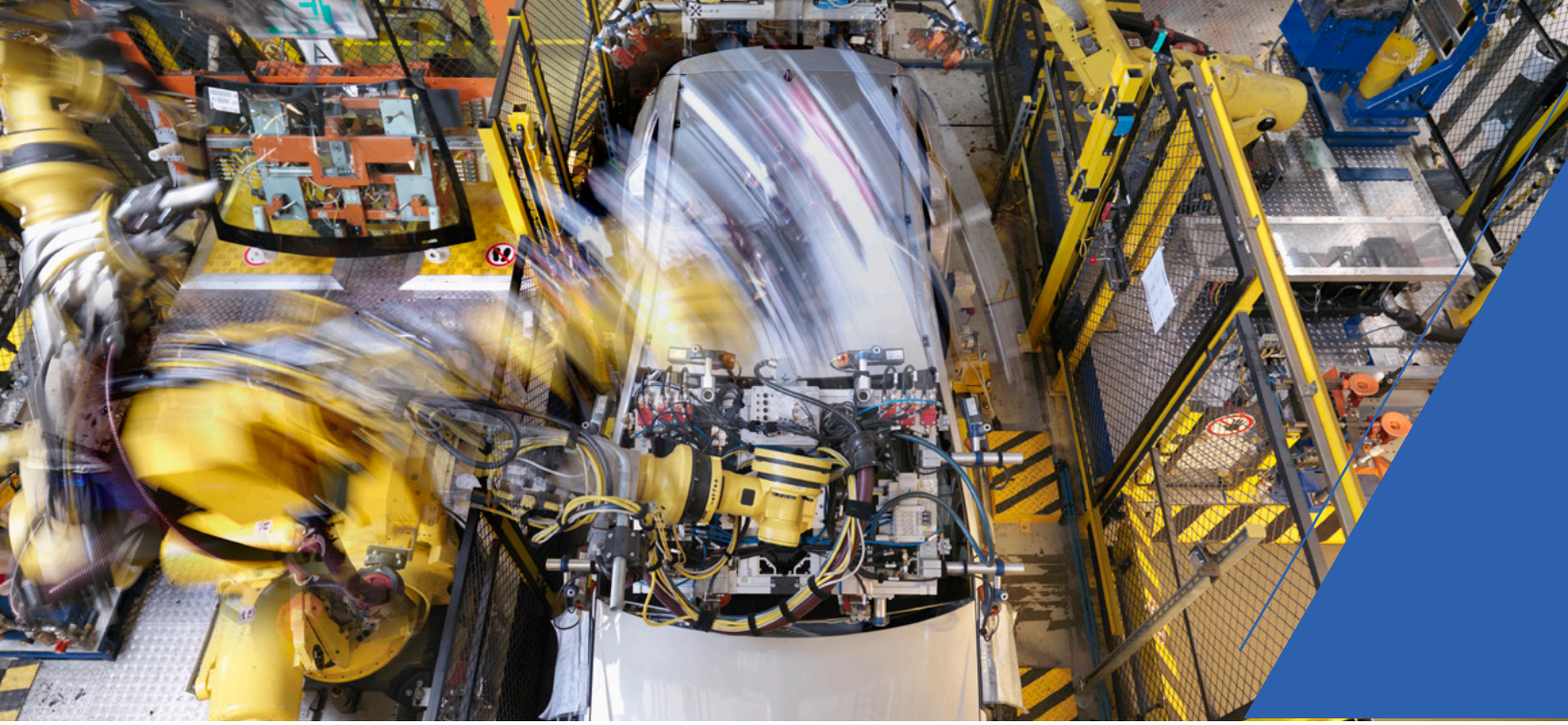

Building smarter cars with smarter factories: How AI will change the auto business

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From driverless cars to robots on the factory floor, AI is transforming the automotive industry. Here are the steps smart companies are taking to seize the opportunities it offers.

Over the next two decades, artificial intelligence (AI) will enable autonomous vehicles to become mainstream. At the same time, AI will transform most aspects of the auto-manufacturing process, from research and design to project management and business support functions. These changes are fast approaching. Manufacturers should understand what the sources of value really are and then start developing the necessary analytical capabilities and establishing an AI-ready culture.

The future is already being automated, and it's enabled by AI

The McKinsey Global Institute has found that robotics and AI technologies such as machine learning (which gives computers the ability to learn without explicit programming) have advanced to the point where it would be possible to automate at least 30 percent of activities in about 60 percent of occupations in both the United States and Germany.

Highly developed economies with high per-capita GDP and rapidly aging populations will soon rely on AI-based automation to power the productivity gains necessary to achieve GDP targets. In Germany, for example, we expect that AI will enable significant automation, yielding up to 4 percent additional GDP in 2030.

There are, of course, many robots and machines already on the job in automotive factories around the world, but these machines generally perform a set of actions in a limited number of scenarios according to well-established rules.

AI is different. Advances in computing power will give machines abilities once reserved for humans—the ability to understand and organize unstructured data such as photos and speech, to recognize patterns, and to learn from past experiences how to improve future performance.

AI will get even better. Advances in algorithmic research, coupled with increasingly powerful computer hardware, will allow AI to demonstrate autonomy and creativity. AI-based machines won't just follow the rules, they'll find ways to create solutions to complex problems within a given solution space.

AI has scored celebrated victories over humans that have grabbed headlines—Deep Blue, Watson, and AlphaGo (developed by Google DeepMind) have vanquished human competitors at chess, Jeopardy and Go—and its application in auto manufacturing is already being felt. Companies such as Tesla and Google are already using AI technologies in their autonomous vehicles, while a slew of start-ups (Argo AI, Drive.ai, nuTonomy, Otto, Preferred Networks, and Zoox) look for ways to extend such AI usage. By 2030, highly autonomous vehicles could account for 10 to 15 percent of new car sales.[1] OEMs and suppliers are already maneuvering and investing in autonomous vehicles and the AI that will power them.

AI will not just change the vehicles that are built, it will also change the entire business of how they get built. Increasingly, AI applications are supported by the adoption of devices and sensors connected to the Internet of Things (IoT). As companies rush to apply AI to high-value industrial tasks such as predictive maintenance or performance optimization, we are seeing a rush of investment in AI technologies. An analysis from venture-capital-investment tracking company Tracxn found that AI-related start-ups raised approximately $6 billion of funding in 2016 alone.

The six areas where AI will revolutionize the auto manufacturing process

At many steps in the manufacturing process, AI will yield results based on its ability to understand its environment, analyze data, draw conclusions, and learn from experience to achieve continuous improvements.

1 Paul Gao, Hans-Wenner Kaas, Detlev Mohr, Dominik Wee, "Disruptive trends that will transform the auto industry," McKinsey.com, January 2016.

Here are six ways in which AI will improve the auto manufacturing sector:

- **Less equipment failure.** If a machine fails unexpectedly on an automotive assembly line, the costs can be catastrophic. Idled employees are unable to complete their production quotas. A whole factory can be thrown into disarray. AI-based algorithms can digest masses of data from vibration sensors and other sources, detect anomalies, separate errors from background noise, diagnose the problem, and predict if a breakdown is likely or imminent. Companies like KONUX feed the sensor data into an AI system that crunches it to improve system performance, optimize maintenance planning, and extend asset life cycles.

    - ***Potential impact:*** More than 20 percent increase in equipment availability, up to 25 percent lower inspection costs, up to 10 percent lower total annual maintenance costs

- **More productive employees through robot-human collaboration.** Advances in computer vision are driving progress toward collaborative, context-aware robots. More computing power and better algorithms will lead to the development of flexible, non-special-purpose robots that can work alongside humans while reacting to changes in their environment with less configuration. For example, Rethink Robotics is designing collaborative robots that a human instructor can program simply by taking the arm of the robot and guiding it through desired movements, such as gripping and releasing objects.

    - ***Potential impact:*** Collaborative robots will simplify factory design by reducing the need for robot-only areas. Because instructing these robots will be simpler, companies will save money on development and deployment costs. Collaborative robots can help with tasks that are not fully automatable, potentially increasing productivity by up to 20 percent.

- **Fewer quality problems.** Quality control, such as inspecting painted car bodies, is performed by human workers. This method is prone to errors and is relatively slow. But even automated methods can break down due to numerous variables in the test environment. If the lighting is not perfect or the product is mounted just a bit off-center for inspection, the current method can yield false positives. By contrast, AI-enabled visual QC can filter out these issues to focus on defects only. The AI system constantly learns to improve its analysis based on feedback. Using these methods, AI-powered hardware can visually inspect and provide superior QC on various products such as machined parts, painted car bodies, textured metal surfaces and more.

    - ***Potential impact:*** AI-based machines can detect defects up to 90 percent more accurately than humans. Insights from AI-based quality testing can also be used to analyze root causes of defects and improve overall production processes. Productivity increases in visual quality inspection of up to 50 percent are possible.

- **Leaner supply chains.** Accurate forecasting is critical to achieving a close match between supply and demand, but traditional forecasting and replenishment systems are being overwhelmed by a mountain of data and an increasing number of influencing factors, such as the storage of many low-volume long-tail items and just-in-time production that eliminates inventory cushions. AI systems can meet these challenges by using machine learning to produce more accurate demand forecasts. AI-powered supply chains have the flexibility to adapt and respond to changes in the product mix or unforeseen events, incorporating near-real-time data on advertising campaigns, prices, even weather forecasts. Eventually, AI will allow fully automated self-adjusting systems to make supply-chain management decisions autonomously, adjusting routes and volumes to meet predicted demand spikes. While some companies are working to develop predictive forecasting and replenishment tools internally, others are turning to established vendors like Blue Yonder, which offer AI techniques capable of optimizing forecasting and replenishment while simultaneously adjusting pricing.

    - ***Potential impact:*** AI-based approaches could reduce forecasting errors by 30 to 50 percent. AI could reduce overall inventories by 20 to 50 percent, generating a cascade of cost savings by eliminating the transport, warehousing, and supply-chain administration of unneeded goods.

- **Smarter project management.** It can be hard to measure R&D progress or understand when to kill a project in order to free up resources for more promising items in the R&D portfolio. As a result, zombie projects with unclear status and milestones tend to linger, burning money, inflating total R&D costs, increasing time-to-market for worthwhile projects, and causing frustration all around. AI-based methodologies can improve R&D project prioritization and increase performance within individual projects, thus liberating budgets and raising overall efficiency. Take the example of F1 race car engineering. Failure rates of R&D projects to improve F1 car performance approach 90 percent. QuantumBlack, a firm specializing in advanced analytics, has successfully employed AI to streamline the R&D process and identify the most promising R&D projects early on. In part, it does this by pulling data from a wide variety of integrated sources and then using AI and machine learning to forecast factors that might detract from performance. Team dynamics are a key performance lever. Projects with a high level of interconnectedness should have high-intensity communications. By analyzing communications and discovering patterns, QuantumBlack can warn managers early on if a project seems to be off-track.[2]

    - ***Potential impact:*** QuantumBlack's AI-based approach typically generates R&D productivity gains of 10 to 15 percent and accelerates time to market by 10 to 40 percent.

- **Improved business support functions.** Business support functions such as finance, HR, and IT are resource-intensive but vital to a company's success. Cost pressures and

2 QuantumBlack is owned by McKinsey & Company.

flexibility requirements are driving demand for digitization. AI has high potential to automate tasks such as IT or finance that are already supported by computer systems. For example, on an IT service desk, codified problem-solving strategies and knowledge (such as server configuration) can be fed into an AI system so it can automatically combine individual pieces of knowledge to build a tailor-made problem-resolution process. This step employs reinforcement learning—the same technique that Google's AlphaGo used to beat the world's human Go champion.

- ***Potential impact:*** Automation rates of approximately 30 percent are expected within business support functions. For the specific example on IT service-desk automation, a degree of automation of around 90 percent is possible. Automation is accompanied by greater accuracy and consistency, increased scalability and speed, and traceability of results, all at around-the-clock availability.

Develop AI capabilities, launch pilot projects, separate truth from hype

Given the immense potential of AI to transform the auto industry, here are five steps that companies can take now to seize the opportunities it offers:

Prioritize projects based on business logic. It's still important to get a solid grounding in AI tech so that you can separate hype from facts. Make sure to establish a solid business case for an AI investment. Prioritize projects according to their technical feasibility and overall impact potential from both financial and productivity standpoints. Given the rapid pace of change in AI technology, you will want to re-analyze these business cases on a regular basis. A project that wasn't feasible months ago might now be within reach.

- **Work with partners to develop your AI systems.** You need data scientists (known as "quants") to design and develop your AI engine, but it's hard to obtain all the talent you need to fill those roles given that there are only 8,900 trained data scientists in the entire North American labor pool of 100 million people. Given such limitations, it makes sense to find external partners who can help with the intensive work of building the AI engine. During the initial building phase, internal and external quants work together to integrate systems, data, and algorithms into a foundation for the AI application.

- **Use translators to bridge the gaps.** Once the AI system is up and running, you enter the operate phase, where a mixed team of internal and external experts apply the AI solution to the company's daily operations. During this phase, you need strong managers who can set guardrails that clearly delineate IP ownership, decision-making rights, performance metrics, and escalation protocols in case disagreements arise. But you also need translators—people who understand AI technology but also business priorities and needs. The translators prioritize AI-based use cases considering both technical feasibility and business priority considerations.

Eventually, once the AI engine is fully functional, the translators should manage the transfer of all essential skills from the external partner to the internal quants who will run the AI systems, perform updates, and identify improvement needs.

- **Store data in its original granular state.** Data is the fuel that AI uses to create value. Estimates suggest that 90 percent of all data produced in a manufacturing context lacks the relational structure that traditionally has played a key role in data analysis. You'll need new tools like NoSQL technologies based on frameworks such as Apache Hadoop to efficiently store and process all this data without any loss of fidelity. Remember that you might need to label certain data sets if you hope to employ supervised learning techniques in AI or machine-learning scenarios.

  Promote your domain knowledge. AI is a tool. Without deep contextual understanding, it will fall short of its potential. Your company possesses specific domain knowledge—a unique understanding of the dependencies between systems, technologies, and players in your own industry or technological environment. By codifying this domain knowledge, you can give the AI algorithm a significant performance boost even before its self-learning processes kick in.

AI now: Smart investing and culture building

All the right pieces have fallen into place to make AI ready to scale. The development of effective algorithms, high-performance computing hardware, and data-generating sensors makes it easier than ever to apply AI to business problems.

AI transformation in the manufacturing process does not require massive up-front investments. Basic programming interfaces are low cost or even free. You can access computational power as needed via the cloud. External partners can provide the necessary knowledge and capabilities to move quickly and in a targeted way—though it's important to maintain ownership of your data and leverage your domain knowledge, a core source of value.

While AI is often described in technical terms, building a culture that can allow it to thrive is crucial and often overlooked. At its core, AI is an intelligent learning capability, and your people will need to learn to operate in the same way. That requires agility, the ability to analyze, respond, learn, and iterate. It's best to take small, fast steps so you can gain experience with the technology of AI systems and new ways of working with new team structures that combine quants, translators, and business managers. This approach helps build momentum. Simulation-based pilots give you the ability to demonstrate AI's potential value for the business. At best-practice companies, cross-functional AI task forces can prototype solutions in one to three weeks, test these ideas with the business units, and then decide whether to move forward.

When it comes to implementing AI technology in the vehicles themselves, it's not clear yet if it will play the same role as classic automotive technologies like ride, handling, and powertrain in helping auto companies differentiate their products. You can limit your risk by partnering with tech company pioneers to license AI technology. If you are determined to develop AI technology in-house for large and complex use cases such as autonomous driving, you need to be fast enough and bold enough to recoup your costs by seizing some of the profit-pool opportunities that await the first companies that can bring advanced autonomous cars to market.

Whichever approach you choose, it's a good idea to start implementing AI solutions as soon as possible. That way your company can become familiar with AI systems while you start reaping the efficiency and cost savings that AI enables.

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