Cloud-based production –
HOW THE CLOUD IS SPEEDING UP THE DIGITALIZATION OF MANUFACTURING
The advantages of cloud technology are clear – from its ability to store enormous amounts of data to its enabling of a wide range of data analytics and machine learning applications. Yet, despite these manifold benefits, many businesses still struggle to implement cloud solutions in their manufacturing operations. Often, they are bogged down by the technological and organizational challenges or lack the necessary knowledge and skills, or are simply overly cautious in their approach, spending too much time and energy trying to avoid potential pitfalls.

To overcome these problems, manufacturers need a solid understanding of both the real potential of cloud-based production and the challenges it presents. In this study we look at how the rise of the cloud-based Industrial Internet of Things and the increasing convergence of IT and operational technology (OT) fundamentally change the rules of the game, enabling manufacturers to connect their assets across all levels of the automation pyramid while using cloud-based apps to implement new functionalities. With this in mind, we look at how cloud solutions potentially revolutionize value and supply chains, delivering both efficiency improvements and cost savings via three distinct cloud archetypes: factory/company clouds, product life cycle management clouds and supply chain clouds.

In some areas of manufacturing, the cloud is already reshaping practices. We look at the steel industry – an industry known for its large share of legacy equipment, which slows down the implementation of digitalization. We examine where companies are finding convincing business cases for cloud-based production, for example by using predictive maintenance to avoid unplanned downtime of machinery.

Finally, we present our recommended three-step approach to implementing cloud solutions, from establishing a dedicated team within the organization whose purpose is to drive digital production use cases, to drawing up a target IT and operational technology landscape and an accompanying implementation roadmap. By following these steps, companies can effectively overcome the challenges of cloud technology – and significantly accelerate their journey to full digitalization.
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Introduction

With the rise of the Industrial Internet of Things (IIoT), more and more physical devices in the production environment now feature data-collecting sensors connected to the Internet. Companies can use technology such as industrial WiFi and 5G to connect large numbers of assets, sensors and "edge" devices to the cloud, generating massive amounts of data. To cope with the enormous bandwidth requirements and the computing power and data storage needs, manufacturers are increasingly turning to cloud platforms, which offer infrastructure, platform and software services to multiple customers, while keeping each customer's data and applications hidden from the others. This cuts development and operating costs for manufacturers and even outsources some aspects of cybersecurity.

The extensive set of development tools and ready-made algorithms provided by cloud platforms simplifies value creation from data uploaded to the cloud. Using the tools provided, manufacturers can now base their decisions on real-time data, improve the human-machine interface, and effectively manage their physical and digital resources. The analytical capabilities of cloud platforms also facilitate autonomous systems, such as robots, automated guided vehicles, drones and process automation systems. In short, the cloud forms the foundation for a whole new digital ecosystem – and the Next Generation of Manufacturing.

Cloud technology can also revolutionize the way that companies manage production. It potentially breaks up IT and Operational Technology (OT) data silos within companies and speeds up the shift to Industry 4.0. Using the cloud, firms can quickly implement digitalization use cases, sidestepping the restrictions of legacy software systems such as Supervisory Control And Data Acquisition (SCADA) or Manufacturing Execution Systems (MES). Within the production environment many companies already rely on the cloud for use cases such as tracking Overall Equipment Effectiveness (OEE) and predictive maintenance. Indeed, analysts expect at least 50% of digital business solutions in production to be IIoT-enabled by 2024.¹ This will particularly affect large automotive Original Equipment Manufacturers (OEMs), whose cloud-based production systems will force suppliers of all tiers to join their platforms in the coming years.

Yet, despite the obvious advantages of cloud technology, many companies still struggle to implement IIoT concepts and cloud solutions in their production environment. The reason lies in the associated technological and organizational challenges – often exacerbated by a lack of information, industry standards and

skills. Developing and implementing an Artificial Intelligence (AI) use case requires an understanding of, on the one hand, the manufacturing process, and on the other, AI methods. Often, a single expert, department or even company will lack knowledge of either one or the other element.

Successfully implementing IIoT use cases therefore frequently requires close cooperation between experts from different domains. In some cases, these experts do not speak the same language. Companies need to train them to understand both areas, applying a "fail fast" approach: try things out, gather feedback, then make adaptations where necessary. This bold approach inevitably means that some use cases will ultimately be rejected – but it prevents the company from being overcautious and enables employees to gain the experience they will need in more complex digitalization use cases later on.

Unfortunately, we often see the opposite in practice – companies spending too much energy trying to avoid potential errors. At first glance this approach seems to be justified, as the Return On Investment (ROI) for a single IIoT use case is difficult to specify, especially at the beginning of the journey to cloud-based production. However, with the correct strategy and foresight, companies can overcome budget restrictions and create a foundation for future positive returns. This calls for a solid understanding of both the potential of cloud-based production and its challenges – as we discuss in the following sections.

2) The five-layer automation pyramid includes actuators, machine controls and higher-level production control systems, ranging from the FIELD system, Programmable Logic Controllers (PLCs), Supervisory Control And Data Acquisition (SCADA) and Manufacturing Execution System (MES), to Enterprise Resource Planning (ERP).

How does the cloud disrupt industrial automation?

One of the reasons digitalization has been slow to take off in the manufacturing industry is the existence of legacy systems. At present, limited exchange takes place between the different production-related systems: while interfaces between the various solutions provided by different system providers work in principle, they are far from intuitive or "plug and play."

This disconnect is largely due to the historical separation between production systems and the business IT. Suppliers of automation solutions were traditionally able to control large parts of the "five-layer automation pyramid," creating lock-in through their proprietary technology and software. Data management and analytics were often integrated into monolithic software systems, such as MES, which require multiyear implementation projects and are often used for decades without major technological upgrades. All of these factors made implementing new data analytics use cases inherently difficult – especially where they were not supported by the supplier of the automation solution.
The rise of the cloud-based IIoT and the increasing convergence of IT and OT change the rules of the game. Assets across all levels of the automation pyramid can now be connected and new functionalities easily implemented by means of apps on cloud platforms. If a company wants to implement a predictive maintenance system for a pump actuator, say, it can simply attach smart sensors to the pump that stream data directly to the cloud, and build a small analytics app with ready-to-use algorithms provided by the cloud platform. Critically, the company does not need to connect the pump to a pre-existing, decades-old SCADA system and be forced to work within its limitations.

In the case of safety-critical systems, where real-time requirements exist or the volume of data is too large for the available Internet bandwidth, processing data in the cloud is not always feasible, however. In response to this challenge, automation vendors have developed what are known as "edge" solutions. Strictly
speaking, "edge devices" are industrial PCs or PLCs that are able to pre-process data locally. They either upload the pre-processed data or status data to the cloud, or download any software or algorithmic updates – without the need for a service employee to be present at the plant.

These disruptions taking place in the industrial automation market mean that new entrants now face fewer technical barriers. The result is an increasingly diverse range of innovative players on the market. We currently see healthy competition between automation providers, startups, cloud providers and IT companies – giving manufacturers a wide range of options for increasing their level of digitalization without having to set up multiyear software implementation projects.

How can cloud production benefit the value and supply chain?

Cloud-based production can deliver significant advantages, including both efficiency improvements and cost savings. Based on the potential use cases, we differentiate three cloud “archetypes”: factory/company cloud, supply chain cloud, product life cycle management cloud. Below, we examine some of the potential advantages of each type for manufacturing companies.

B / Three cloud archetypes

Factory/company cloud
Leveraging the cloud to generate insights in the manufacturing space at machine, line, plant or company level

Supply chain cloud
Leveraging the cloud to generate insights within the supply chain from raw materials via Tier X suppliers to the OEM

Product life cycle management cloud
Leveraging the cloud to generate insights along the life cycle of a product from design to usage and aftersales

Manufacturing benchmarking
Asset management
OEE monitoring
Production flow management
Multisite management
Predictive maintenance
Closed-loop simulation

Capacity management
Transportation management
Traceability
Supply chain and operations planning

Remote control
Digital/field services
Virtual commissioning
Integrated engineering
FACTORY/COMPANY CLOUDS

Cloud-based technology has enormous potential for the manufacturing process itself. Network simulation leads to reduced downtimes for production equipment. Various enabling technologies, such as process mining, Virtual Reality (VR) and AI, create full transparency across the entire manufacturing process, including a 360-degree view of the plant system. In the future, manufacturers will be able to increase their efficiency thanks to a new standard of assembly and production processes. Limitless machine-to-machine communication – in other words, connected machinery concepts – will further break down manufacturing data silos. Not only that, companies can potentially devise ways to monetize the production data that they collect.

The cloud also has benefits for industrial engineering. Increasingly complex processes in industrial manufacturing are placing ever greater requirements on automation technology in terms of performance, functionality and efficiency. Integrating all the different components in an automation project can significantly reduce engineering times thanks to fewer repeated inputs, shared databases and standardized user interfaces for all tasks. Moreover, fully automated synchronizations enable flexible, simultaneous task processing, while the amount of work can be reduced by reliably identifying errors and quickly correcting them. Solutions can be developed faster with the help of automatic human-machine interface visualization, fast machine and plant diagnostics,
Use of the cloud in product life cycle management

PRODUCT LIFE CYCLE MANAGEMENT CLOUDS
Generating information about products during their use phase means that data can be fed back into the value chain in real time. This not only enables customized, real-time error prevention – it can also lead to a more targeted product development process with respect to the next product generation. Overall, manufacturers can break down borders and leverage customer experiences by generating focused customer data and insights in all functions. This increased customer transparency across company boundaries is potentially a game-changer for manufacturers’ performance.

Additionally, detecting and predicting service issues opens the door to new business models, such as data-based and consulting-based services. Companies can do this by monitoring conditions and performing predictive maintenance across different firms, or combining data generation in real time to create an AI-infused 360-degree view of customers – making it possible for them to guarantee certain service levels.

To take an example, in the turbine industry the cloud can be used to connect turbine manufacturers with turbine users. Historically, turbine manufacturers had no ongoing information about the product once it had been produced and transported – no data was collected on customer usage or customer preferences. Thanks to the IIoT, data can be sent from aircraft turbines to the cloud, giving efficient energy management system implementation and automatic program creation. Digital tools such as holistic product and process simulations can also reduce time-to-market.
aircraft turbine manufacturers full transparency about the life cycle of their globally deployed fleet and enabling predictive maintenance concepts and continuous product improvements based on actual usage data.

SUPPLY CHAIN CLOUDS
Cloud-based production enables a greater degree of supplier integration into value-generating activities. Manufacturers stand to benefit significantly from smart warehousing and distribution, which provides them with continuous visibility regarding inventory and warehousing levels – leading in turn to economies of scale. Improved supply chain visibility, agility and profitability also enable intelligent planning and execution, demand sensing and traceability. Digital end-to-end supply chains mean that companies can track and trace information such as CO₂ emissions across the entire value chain, from raw materials onward – something that is becoming increasingly important with respect to environmental restrictions. Furthermore, highly effective cross-company and network-wide development and engineering processes become possible thanks to the power of the cloud.

Cloud-based production in practice
The following example from the steel industry represents a potential use case for cloud-based production and the related business case. We have chosen to
focus on the steel industry, as it is known for its large share of legacy equipment, which in the past has slowed down the implementation of digitalization.

Production machinery makes widespread use of electric motors. Predictive maintenance for electric motors via what is known as "electrical signature analysis" therefore has significant potential to reduce planned and unplanned downtimes, as well as scrap and rework. Major players in the steel industry are already using AI solutions to monitor the complete rotation chain based on current and voltage readings within the motor. The solutions analyze these electrical signals and are able to predict failures up to seven months in advance. The readings are taken inside the relevant control cabinet, so no sensors need to be installed on equipment in the field – particularly useful in harsh industrial environments and in the case of hard-to-reach places. Set up as a plug-and-play solution, this scalable and easy-to-use technology can be implemented within two months. It is also offered by suppliers on an "as-a-service" basis.

One major advantage of this solution is that it can evaluate data on different infrastructure levels at the same time. Historically, this kind of analysis would be performed entirely inside the local electrical cabinet, meaning that different hardware would perform the same analyses for different motors. Cloud computing enables a far more efficient system, incorporating different applications within a single production system. The electrical signals are scanned within the individual electrical cabinets at a high frequency to enable a smooth signal, generating vast amounts of data. This data is then aggregated and pre-processed locally by edge devices and sent to the central cloud. An AI algorithm performs the final analysis in the cloud, for several different applications if desired. Thus, a single resource provides all the data necessary, reducing hardware to a minimum and providing a basis for automated predictive maintenance scheduling or availability tracking, for example.

Cloud-based technology of this type is already in use in the steel industry – for example, in steel casters. Here, 12 to 18 AC induction motor-powered rollers guide metal down the caster. The most common failure in this setup occurs at the cardan coupling or crosslink. If a roller fails, the current casting can be finished; however, repairs are needed, which leads to downtime for the entire caster. If the repairs are not performed in time, the quality of the slabs produced decreases significantly. By applying a cloud-based predictive maintenance solution in this specific use case, manufacturers can avoid up to EUR 600,000 in annual revenue losses and reduce downtime by 13 hours a year. Moreover, they can cut corrective maintenance costs by up to EUR 12,000 annually. The installed system also enables a reduction in energy consumption by operating the motors at their most efficient point, saving a further EUR 4,000 – 8,000 a year.

Another use case for cloud-based technology is in the area of single-stand Cold-Rolling Mills (CRM) and pay-off reels, including mill stand rolls, tension reels and deflector and flatness measurement rolls. The most common issue here is damage to the various rolls, causing looseness and therefore imprecise products. If repairs must be carried out unexpectedly, downtime can be
significant. In the worst-case scenario, a broken roller or reel could lead to strip breakages, necessitating complex, lengthy repairs of the machinery. In this use case, eliminating unplanned downtime can generate savings of up to EUR 440,000 and cut downtime by 20 hours a year. The potential savings thanks to preventive maintenance and reduced energy costs are similar to those for industrial steel casters.

Not only does cloud-based production prevent unnecessary downtime, potentially catastrophic breakdowns and expensive express part deliveries – it also has environmental benefits. Thus, it can reduce energy waste and cut CO₂ emissions. In the two specific use cases presented above, these benefits potentially generate more than EUR 1 million a year in direct value.

Of course, these benefits involve certain costs. Typically, in the first year of implementation, companies face a one-time hardware cost plus a monitoring fee. In subsequent years, the total cost mainly consists of the monitoring fee. Depending on the number of assets monitored, total costs range from EUR 30,000 for ten or so assets to EUR 110,000 for 100 assets in the first year, falling to EUR 23,000 – 60,000 in subsequent years. This means that the cloud-based solution pays for itself within approximately three months, and returns three to five times the investment within the first year. On an ongoing basis, the return on investment could be as high as 750%.

Cloud-based monitoring solutions can also be integrated into a network of smart machines or applications. These networks determine how a system or production process behaves, while the smart machines themselves are self-aware and can adjust according to changes in their internal or external environment. In this sense the next wave of industry automation may no longer be about parameters – it may be about setting goals and outcomes.

Our recommended three-step approach

Clearly, cloud-based technology can significantly accelerate the digitalization of manufacturing, especially in "brownfield" environments – where companies rely heavily on legacy systems. To help manufacturers leverage this technology, we recommend a three-step approach.

STEP 1
Set up a dedicated team to drive digital production use cases

Players with no prior exposure to cloud-based manufacturing will need to build up experience within the organization. Identifying, developing and implementing use cases call for cross-functional competencies and cannot be done within the scope of day-to-day business. For this reason, we recommend that, as a first step, companies set up a dedicated team whose task is to drive digital production use cases. This team should be cross-functional, bringing together traditional IT skills, data analytics expertise and production know-how. We advise companies to start with a small
group of people and focus on use cases with a limited scope. This allows the team to gradually build up competencies. Team members should also function as ambassadors for digital change, disseminating to the rest of the organization a better understanding of what the new technology can offer.

**STEP 2**

Create a dedicated unit for speeding up digitalization and define its operating model

Once the company has gained initial experience in implementing use cases, we recommend that it creates a dedicated organizational unit to speed up the digitalization process. This unit’s task will be to identify further use cases, implement them and roll them out to the rest of the organization in a structured fashion.

The company will need to define an operating model for this unit and set out how it should cooperate with IT and the production side. The operating model must include the following elements:

- Processes for identifying use cases and prioritizing them
- A development process for the chosen use cases
- An approach for piloting use cases – for example, will they be piloted in a central plant or in the plants where they are most needed?
- An implementation approach indicating at which point in the roll-out responsibility for use cases is passed on to the plants where they are being implemented

In addition, we recommend defining an approach for training employees in implementing cloud-based production use cases and building up the necessary competencies.

**STEP 3**

Define a target IT/OT landscape and implementation roadmap

As soon as the company has reached a certain level of maturity with regards to cloud-based production, it is important that it starts thinking about its long-term IT/OT strategy, its target system landscape and its transition plan. The “fail fast” implementation approach focused on use cases we recommend harbors a risk of creating redundant data pools, interfaces and dependencies on cloud providers.

An IT/OT strategy and target landscape provide guidance with regard to investments in new technologies and systems – and ensure that the level of complexity does not explode as the number of use cases implemented increases. We recommend that companies ask themselves the following critical questions:

**WHAT SHOULD OUR FUTURE SYSTEM LANDSCAPE LOOK LIKE?**

Discuss which functions will be covered by traditional systems within the automation pyramid (SCADA, MES, and so on) and which will be moved to
Challenges caused by not having a cloud strategy and target system landscape

System landscape in absence of a cloud strategy and target landscape

WHERE SHOULD WE STORE OUR DATA AND HOW SHOULD WE MANAGE ACCESS TO IT?

Once you have decided which functions you will move to the cloud, you need to determine where the data will be stored (including master data, such as production orders, process data and quality data). You must also decide how data will be accessed from within the different systems. Interfaces between systems should be reusable and data should be stored with minimum redundancy.
WHICH PARTNERS SHOULD WE SELECT?
Focusing on a single cloud provider can lead to significant lock-in effects. You should therefore think carefully about whether to pursue a single-cloud or a multi-cloud strategy. We have seen both strategies within the automotive industry, for example: some OEMs choose strategic partnerships so they can benefit from greater support, while others follow a multi-cloud strategy so they can switch flexibly between different providers.

HOW SHOULD WE MANAGE THE TRANSITION TO THE NEW SYSTEM LANDSCAPE?
We recommend developing a high-level plan for transitioning from your current (legacy) setup to the future system landscape. This plan then helps you decide which use cases you should implement at which point of time. It also ensures that you avoid new developments in systems that are close to their end of life.
Further reading

Next Generation Manufacturing

- Next Generation Manufacturing gets ready to roll

Industry 4.0

- Rise of the machines
- IoT in production: Big changes ahead in manufacturing

Additive Manufacturing

- New business models and comprehensive product innovation
- Polymer additive manufacturing
- De-risking your supply chains
- Taking metal 3D printing to the next level
- Beyond powder bed – AM on the brink of industrialization
- Current status and roadmap to transparent AM

Sustainability

- Climate action A new competitiveness paradigm
- Sustainarama How sustainability will change the world in 2050
- Innovate and industrialize Offshore wind energy
- Hydrogen Transporting the fuel of the future
- Green steel The race is on
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Open up your operations
Integration platforms and bidding platforms offer new ways of working together. Value chains are being deconstructed and production franchised.

Perfect your value chain
Aim for simplicity and maximize resilience. Shorten your value chains to localize production. Make your value chains broader, for shared operations and for better load balancing across ecosystems.

Reorchestrate value generation
Globalization was yesterday; it’s time to make supply local again. Resources are scarce and you must adapt your use of them to their availability. Consumers have increasingly local requirements.

Accelerate the learning game
It’s all about data: data-driven learning is replacing expert know-how, and data is forming the basis of your decisions.

Embrace digital
We are entering an age of “mirror worlds” — representations of the real world in digital form. Virtual Reality 4.0 has arrived. You can now not only test products virtually, you can even simulate their future fields of application.

OPERA — Our Roland Berger core beliefs for the future of operations
ROLAND BERGER is the only management consultancy of European heritage with a strong international footprint. As an independent firm, solely owned by our Partners, we operate 50 offices in all major markets. Our 2,400 employees offer a unique combination of an analytical approach and an empathic attitude. Driven by our values of entrepreneurship, excellence and empathy, we at Roland Berger are convinced that the world needs a new sustainable paradigm that takes the entire value cycle into account and enables us to meet the profound challenges of today and tomorrow.