McKinsey & Company

Operations Practice

Enabling a digital and analytics transformation in heavy-industry manufacturing

To make the most of new digital approaches in manufacturing, heavy-industry players need to put some critical enablers in place.

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December 2019

In earlier articles, we have shown how digital and advanced analytics (DnA) technologies have significant potential to improve manufacturing operations in heavy industry. We have explained that to capture that potential at scale, companies need a systematic approach to identify, develop, and roll out the technologies and approaches that offer the most value to them. And we have shown how the best approach for a given organization will depend on its current level of digital maturity, its goals, and on the nature and distribution of those opportunities.

In this article we turn our attention to four critical enablers: talent, data, technology, and agile delivery. Companies need these enablers in some form for every digital initiative they run, and together they comprise an engine to power any heavy manufacturer's successful DnA transformation. Carefully thinking through the development of digital muscles helps an organization avoid the need to repeat work or reinvent the wheel, aids the efficient use of resources, and promotes the adoption of standardized approaches that are easier to scale, replicate, and sustain.

Let's look at each in turn:

Talent

Digital and analytics projects are skill-intensive activities. Recent advances in software and hardware have done much to improve the accessibility and usability of new technologies, but their successful application still requires people who understand the capabilities and limitations of digital approaches, and who know how to get the best out of the available tools.

In heavy industrial manufacturing, digital projects require new capabilities—and often new roles—in three areas of the business. They need people with expertise in the company's products and production processes. They need technology specialists with expertise in areas such as software development, robotics, and automation. And they need digital specialists who can run agile projects or design an effective user experience.

Critically, projects also require people whose skills bridge these different groups. Data engineers develop more efficient information technology systems such as databases, fast data processing, or new and more reliable data sources. Data scientists use those systems to unlock new insights or knowledge from the data by developing analytical techniques and efficient algorithms. Translators frame business problems in a way that digital specialists understand, and use their domain knowledge to evaluate and continuously refine the resulting DnA solutions (Exhibit 1).
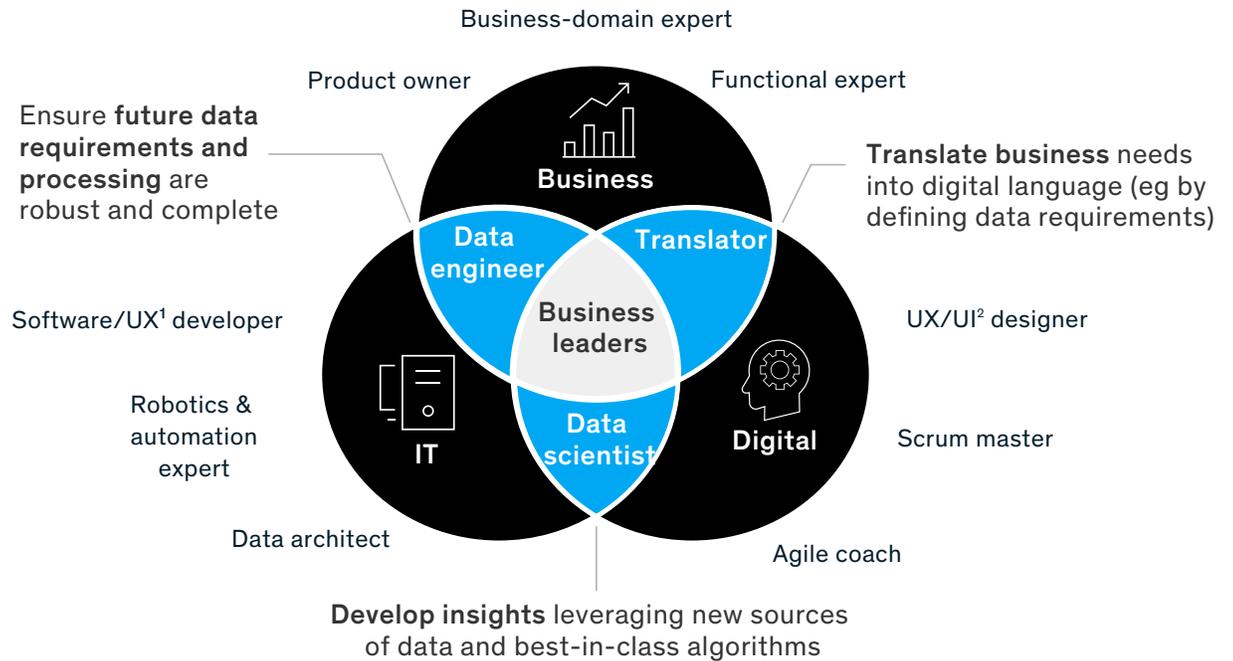
With the exception of tactical interventions, where most of the necessary talent may be provided by the external supplier contracted to deliver the project, talent can be a critical roadblock in digital projects. And it won't be solved by the market alone. With a wave of digitization underway across industries, skilled data scientists and other technical specialists are in short supply globally. Furthermore, becoming much more efficient in those roles requires an in-depth understanding of manufacturing processes and other company-specific knowledge, alongside digital and analytics expertise.

While some external hiring is almost always necessary to fill capability gaps and kick-start digital programs, many critical new skills are best developed in-house (Exhibit 2). Homegrown capability-building efforts can't meet an organization's demand for PhD-trained data scientists, but they can produce large numbers of skilled and competent digital practitioners, who are essential for the application of new tools at scale. Heavy-industry manufacturers are well positioned in this regard, since their existing workforce is already technology savvy. For them, the shift to digital is a natural step: for example, an automation engineer already understands the building blocks of robotics technology.

Companies embarking on large-scale transformation programs (whether focused

Exhibit 1

Digital projects require new roles spanning three core business functions.

Business-domain expert

Product owner

Functional expert

Ensure **future data requirements and processing** are robust and complete

Business

Translate business needs into digital language (eg by defining data requirements)

Software/UX[1] developer

Data engineer

Translator

UX/UI[2] designer

Robotics & automation expert

Business leaders

IT

Data scientist

Digital

Scrum master

Data architect

Agile coach

Develop insights leveraging new sources of data and best-in-class algorithms

[1] User experience
[2] User interface

or enterprise-wide) may set up a dedicated digital academy to develop skills at all levels of the organization. These academies provide online, classroom-based, and experiential training tailored to the objectives of the program and the needs of different stakeholder groups. Senior managers may be provided with a broad overview of digital approaches, for example, while translators and digital specialists dive deeper into specific tools.

In-house academies also make it easier to deliver specific training on a just-in-time basis, so staff can apply new skills immediately on real projects. In line with general best practices in capability building, learning should then be reinforced with continual coaching and mentoring in the workplace. Working this way, academies don't just build skills—they also change mind-sets. Hands-on involvement in
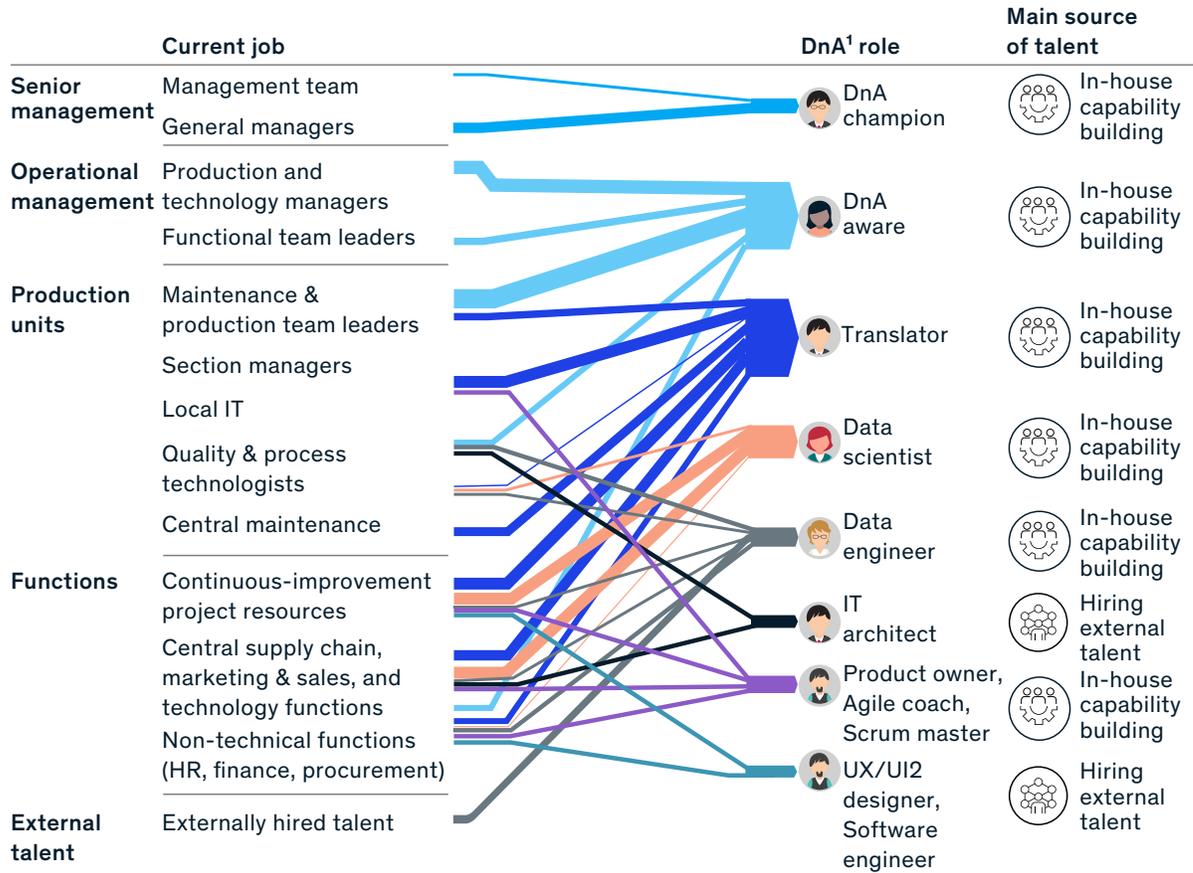
digital projects does much to eliminate fear of new approaches, while also making their benefits clear. Staff can usually see immediately how digital tools can improve their working lives.

Data

Most heavy-industry players already have the majority of the data they need. But an important new requirement in digital projects is to extract that data from silos across the organization, and bring it together in a unified, accessible form. Executives sometimes worry that a digital transformation will require them to rip out and replace their existing data infrastructure. Many have uncomfortable memories of the large-scale IT projects of the past, which were expensive, complex, and prone to failure.

Exhibit 2

The right DnA transformation talent pool combines in-house capability building and hiring for specific specialist roles.

Current job		DnA[1] role	Main source of talent
Senior management	Management team	DnA champion	In-house capability building
	General managers		
Operational management	Production and technology managers	DnA aware	In-house capability building
	Functional team leaders		
Production units	Maintenance & production team leaders	Translator	In-house capability building
	Section managers		
	Local IT	Data scientist	In-house capability building
	Quality & process technologists		
	Central maintenance	Data engineer	In-house capability building
Functions	Continuous-improvement project resources	IT architect	Hiring external talent
	Central supply chain, marketing & sales, and technology functions	Product owner, Agile coach, Scrum master	In-house capability building
	Non-technical functions (HR, finance, procurement)	UX/UI[2] designer, Software engineer	Hiring external talent
External talent	Externally hired talent		

[1.] Digital and analytics
[2.] User experience/user interface

Today's reality is different. Modern data platforms or data-integration systems can be set up as a new layer that sits above existing systems and interacts flexibly with them. This may involve the use of a data lake, fed by streams of data from a variety of operational technology (OT) sources, such as sensor networks, process-control systems, or other manufacturing-automation equipment—or from higher-level IT sources, such as enterprise resource planning systems.

The process isn't entirely plug-and-play: some data sources may require additional action prior to integration. Historical maintenance records or shift reports may exist only on paper, for example, and non-networked or analog sensors may need to be upgraded or replaced. The important rule, which avoids failures and minimizes costs, is to gradually integrate only the data that is needed for ongoing DnA projects.

Once companies understand their data, they need to manage it. That requires robust governance polices and processes along with rigorous standardization—using consistent naming conventions and a single "data dictionary" to ensure future digital projects can identify the data they need (Exhibit 3).

Exhibit 3

Data is a critical resource that requires effective governance.

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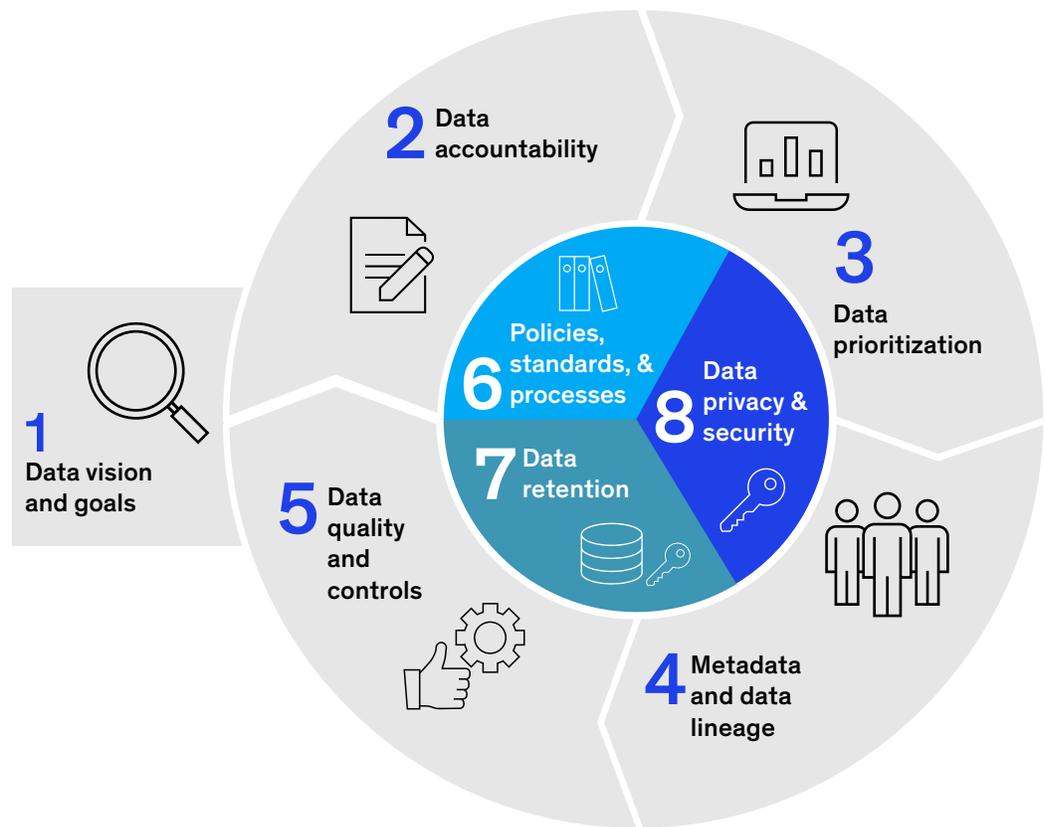
 1 **Data vision and goals** to set the direction of the program and focus investment

....

 2 **Data accountability** to define who is responsible and ensure ownership

....

 3 **Data prioritization** to focus effort on the data that matters the most

....

 4 **Metadata and data lineage** to describe the data and where it comes from

....

 5 **Data quality and controls** to ensure data is clean and data risks are managed proactively

....

 6 **Policies, standards, & processes** to describe how governance should work

....

 7 **Data retention** to control the amount of data needed to process and manage

....

 8 **Data privacy & security** to protect data assets and ensure sensitive information is safeguarded

Data quality is a significant, and often underestimated, challenge that should be addressed early in any digital effort. This will require processes to identify and manage missing or erroneous data. Companies also need to ensure they understand the characteristics of the data they have: the frequency and timing of measurements can have a significant impact on the ability of a dataset to usefully represent the underlying process. And in many industrial applications, inherent measurement errors can be significant, resulting in uncertainty that may be significantly larger than the typical 1 to 3 percent performance improvements unlocked by DnA solutions.

Companies also need a systematic process to identify potential risks and define appropriate mitigation actions and improvements (Exhibit 4). Sharing data or software code across business

Exhibit 4

Digital assets require rigorous risk-management processes.

Dimensions	Typical things to look at
(1) Model context	• Clarity of the **intended business (and regulatory) use** of the model or use case • Clarity and completeness of the initial **business & technical requirements**
(2) Input	• Appropriateness of the (development) **data set** • **Data quality** (eg digit & duplication check) and **integrity** (eg missing or static data) • Soundness of the **data treatments & assumptions**

(3) Development process	• Soundness and reasoning of the:
	   - **Methodological approaches** selected
	   - **Modeling techniques** used

(4) Output	• **Quality of the model outcomes** in terms of **accuracy** (eg back-testing & benchmarking), **precision** (eg sensitivity tests) and **robustness** (ie model's ability to maintain its performance)
(5) Implementation	• Completeness of the **model or use-case documentation** • Adequacy of the selected **production environment** • Accuracy of the **model code and data-import process**
(6) Ongoing monitoring	• Completeness and appropriateness of the **ongoing monitoring plan** • Soundness of **defined KPIs and acceptance criteria** for model performance
(7) Reporting & use	• Completeness and clarity of the **model-performance reports** (including consistency of results with model's intended use, information on model's performance, limitations, weaknesses)
(8) Model governance	• **Model governance** (eg ownership, escalation process) • **Model controls**

The model-review process defines:
- **The types of review** (e.g. model validation) that are expected to be performed
- **Which areas** of the models must be reviewed
- **Who** performs the review
- **What** expected output will result from the review
- **How deep** the review must be based on the materiality of the model (proportionality principle)

Depending on the implementation platform, the model review can be performed by the center of excellence

Model reviews should not be performed by the model developer

units and functions can be a sensitive issue. Managers of manufacturing units can be wary about revealing the true performance of their operations, for example, and business leaders may fear the exposure of commercially confidential information. Ensuring appropriate cybersecurity and access-control processes from the outset of a digital transformation can allay these fears.

Technology

Encouraged by the vigorous marketing efforts of vendors and start-ups, it is common for companies to take a technology-first perspective when they think about digital transformation. They should avoid that mistake. In practice, any of a number of digital tools, technologies, or analytical platforms can be applied to a given problem. Success depends more on the organization's ability to define the problem clearly, access the appropriate data, and integrate the solution into their wider operations.

New digital approaches don't always require significant technology upgrades. Existing controllers and control strategies at manufacturing sites can often be tuned or reconfigured to deliver additional value, using insights from machine-learning systems or related techniques.

More significant than the capabilities of individual digital tools is an organization's ability to support their use. This is becoming especially important with the increasing use of open-source libraries. Companies must be very careful when managing versioning, as the open-source world is continuously releasing new updates that may make existing functions obsolete.

A proliferation of approaches increases the requirements for user training, maintenance, and technical backup. It can also make it more difficult to share successful approaches across the business. As a result, companies should try to standardize wherever possible, selecting appropriate technologies in domains such as data analytics or machine learning after evaluating candidates across a range of use cases.

The tools chosen should reflect the organization's wider working environment. If the enterprise uses general business applications, such as spreadsheets and messaging services, from one particular vendor, new digital applications are usually best built on the same platforms. Indeed, the gap between enterprise IT and OT is narrowing in many industrial environments. Companies can use wi-fi–networked sensors for the collection on noncritical data, for example, or access process and performance data using mobile phones and tablet computers.

Standardization shouldn't keep companies from improving the technologies they use. The digital space is fast-moving, with new solutions emerging all the time. Since frontline teams don't have the time to keep scanning the market, it's useful to establish a corporate group with responsibility for identifying and evaluating promising technologies. Or to build an ecosystem of collaborative relationships with a select group of technology providers.

Agile project delivery

Digital projects are different from other engineering efforts in heavy industry. Most digital organizations have abandoned the traditional waterfall engineering methodology, with its emphasis on formal specifications and rigid stage reviews. Instead, they adopt the agile methodology, in which development work takes place iteratively in short sprints, with the emphasis on early and continuous real-world testing and refinement.

At first sight, this fast-and-loose approach to project delivery can be challenging for teams used to a slower, more cautious cadence. A second look can be more reassuring. In practice, agile delivery has much in common with the incremental continuous-improvement cycle followed by every company that has taken lean manufacturing to heart. And that includes many heavy-industry players.

But even companies with a strong lean pedigree will need to adopt new organizational structures and new ways of working to accommodate agile methods. They will need to convene cross-functional teams that include representatives from operations and IT, working alongside data scientists or other digital specialists. And they will need to adapt to the agile rhythm of quick development sprints, frequent prototyping, and continual testing and refinement. Accordingly, large-scale transformations usually benefit from a dedicated project-management office to track the progress and success of individual initiatives, and ensure emerging best-practices are shared across the organization.

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Digitization at scale requires the right infrastructure. The good news for heavy-industry players is that they already have many of the basics in place, including a technically capable workforce, instrumented equipment, and a culture of continuous improvement. From these foundations, companies can secure the talent, data, technology, and agile project-delivery capabilities they need to support their digital ambitions.

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