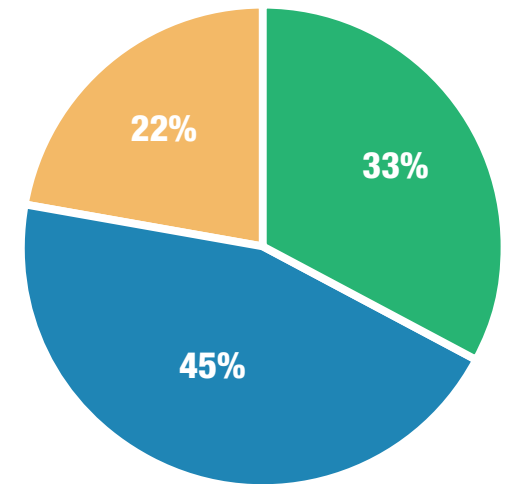
GEOGRAPHY

- North America
- Europe
- Rest of World



REVENUE

- Small < \$250M
- Medium \$250M-\$1B
- Large > \$1B



INDUSTRY

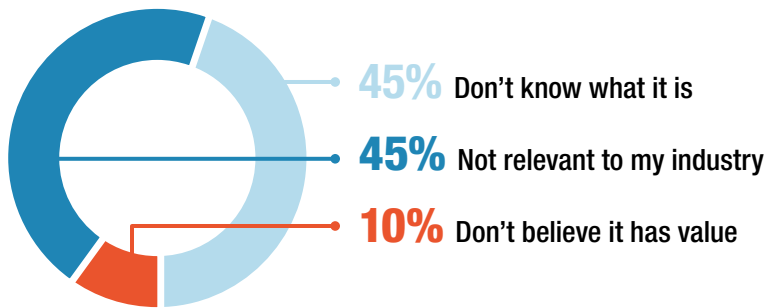
- Batch
- Process
- Discrete

Who's Using Digital Twin

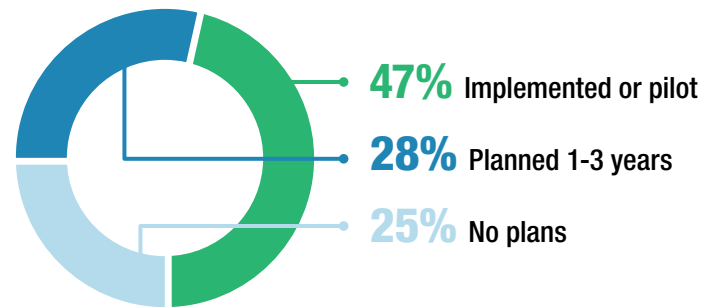
We pre-screened all potential respondents and weeded out many hundreds that do not have a digital twin initiative, or do not operate in an industry congruent with the focus of our work. Of those with no digital twin initiative or plans, we did ask one key question, "Why not?"

The results are reminiscent of IIoT awareness three to four years ago; almost half didn't know what a digital twin is. As the Digital Twin gains traction and importance, awareness will grow. For today, the software vendor and market research communities have a substantial education task in front of them.

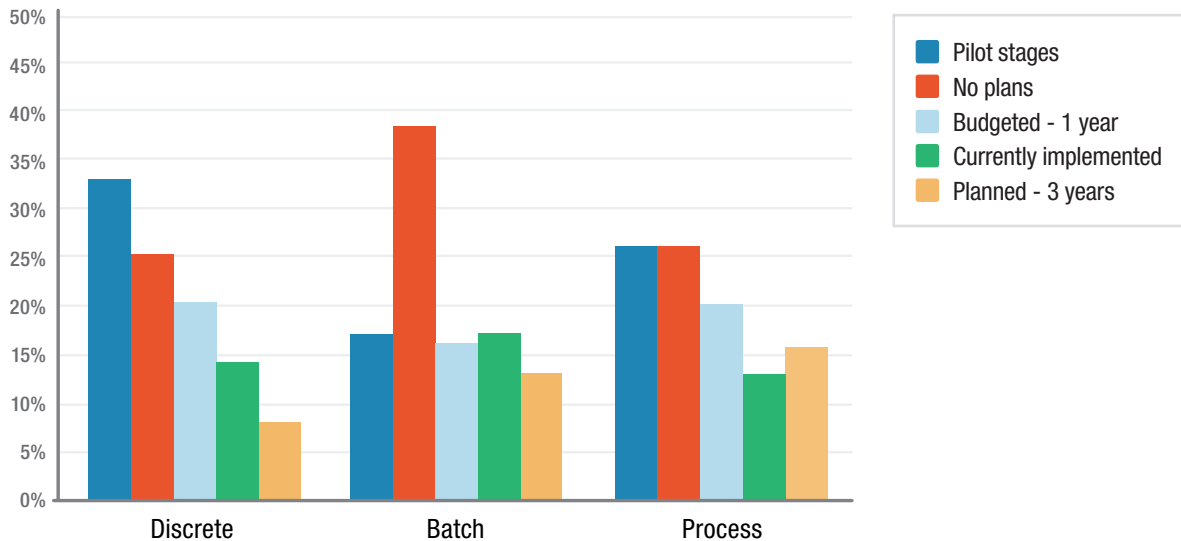
Reason for No Digital Twin Initiative (all industries)



Have or Plan Digital Twin Initiative (all industries)



Does your company have a Digital Twin initiative?



Who's Using Digital Twin (Cont.)

The appetite for the Digital Twin varies by industry segment, and there is a correlation with use of product lifecycle management (PLM) and the IIoT. As we expected, companies that use PLM and the IIoT show considerably more enthusiasm for digital twin technologies. Overall about 40% of companies either have digital twin technology or are in pilot stages, but when we look at just companies that actively use PLM or IIoT platforms, that number rises to an impressive 60%. However, things aren't as rosy as the numbers suggest:

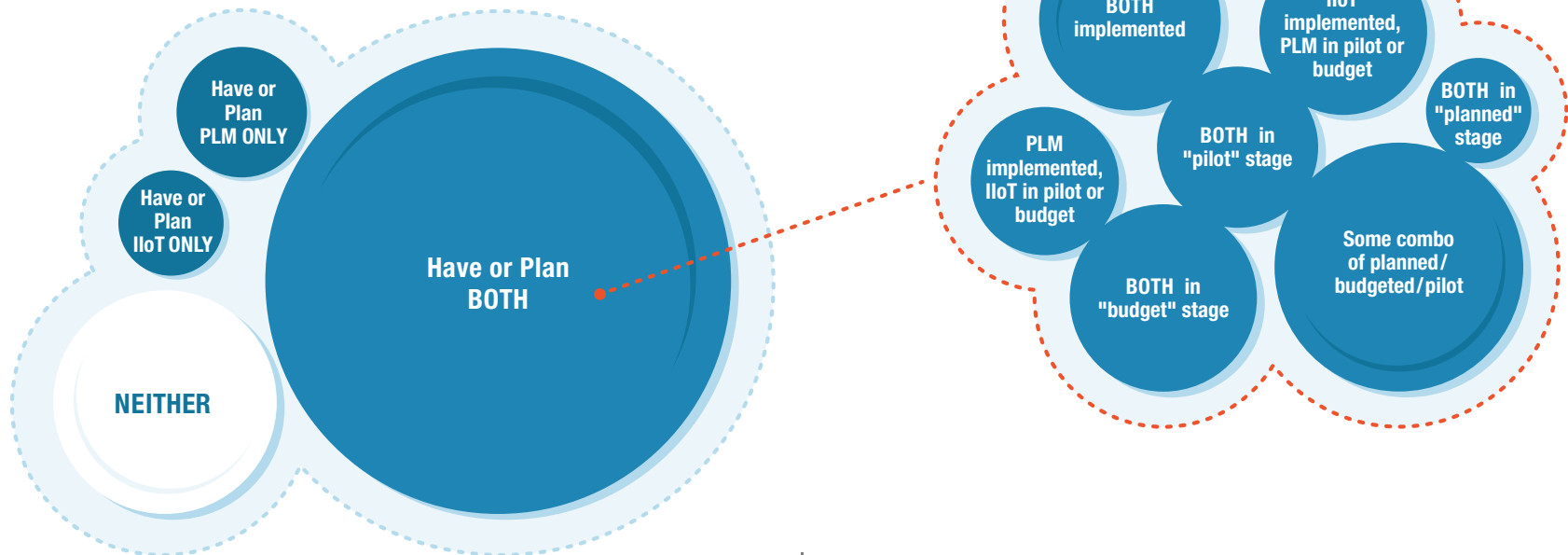
- Among discrete manufacturers, one-third have no plans or plan to wait up to three years.
- While respondent's mean number of production sites is about 25, with very few exceptions, companies have deployed or piloted digital twin technology in only one or two sites.



23% OF COMPANIES WITH A DIGITAL TWIN BUDGET have >\$1 million allocated for the initiative.

- Where implemented, only a median of ten people actually use the Digital Twin software.
- Only 23% of companies have more than \$1 million in the budget for the Digital Twin initiative.

PLM AND IIOT PLATFORM USE & PLANS



Growth Expectations

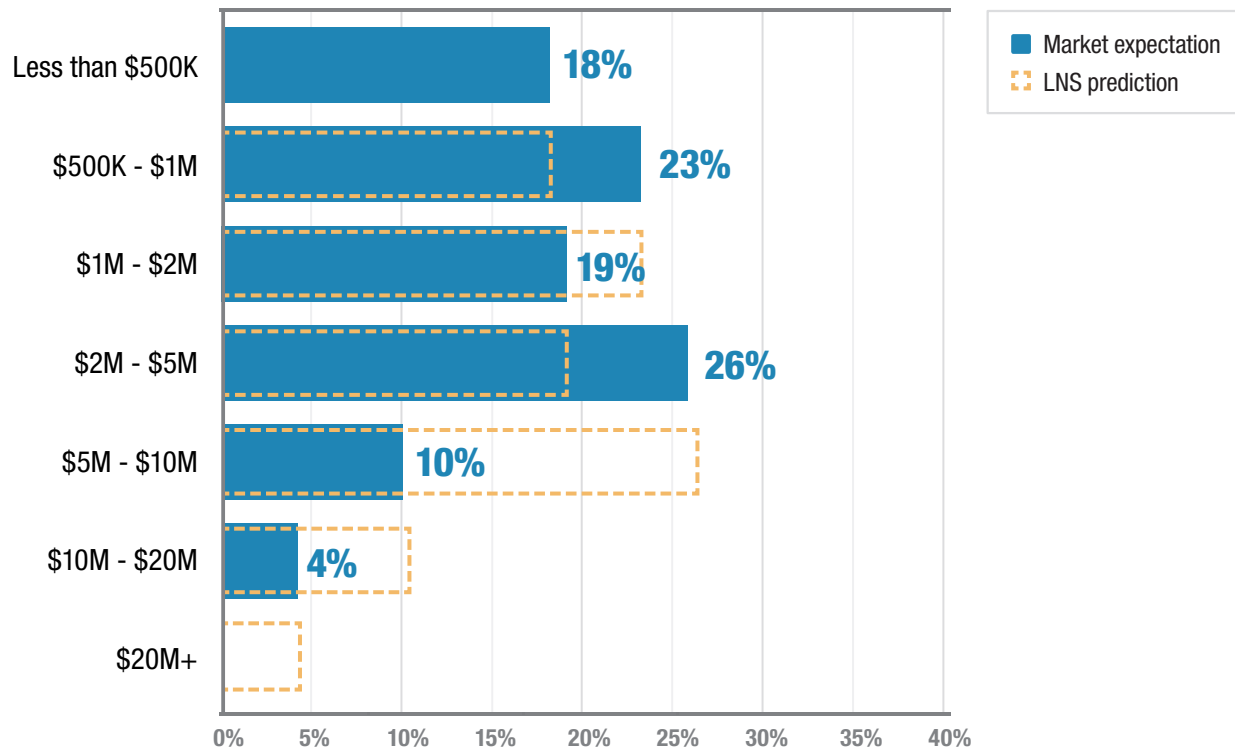
Over the next five years, we can expect to see an increase of about 22% in million-dollar Digital Twin projects. It's important that corporate strategic planning takes into account today the likely spend on Digital Twin. LNS Research predicts that investments will happen faster than the numbers show today.

When it comes to ROI expectations and payback timeline, nearly 60% of companies expect to recoup their investment within one year. That seems quite ambitious for first Digital Twin projects; a full design and data analytics integration for just a high-level digital twin will be hard-pressed to pay back full investment in a year.

Instead, companies with a long-term view and integrate the digital twin projects into industrial transformation programs will achieve the greatest success.

Over a more extended period of five years, things should be different; 75% of companies expect 10-100% ROI. Only 13% of companies forecast that they'll at least double the Digital Twin investment in five years. As companies evaluate Digital Twin opportunities, we hope that a much higher proportion can achieve dramatic ROI; the sky is the limit for the ambitious organization.

Initial Budget for Digital Twin Over Five Years



Companies Have Big Expectations

The possibilities to improve the manufacturing organization with digital twins are impressive. The survey listed a variety of possibilities across several broad categories, and respondents selected as many as they use or intend to use:

- Technologies that deliver data
- Use cases
- Manufacturing business processes

Technologies that deliver data are innumerable. The potential for ROI in a Digital Twin increases as the company applies more data sources to improve twin fidelity and completeness. The first, and most obvious to a manufacturer are data historians and MES/MOM, followed by distributed control systems such as PLC, HMI, and

SCADA, and quality systems. We expect almost all manufacturing companies will use some or all of these in a Digital Twin program.

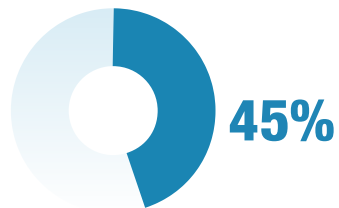
The next level of data is more interesting. For example 45% of companies said they would use customer feedback, 40% vendor models, and over 25% each from ERP/business systems, weather and product data. Companies focused on Digital Twin are clearly thinking laterally to expanding coverage outside a typical plant-centric focus.

While Digital Twin use cases form a substantial list, the top among discrete manufacturers with 25% or more each are:

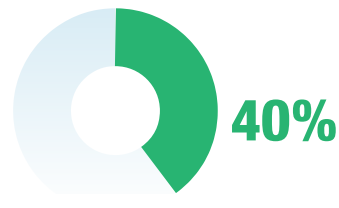
- Improve product quality
- Reduce manufacturing costs
- Reduce unplanned downtime
- Increase throughput

APPLYING ADDITIONAL DATA TO DIGITAL TWIN

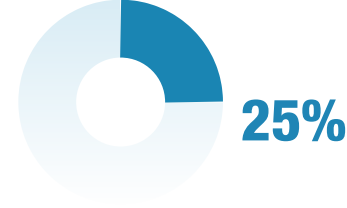
CUSTOMER FEEDBACK



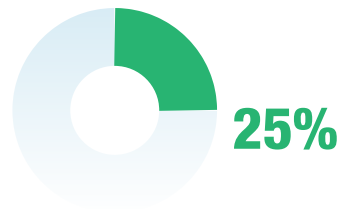
VENDOR MODELS



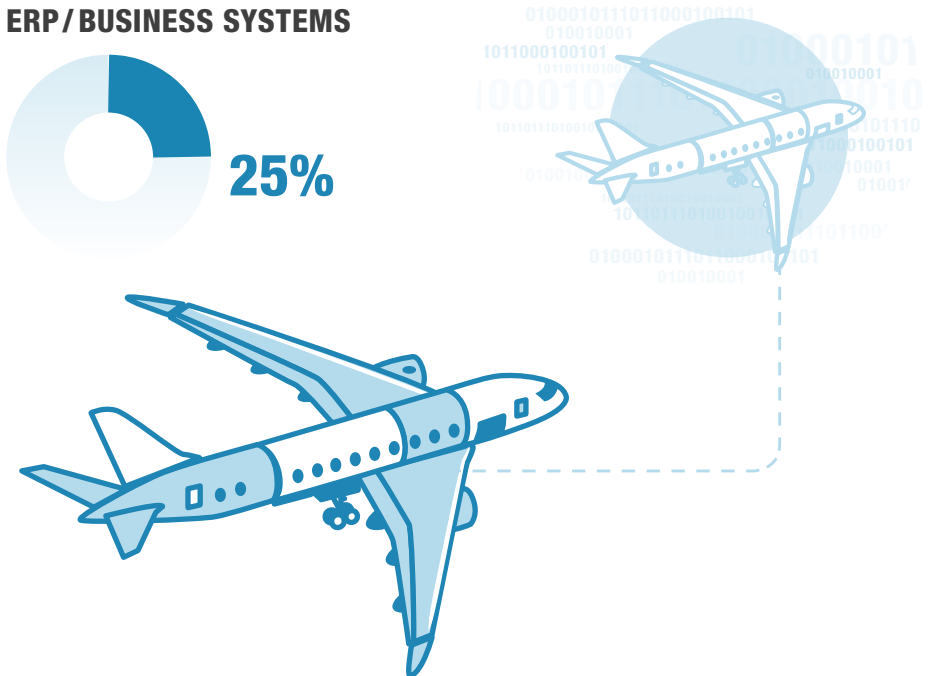
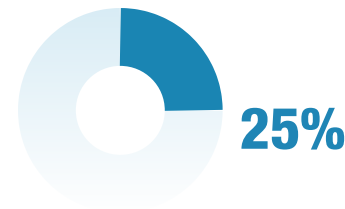
ERP / BUSINESS SYSTEMS



WEATHER



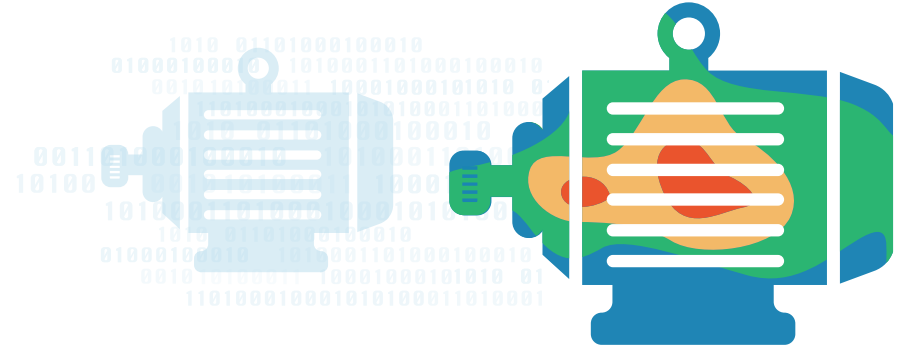
PRODUCT DATA



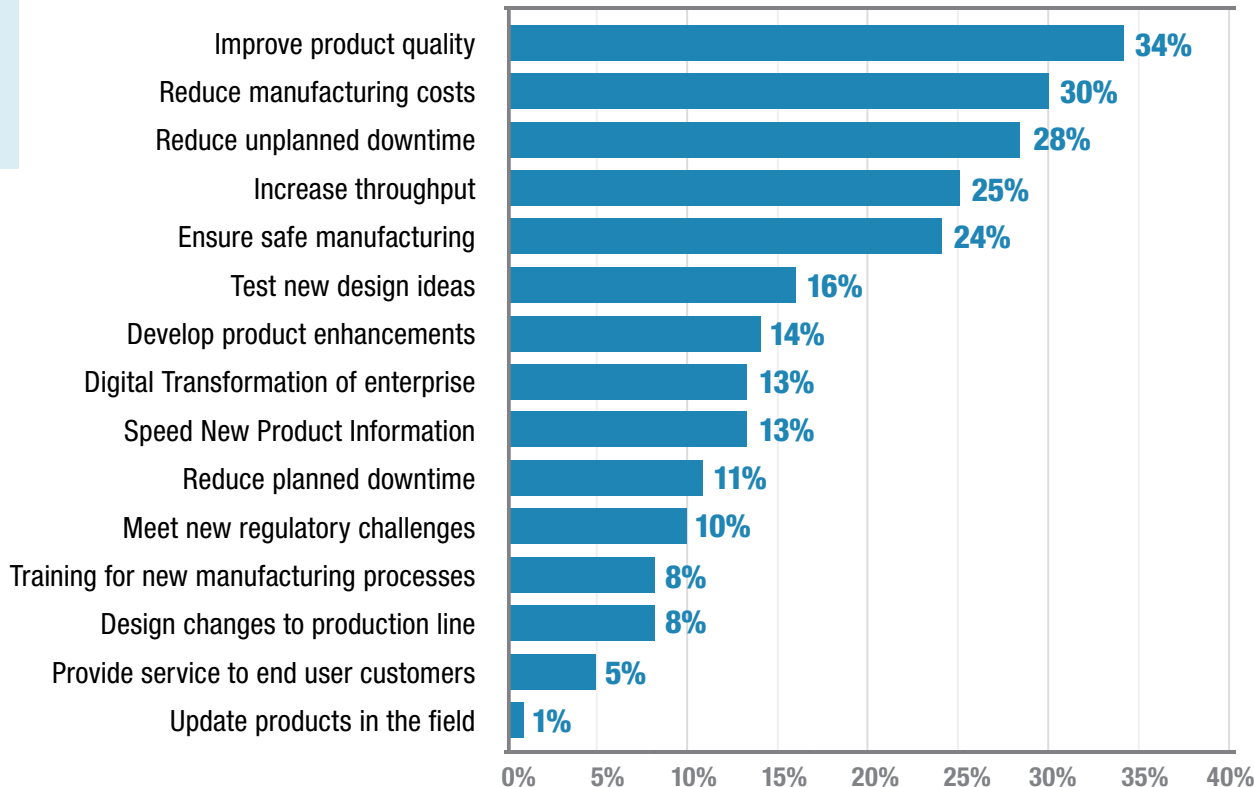
Digital Twin Use Cases

These use cases strongly focus on the manufacturing process rather than the product. In these early stages, this is what we expected. At the bottom of the use case spectrum we find activities like “update products in the field,” and “provide service to end-user customer.” These are the activities that are much more likely among mature twin users.

Finally, as we examine the manufacturing business processes covered by twins, we find that 3D design and manufacturing operations head the list, closely followed by many different forms of simulation including environment, manufacturing process, machine and of course product simulation.



Digital Twin Use Cases



Digital Twin Still “New” But Not Untried

Since the use of Digital Twin is still somewhat new, and this is the first LNS Research survey dedicated solely to the topic, we can't look back to see how the use of the technology has evolved. That doesn't limit our ability to clearly understand where the market is today and what's on the horizon. Overall, we are pleasantly surprised by the results, particularly where discrete manufacturing is concerned. We find broad implementation of the technology across industries, with the more complex manufacturing segments being the leaders. Single plant digital twin systems are becoming widespread. We would certainly expect to see more sophisticated twins in the coming few years, as more companies get access to complex simulation systems and collect data from broader sources.





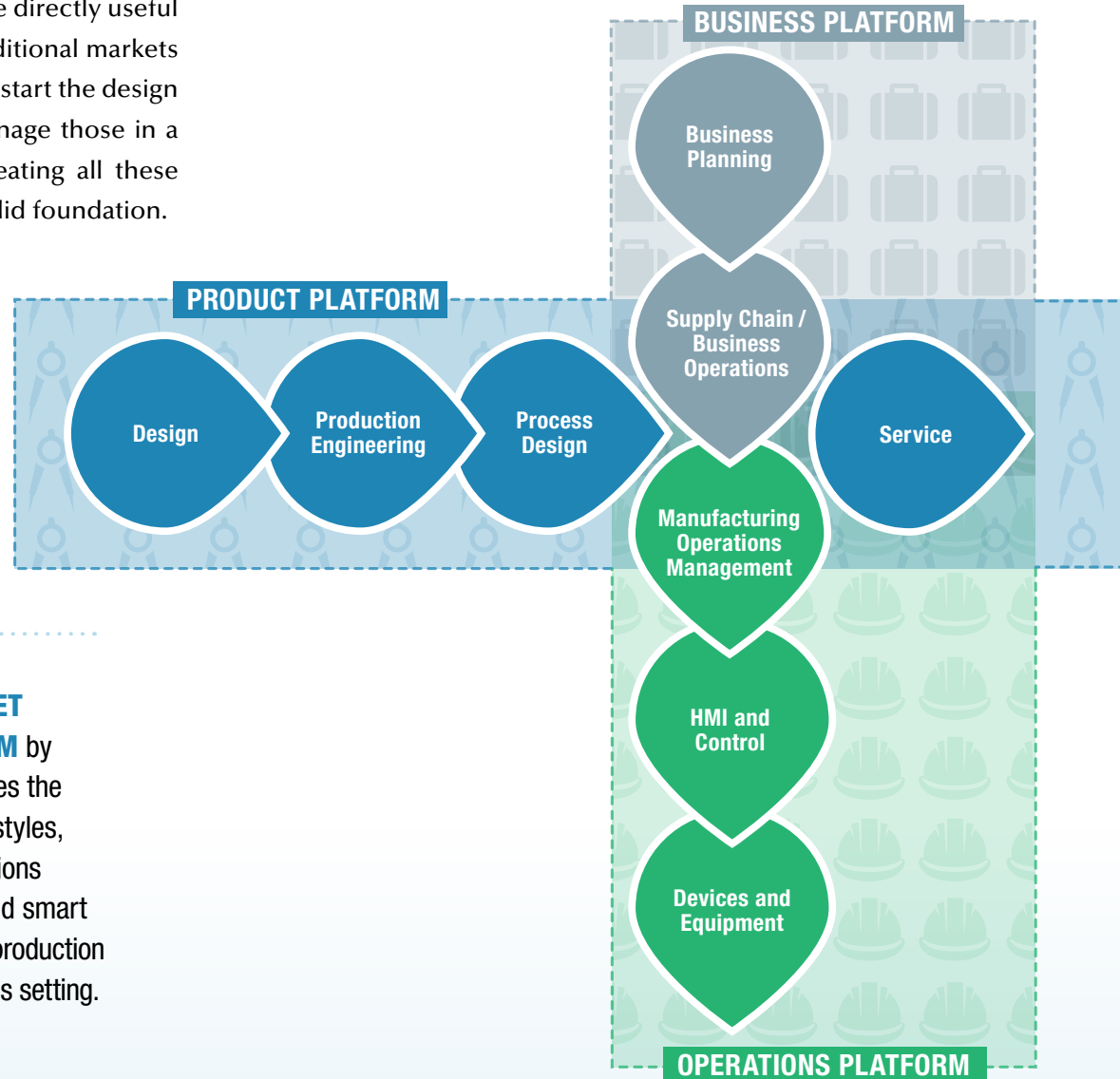
SECTION 2

Exploring Digital Twin Opportunities

Digital Twin Tech in Play

As we have seen, the advent of new technologies opens new opportunities for digital twins across many industries. When we look at the standard technologies used in IIoT systems, many are directly useful in both the real world and the virtual world. The traditional markets for digital twins, automotive, aerospace, and defense start the design process with 3D models of physical parts, then manage those in a product lifecycle management (PLM) platform. Creating all these models and making them “executable” requires a solid foundation.

INTERSECTION OF PLATFORMS ENABLES DIGITAL TWIN



INDUSTRIAL INTERNET OF THINGS PLATFORM by LNS Research describes the connectivity, network styles, analytics, and applications

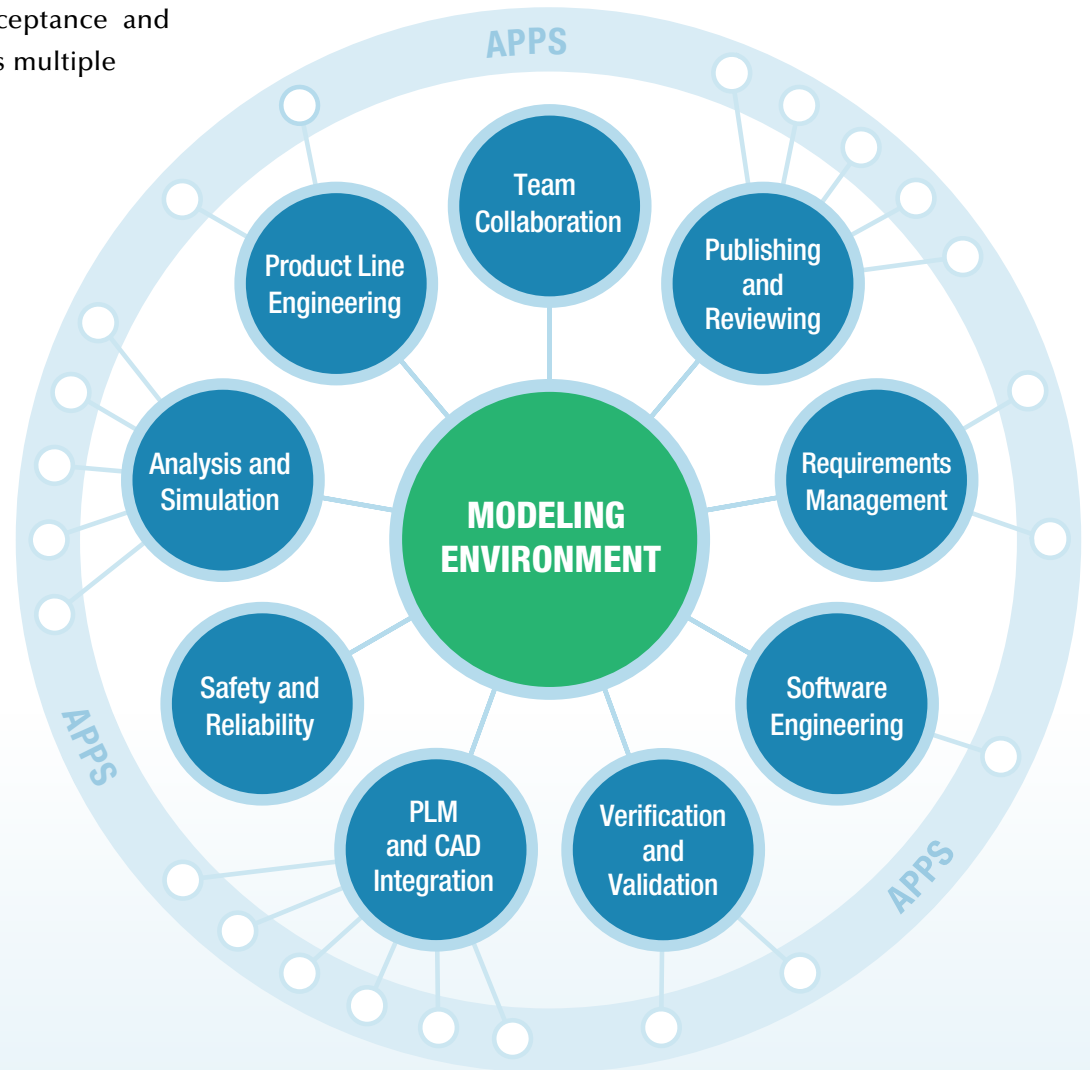
frameworks to support smart connected operations and smart connected assets; within and across a plant, facility or production network in a manufacturing or other industrial operations setting.

 [Click to learn more about the Industrial Internet of Things Platform](#)

Digital Twin Tech in Play (Cont.)

The key to finding a good starting point for a digital twin is to use a rigorous model-based systems engineering (MBSE) approach to product design. MBSE can be used at every level of detail of a system and helps engineers focus on the design rather than the traditional hierarchy complexity of documents and drawings. There are de facto standard MBSE design languages, such as UML and SysML; something that dramatically aids the acceptance and use of the technologies, and eases adoption across multiple teams working on large projects.

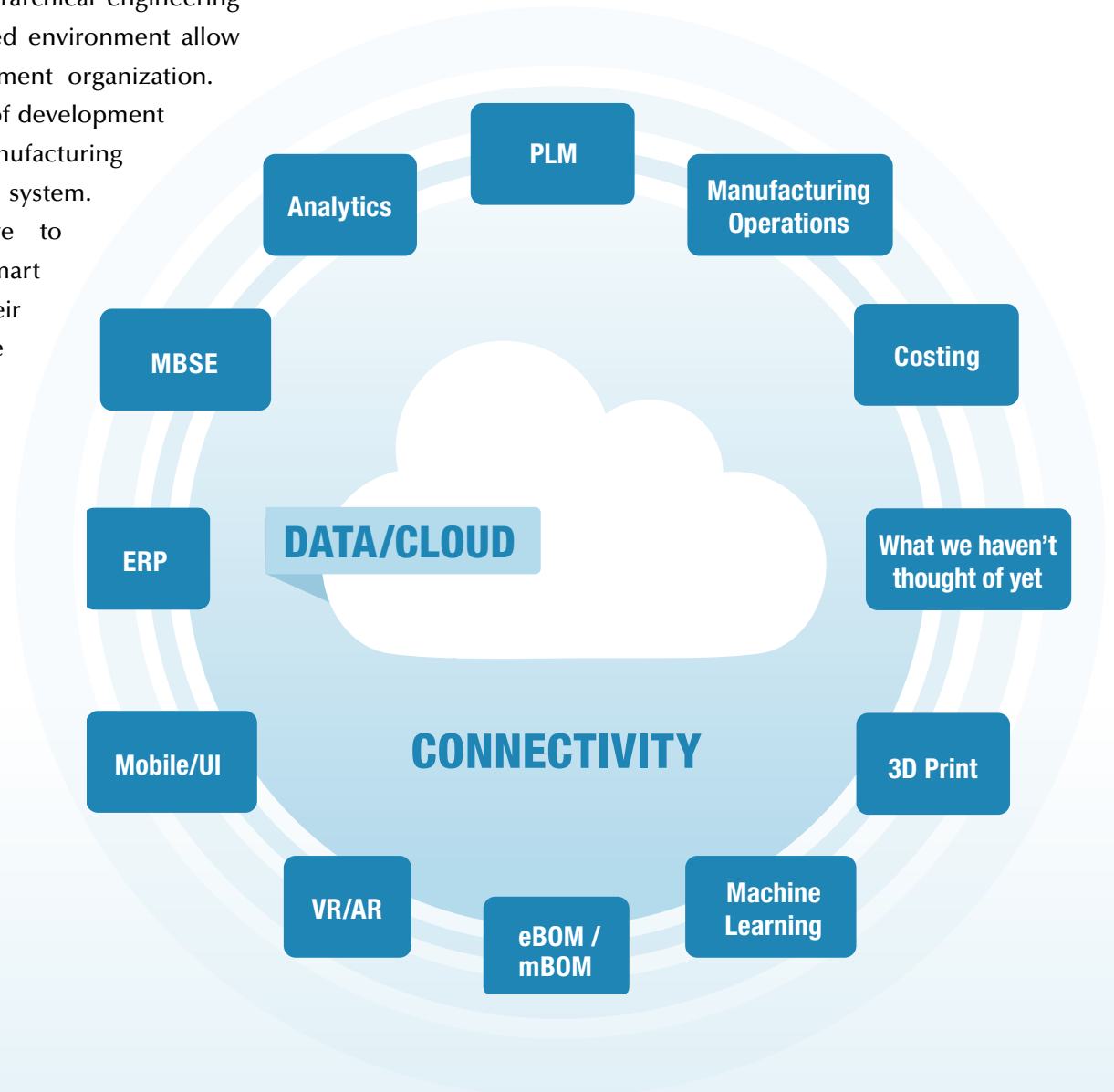
MODEL-BASED SYSTEMS ENGINEERING (MBSE)



Digital Twin Tech in Play (Cont.)

While MBSE is effective, it's not enough. Models are a great way of using and sharing information about a complex product. Furthermore, engineers can build them hierarchically so that many different people can receive views of the same product or system with more or less detail. Traditional 3D models and hierarchical engineering bills of material (BOM) built in a model-based environment allow communication across the product development organization. When it comes to the more commercial side of development such as costing and procurement, many manufacturing organizations will turn to the traditional ERP system. However, as leading manufacturers move to leverage IIoT-based approaches to advance Smart Manufacturing or Industry 4.0, in context of their business processes, the opportunity to integrate engineering models and business functions will increase, and will therefore drive ever more value from product data all the time.

EXPANDED VIEW OF DATA: DIGITAL TWIN DEMANDS MORE THAN "JUST" PRODUCTION DATA



Digital Twin Tech in Play (Cont.)

As we progress into the design detail, engineers combine components in the design world, and the digital representations are similarly brought together to deliver a view closer to reality. People can inspect and combine one digital twin with others, either developed for the current project or already in a library of existing twins. The goal for the Digital Twin is to keep on growing in parallel as the system develops; at each stage the Digital Twin receives more virtual information. This progression is fairly obvious when looking at purely mechanical parts of a product or system. However, opportunities to use the Digital Twin to aid development reach far beyond simple product design; a few include:

- Simulating product use in varying environments
- Simulating the manufacturing process
- Testing product software (that which is embedded in the product)



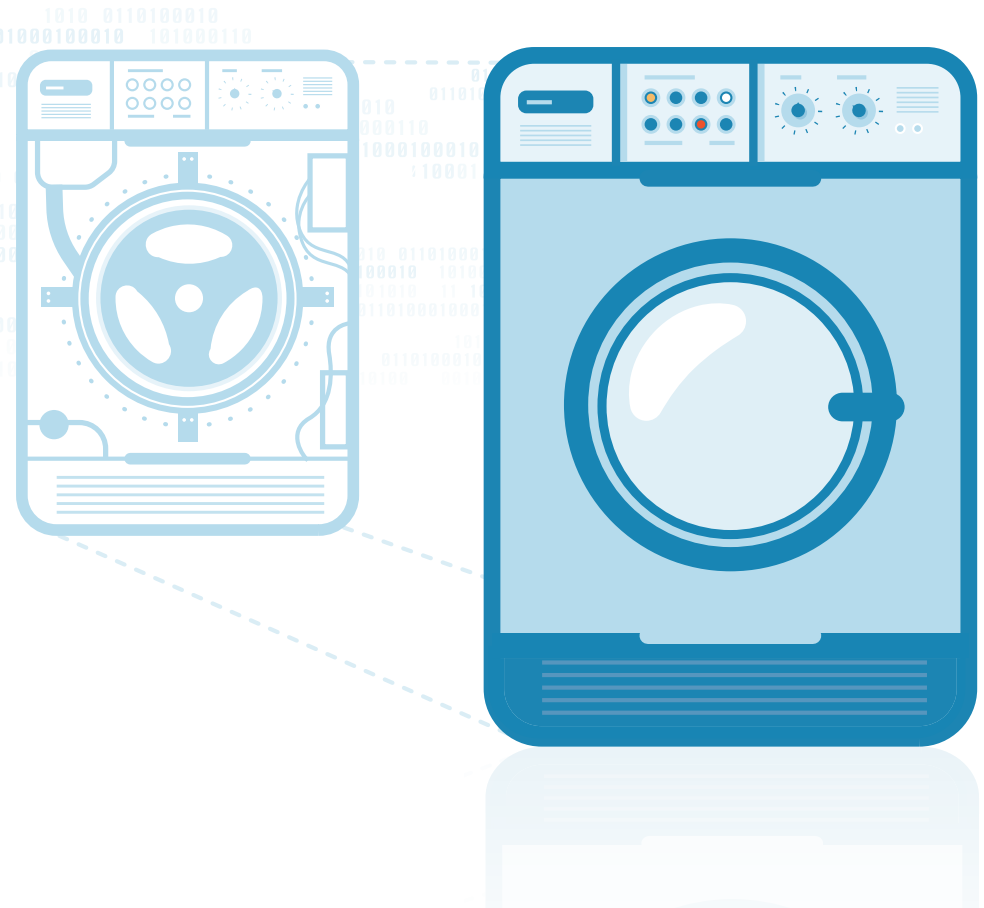
Simulating Product Use

Over the last few years, the market – spanning software vendors, market researchers, and even end-user communities – has spent much time on and written volumes about simulation. Companies involved in design and manufacturing systems have invested heavily in ever increasing fields of simulation. With access to huge computing clusters on the Cloud and multi-physics simulation systems, creating a fully dynamic Digital Twin is now a reality.

Simulation is essential for manufacturers considering a Digital Twin software purchase. The capabilities might be available from a PLM software vendor or even specialist simulation companies that focus on specific solutions such as aerodynamics, heat, people, complete subsystems such as robots, or whole machines like bottling equipment.

As manufacturers undertake industrial transformation, the holy grail is to improve business and manufacturing performance through Big Data analytics. Simulation can be a significant source (and consumer) of Big Data for manufacturing process improvement, and for the product itself.

Simulation comes in many forms, from simulating single parameters (such as a temperature gradient in a process) to multi-physics simulation where the data used covers various first principle laws. Simulation scenarios might include thermodynamics and aerodynamics working simultaneously in a single product. The value of a Digital Twin increases as we move both physical and data-driven models closer to a faithful representation of use in the real world. For each case, the depth and fidelity of the simulation will vary across parts of the system. Today, manufacturers can build a complete virtual model of a complex product like a car, washing machine or even aircraft – the Digital Twin means being able to model all aspects of its behavior.



Simulating the Manufacturing Process

Simulation adds tremendous value to the production process in manufacturing plants. Today companies mainly use it to zero in on process improvements and new product introduction (NPI). Engineers can adjust the virtual model of a process, test it and determine suitability on a "new" production line. Of course using a Digital Twin, engineers can try tens of thousands of possibilities for a system to determine which improvements work best with the process. Trial and error isn't a good strategy when you're testing on a real line but it makes complete sense with a Digital Twin.

In process industries like pharmaceutical, oil and gas, or even plastics there is a strong emphasis on the Digital Twin to ensure process optimization and predictive reliability. Simulation using a Digital Twin is key driver in asset-intensive industries. Use cases around running production lines in discrete manufacturing will rapidly emerge.



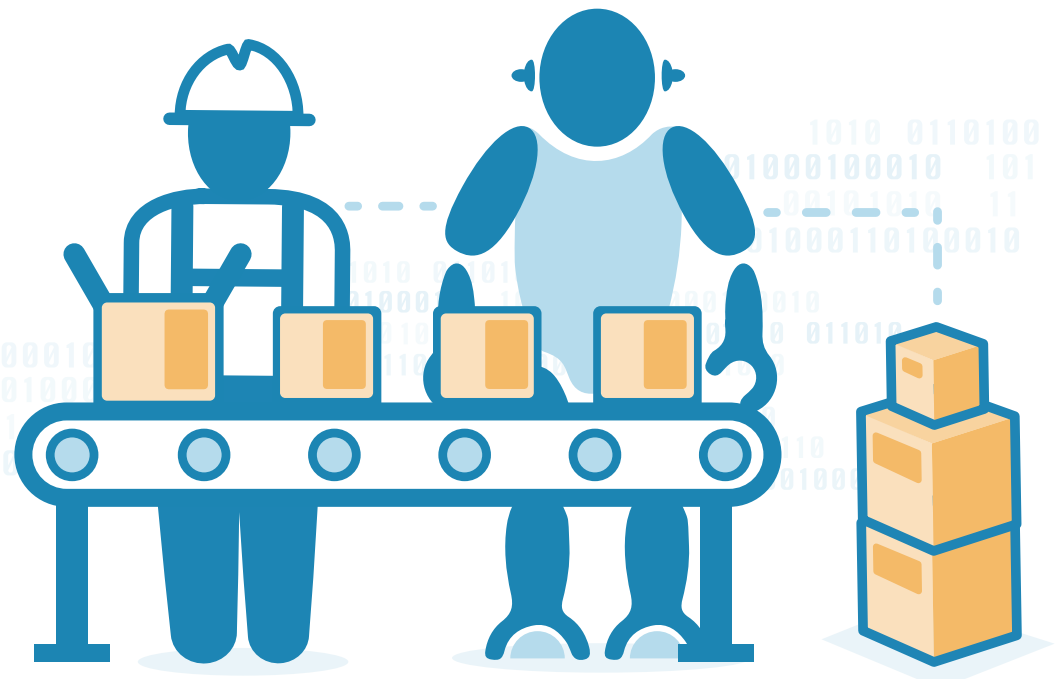
Simulating the Manufacturing Process

Discrete manufacturers, unlike process manufacturers, usually consider production assets somewhat secondary to the design and manufacture of the product itself. Digital Twin will dramatically change the way discrete manufacturers conceive the manufacturing process. When they start to use a digital twin to build a detailed executable model of the production line, virtual manufacturing will allow them to determine the most efficient way to produce goods and which changes are required when the product changes.

As we bring “cobots” to the shop floor (collaborative robots that interact with people and machines), the need for manufacturing process management becomes far greater. Simulation tools will be

required to ensure safe operation and interaction between human and robot, working in the same unguarded spaces. In particular assembly operations that take place in encumbered spaces can hugely benefit from detailed “what if” analysis of the environment and the resources that share it.

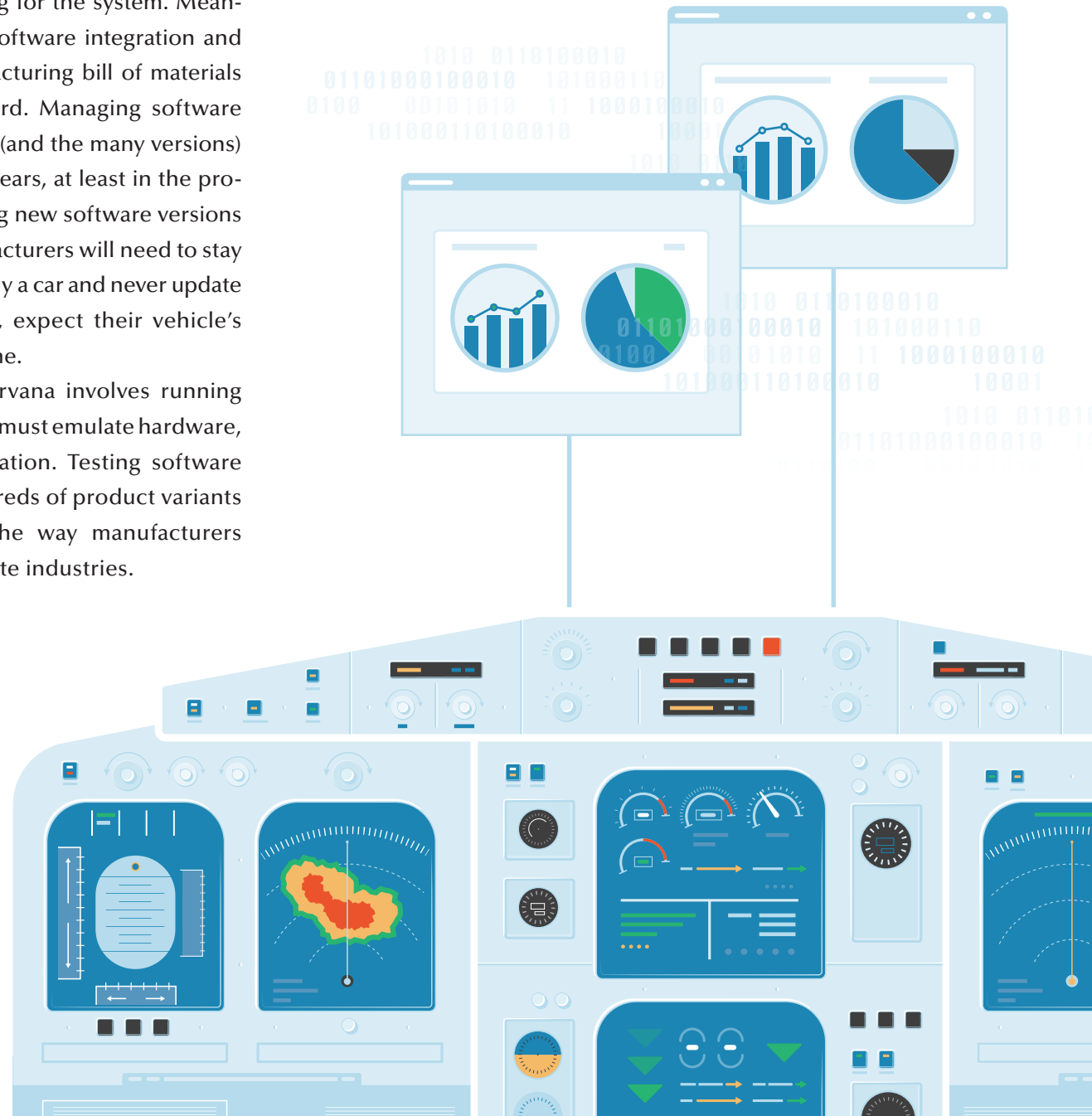
Cobots, effective digital twins, and flexible machines will support a critical change that is coming in the manufacturing world: configure or design to order. The ability to change what you make and as how you make it in near real-time opens up new business opportunities for manufacturers.



Software in Digital Twin

Software and manufacturing have not always been the best of bedfellows. Someone designed the hardware, specified the computing requirements, and neatly laid out the calling for the system. Meanwhile, someone else wrote the software. Software integration and managing software as a part of the manufacturing bill of materials (mBOM) have, in the past, been haphazard. Managing software versions and the relationship to electronics (and the many versions) has taken leaps forward in the last several years, at least in the production world. Tesla's approach to uploading new software versions to a vehicle is an approach that other manufacturers will need to stay competitive. While many older consumers buy a car and never update it, younger generations will, at very least, expect their vehicle's software to be as current as their smartphone.

The first step towards this software nirvana involves running product software in its digital twin. The twin must emulate hardware, operating system and possibly communication. Testing software on a product twin, including perhaps hundreds of product variants (like aircraft), can dramatically change the way manufacturers provide post-sale service in complex discrete industries.



Real Data Versus Virtual Data

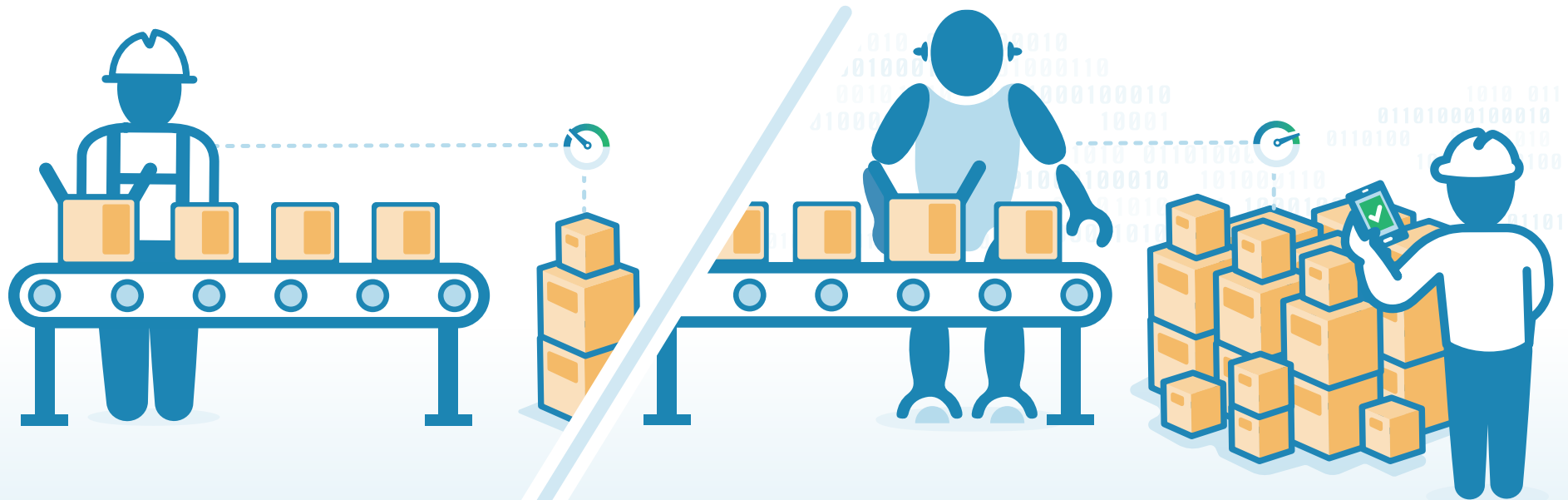
The majority of digital twins today are based on a simple concept — collect real data and use it in the virtual system to model behavior, or simulate virtual data to test the actual system's expected behavior. The goal is to determine system outcomes without direct access to the real system or parts thereof.

For example, operators at a simple assembly station might do everything manually. It's a straightforward exercise to define tools and stations needed, the system parts and the people. The as-built model from CAD or PLM is also usually available; it is the system output. Applying all these elements in the Digital Twin, we can run what-if scenarios to understand if adding a robot would improve manufacturing by:

- Easing the load on the people involved,
- Increasing production,
- Reducing defects, or
- Removing some people.

Engineers could even design the manufacturing cell to do more than one job, some using a robot and others just people. The objective with a digital twin isn't to replace people but rather enhance their capabilities and create new processes to which the people can add value, especially in improving customer relations.

As companies move from basic use of a digital twin like the one above, to more complex applications like testing a finished product while still in the production environment, they compound the value of twin technology. Product testing is a much more common use case in discrete manufacturing. The workforce can use the product digital twin in many ways including designing the manufacturing process and managing the delivered product. In the short term, the most likely scenario is product enhancement and refresh — applying a digital twin to an existing product to improve it. While we mentioned software updates, there are far more opportunities to update a product in service than just code refreshes.



Real Data Versus Virtual Data (Cont.)

As companies move from basic use of a digital twin like the one above, to more complex applications like testing a finished product while still in the production environment, they compound the value of twin technology. Product testing is a much more common use case in discrete manufacturing. The workforce can use the product digital twin in many ways including designing the manufacturing process and managing the delivered product. In the short term, the most likely scenario is product enhancement and refresh — applying a digital twin to an existing product to improve it. While we mentioned software updates, there are far more opportunities to update a product in service than just code refreshes.

Imagine using a digital twin to test physical upgrades for implementation in the field. Large industrial machinery is one example

where the life of a product can involve many upgrades, improvements and maintenance changes. By recording all changes in the virtual asset history, we achieve a digital twin with accuracy that matches the “as maintained” status of the actual equipment. This level of detail allows the organization to consider improvements before it incurs expensive parts and time.

Although this report zeros in on discrete manufactured products, it’s important to consider the Digital Twin in a broader context. A digital twin can model the environment where a product exists; virtual cities with ever-increasing fidelity is the perfect environment to test and develop virtual products. Ultimately, manufacturers should apply imagination and creativity to come up with new ways to exploit virtual environments and enhance digital twins.





SECTION 3

Digital Twin and Your Organization

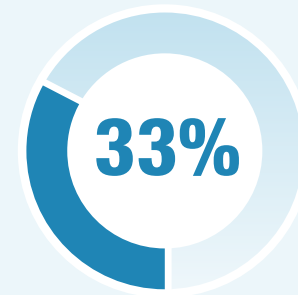
Pragmatic Considerations

The LNS Research survey asked respondents about Digital Twin program ownership, and while the results are somewhat surprising, they're also encouraging. Ownership by production and supply chain leaders implies that the focus is customers rather than internal. However, it also raises some questions about the role Digital Twin plays in technology integration across the enterprise.

A variety of initiatives drive industrial transformation in manufacturing companies. More importantly, we see an ever-growing number of top corporate executives getting involved – even if it's the form of appointing a chief digital officer (CDO) or getting other senior executives directly involved (such as CIO or COO). Ultimately, their role is to set Strategic Objectives and set the course of industrial transformation. The enterprise objectives steer and accelerate decisions about platforms, tools, storage – indeed everything that makes up the IIoT platform.

In many ways, the Digital Twin evolved from an entirely different direction. In discrete manufacturing, PLM, MOM/MES, automation and even business systems such as ERP matured over the years in the plant environment. Much of the early groundwork for the Digital Twin emerged from PLM platforms and connectivity beyond traditional 3D design. Decision makers should recognize this difference and must avoid a clash between IIoT and PLM platforms. So the Digital Twin can manifest the highest form of plant integration and support industrial transformation.

Digital Twin Project Ownership



Production



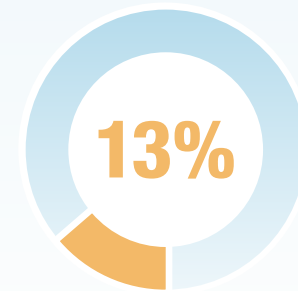
Supply chain



Engineering



Corporate quality



Finance

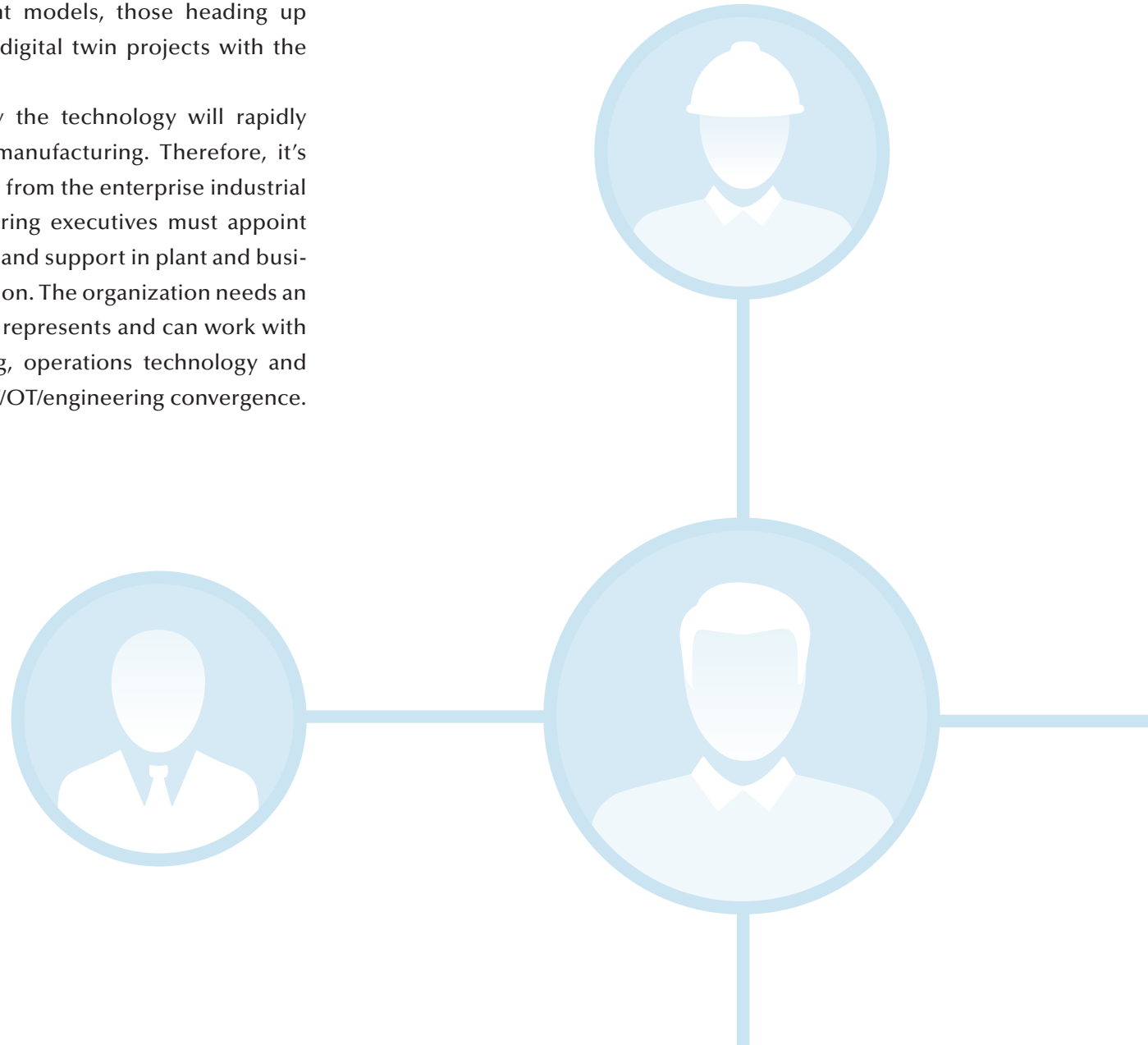


Customer relations

Gather a Team Rather Than Hand Over the Reins

This discussion brings us back to the question of who owns, and who should own Digital Twin projects. The survey revealed that among discrete manufacturers, production and supply chain leaders drive digital twin initiatives. As twin technology shifts toward production assets and development models, those heading up twin projects should also combine digital twin projects with the industrial transformation initiative.

The Digital Twin is here to stay the technology will rapidly become a critical part of modern manufacturing. Therefore, it's inconceivable to keep them separate from the enterprise industrial transformation program. Manufacturing executives must appoint leaders with a breadth of experience and support in plant and business technology to drive transformation. The organization needs an extended cross-functional team that represents and can work with information technology, engineering, operations technology and more. Digital Twin requires proper IT/OT/engineering convergence.



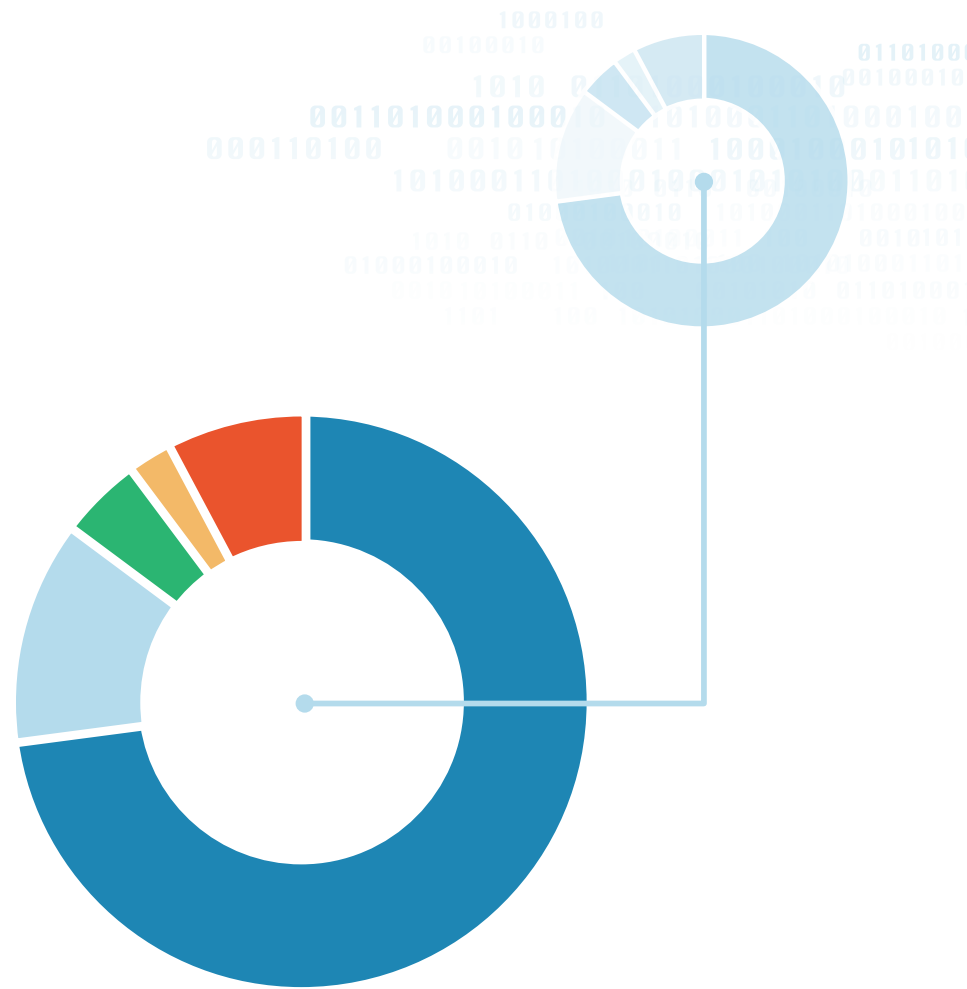
Recommendations for Getting Started with Digital Twin

Today is the ideal time to start looking at digital twin technology to decide which use case to begin with, and how it will impact your company's or products' performance. Even though 25% of survey respondents say they have no plans to start a Digital Twin program, we believe that the posture will rapidly change for many as their own customer base begins to ask for a twin along with the real product or process.

As understanding and attitudes about twin technology matures, the relationship between supplier and customer will likely become more collaborative. Because the Digital Twin will deliver much more intellectual property about the product and how the company makes it, the time to take action is now.

First, define where to apply a digital twin across product and process:

- If your organization already has PLM, start with defining the product in 3D and an environment for product simulation.
- If the company already has an industrial transformation initiative, define a digital twin project as part of that effort.
- If there is no formal industrial transformation initiative, then choose a limited product or manufacturing business process that would benefit from the detailed view a digital twin can provide.



Recommendations for Getting Started with Digital Twin (Cont.)

Partner with customers and upstream suppliers to:

- Develop a Digital Twin project to deliver better customer service, faster NPI, and higher quality with continuous communication and experimentation.
- Use digital twins to gather in-use product information for product improvements.
- Get ahead of the game and anticipate that customers might ask for or insist on a digital twin if they're outsourcing manufacturing to you. It's easy to include a fairly "lightweight" twin during negotiations. Express and demonstrate your ability to deliver digital twins with more fidelity as the program progresses.

Whichever path your company takes, the key is to learn about the benefits now, and distribute that information throughout your organization today so that the entire staff can start thinking about how they can put the Digital Twin to work in their role.

Author:

Matthew Littlefield

Principal Analyst

matthew.littlefield@lns-global.com

Connect:



**ACRONYM
QUICK REFERENCE**

[VIEW ON BLOG](#)

Presented by:

