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# Digital Thread in the Chemical Industry

## Accelerate Your Digital Transformation from Product to Plant to End User

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## Executive Summary

The phrase "digital transformation" carries a lot of weight in the chemical industry, and its overuse can make it difficult to understand what exactly constitutes digital transformation. In order to demystify the conversation, we must define what digital transformation means for the industry and the business value it can deliver.

True digital transformation digitalizes the entire value chain – all of the "steps" it takes to bring a product to market. Digital transformation is possible by employing key foundational concepts including the connected plant, digital thread and digital twin, and with enabling technologies such as artificial intelligence (AI), extended reality, smart connected operations and Internet of Things (IoT).

A focus not on technology, but on use case-based proofs of value that address actual business challenges, combined with human-centered organizational change management, ensures that digital capabilities can be scaled and sustained more quickly and effectively across the organization.

**In this eBook, we will define key digital transformation concepts and lay out a recommended path to successfully digitalize the value chain beyond the chemical plant.**

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# Trends Impacting the Chemical Industry

The impact of the COVID-19 pandemic on the chemicals industry has been significant and widespread. Organizations experienced massive disruptions to demand, supply chain and resources as a result of the pandemic – and many are still recovering. On top of that, chemical companies are also facing other considerable, even related, market trends including:

**Pandemic-influenced growth.** The industry continues to experience growth in geographies outside of North America and Western Europe that can be directly attributed to higher consumer demand for synthetic materials used in the production of personal protective equipment (PPE), ventilators, IV bags, household cleaners, disinfectants and single-use plastics.

**Raw material pricing.** A reduction in raw material pricing has left room for chemical companies to consider other investments. Although raw material inputs are the main factor in profitability, this new trend enables companies to divert spending towards engineering and operational efficiency improvements.

**Growing competition.** Innovation has, and always will be, critical to success in the chemical industry. The adoption of new tools and technologies is accelerating, and at the same time, historically tall barriers to entry are being reduced. This translates to more startups and spinoffs from larger companies entering the competitor pool. As the market becomes more competitive, consumers expect higher product quality and durability. Companies must meet this demand while also maintaining competitive prices.

**Sustainability as a business imperative.** Congruent to the pandemic, increased societal pressures are promoting a move toward sustainability. Chemical companies are striving to operate with reduced energy consumption, carbon emissions and toxic outputs, which require a smarter and more intentional approach to efficiency planning. This means more incentives for maximizing the use of renewables, recycling materials and encouraging re-use of end products. Chemical business leaders are seeing sustainability not only as a societal benefit, but also as a good business strategy.

**The move toward digital transformation in the chemicals industry was already underway when the COVID-19 pandemic hit. As with most industries, the pandemic only further accelerated it.**

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# Digital Transformation for Chemicals: Key Concepts

The phrase "digital transformation" carries a lot of weight in the chemical industry, and its overuse can make it difficult to understand what exactly constitutes true digital transformation. In order to demystify the conversation and understand the real value of digital transformation, we must define what it means for the industry and the key concepts that enable it.

## Digital Transformation of the Value Chain

While some chemical companies have made strides toward digitalization within the four walls of the plant, digital transformation efforts must span the entire value chain in order to deliver game-changing business value. This includes upstream into design and development, and downstream into supply chain and service.

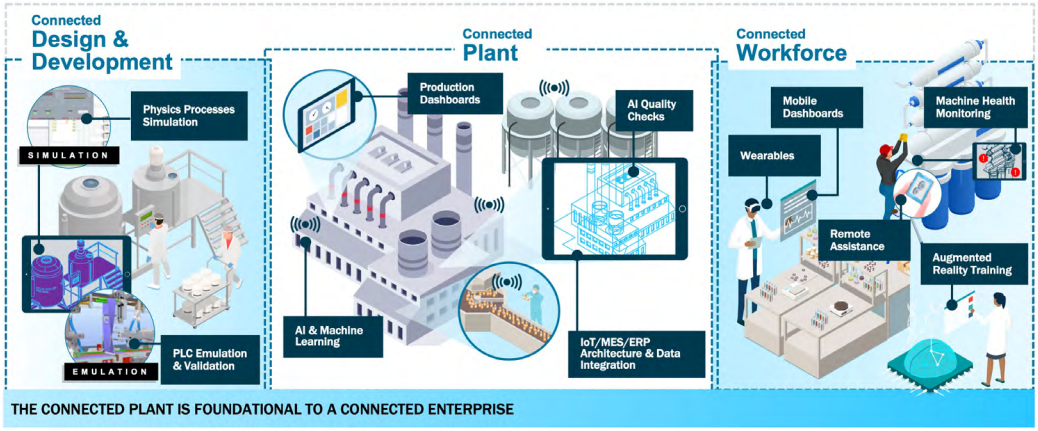
Simply stated, the value chain is all the "steps" it takes to bring a product to market, from idea to design, to plant to end user.

By digitalizing the value chain, companies can fundamentally change the way companies discover, create, make and sell new products. As a result, companies can deliver significant business outcomes and results in the areas of growth, productivity, efficiency, resiliency, sustainability and risk.

## The Connected Plant

As factories have evolved over time, the chemical plant has come to exist as a network of many independent, disconnected but highly individually optimized operations, leading to increasingly inefficient interactions between plants and facilities where data or products needed to cross unit operation boundaries.

To reduce long lead times associated with moving product and data between disparate operations, the connected plant uses advanced technology to create unity between the people, places and processes that drive efficiency and throughput. The connected plant is made possible because it successfully combines digital and physical worlds at every single touchpoint.




**The connected plant uses a combination of digital technologies, including IoT, artificial intelligence (AI) and machine learning (ML) to connect manufacturing operations through a digital backbone that acts as an orchestrator of the engineering process.** The physical chemical processing flow is supplemented by a seamless flow of information that is both complete and readily available, which is also referred to as the digital thread.

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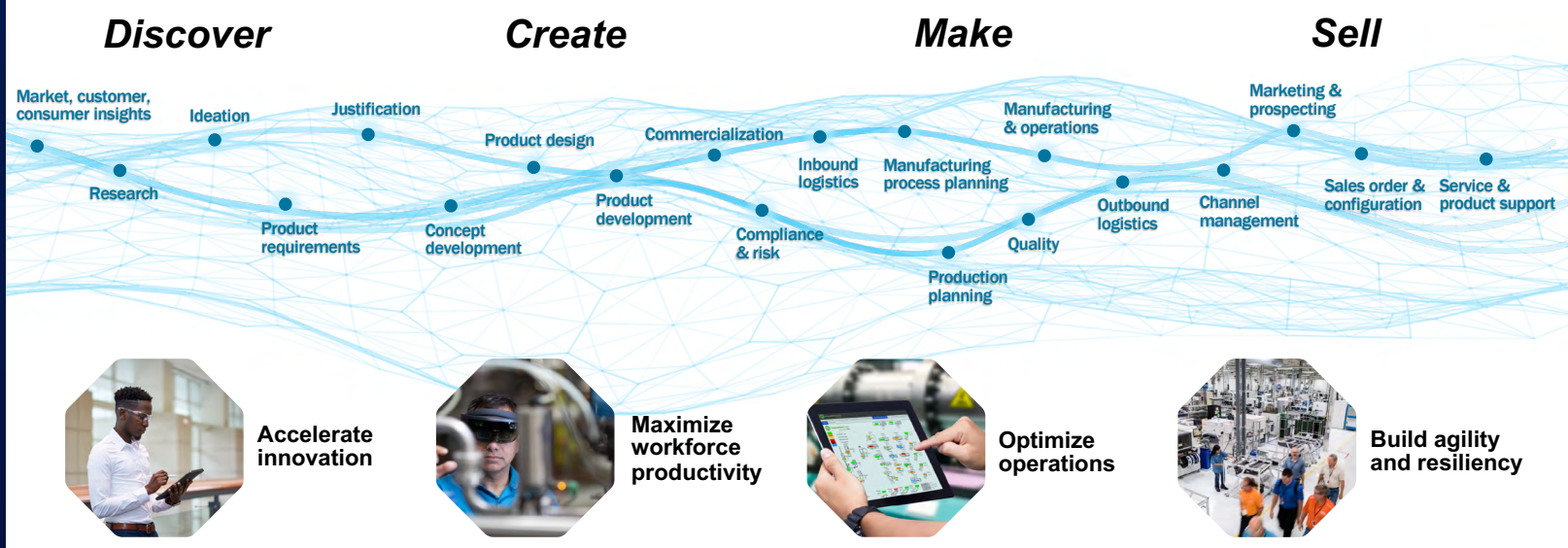
## The Digital Thread

The ultra-connected and efficient operating model of the connected plant is made possible through the concept of the **digital thread.** The digital thread is a seamless flow of data connecting business processes, systems, products and equipment throughout a company's physical and digital value chain.

Each "step" along the value chain contains information about that specific step, such as R&D, logistics, quality, manufacturing, support or sales data, and needs to be easily accessed across the product ecosystem. The digital thread is the connecting factor that allows for this accessible flow of information across all the individual nodes.

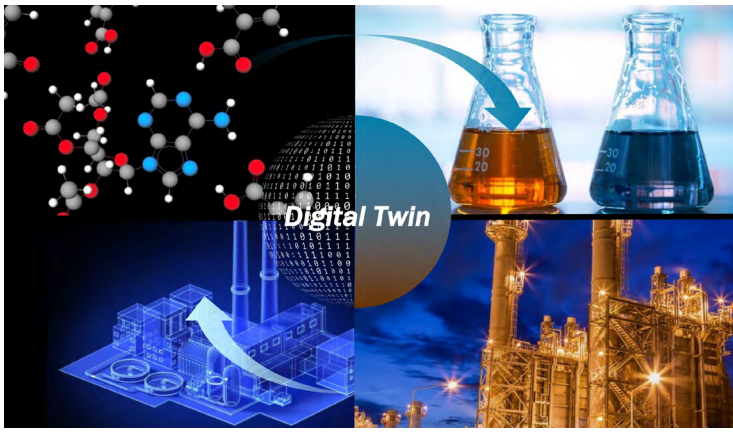
Once the value chain is connected with the digital thread, the siloed functions of engineering, design, manufacturing, operations, maintenance and production begin to integrate together into a truly unified, integrated system that is more efficient, cost effective and productive. If the value chain represents all the activities needed to deliver a product to the market, then the digital thread is the fabric that holds it together. The stronger the fabric, the stronger the value chain.




**A digital thread that spans across the value chain delivers significant business outcomes**

## The Digital Twin

The digital thread is made real with the digital twin. The digital twin is a superior representation of a product, physical entity or system, providing all of the same information in a digital format using data, analytics, simulations and emulations. It models the dimensions, properties, manufacturing sensitivities and performance parameters just as they exist in the physical world. Successful companies have found that a digital twin enables them to make design adjustments prior to beginning mass production, and factory adjustments during production. In the connected plant, the digital twin is used in designing, testing, monitoring, servicing and other functional areas to augment product management capabilities and improve efficiency.




By virtually modeling and piloting the entire value chain and the products in it, companies can quickly and easily optimize products, systems and supply chains in a virtual environment rather than a physical one.

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# Technologies & Tools to Enable the Digital Thread

As the chemical industry begins to gravitate more toward the connected plant, leaders are blending a broader palette of enterprise technologies with digital technologies such as IoT, AI, edge computing, blockchain, cloud and big data, to take the leap into the digital future. Here are some of the key technologies and tools that further enable the digital thread.

**Artificial intelligence (AI) / machine learning (ML)** enables machines to actively and preemptively problem solve without the need for human input. Supervised learning can assist this process by feeding these models examples of correct data to expedite the learning process. Advanced analytics can be diagnostic, predictive or prescriptive. Diagnostic analytics find the root cause of an observation that feeds into predictive analytics, which predicts future events based on existing data. Finally, prescriptive analytics recommend the optimal course of action based on the information available.

True ML models enable the chemical industry to analyze **engineering simulation** and **emulation data** along with digital models. In the chemical industry, this can look like generative design, digital formation, automated "cloud" labs, synthetic chemical development, modeling for sensory and performance characteristics, molecular modeling, plant equipment emulation, plant operation and line simulation, and blockchain supply chain authentication.

**Extended reality (XR)** applies a combination of artificial reality and virtual reality technologies. It overlays standard vision with digital information to help in product design, digital modeling, and product maintenance and repair. XR can improve engineer productivity, address increasing product complexity and solve issues created due to a shortage of skilled workers.

**Product lifecycle management (PLM)** and **enterprise resource planning (ERP)** are critical data backbones for the business. Chemical processors connect disparate data sources into a flowing structure of data for every plant system. PLM connects design requirements across plants and details how a structure fulfills these needs through models, simulations, processing and field data. Linking manufacturing data to the plant record can also enable insightful visualizations and processing optimizations.

IoT and the industrial IoT, Overall Equipment Effectiveness (OEE) dashboarding and analytics, remote monitoring, warehouse management and logistics enhance **smart connected operations.** These technologies and tools unify siloed functions of engineering, design, maintenance and production into one cohesive system.

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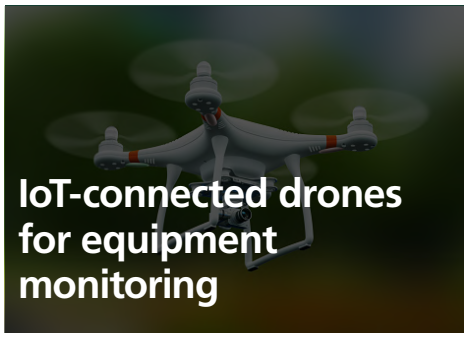
# High-Impact Use Cases

Chemical industry leaders are seeing real business results from digital thread initiatives. Here are some of the most valuable use cases.

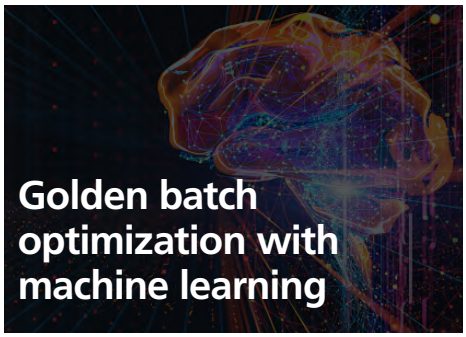
## Autonomous bots for fine chemicals

Deployment of automated robots to simulate human actions in a clinical laboratory and leverage AI to optimize performance, resulting in an exponential improvement in the efficiency of executed tasks.



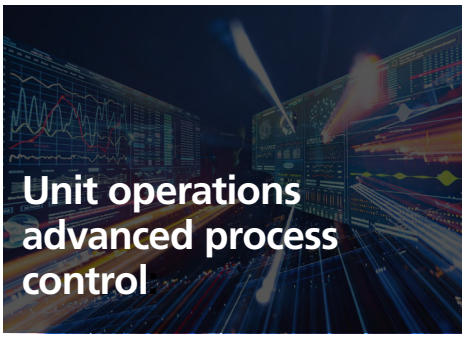
## IoT-connected drones for equipment monitoring

Use of IoT-connected drones in large plants to allow equipment operators and plant managers to safely observe and work on disparate parts of a plant, with less labor overhead and fewer risks to workers



## Golden batch optimization with machine learning

Application of machine learning control and model predictive control to optimize OEE and increase adherence to the golden batch.



## Unit operations advanced process control

Application of prescriptive machine learning algorithms to improve process control, production rate and product quality on individual plant unit operations. Leveraging data feeds from across the digital thread, companies can take actions well before a process goes out of limits and automate steps to increase the throughput and decrease waste.

## Real-time energy efficiency dashboards:

A Real-time monitoring capability focused on energy efficiency measures to daily production operations, enabling corrective action to increases availability, efficiency and quality, and. providing stakeholders different levels of data aggregation to promote continuous improvement

## Sustainability

Use of the digital thread to connect the value chain to data and reporting to achieve sustainability goals including lower emissions, fewer environmental impacts, increased use of recycling and streamlined logistics processes.

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## Nearest Neighbor

Ability to quantitatively compare how similar a formula is at each ingredient level to existing approved formulas to inform the extent of regulatory and safety testing and required approvals, resulting in more efficient testing, approval and monitoring, and reduced costs and risk.

## Simulation and commissioning

Use digital tools to test processes, unit operations and factory layouts "in silico" to reduce the time and expense of plant commissioning by applying data from the digital thread to physics-based models to optimize outcomes.

## Advanced analytics / formulation advisor

Use advanced computer simulation to identify existing recipes and qualify use for new applications, leveraging an existing formulation database. Can also be applied by newer companies that lack the formulation history to cut back on testing and scale-up costs.

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# Recommended Approach for Delivering Results

Digital transformation doesn't start with technology – it starts with business value that fundamentally impacts the top and bottom line. An effective strategy formally defines how the transformation will contribute to business growth and provides a roadmap to keep the focus on executing successfully.

That said, companies shouldn't worry about perfecting the digital transformation roadmap. As companies face investment choices across many opportunities and experiments to drive value, delivering meaningful return early is critical.

Many companies make the mistake of focusing on proofs of concept designed to demonstrate technology. These companies are more likely to have digital transformation initiatives that stall out or fail to scale. *Recent research* shows that just 25% of Industry 4.0 use cases are fully rolled out or used extensively at manufacturers today.

To avoid this challenge, companies should focus instead on a proof of value-- creating digital proof points with measurable business value. This means thinking about the application of the technology as well as the associated process and organization change required to achieve value of solving a particular business challenge, then driving the organization to realize the intended impact.

When it comes to a proof of value, take a minimum viable product (MVP) approach, which is based on the idea that depth of value beats breadth of application. Instead of focusing on building a broad base of foundational digital capabilities generalized across multiple use cases, the MVP approach builds a full stack of capabilities and value focused on a narrow, high-priority use case. When value is realized for the high-priority use case (ideally linked to a significant business challenge), companies can then scale for additional use cases.

This prioritization of value realization coupled with a human-centered organizational change management approach, one can always understand where they fit in the organizational change. The question **"What does Digital do for me?"** becomes a tangible one and one that inspires and motivates change and innovation, rather than instilling fear and hesitation.

As companies in the chemical industry evaluate where they are in their digital transformation journey, the importance of understanding how to connect their value chains with the digital thread will become paramount. Transformation has become a continuous evolution for chemicals businesses and creating and capturing business value beyond the chemical plant will separate the world-class from the laggards.

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**Kalypso, A Rockwell Automation Company,** is a professional services firm delivering consulting, implementation and managed services to clients. We focus on digitalizing the value chain – all the steps it takes to bring a product to market, from idea to design, to plant to end user – to fundamentally change the way companies **discover, create, make** and **sell** new products.

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