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The biopharma factory of the future

Start the journey to smart manufacturing

Contents

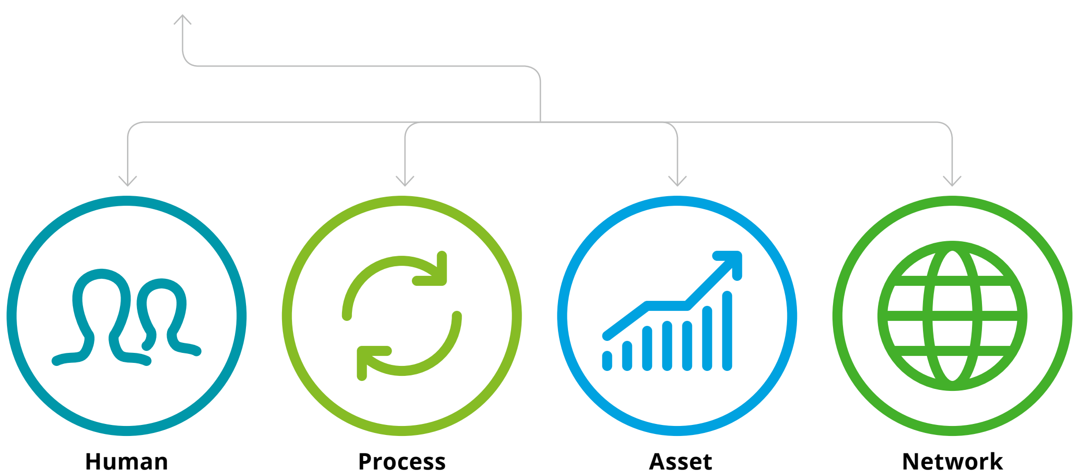
Taking stock: The current state of biopharma manufacturing

Just as the types of biopharmaceutical products being produced today are almost endless in variety, so too are the paths to manufacture them. Yet they share a common challenge: the pressure to produce safe, high-quality, and cost-effective products in a more agile way.

That pressure is profound in part because biopharma manufacturers share common traits:

- Although individual unit production processes are heavily automated, human intervention is typically needed to connect those processes.
- Their products are highly controlled for quality and safety.
- The useful life of heavy capital assets can be relatively short due to rapid technological change and the finite market lifetime of a product, considering impending generic or biosimilar entries causing rapid declines in revenues and margins.
- Many biopharma companies rely on manufacturing networks that shift product from one site to another as they collaborate to build it.

These traits correlate to four primary dimensions of performance within manufacturing:



These drivers are at the crux of achieving improvements in biopharma manufacturing, and a tangible improvement in one or more of them is a must-have in any smart factory deployment. Such an improvement can lead to significant gains in quality, efficiency, lead times, and ultimately the bottom-line.

In a smart factory, machines autonomously run entire production processes. Technologies like robotics, data analytics, distributed ledgers, vision systems, augmented reality, virtual reality, artificial intelligence (AI), and the Internet of Things (IoT) come together to connect different operations, respond to new situations, and adapt as a result of those responses. As lean manufacturing, alternative sourcing, and other traditional improvement levers mature, the smart factory is set to bring about the next dramatic shift in manufacturing efficiencies.

However, interest is one thing. Knowing where to begin, and how to keep going, is something else altogether. In this article, we'll look at some practical ways to gear up for the smart factory journey, with a focus on the capabilities that are most relevant to biopharma manufacturing. These considerations won't take biopharma companies across the finish line, but they can get a company to the end of the beginning—and maybe help deliver some quick wins along the way.

Building the case for change

Manufacturing is a field marked by ongoing advancement—from scientific discoveries to new tools, systems, and production technologies. At the same time, in any company manufacturing is often one of the last functions to take up an innovation because doing so may require costly downtime, increasingly longer license and regulatory updates, and significant investments. To take on the risk of disruption, then, management must be persuaded of any credible, tangible value from plant-floor innovation.

Broadly speaking, there are two parts to gaining support for the transition to a smart factory setting. One is to limit disruption by piloting digital solutions in well-targeted areas. Once the solutions prove out, they can be extended to the rest of the organization. More on this later in "Making the smart factory a reality."

The second part is to build a robust, actionable business case that articulates upfront the benefits a smart factory is likely to bring. For biopharma companies, most of the benefits come from five key smart factory features:

- **Connectivity.** Integration of data from operations and business systems—as well as from suppliers and customers—can boost efficiency by enabling greater visibility across upstream and downstream processes. Consider this in biopharma: A typical bioreactor has six different data feeds, over 300 sensors and actuators, and nearly 50 MB of data generated every second. However, in one example, a biologics contract manufacturer saved three lost lots of production per year and created $35 million in direct top-line value by virtually connecting its sensors, actuators, and other data feeds in a closed loop with subsequent unit operations.
- **Transparency.** Real-time data visualization offers transparency across the network and yields insights for more informed decisions. Tools include role-based views, alerts and notifications, and real-time tracking and monitoring. For example, a typical biopharma production floor generates real-time data across multiple batch process control systems and any automated interfaces between them. Savvy biopharma organizations have begun to connect their process historians that document the production-floor process-parameter history with other data sets from manufacturing execution systems, laboratory information systems, and environmental monitoring systems to create operator dashboards that can reduce the human error rate to one in every 500,000[1] hand-offs on the production floor.
- **Proactiveness.** A smart factory can predict future outcomes based on historical and real-time data. This can empower employees to anticipate and act before issues or challenges arise, rather than simply react to them after they occur. As an example, in life sciences, anticipating raw material variability and acting on the process based on raw material quality have generated process-yield gains of more than 3x for a plasma biologics product. The gains from such proactive, predictive feed-forward control can surpass the incremental yield improvement targets that manufacturing, science, and technology or process development organizations strive for.
- **Agility.** A smart factory can adapt to schedule and product changes with minimal intervention. Depending on the product, advanced smart factories can also self-configure equipment and material flows while evaluating the impact of changes in real time. For example, in small molecule manufacturing, process intensification and miniaturization—along with high-frequency IoT sensors—have improved the agility of changeovers and reduced the latency in clearance and cleaning validation times.
- **Optimization.** A smart factory operates with minimum manual intervention and high reliability via automated workflows and synchronized assets. The result is typically greater yield, uptime, and quality, along with reduced costs and waste. For example, some life sciences manufacturers are trying to achieve multi-echelon optimization of yield and equipment uptimes toward a global optimum rather than a local optimum. In fact, one biopharma manufacturer looked to weed out sudden yield declines by leveraging machine learning algorithms on its production data.

Manufacturers can prioritize these features based on their most pressing needs. Prioritization helps not only to manage the scope of a business case—a smaller case or two may be more manageable than a sprawling, ambitious one—but also to quantify benefits such as asset efficiency, quality management, cost optimization, and safety and sustainability.

1. Deloitte Consulting LLP Analysis

Case Study: A leading biotech/ pharmaceutical manufacturer

The digital journey of a leading biotech/pharmaceutical manufacturer began with a robust case for change that unfolded in three main steps: a rapid assessment, the identification of areas where digital capabilities could be scaled more effectively, and an estimate of the quantitative impact of the digitization exercise.

Rapid assessment. During a retreat, 20 leaders from the company took part in a handful of digital immersion sessions aimed at generating ideas and understanding current pain points. Beginning around the same time, a group of operators, staff, and plant leaders carried out an eight-week assessment of two manufacturing plants to define the capabilities and identify improvement opportunities.

Identification of capabilities. With the findings from the two pilot sites in hand, the group visited five additional plants to determine whether the same opportunities were applicable on a larger scale. This resulted in a further refinement of global capabilities that the company would use to reinvent itself into a smart factory. The global capabilities were mapped to the company's global operational and strategic imperatives to promote alignment and advocacy for the digital journey.

Quantification of benefits. To put numbers against the smart factory's expected benefits, the company combined top-down financial analyses with bottom-up evaluations of the impact of the proposed use cases on operational key performance indicators (KPIs) at the two pilot sites. The company then scaled the opportunities across the network at full potential to determine which benefits were recurring and which were one-offs. Finally, the company validated the scaling and clustering approach and confirmed business case input parameters such as duration, rate of return, and cost of capital.

The net value of the smart factory platform was projected to be at $50 million to $75 million year-over-year in operational expense reduction on a baseline of $700 million—a direct bottom-line impact. This approach also created additional capacity that effectively negated the need for $500 million in capital expenditures over a five-year period.

Creating a smart factory strategy

As the number of disparate systems grows in a smart factory, eventually it can become challenging to reconcile their data and draw meaningful conclusions. It is imperative to address this challenge in a smart factory strategy.

When formulating the strategy, it's important to be clear on the difference between smart factory and technology. The smart factory is about business functions operating in a connected way. Technology's role is to enable smart factory capabilities while remaining compliant with evolving regulatory requirements.

With that in mind, a smart factory strategy should describe:

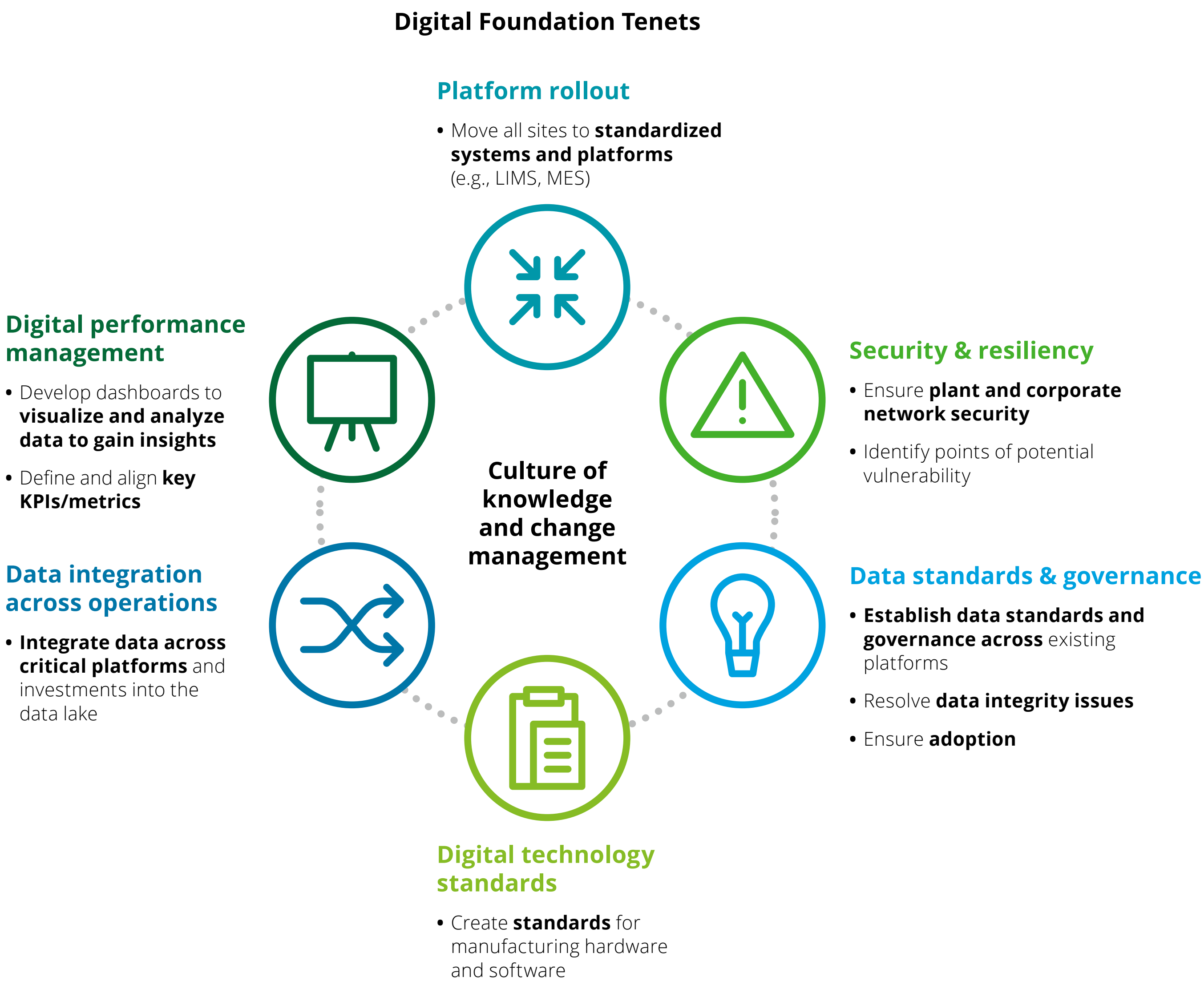
- **The digital foundation.** These include platforms, applications, and technology tools that can scale to a higher level of capability, plus business processes and hierarchies to exploit the unique capabilities of each platform. All should be stable and standardized, so they can share critical events or transactions (see figure 1). For example, life sciences companies today deal with a disparate ecosystem of manufacturing systems, operational technology assets, and communication networks. Some have begun the journey to modernize the foundation to build a strong smart factory fabric in biopharma manufacturing.
- **The movement of data.** Once the organization has converged on a common set of platforms, the next step is to get them connected. A smooth, real-time exchange of information can help achieve productivity and data integrity gains critical to smooth shop floor operations. These interconnections can also break down information silos, enabling collaborative workflows between functions and end-to-end visibility of information. For example, event-based triggers for data extraction from environmental monitoring systems or process historians are essential for running AI or machine learning–based algorithms for global yield optimization.

- **Evolution to the future of work.** This involves identifying certain personas on the manufacturing shop floor and explaining how smart factory advances will put intuitive, easy-to-use tools in their hands. Accompanying this should be an analysis of how the new processes will affect stakeholders, along with a plan to communicate and secure buy-in on the new expectations. As an example, incorporating collaboration suites using AI chatbots and augmented reality capabilities can help transform and improve human performance on the production floor.
- **Anticipated use of data in decision making.** Combining the data that plant and enterprise platforms generate can reveal ways to further optimize operations via new workflows. With technologies like IoT-based sensors and machine learning a biopharma manufacturing organization can put this data to work toward smart process monitoring, advanced operator solutions, condition-based maintenance, and other advanced capabilities.

When it comes to defining advanced capabilities, focus on those that are unique, achievable within three years, and developed in collaboration between IT and the business. In addition, verify that each capability enables a critical business imperative providing a sustainable competitive advantage.

Finally, remember to set appropriate expectations among stakeholders and business partners—e.g., manufacturing, science, and technology; quality; corporate IT; and manufacturing site leadership. Emphasize that the smart factory is a journey rather than a destination. The mindset should be one of continuous change, with an aim to encouraging sponsorship over the long term.

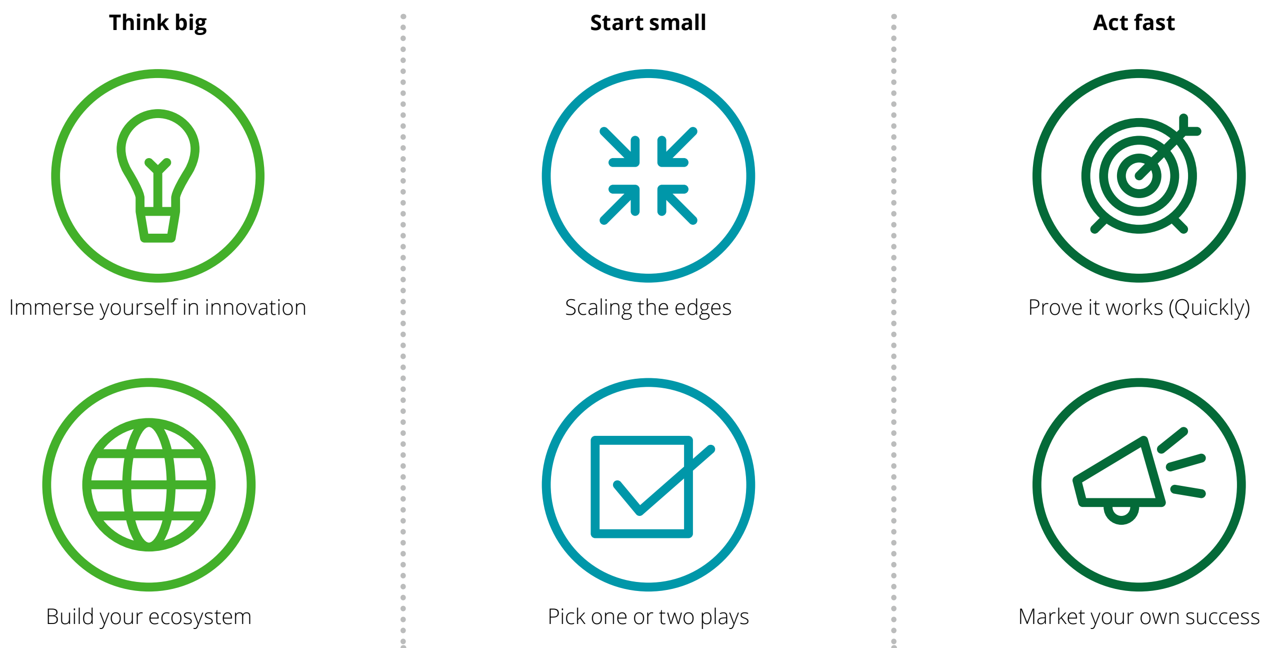
Figure 1. A stable digital foundation maintains consistency across sites and enables advanced smart factory capabilities



Making the smart factory a reality

A smart factory solution can seem overwhelmingly complex. But by *thinking big* and embedding levers of performance improvement throughout the smart factory capabilities, *starting small* with manageable parts, and *acting fast* to scale the smart factory to the manufacturing network, biopharma manufacturers can realize the promise and benefits that the smart factory has to offer (figure 2).

Figure 2. Three basic steps can reduce complexity and start organizations along the smart factory journey



Effective smart factory deployments in biopharma have common attributes that can result in a fundamental shift in the organizational culture. Companies begin to think digital in order to be digital—i.e., any process discussion includes consideration of how digital technology can enhance human capabilities, as well as changes to how the processes are executed to deliver the end result—effective, safe, high-quality product to patients. Company leaders take an open mindset regarding their operations talent base, focusing on upskilling the workforce with basic digital skills. And, they enact a self-sustained funding model through a digital incubator.

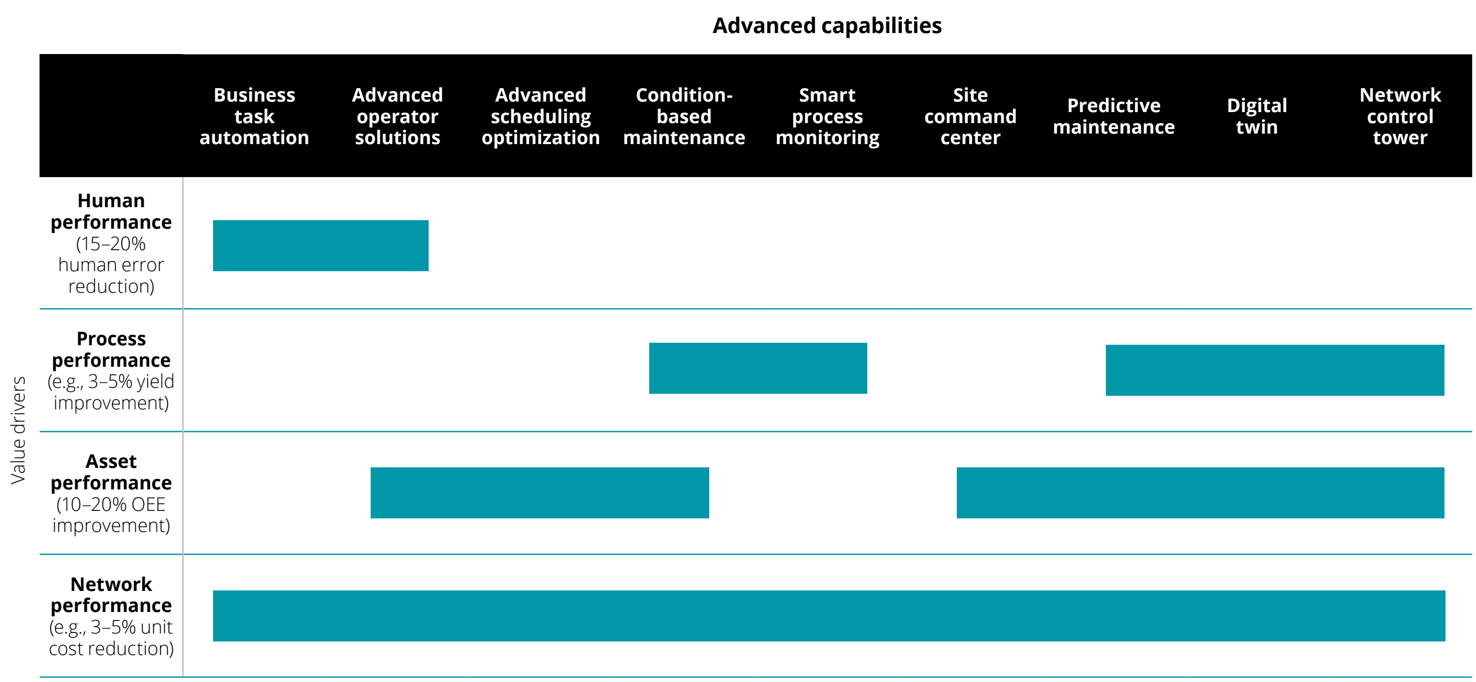
These ingredients are all critical for success. Without them, biopharma organizations are likely to continue to experience increasing budgetary and bottom-line pressures and a lack of substantial sponsorship by leadership—both at site and above site—creating insurmountable hurdles for the smart factory deployment. In fact, site leaders who would gain most from smart factory capabilities would likely continue to question the effectiveness and bottom-line impact of smart factory deployments as mere actions on budgets if the talent and human performance successes are not made an essential component of such transformations.

Think big

As a first step, try to imagine all the ways digitization can bridge operational gaps throughout the organization. For example, collaboration and active access to production floor data can enable biopharma plant floor operators to act quickly and drive value by preventing errors and reducing lost production time. Look into different approaches for rationalizing tools and features across different environments. Make a list of the user personas, data models, and key processes that exist today, and consider how each could change in the future.

There are two aims behind all this expansive thinking. One is to create a bold vision that generates excitement among stakeholders. The other is to avoid incomplete solutions: A too-narrow scope of requirements or an excessive number of design constraints can prevent effective scaling across sites or functions. This can leave life sciences organizations at a competitive disadvantage, especially given the myriad use cases for digital factory technologies and solutions (see figure 3).

Figure 3. Life sciences organizations have myriad opportunities for digital transformation across the supply chain



Start small

With a big vision to coalesce around, the next step is to set up pilot sites or functions to serve as digital incubators. Here is where smaller business cases—such as digitizing a single asset, production line, or factory—can be tried out in a protected space. On the production floor, these proofs of concept must deliver tangible performance improvement against one or more performance verticals in order to resonate with site leadership (figure 4). For example, a simple proof of concept in biopharma human performance and human error-rate reduction could be developed around shift hand-offs and operator collaboration. The objective could be to drive a shared understanding of manufacturing lot progress in bulk drug substance manufacturing. If proofs of concept like these prove effective, they can be extended to the entire factory network (figure 5).

Figure 4. Sample performance objectives for a proof of concept project

Human

Smart Factory designed to reduce "touch-time" and provide real-time process visibility for **timely intervention**

Leveraging analytical insights to enhance **on-the-spot discretion** resulting in:

- Reduced human error
- Empowered shop floor personnel taking productivity and quality to the next level

Process

Predictive analytics identifying **quality and productivity trends** can:

- Identify discrete human, machine, or environmental causes of poor process performance
- Lower scrap rates and lead times
- Increase fill rates and yield
- Lead to fewer defects and recalls

Asset

Reams of data generated through continuous analysis reveal asset performance issues for **proactive corrective optimization**

Asset efficiency translates into:

- Lower asset downtime
- Optimized capacity
- Reduced changeover time

Network

Optimized processes resulting in **cost–efficient production** through:

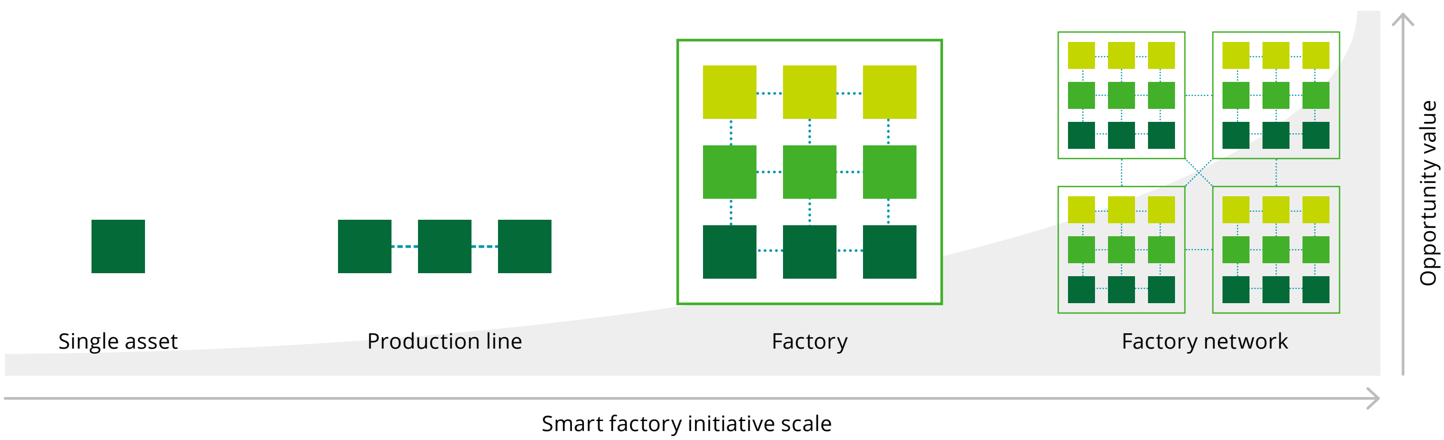
- Reduced operational variability
- Predictable inventory requirements

Increase in process quality may increase **product quality**, lowering warranty and maintenance costs

By focusing on increasingly bigger assets, the value that companies can unlock can follow an exponential rather than linear trajectory as economies of scale and redundancy reduction come into play. For example, after creating a line-clearance proof of concept in which an advanced vision system was deployed at a filling line, a contract fill/finish manufacturer was able to optimize line clearance and improve line readiness by tying the data from the vision system to near-real-time equipment and clean-room asset-sensor data and real-time environmental monitoring data to clear reduced queue time on filling lines by 30 percent.

To manage the number of pilot projects in development, consider prioritizing them by feasibility, time to value, and alignment with the overall smart factory vision. Recommendations for pilots can come from subject matter and functional area leads, with input from quality control and regulatory affairs. A governance process is necessary to review for business value and either terminate the idea or advance it to the next stage of scaling and refinement, and other oversight is required to limit exposure to protected health information (PHI) and personally identifiable information (PII), for example in next-generation therapy manufacturing such as CAR-T therapies. At the same time, it's important to avoid so much process that it discourages innovation.

Figure 5. Manufacturers can extrapolate the results of a pilot implementation to the rest of the factory network



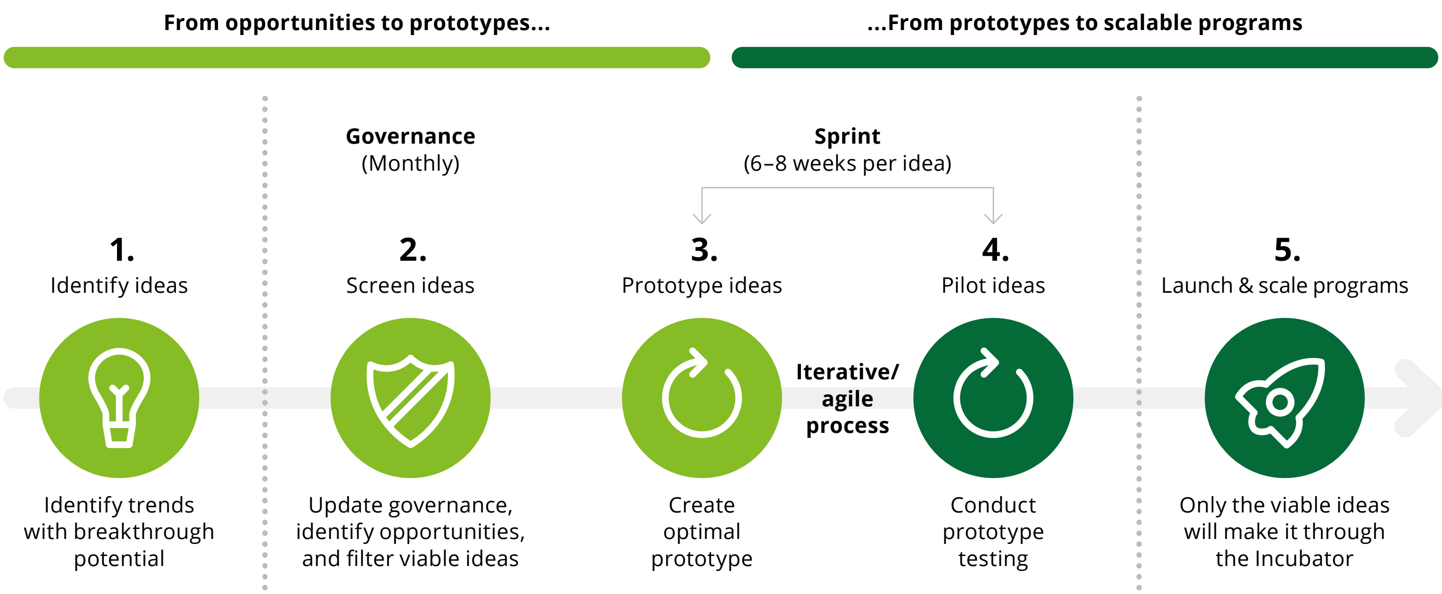
Scale fast

Once a pilot concept has proven business value, longevity, and maintainability—among other requirements of the review process—it's time to scale it beyond the digital incubator (figure 6). This transition should happen smoothly but quickly to avoid a fragmented approach to smart factory innovation. Meanwhile, key production floor and quality metrics such as overall equipment effectiveness, process yields, and lot release cycle times should be reviewed and adjusted simultaneously so that data and insights remain consistent across the organization.

Although the digital incubator reduces technology and process risk, scaling introduces change management and other challenges that require careful management.

This end-to-end deployment of smart factory capabilities requires an ongoing, sustained source of funding where past deployments release value for future deployments. Much easier said than done, this self-funding approach requires clarity on how the new smart factory capabilities deliver that value, who champions the value capture at site and among above-site leadership, and the organizational adoption of the smart factory capabilities.

Figure 6. Activating the digital incubator



Conclusion

For biopharma companies, the question is no longer whether to embark on a digital journey for their supply chain and global operations functions. Rather, it's about where and how to start.

In this article, we laid out three basic steps to launching a smart factory journey. First, build the case for change by articulating the expected benefits of a smart factory. Next, create a strategy that describes the smart factory's digital foundation, data flow, everyday processes, and effect on decision making. After that, start making the smart factory a reality by thinking big, starting small, and acting fast from a few selected areas to the extended organization.

On a final note, keep in mind that no two smart factories will look the same. Each one will have variations in line layouts, products, automation equipment, and other attributes. That said, the components needed to enable a smart factory are largely universal, and each one is important. They include:

Data. To power the smart factory, manufacturers should have the means to create and collect ongoing streams of data, manage and store the massive loads of information generated, and analyze and act upon the data in varied, potentially sophisticated ways.

Technology. Smart factory technology comprises robotics, high-performance computing, AI and cognitive technologies, advanced materials, and augmented reality—all to connect assets and facilities, make sense of data, and digitize business operations.

Process. An autonomous system can make and execute many decisions without human intervention, potentially shifting decision-making responsibilities from human to machine or concentrating decisions in the hands of fewer individuals.

People. The successful smart factory journey will require a motivated workforce that embraces the greater impact of their roles, innovative recruiting approaches, and an emphasis on cross-functional roles.

Security. Cybersecurity risk seems to only grow more pronounced as the smart factory scales and potentially moves beyond the four walls of the factory to include suppliers, customers, and other manufacturing facilities.

The smart factory is a long-term, systemic change to the way biopharmaceuticals are manufactured. Make the most of it by keeping the focus on what makes biopharma manufacturing unique, then following through on the changes that are the most relevant and valuable in the context of the specific organization's production floor.

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