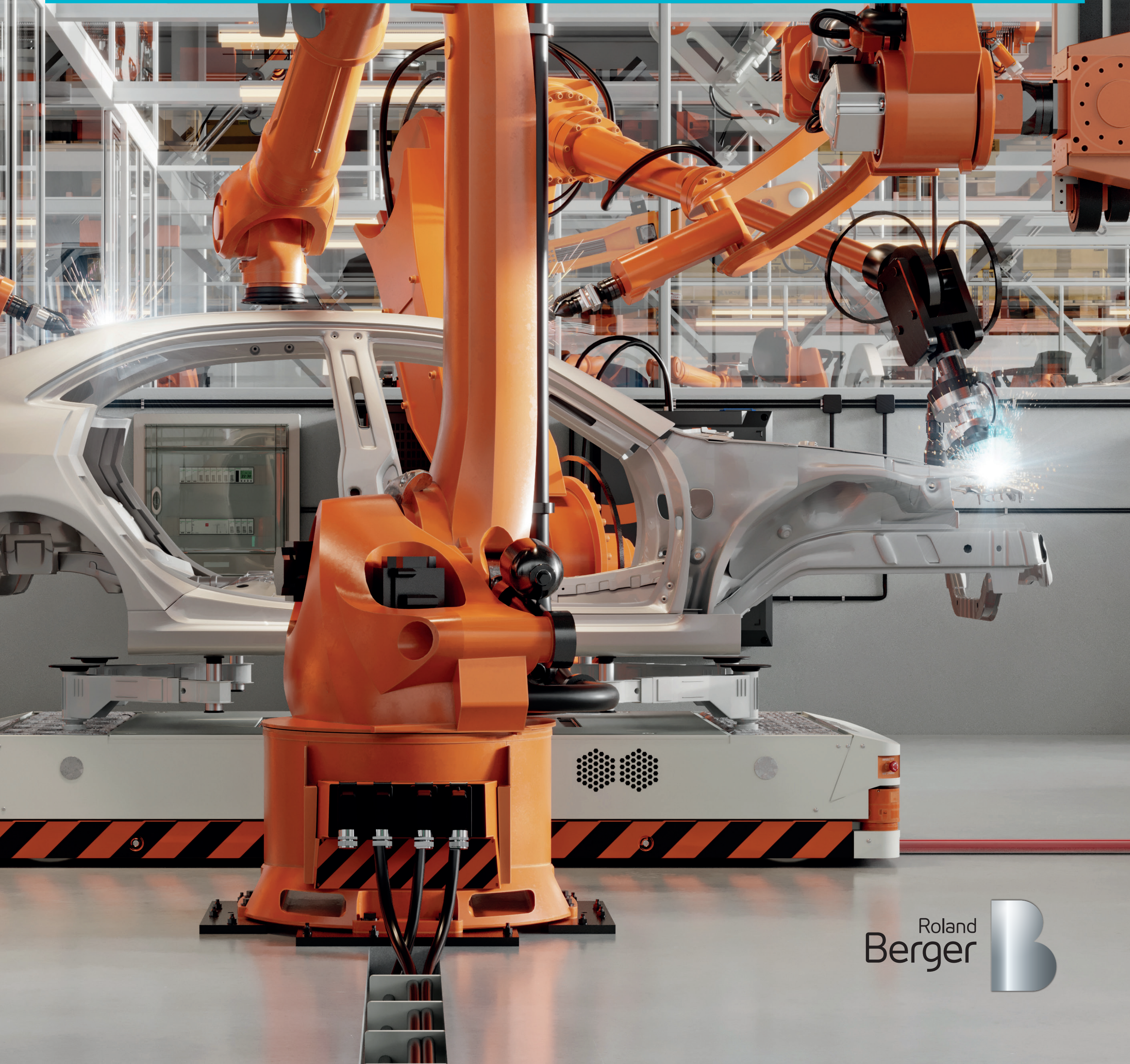
Focus

Roland Berger

The current state of "Industry 4.0" | What can other industries learn from leading automotive manufacturers?



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The current state of "Industry 4.0" / *What can other industries learn from leading automotive manufacturers?*

The term "Industry 4.0" was coined more than ten years ago at the Hannover Fair to describe the revolutionary efficiency gains that could be achieved by digitalizing manufacturing operations. Since then, it has become clear that various technological and organization challenges make the digitalization of manufacturing more complex than initially expected. Despite these challenges, some industries have made significant advances over the past decade – the automotive industry being one of them.

To better understand the progress the automotive industry has made in this period, Roland Berger talked to leading global automotive OEMs, Tier-1 suppliers and other industry experts. From these discussions, we derived key learnings such as the clear prioritization of digital manufacturing use cases, the setup of a dedicated cross-functional smart manufacturing team following a hub-and-spoke approach, the definition of a clear IT/OT target landscape and a strong focus on employee training. By applying these "lessons learned" automotive and non-automotive players can accelerate their journeys to "Industry 4.0".

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1 / Digitalization of manufacturing – Where do we stand ten years on?

The digitalization of manufacturing, also referred to as "Industry 4.0", is a key building block in the "Next Generation of Manufacturing". It enables a higher degree of automation on the road to autonomous production. Manufacturers have invested significant time and resources in building up the necessary capabilities and identifying, developing and rolling out use cases within their production plants.

The automotive industry in particular has been pushing digitalization in manufacturing and is often considered to be leading (together with the semiconductor industry) when it comes to implementation. However, as the initial hype ebbed, it became clear that the road to fully digitalized or autonomous production will be steeper than expected. Various technological and organizational challenges are limiting the speed with which manufacturing sites can move forward. To mention just a few of the many examples:

- Manufacturing sites in many companies are highly independent of corporate headquarters, which has given rise to decentralized activities, a heterogeneous infrastructure and plant-specific solutions
- The long lifetime of production structures and automation systems forces manufacturers to work with a patchwork of legacy equipment
- The value of some digital manufacturing use cases is hard to quantify and can only be realized in the medium to long term, making it difficult to justify the capital for necessary investments
- Existing employees often lack the necessary skills, and companies struggle to find the competencies they need to fully reap the benefits of digitalization
- The implementation of machine learning use cases requires cooperation between corporate functions (e.g. production and IT) that have had limited interaction in the past and often do not "speak the same language" when it comes to technical terminology

More than ten years after the term "Industry 4.0" was coined at the Hannover Fair, we are still a long way away from the original vision of an intelligent, fully flexible and self-organizing factory. But where exactly do we stand right now? Which digital manufacturing use cases have already been implemented? Which ones are currently being piloted, and which ones are still in an early development phase?

Reading through press releases and marketing materials gives the impression that everybody is doing everything. This can be explained by the experimentation and fail-fast approach that is often referenced when it comes to digitalization. To analyze the current state of digital manufacturing, we therefore narrowed down our analysis and looked at the use cases that are seen as the key value drivers and attract the lion's share of digital manufacturing investments. As part of this study, Roland Berger talked to leading global vehicle manufacturers (OEMs), Tier-1 suppliers (OESs) and other industry experts and identified these value-driving use cases, assessed their state of implementation and highlighted differences between OEMs, OESs and various regions.

Furthermore, we looked into how these companies are tackling the organizational challenges that come with identifying, developing and implementing these use cases. Besides painting a clearer picture of digital manufacturing in the automotive industry, the findings of this study can also be considered best practices for manufacturers in other sectors.

2 / On which "Industry 4.0" use cases is the automotive industry currently focused?

There are a wide range of digital manufacturing use cases, many of which are industry and manufacturing process specific. In general, use cases can be divided into the seven archetypes that formed the basis for our discussions with automotive OEMs, OESs and industry experts. → A

While most automotive players have at least experimented with one use case from each archetype, priority is clearly given to the following six use cases: in-process (real-time) parameter optimization, condition monitoring and predictive maintenance, automated vision-based inspection, process data-based inspection, autonomous material handling in intralogistics and tracking of transports along the supply chain. These six prioritized use cases account for a large part of companies' digital manufacturing investment. Interestingly, two heavily hyped use cases are missing from this list: While cobots and lightweight robotics have attracted significant attention in recent years, the number of use cases with a positive business case is relatively limited. One of these limited use cases is the retrospective automation of manual workplaces that do not allow the use of traditional robotics due to space constraints. Furthermore, there is a limited focus on real-time performance monitoring applications at OEMs and mature OESs, since the relevant systems have either already been implemented (especially in new plants) or the monitoring solutions of existing Manufacturing Execution Systems are still sufficient and do not justify upgrades and retrofits.

Another dimension to consider when investigating digital manufacturing use cases implemented by the automotive industry is the production technology and manufacturing process. An automotive OEM's press shop, for example, possesses completely different characteristics and digital manufacturing requirements than the final assembly line. Figure B roughly indicates the volume of implemented high value-add use cases that can be found in each shop. This correlates with the value

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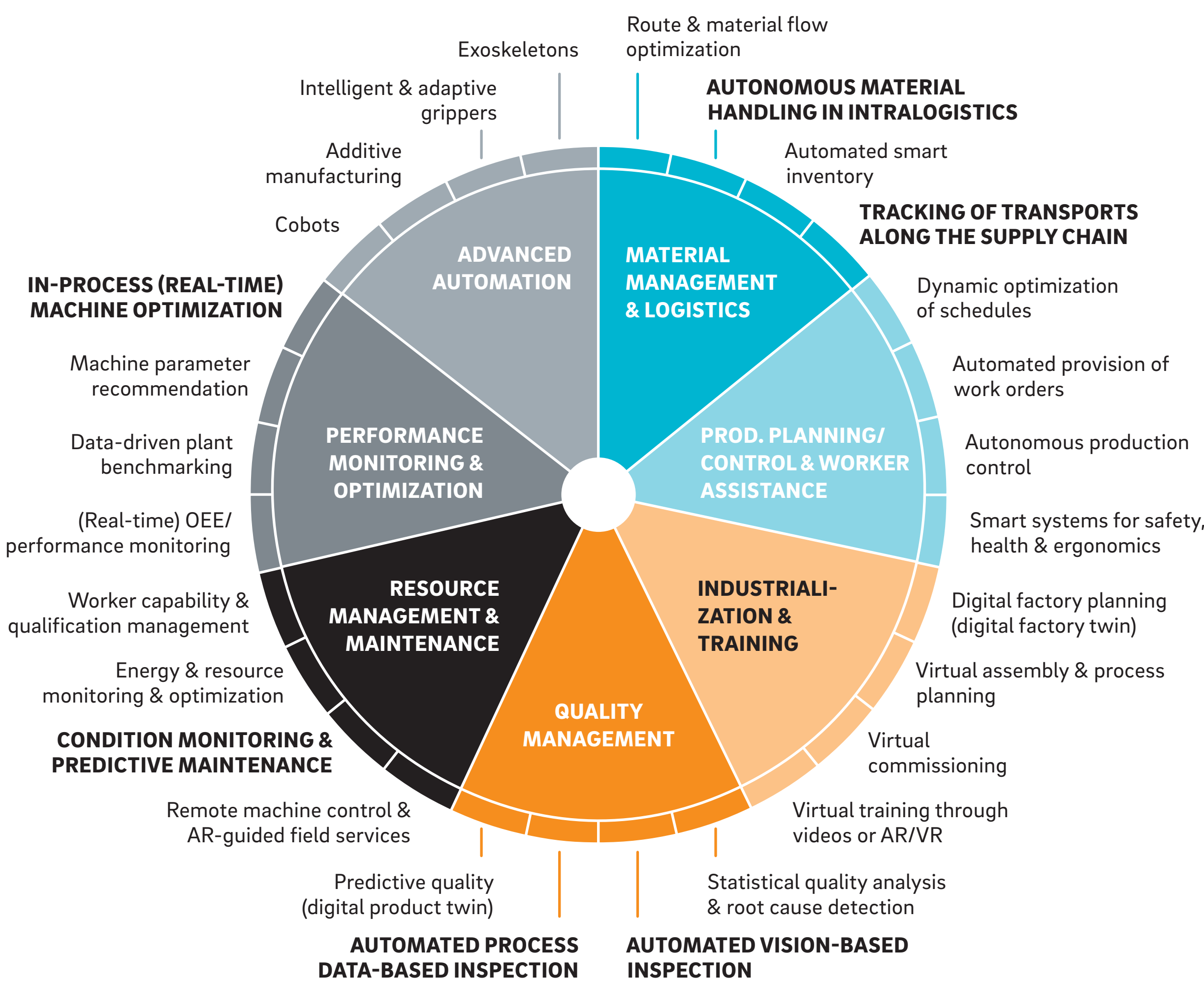
Bernhard Langefeld
Senior Partner

A: Leading automotive players clearly prioritize digital manufacturing use cases that add the most value

Key prioritized digital manufacturing uses cases in the automotive industry



Source: Roland Berger

they add for the respective production technologies. → B

Given their heterogeneous nature, it is even more important to take a detailed look at manufacturing processes for automotive OESs, as these companies produce everything from electronic components to wire harnesses to crash management systems. While a detailed mapping between digital manufacturing use cases and all potential OES processes is beyond the scope of this report, our work with Tier-1 suppliers shows that technologies and lessons learned from OEMs can be transferred to OESs with comparable production processes and that, for the majority of suppliers, the same digital manufacturing use cases take priority.

Lastly, the priorities assigned to these six key use cases are also subject to regional differences. While autonomous material handling is generally one of the prioritized use cases, it is far more important in high-cost countries than in low-cost countries.

The section below takes a deep dive into the different high value-add use cases in focus, describing both their current state of implementation and their future outlook.

CONDITION MONITORING & PREDICTIVE MAINTENANCE

One use case that was cited early on in the context of "Industry 4.0" and is still in focus for most automotive players is predictive maintenance. Instead of using fixed maintenance intervals, which have a tradeoff between the cost of maintenance and the risk of defects or failure, machine, equipment or tool behavior is analyzed for anomalies or changes in order to predict the remaining useful lifetime (RUL), a health index or the degradation pattern. Among other benefits, these predictions lead to higher availability and thus to higher overall equipment effectiveness (OEE) across the entire plant. In practice, there are unfortunately several challenges that have slowed down the rollout of predictive maintenance use cases.

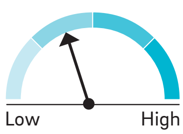
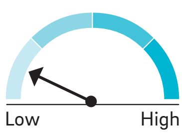
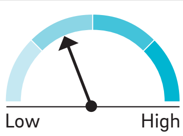
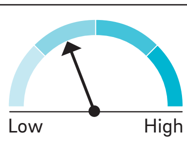
"The substantial value of predictive maintenance use cases and the resources that are invested in their development indicate that the number of predictive maintenance use cases that are globally rolled out is expected to increase sharply in the years ahead."

Michael Rüger
Senior Partner

Anomalies occur frequently in daily production, many of which are not related to wear and tear. The available sensor and data signals often only provide limited information that is not sufficient to differentiate between wear and tear issues and other non-critical influences. The retrofitting of high-quality sensors to capture this information often proves to be complex and relatively expensive; and even if this information is available, companies often lack the competency to extract it from the huge amount of data captured. Moreover, basic model-free machine learning algorithms are difficult to

B: The value added by digital manufacturing use cases is highly dependent on production technologies and processes

Number of key, prioritized use cases observed

High-value use cases	Maturity	Press shop	Engine/ component	Body shop	Paint shop	Final assembly	Supply chain
CONDITION MONITORING & PREDICTIVE MAINTENANCE		Medium	High	High	Medium	Low	None
AUTOMATED VISION-BASED INSPECTION		High	Medium	High	High	High	None
AUTOMATED PROCESS DATA-BASED INSPECTION		Low	High	Medium	Low	Low	Low
IN-PROCESS (REAL-TIME) MACHINE OPTIMIZATION		High	Medium	Medium	High	Low	None
AUTONOMOUS MATERIAL HANDLING IN INTRALOGISTICS		Low	Medium	Low	Low	Medium	None
TRACKING OF TRANSPORTS ALONG THE SUPPLY CHAIN		None	None	None	None	None	High

Number of use cases observed: None, Low, Medium, High

Source: Roland Berger

train and tend to identify causalities where none exist, especially if the data quality is poor. Fixed maintenance schedules anchored in automotive companies' production planning also pose an organizational hurdle. Predictive maintenance requires flexible, condition-based maintenance planning, which is often still a challenge in the context of daily plant management that further slows down the implementation of use cases.

Use cases that are currently being rolled out are therefore mostly relatively simple, focusing on individual components and a limited number of well-understood sensor signals. One example is predictive maintenance of drives using voltage and current readings. Other easy-to-start use cases include vibration and (bearing) temperature analysis. Many easily scalable plug-and-play sensor solutions for these simple use cases are already on the market.

More complex use cases, such as ultrasonic noise analysis, lubrication analysis and infrared thermography, or use cases that cover complete systems (e.g. industrial robots) are currently still in development. Despite these challenges, predictive maintenance is seen as a high-value use case due to its scalability and to the considerable savings effect, especially thanks to significant OEE improvements. The body shops of large automotive OEMs contain several hundred industrial robots (many of them of the same or a comparable type). Once implemented for a single robot, the use case can therefore quickly be transferred to the whole fleet. Also, component manufacturing relies on a large number of CNC machining centers. Predictive maintenance applications for machining tools can therefore also be rolled out for anything from several hundred to a thousand machines. Scalability aside, the mentioned applications in the body shop and in component manufacturing are very expensive in the event of failures. Failures of industrial robots easily cause stoppages on the overall production line and thus have a major impact on production output. Furthermore, even if a failure can be quickly resolved, restarting these highly connected lines is complex and time consuming. Machine tool failures can also cause defects in the parts being manufactured. Depending on the material, the dimensions and the processing steps already completed, scrapping such parts can be very costly.

The substantial value of predictive maintenance use cases and the resources that are invested in their development indicate that the number of predictive maintenance use cases that are globally rolled out is set to increase sharply in the years ahead. Since improving data quality with additional or better sensors often leads to better results than relying on complex machine learning algorithms, retrofitting of sensors will likely be required for many applications.

AUTOMATED QUALITY INSPECTION

Automated quality inspection and prediction is regarded as another high-value use case that is currently a focus of automotive OEMs. Under this use case, process and sensor data is used to detect or predict potential quality issues by identifying anomalies in the data. Besides automating manual processes, automated quality inspection can replace random spot checks with data-based ones. Alternatively, it can add additional checks to the process to identify quality issues early on and with greater accuracy. When looking into the maturity of these use cases, a distinction must be drawn between the type of data used for prediction, i.e. between vision-based quality inspection and quality inspection based on process/time series data.

AUTOMATED VISION-BASED INSPECTION

The rise of deep machine learning has yielded significant improvements in vision-based quality inspection (especially where it is based on object detection). In contrast to classical methods, deep learning-based approaches often do not require specialized sensor systems and highly controlled environments. Above all, the improved capabilities of deep learning-based machine vision enable inline quality checks (in tight spaces and under suboptimal lighting conditions). Associated use cases that are highly attractive for automotive players include:

- The vision-based inspection of single parts (e.g. stamped or molded parts or circuit boards)
- Inline checking that all the correct parts have been installed during final assembly
- The replacement of existing end-of-line checks to not only allow for the earlier detection of defects, but also to reduce the number of required tacts and simplify the root cause identification and rectification of systematic quality issues

Relying on pre-trained machine learning models as well as good part classifiers that can be trained using images of failure-free parts (which are usually available in high quantities), vision-based quality inspection can be quickly implemented. Since machine learning-based quality inspection is relatively new, most use cases are still in the development, pilot or early rollout phase. More and more use cases that rely on "cheap" cameras are expected to be rolled out in the coming years. These solutions can often be easily integrated in existing lines without impacting the existing production flow. If expensive automation and sensor technology is required (e.g. for vision-based quality inspection in the paint shop), rollout will be linked to new plants or new vehicle models.

AUTOMATED PROCESS DATA-BASED INSPECTION

Instead of using vision sensors, part quality can also be predicted based on process data. Use cases that rely on well-understood processes and parameters can use simple statistical models such as statistical process control and other Six Sigma methods that have already been rolled out as part of many quality management systems. Examples include quality prediction for screwed parts based on applied torque and the screw angle, and quality prediction for spot-welded parts based on temperature and current at the welding spot. In contrast, use cases that rely on complex processes and account for a large number of parameters are still mostly in a research state and are not expected to be widely implemented within the next five years. While deep learning has fueled great advances in machine vision, its use for process data-based prediction, i.e. time series data, is still relatively immature.

IN-PROCESS (REAL-TIME) MACHINE OPTIMIZATION

Machine parameters for machining centers and presses are usually set by process experts. While parameter selection based on process experience usually works well, it is often still suboptimal. The automated setting and optimization of process parameters is therefore another focus area of the automotive industry. Observed use cases include optimizing press parameters based on raw material properties and the automated adjustment of process parameters for clean room management and paint dispersion. Since these use cases directly influence product quality, they can add a lot of value by having a significant impact on scrap and throughput times. The key challenges in the implementation of these use cases are that:

- Parameters influencing a specific process are often not completely understood

- Existing sensor signals are often not sufficient, requiring the addition of specialized and custom-developed sensor systems
- The training of modern deep machine learning algorithms on process/time series data is still relatively immature
- While a lot of data has been recorded in the past, the required large data sets for highly specialized use cases are often not available and need to be captured first

While some very simple use cases focusing on selected parameters of well-understood processes are already in the rollout stage, more complex ones that focus on the complete replacement of process experts are not expected to be widely implemented within the next ten years. As a first step towards implementing these use cases, manufacturers often concentrate on supporting process experts by providing additional information or suggestions before automating the overall process.

AUTONOMOUS MATERIAL HANDLING IN INTRALOGISTICS

Autonomous material transportation and handling is expected to be the next major lever for cost reduction in production settings. It will therefore be another focus of the automotive industry. While direct transportation tasks (such as the moving of products within production lines) are already automated in most production technologies, indirect transportation tasks (such as the transportation of raw material/subassemblies to the lines) are often still done manually, especially where the parts to be transported are heavy. Automating indirect material handling thus has huge potential to reduce errors and increase efficiency and is therefore a use case that adds considerable value.

Despite many advances in recent years that are based on machine vision and the fusion of multiple sensors (e.g. LIDAR, cameras), autonomous material transportation is still challenging given:

- Completely autonomous navigation without any guidance within plants is still not perfectly reliable, especially considering that the available space is often limited and shared by people, storage and transportation vehicles
- A reliable solution for the handling of objects with varying and often unknown shapes and orientations has not yet been found
- For brownfield applications, existing layouts are not designed with autonomous material transportation in mind

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Jan Gudat
Partner

In light of these challenges, use cases for the transportation of heavy components that are currently being rolled out mostly concentrate on controlled areas where markers can be selectively used for guidance and other obstacles (such as people walking around) can be minimized. In these implementations, handling tasks are usually highly standardized, e.g. through the use of part trays. Autonomous transportation of heavy components in completely uncontrolled areas and without markers is still mostly in the development or pilot stage and is not expected to be widely rolled out within the coming years. This application will very likely come first to warehouses that can be at least partly controlled.

In contrast, the transportation of small and lightweight components (such as circuit boards and other electronic components) for which failures and collisions are less critical are currently being rolled out at mature manufacturers. The automated guided vehicles (AGVs) are used either to transport components between warehouses and assembly lines or in outbound logistics (especially for suppliers with just-in-time (JIT) requirements). While the AGVs are able to move flexibly through existing brownfield layouts, docking is often handled via floor markers and components are transported in trays.

TRACKING OF TRANSPORTS ALONG THE SUPPLY CHAIN

Due to just-in-time production and the associated risk of production line stoppages if supplies arrive late, the real-time tracking of transports within the supply chain is another focal use case in the automotive industry. While implementation of the use cases described above is impacted mainly by technical challenges, the tracking of transports is to a large extent a business challenge. The industry typically relies on a large number of 3rd party carriers that all need to be integrated for the seamless tracking of incoming parts. Additionally, sensor systems used to track deliveries need to be cycled back to the suppliers. Due to these challenges, automotive players have mostly focused on inbound logistics for critical components in recent years. Lately, however, the tracking of outbound deliveries of finished vehicles, especially in the case of international shipments, has become another focal area for some OEMs.

"Due to just-in-time production and the associated risk of production line stoppages if supplies arrive late, the real-time tracking of transports within the supply chain is another focal use case in the automotive industry."

Michael Rüger
Senior Partner

3 / How is the automotive industry driving the development and implementation of "Industry 4.0" use cases?

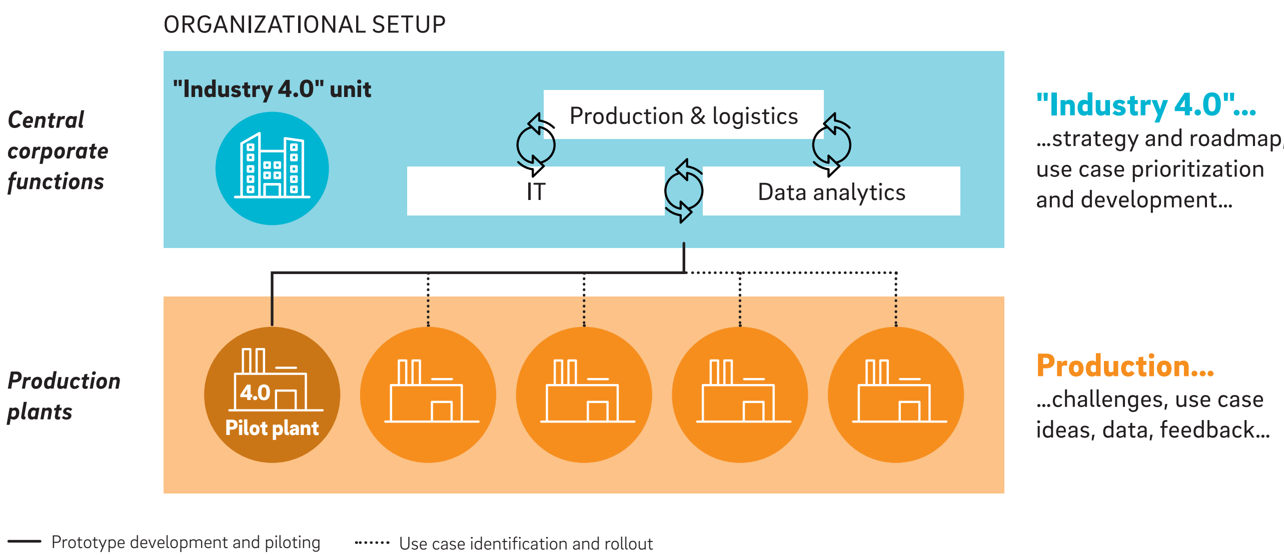
As discussed in the previous section, the development and implementation of any new digital manufacturing use case – not just those discussed above – is often not straightforward and requires solutions to various technical and organizational challenges. In our discussion with OEMs, OESs and market experts, we sought to understand the organizational setup and operating model as well as the IT/OT architecture on which automotive players rely to resolve these challenges. While the concrete setups vary from company to company, our discussions revealed many similar patterns and a general blueprint for the implementation of "Industry 4.0" use cases. This blueprint and these patterns are described in the section below.

ORGANIZATIONAL SETUP AND OPERATING MODEL

Historically, manufacturing plants in the automotive industry have had a relatively high degree of organizational autonomy. The implementation of digital manufacturing use cases has therefore often been driven by each plant's local automation department (often in cooperation with suppliers), resulting in redundant activities across the company and the development of solutions that are difficult to roll out across multiple plants. While this is often still the case at many OESs (and especially smaller ones), OEMs have progressed further in their journey towards digital manufacturing.

C: The hub-and-spoke organization has proven to be the most effective for implementing digital manufacturing use cases

The digital pioneers among automotive players prioritize use cases centrally and cooperate closely with local plants



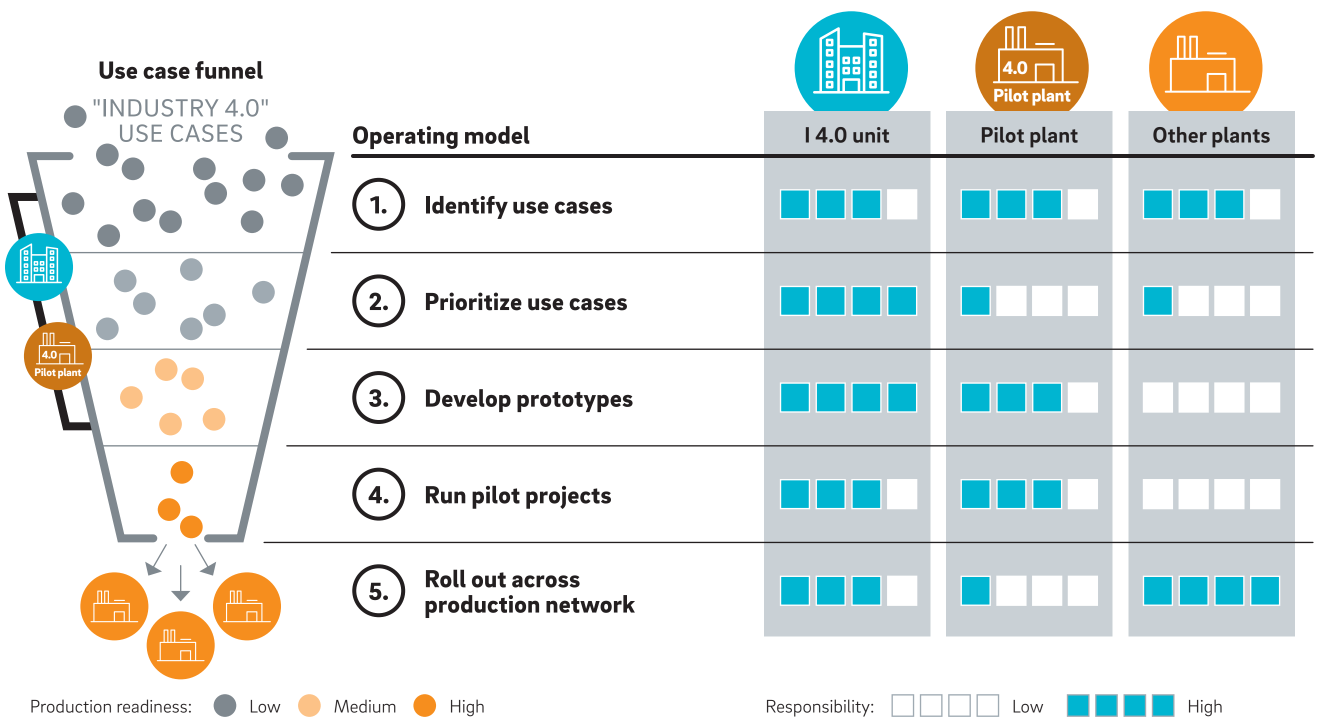
Source: Roland Berger

Many OEMs have created new departments or subdepartments specifically to push new solutions. Since the implementation of digital manufacturing use cases requires data analytics, IT and production skills, the newly founded departments usually combine experts from these functions. The digital manufacturing units usually cooperate closely with the production plants in order to capture requirements, elicit feedback and pilot new use cases. Pilot plants are generally intended to test use cases at an early stage before deciding whether to scale the use case across the wider production network. Figure C illustrates the kind of organizational setup used by those OEMs that are leading the way in digital manufacturing. → C

While OESs that still drive digital manufacturing decentrally from their plants often lack a holistic strategy, structured processes and a consistent operating model resulting in a patchwork automation system landscape, leading OESs and especially OEMs mostly rely on a use case-driven approach. As a general rule, they tend to adopt

D: A clearly defined and carefully aligned operating model is vital to the efficient operation of a digital manufacturing unit

Operating model for automotive OEMs that lead the way in "Industry 4.0"



Source: Roland Berger

a five-step roadmap (see Figure D) to identify, develop and roll out use cases across the production network. → D

1. Identify use cases by collecting opportunities and the ideas proposed by plants and/or by experimenting in dedicated "Industry 4.0" test labs
2. Prioritize use cases based on type, scalability, added value (downtime reduction, gain in OEE, etc.), business case (ROI, NPV, etc.) and CAPEX requirements
3. Develop prototypes by bringing together experts from different domains such as data analytics, IT and production
4. Run use case pilot projects in close cooperation with the pilot plant to identify requirements, receive feedback and validate the technical feasibility and business case
5. Roll out use cases across the production network by sharing best practices and lessons learned with other plants

Dedicated digital manufacturing units are responsible for identifying, prioritizing and developing new use cases. Plants and employees are usually involved in the identification process by suggesting new use cases and applications based on their daily challenges. Communication campaigns demonstrate the value of the digital manufacturing units to the plants and secure their support. Some OEMs have also set up test labs in which employees can experiment with new technologies. To prioritize use cases, factors such as scalability, value added, technical feasibility and the cost of implementation are considered. The piloting of new use cases is then conducted with one or a small number of selected plants. These can either be dedicated digital manufacturing pilot plants or the plants that suggested the specific use case. After successful piloting, the digital manufacturing unit manages the overall rollout to all applicable plants within the network.

IT/OT ARCHITECTURE

While the use case-driven approach has the advantage of tangible results that can be achieved quickly and are directly linked to a specific business case, it also comes with challenges. If use cases are implemented one by one, there is always the risk of redundant interfaces and data storage, as well as the absence of an overarching architecture. Leading automotive players that have implemented many use cases are already struggling to manage the different use case-specific implementations.

To address this challenge, an overarching IT/OT target architecture is required as an implementation guideline for individual use cases. This includes uniform MES/ERP systems, but also standardization and interoperability at the control level (sensors, vision systems, PLCs, etc.) to enable the quick rollout of new digital manufacturing use cases across plants. IIoT (Industrial Internet of Things) based solutions also play an important role in these target architectures (see our latest study on cloud-based manufacturing).

Many OEMs have already embarked on large-scale projects to develop their future target system architecture. For example, all major German OEMs have defined a cloud-based IIoT platform architecture, while many global OEMs have launched similar initiatives. In the future, many OEMs intend to integrate not only their own complete factory network but also Tier-1 suppliers and equipment and automation providers in these platforms.

OESs focus more on the basics and on their internal IT architecture, harmonizing ERP and MES across the network. While we see some companies advancing central IT and analytics functions, most OESs are investing only to a limited degree in cloud-based architectures due to their lower digital manufacturing maturity and less available capital.

4 / What can we learn about "Industry 4.0" implementation from the automotive industry?

The automotive industry is seen as a front-runner in terms of digital manufacturing. And while the experience of leading automotive OEMs can easily be transferred to OESs with comparable production processes, the same also applies to non-automotive industries. Based on our analysis, we see four key take-aways for companies in most industries.

CLEAR PRIORITIZATION OF USE CASES AND RESOURCES

While experimentation is good to build up initial experience, clearly prioritizing use cases and resources is necessary to achieve real impact. Prioritizing use cases requires a quantification of the value they add and, in a further step, a business case for the given digital manufacturing use case. The value added is driven by achievable cost savings through downtime/cycle time reduction, quality improvements, savings on energy consumption, faster throughput, equipment lifetime extensions, etc. The associated business case calculation must address both the initial investment (e.g. sensor and connectivity equipment) and operating expenses (e.g. cloud and software licenses and maintenance) related to the digital manufacturing use case.

How much value a use case adds depends heavily on the economic environment. Reducing direct labor costs obviously has a much higher positive impact on the business case in high-cost countries than in low-cost countries. OEMs and suppliers with hundreds of plants across the world may not be able to calculate all business cases for each plant individually, but they can define plant archetypes based on representative economic assumptions in order to prioritize use case rollout across the network.

Use cases that add substantial value generally exhibit either relatively advanced technical maturity, which enables quick implementation, or a highly standardized process or machine that enables high scalability. From a technical perspective, predictive maintenance and automated vision-based inspection are comparatively mature and can enable cost savings in the short term. The value proposition for these technologies is relatively high but simple to quantify.

"Use cases that add substantial value generally exhibit either relatively advanced technical maturity, which enables quick implementation, or a highly standardized process or machine that enables high scalability."

Bernhard Langefeld
Senior Partner

A HUB-AND-SPOKE ORGANIZATION

To drive the identification, prioritization and implementation of use cases quickly and without redundancies, a centralized (hub-and-spoke) approach is necessary.

A central unit cannot merely be attached to IT or production: It needs to combine both sets of capabilities.

Since many digital manufacturing use cases require data-driven methods, it is necessary to also incorporate data analytics capabilities and resources in the central unit. While close cooperation between the central digital manufacturing department and the plant is inevitable, the unit also needs the necessary authority to drive development and make final decisions.

Systematic bidirectional knowledge transfer between the digital manufacturing unit and the plants is extremely valuable. But it is also essential to ensure that the plants buy in to this development and remain committed. Communication activities need to ensure that the work of the central "Industry 4.0" unit is transparent and perceived as valuable. Such campaigns must make it clear that the unit supports the plants and is not doing research in an ivory tower. Knowledge bases can be used to make the unit's work and its "Industry 4.0" related expertise accessible to all plants.

TALENT AND TRAINING

Overall equipment effectiveness and uptime at highly automated plants will depend to a large extent on predictive maintenance, rapid error resolution and the proper handling of equipment. This will require companies to retrain operators to work with and alongside automated equipment. At the same time, companies will face the challenge of recruiting engineering talent in remote locations.

In addition, shopfloor and operations leaders must gain a better understanding of the potential of digital manufacturing solutions and their potential. To get plants and regional leadership to buy into digital manufacturing use cases, the local team has to be able to run them and realize their benefits. Since both the shopfloor and operations leaders of the future will require digital and data analytics skills, companies must rethink their talent acquisition and training programs.

IT/OT TARGET LANDSCAPE AND ROADMAP

While a use case focused approach is needed to build up knowledge and achieve results early on, a clear digital manufacturing strategy – including an IT/OT target landscape and implementation roadmap – is necessary once a certain level of maturity is reached. The IT/OT target landscape helps to avoid the redundant buildup of IT infrastructure and interfaces for different use cases, and ensures that the use case implementation roadmap is aligned with the investment in new systems. In addition to standardization of the company's internal IT/OT landscape, the need to integrate customers, suppliers and equipment providers must also be addressed in the future in order to exploit the full potential of "Industry 4.0".

Conclusion

Our analysis of the automotive industry shows that leading players follow a clear strategy to drive the digitalization of manufacturing. **First,** they prioritize use cases to ensure that resources are focused on the ones that add the most value and are not scattered across many small activities throughout the company. **Second,** a dedicated digital manufacturing unit with a clear operating model ensures that the necessary capabilities and capacity are available to efficiently leverage the resources channeled into the prioritized use cases. **Third,** an IT/OT target landscape simplifies the rollout and subsequent maintenance of the implemented use cases. In combination, all three building blocks of this strategy mutually reinforce each other to maximize the efficiency of all digital manufacturing activities. In contrast, players that find themselves not progressing, or not fast enough, often lack one or more of these crucial elements. To these players, we recommend stepping back and taking the time to define or refine their "Industry 4.0" strategy. With an improved setup, they will regain momentum and quickly see positive results.

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Roland Berger's study takes a close look at the six trends reimagining manufacturing and how companies can benefit from this next generation of opportunities.

Cloud-based production – How the cloud is speeding up the digitalization of manufacturing

Cloud-based production solutions for manufacturers
Cloud technology is revolutionizing industry. It offers a wide range of advantages for manufacturers – from its ability to store enormous amounts of data with enhanced cybersecurity to its enabling of autonomous systems and robots.

We welcome your questions, comments and suggestions

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