The rise of the digital supply network

Industry 4.0 enables the digital transformation of supply chains

Introduction

SUPPLY chains traditionally are linear in nature, with a discrete progression of *design, plan, source, make,* and *deliver*. Today, however, many supply chains are transforming from a staid sequence to a dynamic, interconnected system that can more readily incorporate ecosystem partners and evolve to a more optimal state over time. This shift from linear, sequential supply chain operations to an interconnected, open system of supply operations could lay the foundation for how companies compete in the future.

We call this interconnected, open system a *digital supply network* (DSN). DSNs integrate information from many different sources and locations to drive the physical act of production and distribution.[1] The result can be a virtual world, which mirrors and informs the physical world. By leveraging both the traditional and the new, such as sensor-based data sets (such as unstructured data), DSNs enable integrated views of the supply network and rapid use-case-appropriate latency responses to changing situations.

Many organizations already on the path to creating DSNs are shifting their focus away from managing and optimizing discrete functions, such as procurement and manufacturing. Instead, they often use DSNs to focus more holistically on how the full supply chain can better achieve business objectives, while informing corporate, business unit, and portfolio strategies. Indeed, DSNs increasingly allow supply chains to become an integral part of strategic planning and decision making. To this end, organizations can develop and leverage multiple DSNs to complement different facets of their strategy and more effectively target specific needs.

DSNs integrate information from many different sources and locations.

Historically, supply chain professionals managed the "four Vs" (volatility, volume, velocity, and visibility)[2] as they attempted to optimize results across a series of objectives that include total cost, service, quality, and support for innovation. These traditional priorities are not likely to change, but going forward, supply chain decision makers should be able to achieve higher levels of performance with supply chain capabilities developed with new digital technologies. Additionally, supply chain professionals can help create new sources of revenue by providing new and faster access to markets, and supporting the production of smart products. Such opportunities would add revenue to the existing list of objectives for the supply chain.

Change is often hard, but the digitization of information and the application of advanced innovative technologies present the opportunity to drive business value throughout the supply chain. Moreover, digital disruption can change supply chains in any industry. To avoid becoming a victim of disruption, it helps to understand these shifts and adapt accordingly. In the pages that follow, we explore and analyze the next stage of growth for supply chains in DSNs by:

- Tracing the technological evolutions that enable the rise of the DSN
- Defining what the DSN is, along with its role within a wider business strategy
- Examining the trade-offs inherent in a typical supply chain, and identifying the characteristics that can mitigate those trade-offs
- Considering how to build a DSN

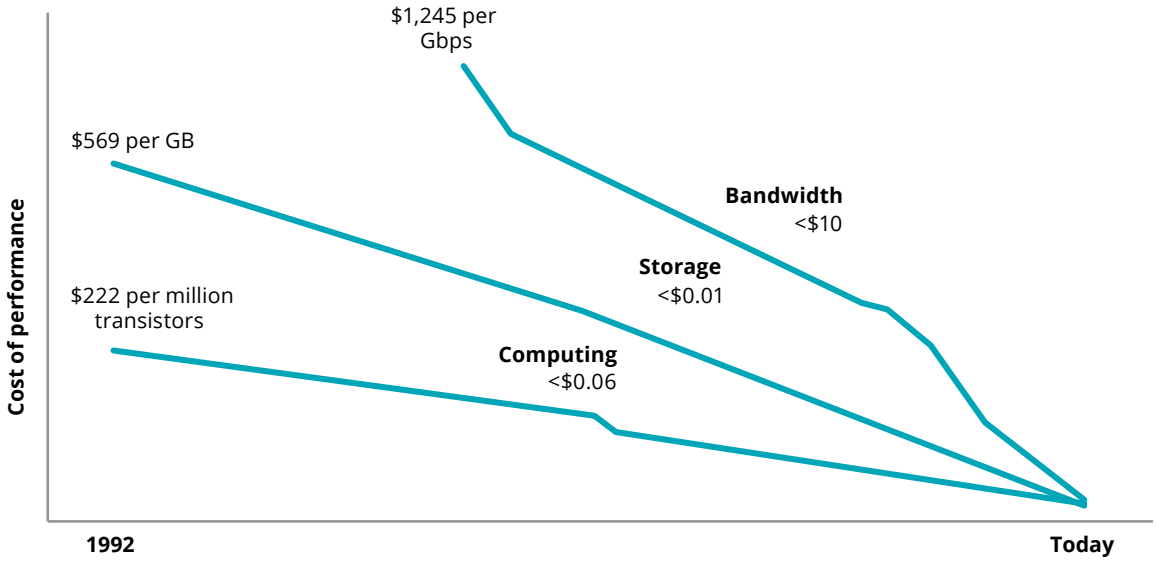
Technological evolution spurs the rise of Industry 4.0—and ushers in disruption

DIGITAL technologies have changed dramatically in recent years, driven largely by three key developments: lower computing costs, cheaper storage, and less costly bandwidth, in keeping with Moore's Law[3] (figure 1). The sharp cost decline over the last few decades has made it possible for companies to invest less and still reap the benefits of digital technologies on a wider scale.

However, the surge in digital technologies has likely not been driven by cost alone. Even as these costs have declined, computing power and technological capabilities have grown significantly.[4] Indeed, between 1992 and 2002, computing power increased at an average of 52 percent per year,[5] enabling organizations to gather, store, and analyze greater amounts of data than ever before. By 2020, we expect that 44 zettabytes of data will be created and copied each year, up from 1 zettabyte in 2010.[6]

The confluence of these developments—significantly lower costs, and improved power and capabilities—has led to exponential changes that enable leaders to combine information technology (IT) and operations technology (OT). Companies are now empowered to create value in new and different ways. Improved processing capabilities now augment human thinking to analyze more data more quickly, and then act upon it. Such changes have ushered in the new era of Industry 4.0.[7]

Figure 1. Declining costs in bandwidth, storage, and computing



Source: Deloitte analysis.

Industry 4.0, or the fourth industrial revolution, is characterized by new technologies that blur the lines between physical and digital worlds—driving real-time access to new and existing data sources. Paired with powerful analytics tools, such as visualization, scenario analysis, and predictive learning algorithms, this access to data is fundamentally changing how companies operate. Companies can now gather vast data sets from physical assets and facilities in real time, perform advanced analytics to generate new insights, and execute more effective decisions.

These decisions can then be actualized by the capabilities of advanced physical technologies, such as robotics, drones, additive manufacturing, and autonomous vehicles. At its core, this digital revolution is likely changing the way products are designed, created, and delivered to customers—and it has tremendous implications for the supply chain.

Between 1992 and 2002, computing power increased at an average of 52 percent per year.

Impacts of technology disruption

From a supply chain to a DSN

THE function of any supply chain centers on the movement of materials, finished goods, capital, and other assets from place to place, as well as the production of finished goods. At their core, however, supply chains consist of many transactions: the exchange of time, money, information, or physical materials for some other unit of value. Dramatic technological and digital developments, such as greater computing power and lower overall costs, have impacted the traditional supply chain in several key ways, including a reduction in transaction costs and increase in innovation related to the production process itself.

Reducing transaction costs

The increase in power and efficiency of technologies has manifested itself in greatly reduced transaction costs for business operations both internally and externally.[8] No longer does it have to be prohibitively expensive or time intensive to gain insight into each minute step of operations, or to deeply understand customer or supplier demand patterns. The influx of inexpensively acquired and easily manipulated information seems to demand that supply chains begin to incorporate and utilize increased intelligence. While the linear flow of designing, creating, and moving physical goods remains unchanged, the underlying data now flow through and around the nodes of the supply chain, dynamically and in real time (or at whatever pace may be required). The new interconnections between processes and subprocesses have transformed supply chains into efficient and predictive networks. When the cost of transactions falls, the ability to transact with more and different partners increases. This creates an opportunity to shift to a world of more networked supply chains, as companies can simply connect with more different partners when and where necessary in order to deliver substantially increased value.

Innovation in production

Simultaneously, how production is enabled in the physical world also seems to be changing as a result of dramatic improvements in both the process by which matter can be manipulated and the embedded computing power that actuates those processes in pursuit of production. Improvements in the flexibility and capability of capital equipment should lead to less of it being required to commence production. When less capital is required, the minimum efficient scale comes down as well, and production is allowed to scatter, locating closer to demand.[9] Furthermore, smaller and more nimble players can enter the playing field more easily. These shifts in physical capabilities should be addressed both strategically and operationally.

The shift from linear supply chain to dynamic network

Ultimately, these changes can lead to a virtual collapse in the supply chain. This does not signify catastrophe but rather an opportunity that marks the shift from traditional, linear supply chain nodes to a set of dynamic networks. Furthermore, this could allow dramatically increased differentiation for the organization that is able to harness and leverage them.

The increase in digital connectivity and technological capabilities should reduce the latency between

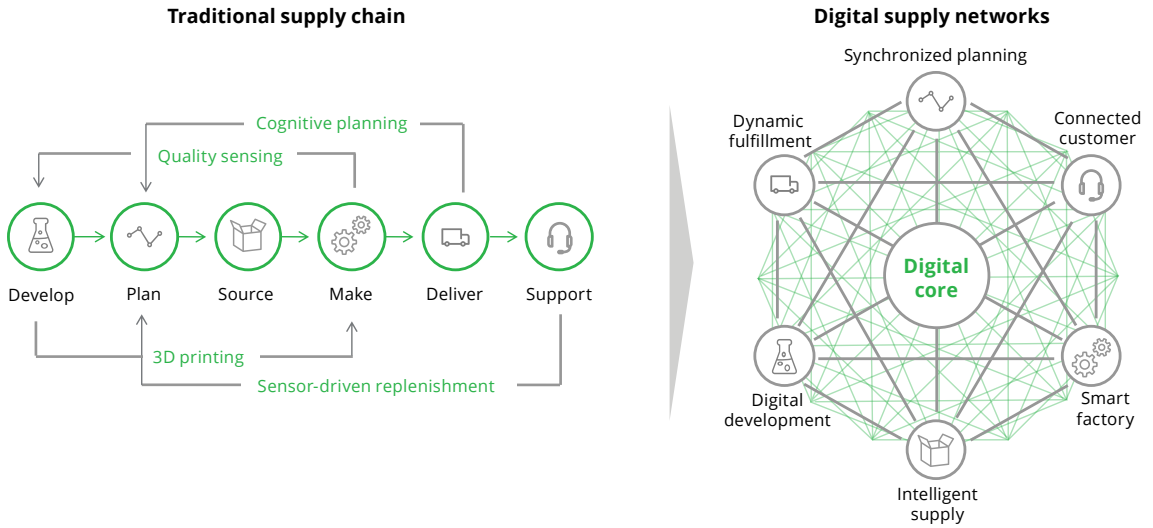
new information and material action. In traditional supply chains, information travels linearly, with each step dependent on the one before it. This chain of events is linked in a very structured way: develop, plan, source, make, deliver, support (figure 2). Inefficiencies in one step can result in a cascade of similar inefficiencies in subsequent stages. Stakeholders often have little, if any, visibility into other processes, which limits their ability to react or adjust their activities.[10] To operators, this is understood to be the expensive "bullwhip" effect, in which inventory fluctuations due to changes in customer demand grow larger, and thus less predictable, further up the supply chain.[11]

As each supply node becomes more capable and connected, however, the supply chain collapses into a dynamic, integrated supply network. DSNs overcome the delayed action-reaction process of the linear supply chain by employing real-time data to better inform decisions, provide greater transparency, and enable enhanced collaboration across the entire supply network. Figure 2 represents the shift from the traditional supply chain to a single DSN. It is important to note, however, that organizations will likely have more than one DSN.

Supply chain management has typically broken supply chain activities into first planning and then executional parts of the supply chain: procurement, manufacturing, and distribution. This is often described as *plan-source-make-deliver* or some variant thereof, as shown in the left side of figure 2. Although historically helpful, this language represents a separation that no longer exists in a DSN world, nor does it acknowledge new capabilities that can be built using digital technologies. Our new approach means that the language of supply chain management—and the new collapsed supply network—must evolve to reflect these new capabilities.

The DSN nodes in Figure 2 depict this new terminology. The interconnected lattice of the new DSN model is clearly visible, with digital at the core. There is potential for interactions from each node to every other point of the network, allowing for greater connectivity among areas that previously did not exist. In this model, communications, for example, is multidirectional, creating connectivity in what traditionally has been disconnected by links in the supply chain. For example, drone video monitoring of remote work sites enables site optimization analytics and rapid issue detection, while on-site 3D printers rapidly make replacements to reduce downtime. While there are multiple underlying Internet of Things technologies that would enable this process and others like it, the key is identifying how

Figure 2. Shift from traditional supply chain to digital supply network



Source: Deloitte analysis.

to communicate, aggregate, analyze, and act upon available information to achieve improvements[12]

The transition from linear to network often requires the organization to embrace a new way of linking physical and digital assets. Traditionally, linear supply chains rely on periodic relayed forecasts and plans, which become increasingly outdated—and thus inaccurate—with each stage. By connecting all the stages to one another via advanced technologies, DSNs can minimize the latency, risk, and waste found in linear supply chains. As DSN usage progresses and companies leverage their full supply networks, the traditional barriers of time and space should shrink. Companies would then be poised to achieve new levels of performance, improve operational efficiency and effectiveness, and create new revenue opportunities.

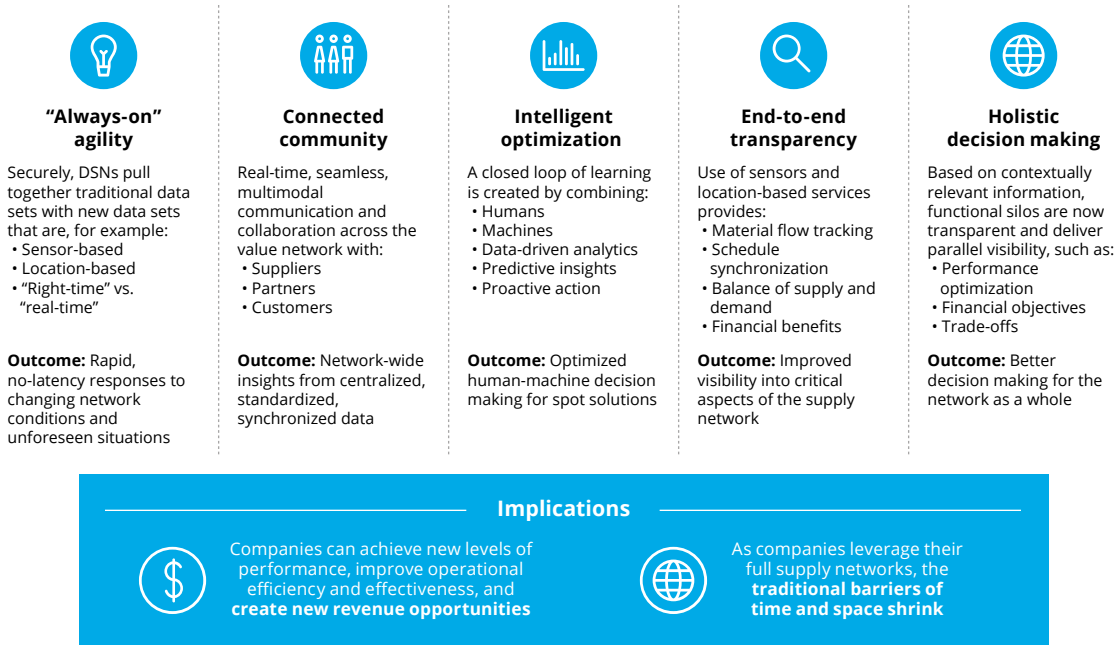
As noted above, organizations will likely have more than one DSN. Concurrent DSNs may leverage parts of the others—for example, they may share distribution facilities—but other pieces of the DSN would be separate, as in the case of manufacturing a different product or subassembly. Where there are multiple DSNs, however, organizations have the opportunity to match DSNs to commercial strategy and update them for the needs of the specific part of the business they support. It is this capability that allows DSNs to be more nimble, flexible, and customizable, in turn to better serve the strategic needs of the organization.

Thinking strategically about DSNs: What makes them different?

What separates DSNs from traditional, linear supply chains is the fact that DSNs are dynamic, integrated networks characterized by a continuous flow of information that facilitate automation, add value, improve workflow and analytics, and generate insights. With the ability to ascertain information in real time, many of the latency challenges inherent in linear supply chains can be avoided.

For example, Tesco, a multinational grocery retailer, tries to maximize revenue by reducing the chance of product stock-outs. Tesco feeds weather data into its predictive analytics tool to forecast demand of weather-dependent products (such as coleslaw and ice cream), and adjusts inventory and supplier orders in advance on a store-by-store basis

Figure 3. The characteristics of a digital supply network



Source: Deloitte analysis.

to minimize missed revenue.[13] Such analysis saved the company approximately $140 million, mainly through the reduction of wasted stock.[14] Although historically the local grocer may have had the foresight to adjust orders when warmer weather was forecast, traditional supply chain latency may not have allowed a fast-enough reaction time to prevent a stock-out. A DSN sidesteps that latency by making changes based on data, communicating changes throughout the supply network in real time.

Figure 3 describes the main characteristics of the DSN: always-on agility, connected community, intelligent optimization, end-to-end transparency, and holistic decision making. Each of these characteristics plays a role in enabling more informed decisions and can help organizations address the central question in their strategic thinking: *how to win*.

Since the DSN is **always on**, sensors and other location-based tools can continuously transmit data to provide integrated views of multiple facets of the network with little to no latency. At the same time, each of the attributes in figure 3 enables the DSN to address many more issues within the supply chain beyond simply overcoming latency challenges. Indeed, the five main characteristics of the DSN describe much more than faster data transmission. They illustrate how companies can develop a far more complete picture of the total supply network—which can foster more informed strategic decisions.

The **connected community** allows multiple stakeholders—suppliers, partners, customers, products, and assets, among others—to communicate and share data and information directly, rather than through a gatekeeper. Being connected in this way allows for greater data synchronicity, ensuring that stakeholders are all working with the same data when making decisions, and allowing machines to make operating decisions.

Intelligent optimization describes the ability for machines and humans to work together, sharing data that can be analyzed to optimize decision making.

Likewise, **end-to-end transparency** can provide instant visibility across multiple aspects of the supply chain all at once, providing insights into critical areas. Rather than simply viewing discrete, siloed batches of information from multiple sources and attempting to piece them together manually or via other systems, DSNs enable companies to track material flow, synchronize schedules, balance supply and demand, and peer holistically into financials. In a sense, this amounts to a full map of the supply network, in which companies can see how all components interact and relate to each other.

This, in turn, can enable **holistic decision making**, wherein transparency of information across all areas of the supply network—and across all functions—can enable better supply and demand balancing as well as decision making. Strategic planning can enable organizations to clearly understand the trade-offs any decision may entail.

This type of holistic thinking can enable broader strategic transformations: Instead of planning incremental improvements within the supply chain, organizations can consider how the supply network can be used to fuel growth across the business. For example, Nissan improved the manufacturing capabilities of its automobiles using product life cycle management (PLM) software to enable collaboration among production teams across the world. Its virtual production process tests design feasibility in real time, incorporating input from PLM and designers in various facilities. In 20 percent less time, this process helped Nissan create a final design that ultimately was named the 2014 UK Car of the Year.[15]

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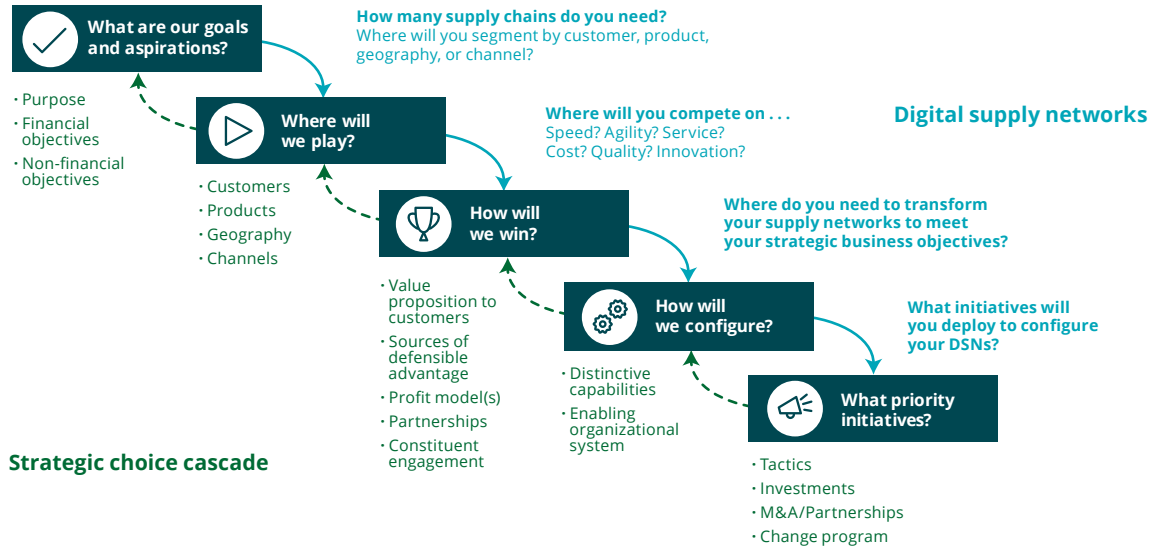
Making DSNs an integral part of business strategy

As organizations seek to determine and achieve their business strategies, they must make a variety of choices. With any strategic choice, however, come trade-offs: the choices or capabilities that are often surrendered to pursue the preferred option.[16] One strategic choice may be to focus on agility and speed to market, with the understanding that this choice can close off other avenues such as lower cost. Still others may focus their strategic efforts on higher quality while recognizing that service level may be a necessary trade-off.[17] Manufacturers often question whether they can pursue multiple goals or develop strong capabilities in multiple areas, as focusing on one area can often mean sacrificing capabilities in another.[18] In this traditional scenario, trying to do too much can result in not being able to do anything exceptionally well.

This can make the strategic decision-making process particularly tense, as making inopportune choices can impact the outcome. Focusing on simple questions—where to play and how to win—can help identify major considerations and stakeholders, streamline the process, and prioritize where companies should be devoting their efforts. By answering these and other strategic questions, organizations can better understand their needs and make choices more specifically geared toward their goals and aspirations. With the advent of the DSN, however, these questions can evolve to enable more transformative decisions.

Figure 4 depicts the strategic decision-making process with traditional considerations (the strategic choice cascade) mapped against the new, more transformational questions enabled by the rise of DSNs.

Figure 4. Strategic choice cascade, with supply chain focus



Source: Deloitte analysis.

DSN capabilities can impact strategy by enabling organizations to achieve multiple priorities, thereby lessening or eliminating trade-offs while still maintaining competitiveness. Since organizations can deploy multiple DSNs, once they have answered the key questions detailed in figure 4, DSNs can be implemented to address each area of strategic priority identified. Depending on the specific DSN, transformations can address a variety of considerations.

It helps to examine the specific attributes of the DSN that can make this possible, and understand the importance of involving DSN planning in all stages of the strategic development process.

From trade-offs to customization: How to think about the DSN's strategic role

Given the interconnected nature of the DSN, its systems can theoretically see and sense what is happening at any other node in the network at any given time. In this way, a DSN can serve as an integral part of business strategy, enabling the business to negotiate and in some cases even avoid trade-offs.

As companies make choices around the customers they want to serve and the products they wish to offer, they can also customize supply networks to address customer goals. These include getting products sooner or at the lowest possible cost. Some customers may want the ability to change their minds and shift product mix in real time, or only receive the "newest and best" goods while excluding outdated products from shipments. Thus companies can take segments of the supply network and align them to what is most important to current needs.

The integrated DSN may also allow organizations to compete on a variety of differentiating factors, such as speed or service, and apply them across all the traditional nodes of the supply chain as needed. As different stages of the supply chain communicate with each other via connected, Industry 4.0–driven technologies, priorities identified during the strategic decision-making process can be addressed on multiple fronts. In effect, this gives DSNs (and supply chains) new strategic decision-making abilities unlike any they have had before.

Given the interconnected nature of the DSN, its systems can theoretically see and sense what is happening at any other node in the network at any given time.

For example, GE Aviation changed its business model from merely manufacturing and selling engines to selling services measured by flight hours. Traditionally, aircraft engines were geographically isolated, with assets moving around the globe at all times. The performance management of the engine was also limited to the required periodic inspections, aside from some outputs in the cockpit. GE Aviation closed time and geography gaps by adding sensors to its aircraft engines that collected and transmitted data. GE is now using predictive analytics to lower maintenance costs and reduce engine downtime, offering economic value to the customer and a potential new revenue stream to GE.[19]

Transitioning to a DSN: Shifting strategic choices

Transitioning a traditional, linear supply chain into an always-on, holistic DSN can allow companies to shift their strategies, competing across different nodes of the supply chain simultaneously rather than simply focusing on one area. Once organizations have determined how they want to win, however, they should consider how to effectively configure their supply networks to successfully execute their plan. One of the benefits—and challenges—of the DSN is its agility, and the multitude of options companies can pursue to build one. Thus, as companies determine the strategy they wish to pursue, they should identify the type of supply network needed to achieve it. They can then determine the capabilities their supply network will require.

Figure 5. Strategic transformations via the DSN

Supply chain transformations	Sample tactics
Design process optimization	• Sensor/data-driven design enhancements • Open innovation/crowdsourcing • Rapid prototyping • Virtual design simulation
Product optimization	• Data as a product or service • Make-to-use with 3D printing • Ultra-delayed differentiation
Planning & inventory efficiency	• Analytics-driven demand sensing • Dynamic inventory fulfillment • POS-driven auto-replenishment • Real-time inventory optimization • Sensor-driven forecasting
Risk prevention & mitigation	• Proactive quality sensing • Track-and-trace solutions • Proactive risk sensing
Supplier collaboration	• Analytics-driven sourcing • Asset sharing • Blockchain-enabled transparency • Cloud/control tower optimization • Supplier ecosystem
Operations efficiency	• Augmented reality-enhanced operations • Automated production • Predictive maintenance • Sensor-enabled labor monitoring
Logistics optimization	• Augmented reality-enhanced logistics • Automated logistics • Direct-to-user delivery • Driverless trucks • Dynamic/predictive routing
Sales optimization	• Inventory-driven dynamic pricing • Sensor-driven replenishment pushes • Targeted marketing
Aftermarket sales & services	• Augmented reality-enabled customer support • End-to-end transparency to customers • Make-to-use with 3D printing • Predictive aftermarket maintenance

Source: Deloitte analysis.

To configure and realize a DSN-driven strategy, companies can execute multiple different supply chain transformations. Figure 5 depicts a sample of nine strategic transformations companies can make by leveraging DSNs, along with a list of sample tactics that can enable each transformation.

However, it is important to reiterate that many large organizations can pursue multiple supply networks, depending on their needs and the needs of their customers and stakeholders. In these cases, organizations might require multiple transformations for each, depending on what they wish to change and why. For instance, a supply network that focuses on low cost as its main differentiator might want to be more agile, and mitigate some of the trade-offs associated with planning and inventory inefficiencies or inadequate design process optimization.

EasyJet, for example, employs augmented reality smart glasses to enable two-way communication between its network of remote maintenance technicians and the central engineering team. Virtual step-by-step walkthroughs in real time enable technicians to effectively perform complex maintenance tasks and reduce downtime. EasyJet also uses drones to perform efficient and immediate visual safety inspections of the exteriors of its plane bodies, reducing the time the plane is out of service, how much hangar space is required, and the amount of inspection labor.[20]

Alternatively, a supply network focused on service might want to use DSN transformation tactics to mitigate some of the trade-offs around operations efficiency and supplier collaboration. In one such example, Spine Wave utilizes Medical Tracking Solutions' iTraycer to create a device-focused inventory management system. Sensors are placed on each piece of spinal implant equipment, enabling Spine Wave to remotely track each piece within a spinal surgery kit. Spine Wave can then immediately replenish inventory, and automate invoices at the point of use.[21] In contrast, most hospitals today must return the surgical kit to the company, which identifies which parts must be replenished and triggers invoicing.

Implementing a DSN

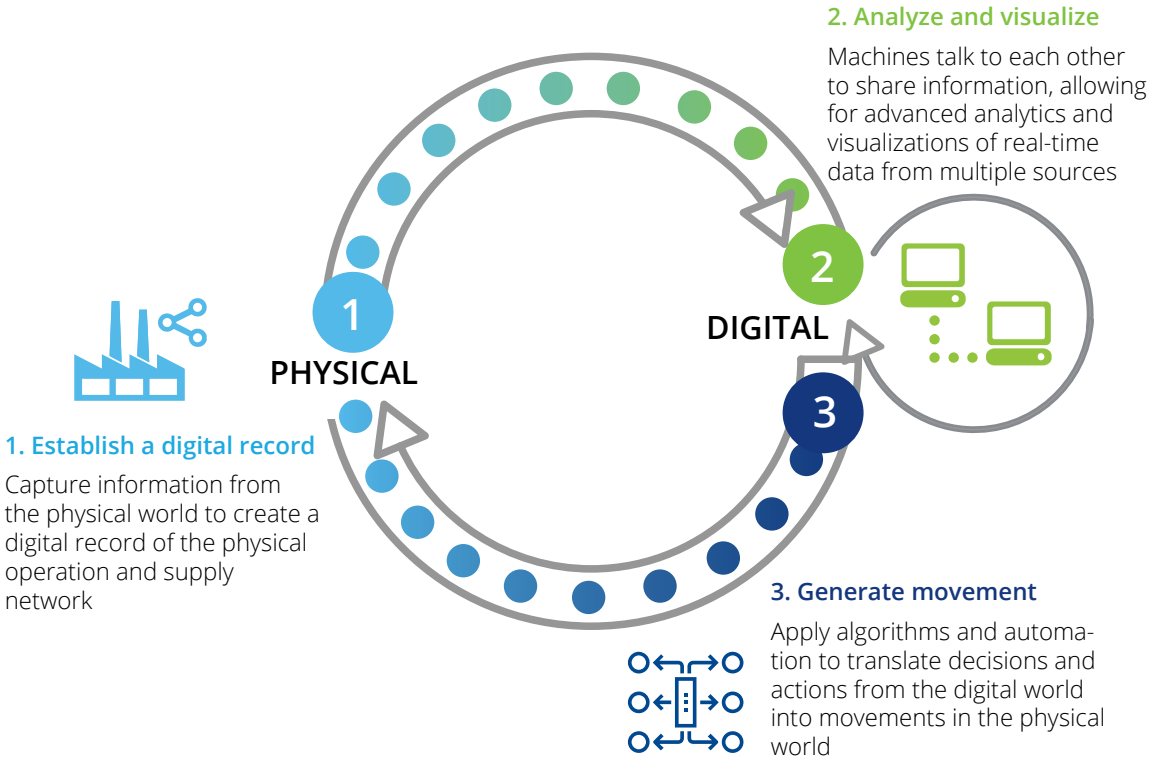
The physical-to-digital-to-physical loop

FOR business leaders accustomed to traditional linear data and communications, the shift to real-time access to data and intelligence fundamentally transforms the way they conduct business. Once organizations make the decision to adopt a DSN, they should consider how to develop, connect, and use the various Industry 4.0–driven technologies that power it. Before developing a DSN, it can be useful to consider the process of information creation, analysis, and action as a loop. The integration of digital information from many different sources and locations drives the physical act of manufacturing and distribution, in an ongoing cycle.

Real-time access to data and intelligence is fundamentally driven by the continuous and cyclical flow of information and actions between the physical and digital worlds. This flow occurs through an iterative series of three steps, collectively known as the physical-to-digital-to-physical loop:

- **Physical to digital**—Capture information from the physical world and create a digital record from physical data

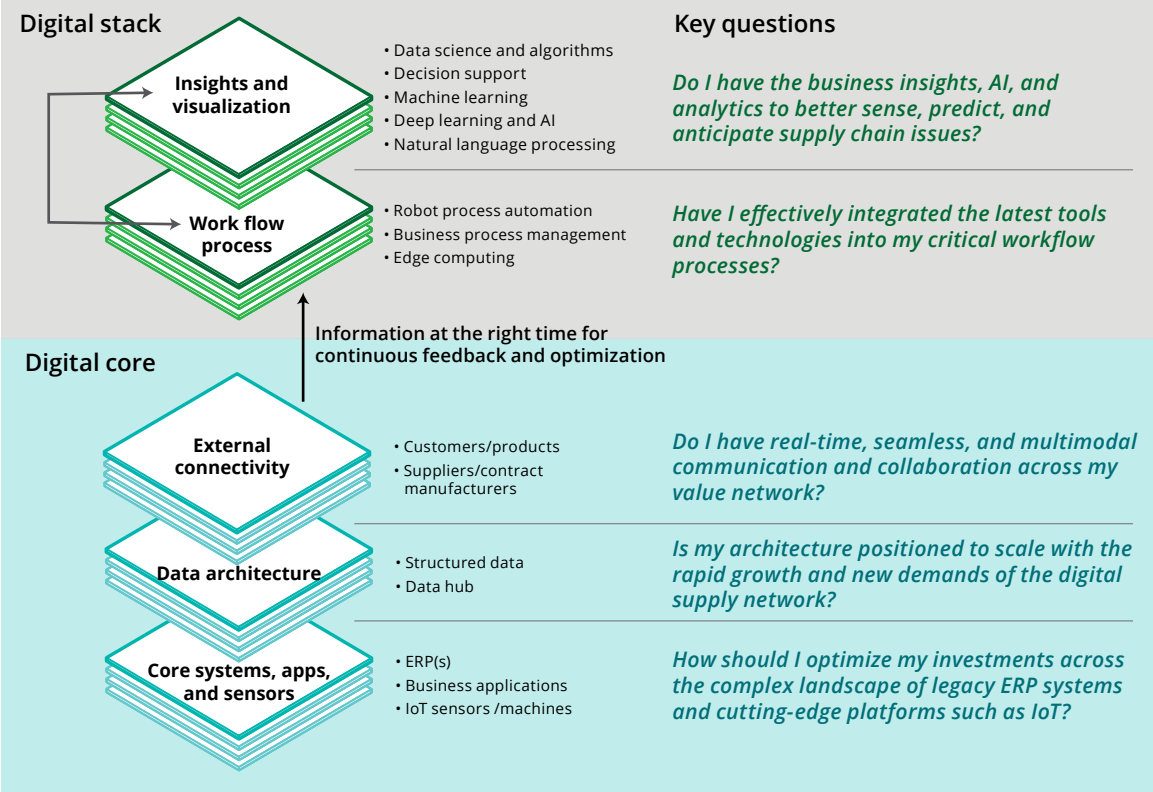
Figure 6. Physical-to-digital-to-physical loop and related technologies



Source: Center for Integrated Research

Figure 7. The digital stack

The digital core architecture provides a single place to access near-real-time supply network data



Source: Deloitte analysis.

- **Digital to digital**—Share information and uncover meaningful insights using advanced analytics, scenario analysis, and artificial intelligence
- **Digital to physical**—Apply algorithms to translate digital-world decisions to effective data, to spur action and change in the physical world

Figure 6 depicts not only the physical-to-digital-to-physical loop but also the various digital and physical technologies that drive and enable it.

Making the DSN real: Building and powering the digital stack

As manufacturing organizations evolve, information clusters will likely move from separate silos to free-flowing, integrated information supported by interconnected technology solutions. In traditional, linear supply chains, data tend to be siloed into separate information clusters. Customer engagement data, sales and service customer operations data, core operations and manufacturing data, and supply chain and partnership data are all kept separately from each other where none can inform the other. This can often lead to missed opportunities as organizations cannot see where these areas intersect or align.

An integrated DSN hub can enable a digital organization and support for the free flow of information across information clusters. This hub, or digital stack, provides a single location to access near-real-time DSN data from multiple sources—products, customers, suppliers, and aftermarket support—encapsulating multiple perspectives. The digital stack includes multiple layers that synchronize and integrate this data to support and enable informed decision making (figure 7).

Getting started

Building a DSN

DIGITAL supply networks represent the evolution of supply chains, a result of the changing technology landscape, and increasing connectivity between the digital and the physical worlds. New access to information, computational abilities, and innovative technologies have collapsed and connected the formerly linear and siloed supply chain. Now real-time information and insights can be shared across the entire supply network to drive actionable decisions.

These changes are happening quickly. But with change comes opportunity: the ability of DSNs to play an integral role in strategic decision making, fewer trade-offs, customizing multiple supply networks to the specific needs of customers and clients. To start building a functional DSN, organizations can take several steps:

Think big

Often the first step in transforming a supply chain into a DSN is understanding what drives the need to differentiate. With a firm grasp on how and why one wants to differentiate, organizations can examine real supply chain applications that suit their business objectives.

Now real-time information and insights can be shared across the entire supply network to drive actionable decisions.

- **Immerse yourself in innovation.** Explore the art of the possible to push the organization to understand the application of various technologies and their potential impacts on the business.
- **Build your ecosystem.** Assess the organization's digital maturity to understand what might be feasible, and what steps should be taken to build the technological capabilities necessary for a functional DSN.

Start small

The journey of a thousand miles begins with a single step. Consider ways to make the transition to DSNs a manageable and realistic one.

- **Scale at the edges.** At times, it makes sense to start with smaller stakes, where strategies can be tested and refined with relatively fewer consequences. Selecting projects at the "edges" of the organization can provide greater latitude for building DSN capabilities, and can also help individuals feel less afraid to fail, which ultimately leads to greater innovation.
- **Start with one or two transformations.** Prioritize areas that can unlock several waves of potential value, and build on those successes to continue to establish DSNs where they make strategic sense. At the same time, it can be essential to act with growth in mind: Focus on areas that might unlock several waves of potential value, creating a ripple effect that leads to exponential growth.

Act fast

Don't wait for "perfect." Exponential growth techniques are rapidly evolving, requiring constant iterations. Establishing a competitive advantage requires the willingness to join the fray, but you should do so quickly.

- **Prove it works.** Small successes can serve as proof points, leading to a greater willingness to take a chance on more substantive investments. By starting small and moving quickly, organizations can generate success stories that prove the value and importance of the DSN.
- **Market your successes.** Success generates success. Sharing examples of successful DSNs can evangelize skeptics within the organization. It can also demonstrate to customers that the organization is at the forefront of technology and is focused on their needs.

Advancing to an "always-on" DSN is not about a single technology implementation; it is more about developing an agile supply culture and promoting a more strategic approach to meeting customers' needs. Investments in DSN technology and tactics can become key differentiators in not only supporting but also advancing business strategy.

ENDNOTES

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