Next-Generation Operational Technologies
Enable the Smart Enterprise in a Changing World

Antonio Pietri, President and CEO, Aspen Technology, Inc.

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Introduction

Since the first use of advanced software solutions in the process industries more than 40 years ago, manufacturers have been on a digital journey to transform their businesses and create value for stakeholders. Drawing on the data generated over decades of operation, these organizations have consistently found ways to leverage technology to run their assets safer, greener, longer and faster. Today, a new generation of technologies is opening the door to opportunities that were previously impossible.

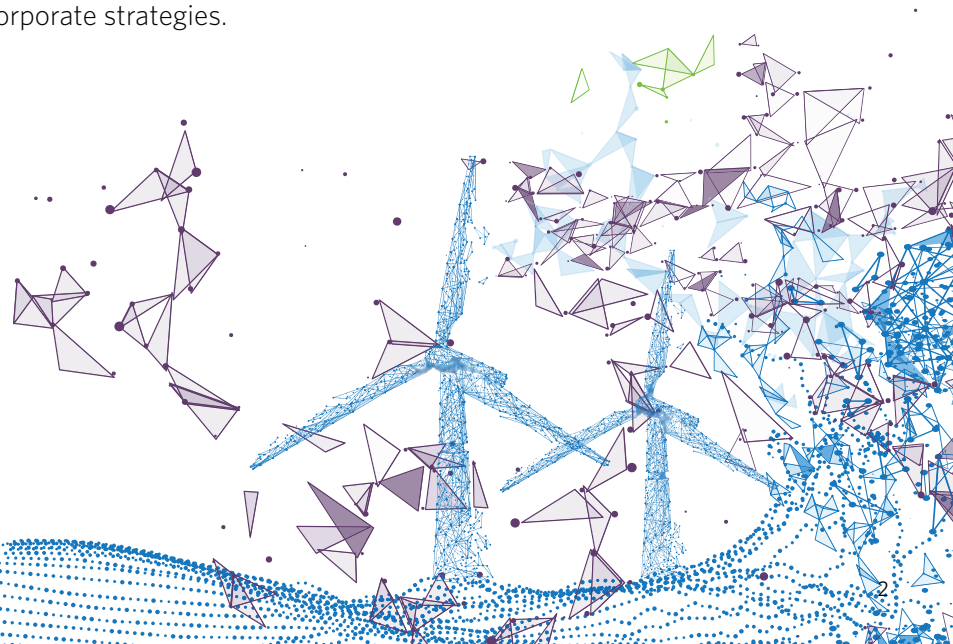
It is the convergence of 40 years of industrial technology with digital solutions and the enabling capabilities of today's Industry 4.0 technologies that unlocks a completely new paradigm. This paradigm blends the physical and chemical principles coded in the software with the analytics capabilities of advanced technologies to **completely reassess the upper bounds of operational excellence.**

As organizations around the world search for ways to thrive amid volatile, uncertain, complex and ambiguous (VUCA) market conditions, many are turning to the latest digital technologies to adapt as necessary. The world is changing, and the market is demanding new business models.

Approximately **160 million people per year** are expected to move into the middle class through at least **2030**[1]. That's 13 million people every month, along with the increased energy demand and petrochemical use that comes with their new affluence. Global energy demand is expected to increase more than 25% by **2040**[2], and keeping up with it will require a wealth of new capabilities.

Consumption trends evolve as populations and incomes grow. The demand for electric vehicles and the growth of renewables are affecting energy usage patterns worldwide, driving oil companies to transition their business models. "Crude oil to chemicals" (COTC) is rising as a popular strategy for oil business transformation. Expanding refining operations to petrochemicals requires the full integration of refining and chemical assets. This is a major, complicated and somewhat daunting change for large organizations, especially for those with significant sunk capital in existing assets.

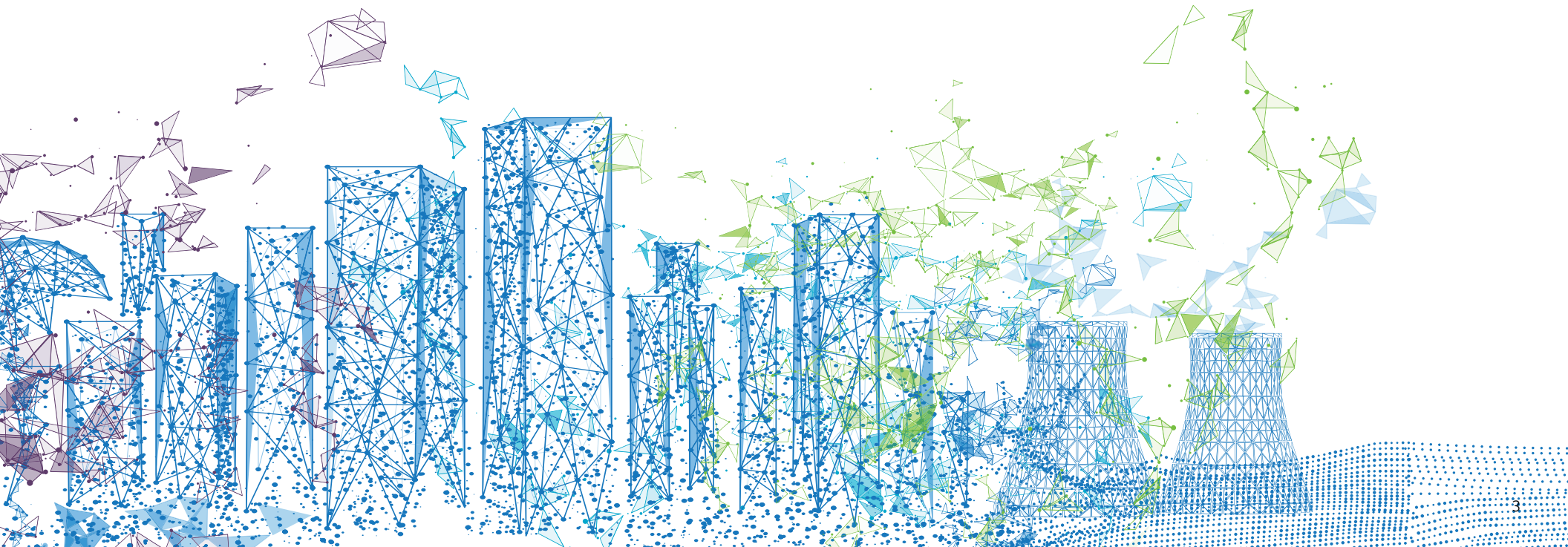
The response to these consumption trends is happening under greater pressure for **sustainable practices.** Zero-carbon and low-carbon initiatives, a need for energy and water efficiency, air quality regulations and climate change are prime concerns for shareholders — and therefore are at top of mind for today's industry leaders. These issues are calling for innovative approaches and are driving new corporate strategies.



The circular economy of plastics requires a “full-cycle” approach to production and extended use-life to conserve resources and protect the environment. Demand for plastics is the key driver for petrochemicals, which are the single largest source of growth in oil use[3], outpacing planes, trains and automobiles.

Across the globe, leading organizations are already embracing and implementing advanced digital technologies. Now the exciting questions are, what is possible, and do these enterprises have the vision and organizational excellence to take advantage of the new economic opportunities?

To achieve this transition, capital-intensive businesses need to transform their industrial facilities and value chains into a system of smart, self-optimizing, semi-autonomous assets — thereby unlocking higher levels of operational performance, agility and profitable growth while also enabling critical new business models.



A Vision for The Future State of Industry

The "digital enterprise of the future" is on the horizon, and it will be the main driver of margin and demand optimization in the coming years. Research by the Boston Consulting Group[4] has found that the adoption of Industry 4.0 technologies alone can reduce operating costs by 10-15% — and when combined with lean management techniques to achieve operational excellence, cost **reductions of up to 40%** are achievable.

Drawing on the extensive availability of operational data, process manufacturers and other organizations can now leverage technologies such as high-performance computing, artificial intelligence and analytics to generate insights that go deeper than ever.

By incorporating artificial intelligence (AI) capabilities into their existing operating technology (OT) and information technology (IT), **systems will be empowered to transcend functional silos and operate semi-autonomously (and eventually autonomously)** to drive maximum profit — while at the same time operating safely, minimizing environmental impact and ensuring greater reliability and efficiency.

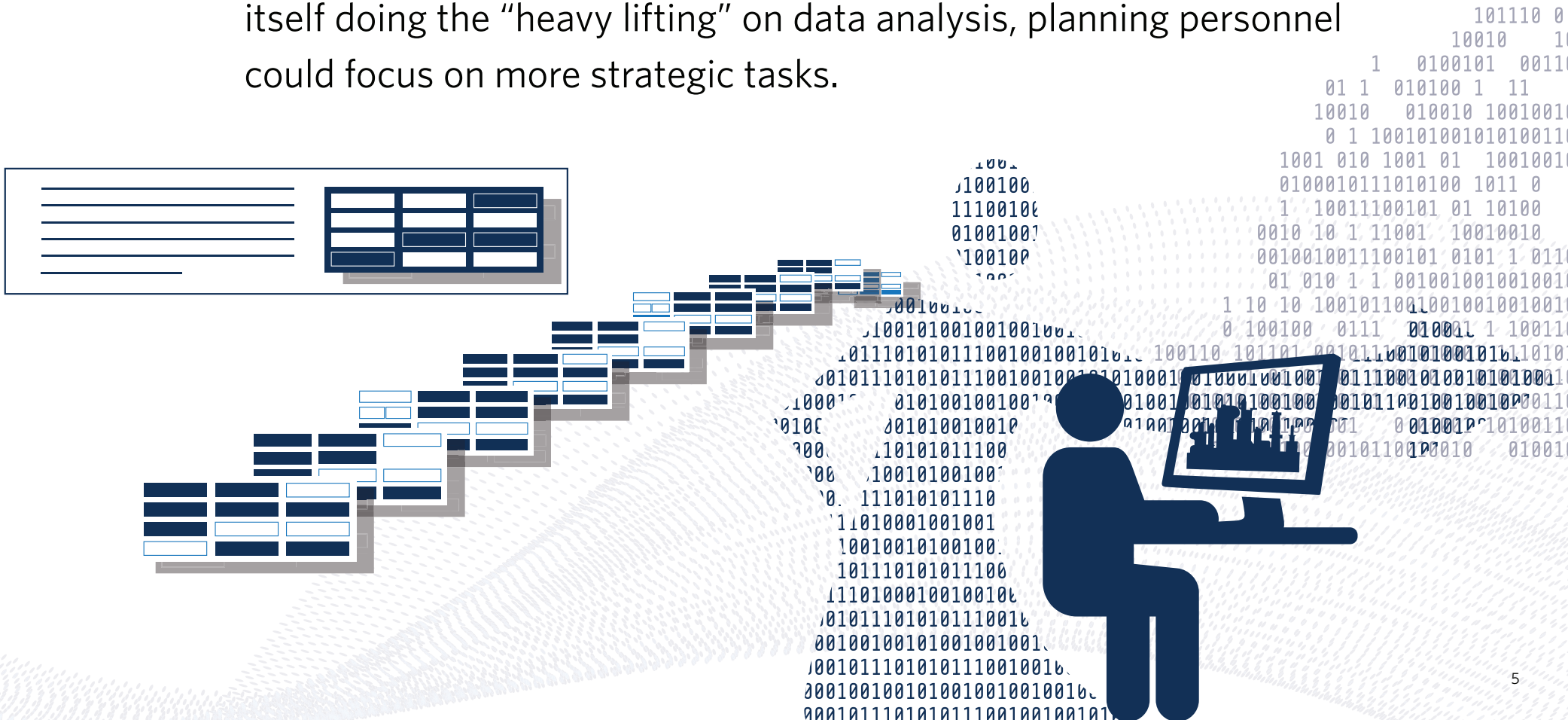
Semi-autonomous and autonomous processes will be created over time, as live data is collected, aggregated, conditioned and fed into digital models to evaluate scenarios, gain insight and drive continuous operational improvements. The systems themselves will determine optimal scenarios, which will be presented to personnel to support their decision-making and set new operating targets and directives as conditions dictate.

We envision a day when **planning and scheduling become semi-autonomous and, eventually, autonomous processes,** as was done with multivariable process control more than 30 years ago. The role of the planner and scheduler will change with the addition of supervisory and monitoring responsibilities, similar to what has happened over the last 30 years with operators in the control room.

AI will also power cognitive capabilities that enable the workforce of tomorrow to accomplish more than ever before, driving greater levels of productivity throughout the organization. This change will open the pathway for a new generation of talented and ambitious individuals comfortable with digital technology to lead the transformation of these businesses.

Imagine if…

…A refinery had the technology to simultaneously evaluate thousands of different scenarios to identify the optimum crude oil slate for processing, coupled with the cognitive capabilities to improve decision-making and ease-of-use. With the technology itself doing the "heavy lifting" on data analysis, planning personnel could focus on more strategic tasks.

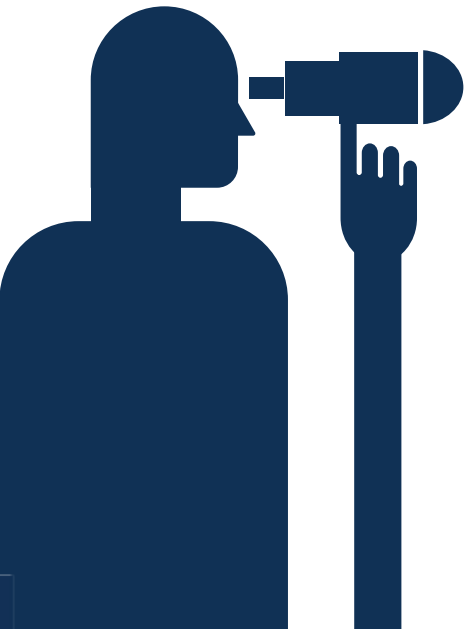


Imagine if…

…A mining operation had a system to automatically flag equipment failures weeks or months in advance — complete with detailed prescriptive maintenance recommendations, thanks to always-on AI software components. A heavy-duty truck, a conveyor system or excavation equipment could have a work order and maintenance plan generated before anyone even knows there's a looming failure.

Imagine if…

…A chemical plant could leverage real-time demand insights from customers to supercharge its supply chain networks, making them more agile and adaptable to changing demand by adjusting its operating plan and schedule. Supply chain and operations technologies could be seamlessly linked together to create a system that detects changes in market conditions and automatically responds to them.



The possibilities become almost limitless when the right technologies are integrated across the value chain and skillfully applied to the specific business needs of an organization.

Self-optimizing systems are becoming a safer, more efficient, more sustainable and more profitable reality. The building blocks and pathway to the "digital enterprise" are here today.

These are some of the new technologies that enhance the usability of advanced digital solutions.

Access the Key Technology Now

The digital advances that will create the future state are real and accessible. Self-optimizing systems and semi-autonomous operations are no longer utopian promises that can't be delivered. Research by the McKinsey Global Institute indicates that almost half of all companies (47%) have now adopted at least one AI capability[5], up significantly from 20% in 2017.

By implementing advanced technologies in a thoughtful way that targets specific business needs, companies gain the ability to optimize each critical asset and the network throughout the full lifecycle. For every piece of equipment, every system and every network, engineers can explore all the best design options, run assets at maximum productivity and safety, and create reliability programs that reduce unplanned downtime to a minimum.

With the incorporation of AI and machine learning, today's solutions also set the stage for cognitive guidance systems that will empower personnel across critical operations, extending their capabilities so they can make faster and more accurate decisions. And the sooner these technologies are incorporated, the better.

A survey conducted by the World Economic Forum and McKinsey found companies that adopt AI technology within the first five to seven years significantly outperform those that follow or lag behind. In fact, **AI "front runners" are projected to see a cumulative 122% cash-flow change,** while "followers" can expect a cash-flow change of only 10% (Figure 1)[6]. This is the bottom line, according to the report: "Company leaders who move to implementation early, rather than waiting for decreased technology and transition costs, will realize the greatest benefit."

There is a considerable competitive advantage available to those who blaze the trail for AI adoption. To be relevant and competitive in the decades to come, industry leaders will need to put the technology and talent in place today.

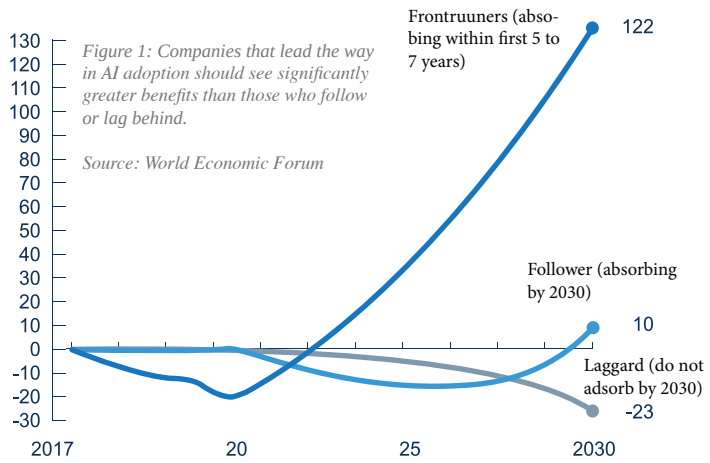
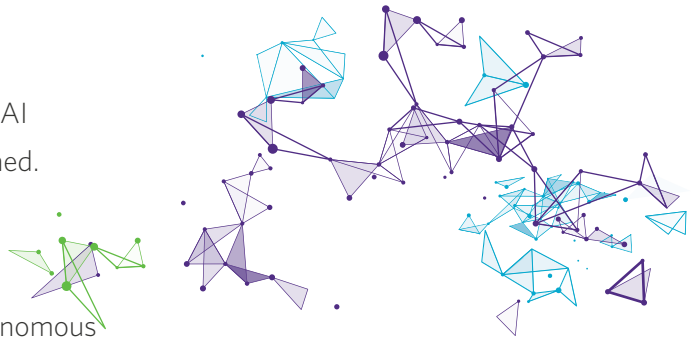


Figure 1: Companies that lead the way in AI adoption should see significantly greater benefits than those who follow or lag behind.

Source: World Economic Forum

Domain Expertise Is Critical to Digital Optimization



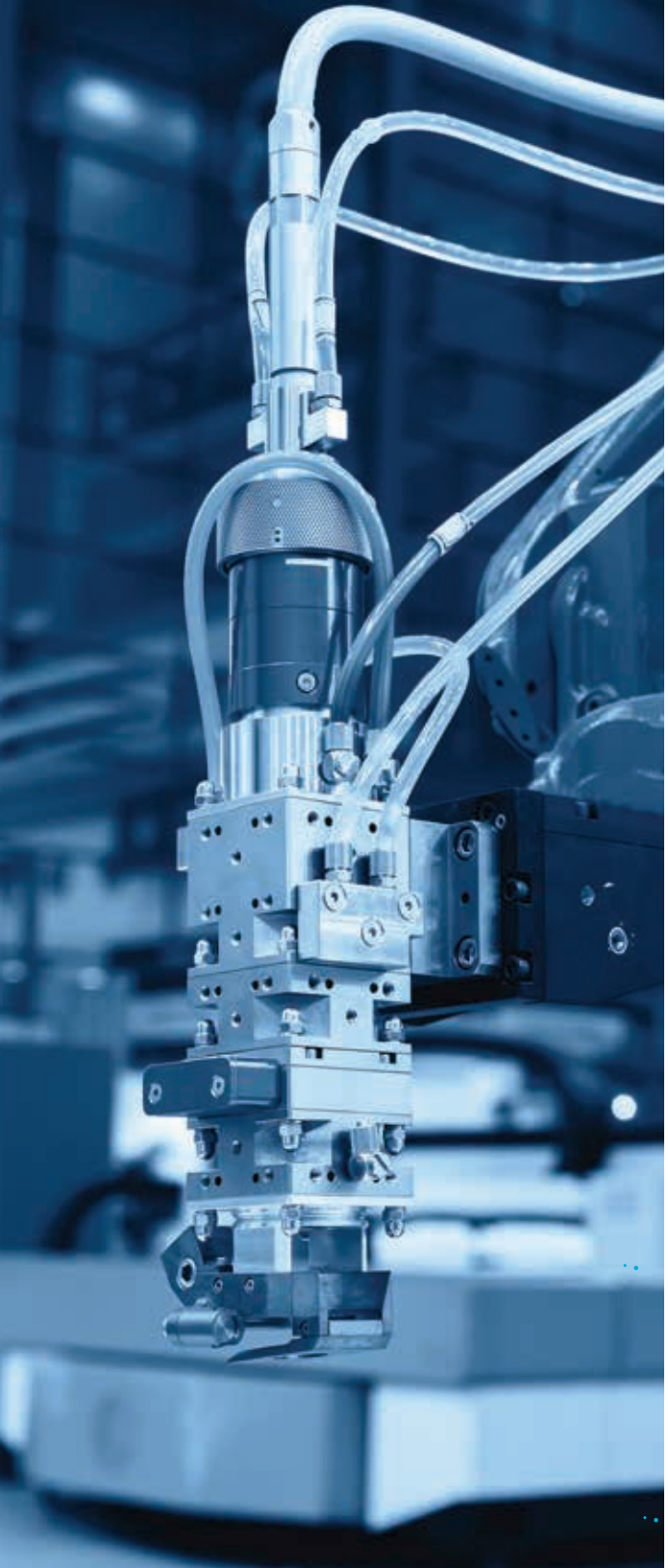
Combining the physics and chemistry that form the foundation of these highly complex assets with AI capabilities will transform how work is done and elevate the operational efficiencies that can be gained. Think of the physics and chemistry as the "infrastructure" for safe and efficient operations, while AI capabilities act as the enablers or accelerators of semi-autonomous or autonomous processes.

An example for what could be accomplished in the process industries is the technology behind autonomous vehicles. While AI creates the opportunity to have these vehicles move around cities and highways without human command, it operates within the taxonomy (transportation infrastructure and rules of the road) that allows the AI to maneuver the vehicle safely.

In the process industries, "rules of the road" are defined by the design characteristics and capacity (limits) of the asset, which are captured in the model of the asset dictated by the physics and chemistry of the process. The AI, like previous multivariable and adaptive control capabilities, is used to gain greater insights to operate the asset within the physics and chemistry of the process and the process design limitations.

While AI will be available to model the safer, greener, longer and faster operation of assets, it will always have to rely on real-world engineering principles to understand problematic or unsafe operations to predict corrective measures. Physics, chemistry and engineering principles will always be relevant, even with the deeper insights that can be gained through AI.

Algorithms will come up with spurious correlations unless properly operating within "the rules of the road" — that is, the domain expertise specific to each industry.



Refining:

Automating to Meet Shifting Business Models

The growing importance of sustainability in the energy industry is driving companies to consider new business models and alternative sources of fuel to meet the energy needs of the future. For example, refiners in some parts of the world are evaluating and starting to adopt a demand-driven model. As a result, they are investing in integrated systems and visual interfaces that allow them to meet demand profitably.

With the autonomy that aligned, self-updating models provide, feedback throughout the entire system will become more extensive, enabling instant corrective actions to create optimal conditions and hold limits. This process also enables an organization to coordinate multiple units with higher-level insights on properties and economics.

The integration of scheduling with the execution layer will enable real-time feedback and automation when enhanced with powerful cognitive and deep learning capabilities — leading to "closed-loop" or autonomous scheduling. Extending the reach of the technology further into the supply chain with improved visibility allows coordination across multiple manufacturing assets through adaptive value chain optimization.

The end goal is a fully integrated supply chain, where machine learning derives insights from real-time information to enable decision-making on demand scenarios or logistical adjustments. System-level thinking and design — another critical capability enabled by the digital solutions of the future — will ultimately drive closed-loop execution, incorporating continuous feedback to correct deviations from targets and reduce the impact of disturbances.

Two large refining operators are already putting key pieces of this technology in place. Both have used cloud computing capacity to improve business risk mitigation with advanced scenario analysis, and they have been able to do this analysis **20-80 times faster** than was previously possible.

Petrochemicals:

Aligning Functions for Optimization

Advanced planning tools are critical to bulk manufacturers, as they provide detailed insight into possible scenarios across multiple sites, feedstock options and product types. This can help break the silos that most supply chains run in today. By applying adaptive, self-optimizing technologies, the system as a whole can adapt with greater agility to market changes or plant disruptions and still coordinate an optimal supply chain strategy.

Configuration between planning, scheduling and execution systems becomes consistent, simpler and easier to maintain thanks to the use of shared model components. Manufacturers can augment these capabilities with dynamic optimization technology, which draws data from planning models (including economics) and models abstracted from the APC system (including all key constraints) to tie these layers together and ensure economic consistency.

For specialty chemicals companies, the complexity of the product mix and the wide variety of assets involved demand digital solutions to help decision-making across the business. The specialty additives producer **Lubrizol** has applied the latest batch modeling tools to several production processes to realize an increase in capacity of 5-10%. The company has also been able to accelerate time-to-market of new products by as much as 22 months.

In another example, pharmaceutical manufacturer **GSK** implemented an advanced system that creates and maintains electronic records automatically as a batch moves through the production process. This has significantly accelerated their batch release process, reducing the cycle time for order preparation by 95% and cutting the time for record review by 50%.

The future chemical or pharmaceutical plant will rely on digital capabilities to adjust operating conditions, ensuring not only personnel safety but also confidence in quality and efficiency of production. Fully integrated production units will operate seamlessly across multiple products, coordinating the flow of intermediate products to final processing with maximum productivity.

Metals & Mining:

Exploiting Opportunities Across the Value Chain

The use of advanced analytics and prescriptive maintenance technology is helping mining companies to identify impending equipment and process failures. Machine learning algorithms can analyze massive volumes of data to alert of impending failures, weeks in advance.

This type of system gave one steel manufacturer a 23-day time-to-failure warning on a specific pinch roller, as well as a 21-day warning on a bending roller. These alerts allowed the company to proactively schedule maintenance, thereby avoiding unplanned downtime and production losses.

In another facility (one of the world's largest fully integrated zinc and lead smelting and refining complexes), autonomous agents created through machine learning were able to call out a time to failure of 40 days on a process-critical pump. Within a year of implementing this technology, the company had realized more than $2.1 million USD in cost avoidance through advanced analytics.

Applying machine learning to the operational data of specific equipment can potentially eliminate unplanned downtime, enabling mining companies to schedule maintenance aligned with their goals. Collectively, these technologies will transform how firms mine, process and market their products, while also making them more efficient and sustainable.

Engineering, Procurement and Construction:
Building Tomorrow's Industries

The capital projects initiated by oil and gas and chemical companies involve complex, complicated networks of equipment, offering thousands of options for how capital could be spent to improve performance.

So how can engineering, procurement and construction (EPC) firms really explore all available design options to make sure the best choice is identified? And how do they translate models across planning, scheduling and other key disciplines to drive greater profitability for their customers?

High-performance computing enabled by the cloud empowers engineers to instantly evaluate thousands of design options to find the best return on investment. By leveraging this on-demand compute power to drive their AI applications, firms can know instantly if they are choosing the best option.

With knowledge embedded in the assets through IIoT sensors and devices to capture data locally, owner-operators can also leverage the power of shared model components across design and operations. When models are updated automatically with the most current data, the system becomes safer, faster and more agile.

By digitizing the flow of information across project participants and phases, EPCs can quickly evolve from using document-centric processes to embracing fully digital processes across design and engineering. All of this makes it easier to accommodate changes in scope, schedule and budget throughout the EPC cycle. **Technip Energies** was able to improve its front-end engineering design (FEED) efficiency by 9% on licensed technologies by integrating work processes from bidding through delivery of FEED packages.

Cognitive guidance driven by AI will allow firms to distill the experience of experts and make it available throughout the work environment. When engineers are taking an action, they can receive automated guidance and be automatically alerted of optimization opportunities in a certain area, or they will be warned if a procedure is not in line with company practices. line with company practices.

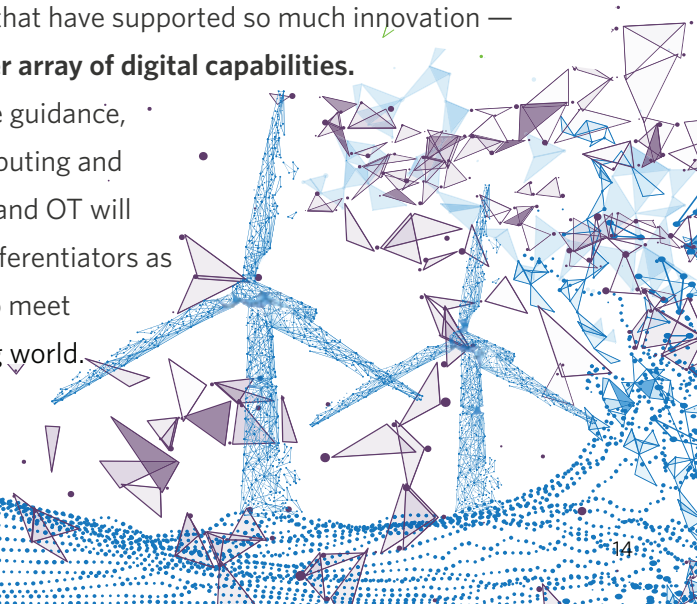
Conclusion

While we have long heard the promises of what can be achieved through autonomous operations and self-optimizing systems, they have only been partially realized in the past with closed-loop control and optimization. The difference now is that **the enabling technologies are real, they are accessible, and they bring capabilities that we have not seen before**.

These technologies will be especially critical as companies strive for market leadership while maintaining their "social license to operate." Achieving these objectives will require that digitalization and operational excellence occur and progress in a world of changing expectations because of the global VUCA environment.

More importantly, digitalization as a driver of operational excellence will facilitate the successful transition to new business models. To remain competitive and relevant, companies will need to adapt to a world where oil is increasingly used to produce chemicals and the need to recycle plastic waste is ever more pressing. New technologies will be required to address these two disruptors facing the process industries.

- Companies will have to focus on the **complete lifecycle** of both the asset and the products produced, in the context of ever-changing supply and demand conditions. This presents one of the most significant innovation challenges to the process industries and capital-intensive industries in general.
- Rising to meet this challenge will require new research and technology to achieve the potential depolymerization of plastics and to drive greater conversion of crude oil to chemicals. Changing business models will increasingly require the **full consideration of dependencies** in the design, operation and maintenance of these assets and their role in meeting the demand-supply balance.
- To remain relevant in the future, organizations will need the capabilities to derive deep insights from embedded AI and analytics. They will also have to have semi-autonomous or autonomous systems in place to act on those insights, along with advanced decision-support capabilities to enable **greater agility.**
- New business models will be anchored on the engineering principles, physics and chemistry that have supported so much innovation — enhanced with a **greater array of digital capabilities.** Embedded AI, cognitive guidance, high-performance computing and the consolidation of IT and OT will be the technological differentiators as companies transition to meet the needs of a changing world.



When applied with domain expertise and insight, these technologies will empower organizations to capture and spread the insight of their experts, accelerate decision-making across the business, drive organizational alignment and leverage advanced analytics throughout the organization.

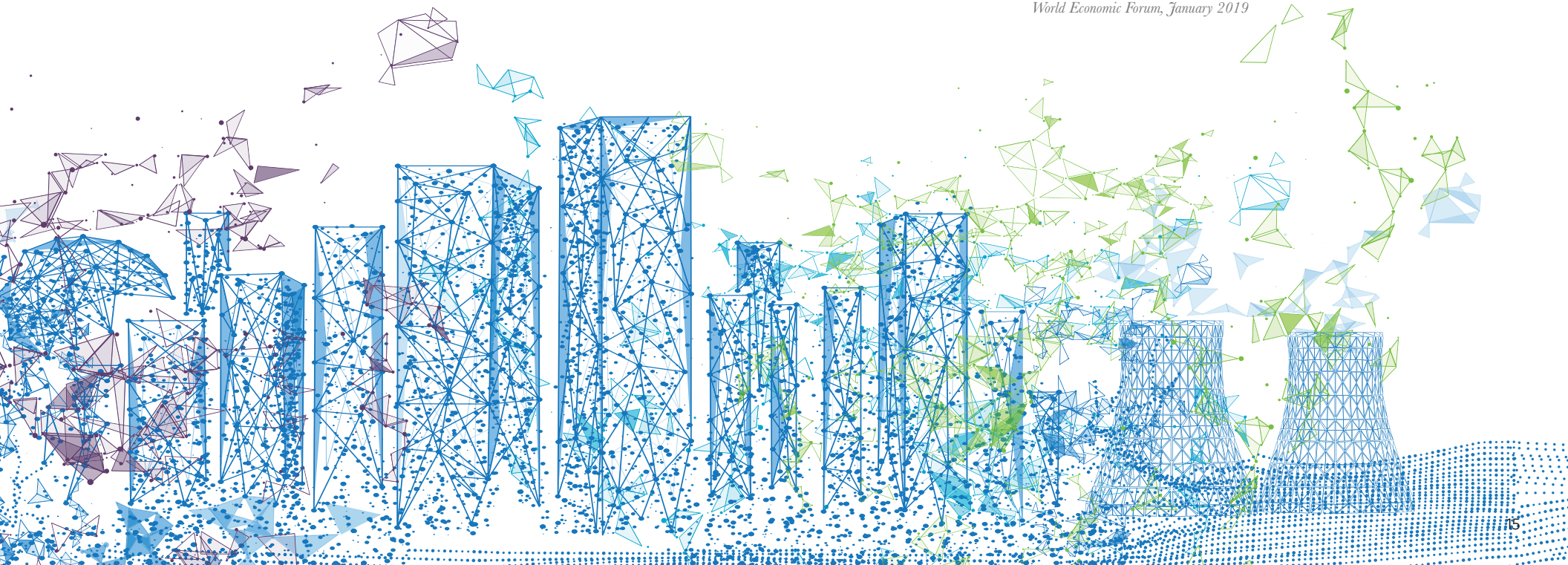
The shift to new business models, facilitated by these next-generation technologies, will not happen overnight. Leaders who leverage Industry 4.0 technologies and new AI capabilities are taking a pragmatic and decisive approach — learning from targeted initiatives and informing new programs based on those learnings, while also capturing value from "low-hanging-fruit."

The skills required to adopt and sustain these new technologies will demand a focus on organizational excellence to build and sustain them. The identification of best practices and maturity models will define the path to a new level of performance.

Successful organizations today and in the future will be those that combine the benefits of technology with organizational capabilities and processes to achieve market leadership in a changing world. The sooner this happens, the better — as the research shows.

This is how tomorrow's leaders will create not just the digital enterprise — but the truly smart enterprise of the future — and achieve operational excellence that is sustainable regardless of market conditions. The building blocks for all of it are here today.

1. *The Unprecedented Expansion of the Global Middle Class, Brookings, February 2017*
2. *World Energy Outlook 2018, International Energy Agency, November 2018*
3. *World Energy Outlook 2018, International Energy Agency, November 2018*
4. *When Lean Meets Industry 4.0, Boston Consulting Group, December 2017*
5. *AI Adoption Advances, but Foundational Barriers Remain, McKinsey Global Institute, November 2018*
6. *Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing, World Economic Forum, January 2019*



About Aspen Technology

Aspen Technology (AspenTech) is a leading software supplier for optimizing asset performance. Our products thrive in complex, industrial environments where it is critical to optimize the asset design, operation and maintenance lifecycle. AspenTech uniquely combines decades of process modeling expertise with machine learning. Our purpose-built software platform automates knowledge work and builds sustainable competitive advantage by delivering high returns over the entire asset lifecycle. As a result, companies in capital-intensive industries can maximize uptime and push the limits of performance, running their assets safer, greener, longer and faster. Visit AspenTech.com to find out more.