CONTENT UNIT 7

NEW TECHNOLOGIES

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7 New technologies

7.1 The introduction

The topic

The automotive industry is one of the sectors in which innovation is almost the order of the day - the research and development of new prototypes and features is just as much a focus as the most efficient mass production and supply chain.

This has the advantage that, at least if you are interested in technology, it never gets boring! Did you know, for example, that robots and humans will soon work together without fear of contact, just like humans work together? Or what the current drivers of an efficient supply chain are? Or how 3D printing is being used in the automotive industry?

In this unit, we look at exactly these questions and technologies. We look at the current and future state of industrial robots and why human-robot collaboration is becoming an important topic. We also look at the basics of supply chain management which strategies and metrics are best practices right now and why they are so important for a company in the automotive industry. Finally, we give an overview of the current state of additive manufacturing - i.e., 3D printing. You will learn about different technologies and materials and how the 3D production process works.

So, in summary, in this unit you will learn:

- You have an overview of human-robot collaboration.
- You know the advantages and limitations of human-robot collaboration.
- You can name different robot programming languages.
- You are able to describe the goals and functions of SCM.
- You know what SCM strategies are.
- You know the most important key figures for optimising the supply chain.
- You can describe different technologies and materials of 3D printing.
- You know the basic 3D production process.

7.2 Basics robotics

It is impossible to imagine production facilities, factories and industrial plants without robots. The degree of automation in production processes, especially in the automotive industry, is enormous and constantly growing. What is still rather rare, however, is that humans and robots really work together, i.e., perform work steps together instead of being spatially separated from each other by barriers. This new type of industrial robot's current and future state (or sometimes simply a "cobot") enables so-called human-robot collaboration (HRC).

Note

The term **human-robot collaboration** means **direct cooperation of humans with robots**. In contrast, there are the terms "human-robot co-existence" (humans and robots work in different work areas in the same factory) or also "human-robot cooperation" (humans and robots work in the same work area, but on time-shifted tasks in the process, without direct interaction).

Example

The robot can replace the human in the tasks of assembling car parts, while in parrel the human operator will perform the tasks of picking-up ready-made elements.
The human can also be responsible for fastening the harness or hinges of an element, while at the same time the robot will be positioning different elements.
A human operator assembles the first two or last two components of a vehicle, while a robot, or two of them will be manipulating screwdrivers (pick-and-push) and applying fasteners.
Robots can also be equipped with machine vision or AI (artificial intelligence) systems to respond and/or provide feedback in real-time, with the human overlooking the process and introducing changes into the production processes.
A cobot can fill engines with oil or support quality checks, safeguarding incidents at the workplace affecting humans in contact with hazardous chemicals.
The provided examples are **just a few human-robot collaborations**.

The core aspect of HRC is therefore essentially the direct proximity of robots to humans, without protective devices such as separate rooms or barriers. This presupposes that **collaborative robots cannot endanger humans,** since contact between robots and humans cannot be ruled out and is sometimes even necessary.

Collaborative robots must therefore also be "**sensitive**". This means that they must be able to detect unexpected contact with people or environments and react accordingly - i.e., either stop or reduce the speed of movement. For a robot to be sensitive, it must be equipped with **integrated sensor technology**. These are certain components that enable recognition of the environment (for example, pressure sensors on the surface of the robot). The safety of collaborative robots is also standardized (in ISO 10218 and ISO/TS 15066).

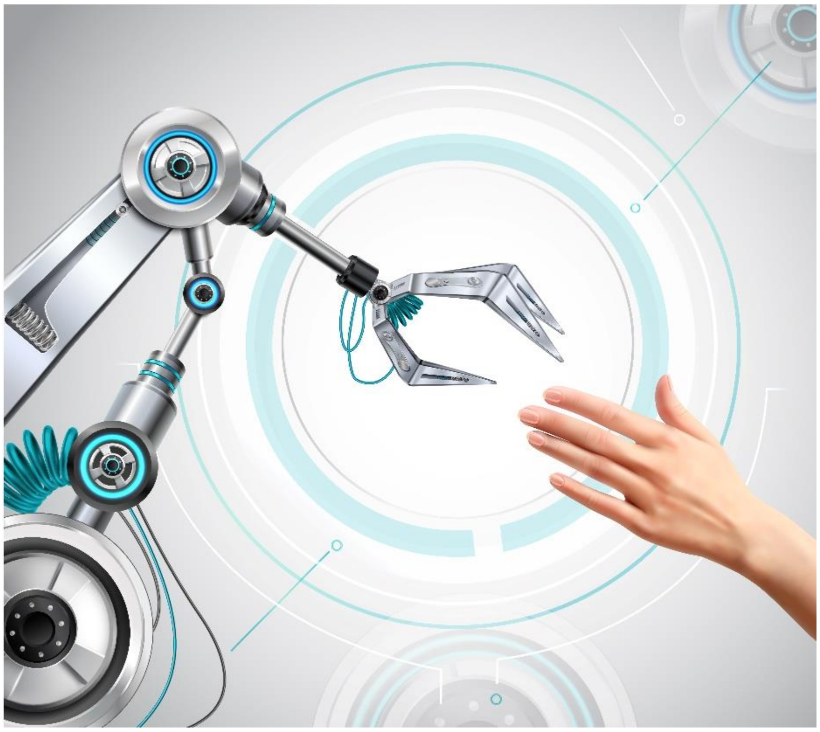
Hint

If a robot is **collaborative** and **sensitively** safe, other safety precautions that were previously indispensable on a factory floor, such as the aforementioned barriers or spatial separations but also light barriers or other measures, may be superfluous.

In practical use, there are two possibilities - either the robot is controlled **directly by humans through manual guidance** (already common technology in modern factories today) or the **robot acts independently** in contact with humans.

The use of HRC now has three main advantages:

1. **The space required in factories is decreasing**: Collaborative robots can operate in the same workspace as humans - separate areas or rooms are therefore no longer necessary.
2. **Collaborative robots relieve personnel:** Heavy and monotonous work can be taken off the hands of production personnel. This includes strenuous, unergonomic (such as working head over heels) or very repetitive tasks.
3. **HRC-assisted processes are economical:** the use of collaborative robots not only increases efficiency and production output in the individual work steps but also increases utilization through increasingly intelligent, mobile and flexible systems, as collaborative robot systems can be used for different areas of application.



The current limitations of HRC mainly concern the **safety aspect**. Security must not only be guaranteed locally in contact with people but must also be **adopted in the general IT security goals** - so that protection, operation and availability of the HRC systems can be ensured. Up to now, IT security goals have focused more on the protection of information than on the protection of operating equipment. This is important because the networking of intelligent industrial robots creates **new danger scenarios**, such as hacker attacks from outside, which can then paralyse the entire security system in the factory.

For a robot to do what it has to do, it naturally needs **correct programming** in addition to the corresponding sensors.

Example

There are many programming languages for industrial robots - these are usually specified directly by the manufacturer. Some examples are: V+ (from Omron), RAPID (from ABB), KRL (from Kuka), VAL3 (from Stäubli), URSript (from Universal Robots), SPEL+ (from Epson) and MELFA-Basic (from Mitsubishi).

It is important to know that programming can be done either "online" or "offline".

Online programming exists when programming is done **directly on or with the robot itself.** This is the case, for example, when the programmer moves the robot with a control console to desired positions or certain paths, which the robot then "remembers" (for example, in painting robots). These types of programming are also called teach-in or playback methods.

Offline programming, on the other hand, is carried out **independently of the robot** on a separate computer. This has the advantage that the robot can continue to work productively without stopping. Offline programming is carried out **textually** (using programming languages as in the example above), **CAD-based** (using construction drawings and simulations), **macro-based** (frequent sequences of commands that are programmed once and then used again and again) or **acoustically** (using voice input via microphone).

7.3 Supply-Chain-Management (SCM)

Things are also changing along the supply chain - which is why the demands on supply chain management are also changing. Let's first clarify the basics:

Definition

Supply **chain:** The supply-chain is essentially the entire process around the delivery of products or services until it reaches a company's actual customers. Because companies today specialize and can deliver globally at the same time (for example, a company that makes microchips and then sells them to various other companies), supply chains consist of what is usually a multi-level network of organizations that trade with each other.

Supply chain-management (SCM): SCM now deals with the question of how this network is best managed. It is about planning and managing all the processes involved in the supply chain, such as procurement and sales, logistics but also disposal - in principle simply about coordinating the trade and exchange of goods of all the companies involved in the supply chain.

In the past, the term SCM was equated with logistics - but this has changed due to the networked cooperation between companies. SCM and logistics both deals with the **development of object flow along the supply chain** and have two main goals:

- System-wide internal improvement of the cost-benefit ratio
- Increasing the added value of the product

However, SCM goes **beyond the boundaries of one's own company** - especially when it comes to transport and warehousing. Thus, an attempt is made to obtain the most **comprehensive and cross-company view** possible **of all processes** along the supply chain. Through all the companies involved, an attempt is made to achieve optimal structuring and coordination in terms of purchasing, production, and distribution, but also controlling, marketing and recycling, etc. SCM is therefore very strategic or "high-level". The "tactical" implementation of an SCM strategy is then left to the individual companies or departments.

Note

Let's summarize: SCM is **the cross-company and process-oriented planning and control of** the entire supply chain. The delivery of goods, the flow of money and the transfer of information between companies should be optimally designed and managed.

Based on the current requirements of the market (high expectations of the clientele and ever shorter product life cycles), **three decisive factors for SCM** can be defined, which are interrelated:

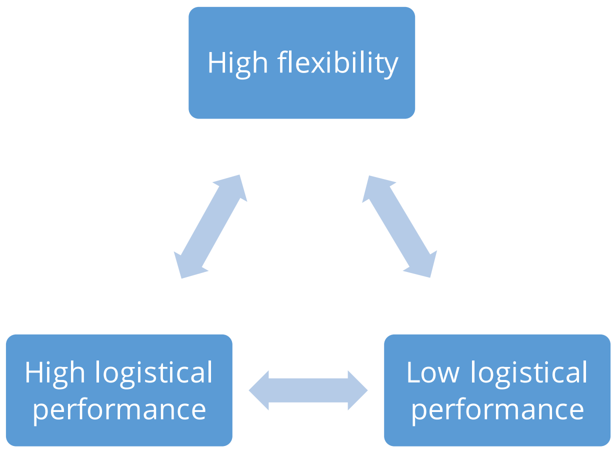


Figure 2 (created with Smart-Art in Word)

This results in three main objectives of SCM:

1. **Flexible customer relationship management:** A consistent focus on market demand about the increasing requirements of the target groups should create a high degree of flexibility.
2. **Demand-driven and flexible production:** Optimization of supply stocks and resources along the entire value chain is designed to reduce costs across the board.
3. **Synchronization of supply with demand:** The adaptability of the supply chain is to be increased.

At first glance, this seems a bit vague, but it makes more sense if we derive **concrete tasks from it:**

- Unnecessary inventories should be kept as low as possible along the supply chain to reduce storage costs.
- Strategies such as Just-in-Time or Just-in-Sequence are intended to guarantee demand-oriented deliveries.

- The aim is to shorten companies' cash-to-cash cycles, i.e., the time between paying for delivery and payment by the customer at the end of the supply chain.
- Lead times are to be shortened.
- Communication, information transfer and interfaces between the companies should work without disruptions.

Important

SCM is **critical to the success of large industrial companies**. Due to close cooperation and the division of tasks, companies are interdependent. After all, competitiveness and ultimately success can no longer be guaranteed by just one company - **the entire supply chain is responsible for this**. As a result, it is often no longer just individual companies that compete with each other, but entire networks of companies. However, the interests of the companies involved in a supply chain can also collide

So SCM is not that simple. So, what about practical implementation? Let's take a look at some **strategic approaches and current developments.**

The first thing worth mentioning is the **just-in-time approach,** which can also be described as one of the first SCM strategies. This involves the closest possible coordinated coupling of production between supplying companies and their buying companies. This approach was and is used in the automotive industry, in particular, to be able to coordinate deliveries in a particularly timely manner and to keep inventories as low as possible. A well-known implementation of this strategy is also the Kanban method.

The Efficient Consumer Response (ECR) concept is an initiative that aims to optimize the cooperation between industry (manufacturing) and trade (sales) specifically according to the requirements of the market and the clientele. Through this cooperation, potentials are to be discovered that would not be visible if viewed individually. The focus is on possible standardization (for example, uniform packaging carriers - the best example is the Euro pallet, but connecting software or uniform coding is also an issue here) and multilateral cooperation between the companies. Multilateral means that all companies cooperate (instead of only two companies always cooperating, i.e., "bilateral").

The Supply Chain Operations Reference Model was created by several large companies across industries to model supply chain processes. In it, five essential SCM processes are linked (planning, procurement, production, delivery, and return) and these are again divided into three process types (planning processes, execution processes and support processes). This is intended to make the interfaces or relationships of the companies involved transparent so that performance measurement and performance comparisons can be made meaningful.

The software also plays a strategically important role in SCM - modern enterprise resource planning (ERP) systems can map the status along the supply chain in near real-time. This is also helped by technologies such as electronic data interchange (EDI), which fully automates the exchange of business documents such as orders, delivery notes and invoices and integrates them into ERP systems.

Example

ERP is crucial for the automotive industry since on the one hand there are many steps already in the manufacturing process (not mentioning the sales and purchasing) and on the other hand to be more efficient you need to adequately monitor the different steps. Some automotive ERP modules are: updates and maintenance, versatile deployments, customisation, reporting and dashboards, quality management, inventory management, accounting and financials.
EDI also supports efficiency and allows for traceability and optimization of the supply chain. With EDI software the manufacturers can send demand figures in real-time and the suppliers can adjust production with more precision and increased automatization.
When integrating EDI solutions into ERP systems, the company will improve automation processes and work towards the elimination of errors.

When we consider that suppliers have to collect their goods, place transport labels and ship them, EDI integrated into ERP records the data and reports the time the goods arrive, the sequence of the packages and the load carriers. These digital notifications then pass on the information about invoices, among others. All these steps also contribute to reducing costs and saving time.

Hint

Other well-known technologies will also soon influence the design of SCM strategies. Artificial intelligence can capture demand trends faster, blockchain enables tamper-proof information exchange along the supply chain, and self-driving trucks or drones can make the exchange of goods even more timely and cost-effective.

What are the key indicators that can be used to measure the success or failure of SCM? The five most important measurement criteria are:

- Perfect Order Index: This measures the percentage of error-free order fulfilments along the supply chain. The Perfect Order Index provides a good comparison of overall performance, for example of the current year with the previous year.
- Cash-to-cash time: Sometimes referred to as cash conversion, this is the period between payment at the supplier and payment by the customer at the end of the supply chain. Integrated into this are inventory duration, receivables, and payables.
- Supply chain cycle time: This key figure indicates how long it would take to process an order if all stocks were empty. This is used to determine the longest possible lead times and add them up. Supply chain cycle time is a good indicator of supply chain efficiency.

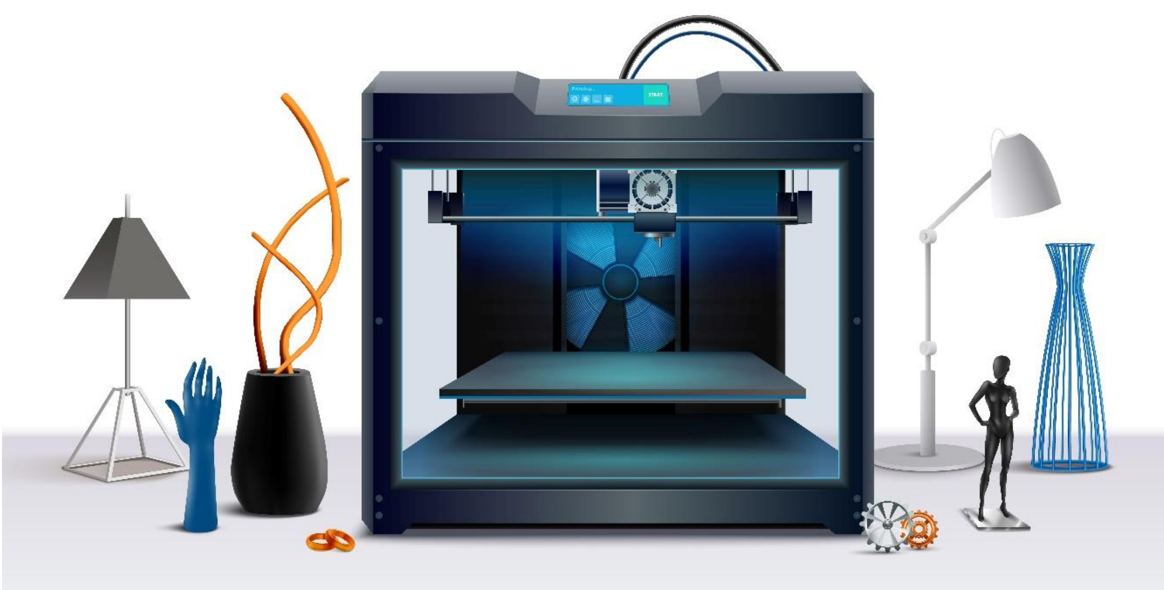
- **Inventory** Turnover: This measures the inventory turnover, i.e., how often the entire stock is sold over a certain period. Again, this is a useful metric to assess the efficiency of the entire supply chain.
- **Fill Rate**: Also referred to as the demand coverage rate, the fill rate indicates how much demand can be met with currently available inventory without falling behind on deliveries. This determines whether companies could achieve more turnover with a higher inventory performance.

7.4 Additive manufacturing

Additive manufacturing is a **particularly innovative manufacturing process that differs** fundamentally from conventional manufacturing processes and offers completely new possibilities in research and development as well as in industry.

Note

When people talk about additive manufacturing, they are simply referring to **3D printing.** This includes all manufacturing processes in which **material is applied layer by layer to** create workpieces or objects.
This layer-by-layer build-up is **computer-controlled** and involves **one or more liquid or solid materials** that are physically or chemically hardened or melted.



The 3D printing process is used when you want to create **geometrically complex shapes in one-off or small batch production** - for example, prototypes or models, but also tools or finished parts in small quantities are usually produced with 3D printing. What makes additive manufacturing so different from other manufacturing processes (such as primary forming, forming or subtractive manufacturing processes) is the fact that the **economic efficiency increases with higher geometric complexity and decreasing number of pieces**.

There are **many different 3D printing technologies**, which also use **different materials.** These are divided into seven categories according to DIN EN ISO/ASTM 52900:2022-03:

- **Free-jet binder application**: This includes all additive manufacturing processes in which liquid binder is selectively applied to bring powdered material (made of plaster, plastic, ceramic or metal) into a desired solid form. One example is so-called binder jetting.
- **Material application with directed energy input**: Here, thermal energy (laser beam, arc, plasma or friction) is used to join metals in powder form, as wire or as bars accordingly. This includes laser deposition welding, for example.
- **Material extrusion**: The raw material (plastic, metal, ceramic, metal, but also concrete or mixtures of materials) is selectively deposited using a nozzle or orifice and then hardened by heat or chemical reaction. This process is used, for example, in fused layer modelling.
- **Free-jet material application**: In this process, the raw material (liquid plastic or liquid wax, dispersions of metal and a carrier liquid but also aerosols of gas and a carrier liquid with metal and ceramic particles) is selectively deposited as drops and solidified by heat, ultrasound, UV light or also by a gas flow. This includes, for example, poly jet modelling and multi-jet modelling.
- **Powder fat-based melting**: Here, regions of a "powder bed" of metal or plastic (often mixed with sand or ceramics) are selectively fused using lasers, LEDs or electron beams. The most prominent examples are laser sintering, electron beam melting and laser beam melting.
- **Layer lamination**: In this process, entire layers of a material (paper, plastic, ceramic or metal) are joined together as sheets, foils or metal plates to form a component. The most important manufacturing process of this type is Layer Laminated Manufacturing.
- **Bath-based photo-polymerisation**: The most difficult process of all to spell includes all additive manufacturing processes in which so-called photopolymer, which is initially liquid, is selectively cured in a container with the help of light. Important to note here are stereolithography and digital light processing.

Note

For ease of reference, let's summarize the most important 3D printing techniques and the most used materials:

Laser beam melting and electron beam melting are suitable for metals.

Laser sintering is suitable for polymers, ceramics, and metals.

Digital light processing and stereolithography are suitable for liquid synthetic resins.

Fused layer modelling and the poly jet method are suitable for plastics as well as synthetic resins.

Example

Top brands like Toyota and Audi use platforms to develop VR and AR tools to create real-time interactivity (marketing), improve quality of design (building 3D models) and introduce innovation to training (immersive experiences).
Moreover, 3D print in the automotive industry plays a key role in increasing the efficiency in several areas, including:

- Design verification
- Creating spare and end parts
- Tooling assembly
- Testing
- Reducing the loss of materials

7.5 Summary

Save knowledge

Human-robot collaboration is the next step in the use of robots in industrial companies. This involves robots and humans performing **work steps together at the same workplace** instead of being separated in the process and workspace.

This has the advantage that safety precautions (such as barriers) are no longer necessary and factory spaces can be smaller or used more efficiently. Furthermore, robots can **effectively relieve** employees of **heavy and monotonous work**. Such collaborative robots must be equipped with sensitive features. This means that they must be able to perceive their environment **via certain sensors** (such as pressure sensors on the "skin") and react accordingly to avoid injuries to people or accidents at the workplace.

Robots must of course also be **programmed** accordingly. This can be done either **offline,** i.e., independently of the robot on a separate computer, or **online,** i.e., directly on or also with the robot.

Supply chain management (SCM) must also adapt to technological and consumer-oriented changes. This involves the comprehensive **planning** and **management of** all **processes** and **companies involved in** a **supply chain**. Currently, important drivers for a successful supply chain are **high flexibility**, **high logistics performance** and **low logistics costs**. For example, inventories should be kept as low as possible, lead times should be reduced and communication between companies should be established as error-free as possible.

To achieve this, there are **various SCM strategies and initiatives that** are co-designed and applied by entire company networks. Important examples are the **just-in-time approach,** but also methods such as the **efficient-consumer-response concept** or the **supply-operations-reference model**.

Software plays a particularly important role in SCM to be able to map the efficiency of the supply chain based on important **key figures** (such as the perfect order index, cast-to-cash time or inventory turnover) as far as possible in real-time - **enterprise resource planning systems (**ERP systems) are used for this purpose, which can automatically exchange delivery and order information with each other along the supply chain with the help of technologies such as electronic data interchange (EDI).

3D printing also plays a particularly important role in industry and research. With these so-called **additive manufacturing processes,** in which raw material is applied in **layers to form a desired shape**, one-off and small series productions can be produced particularly economically. With a wide variety of technologies, different materials can be used, mostly plastics, metals, or ceramics. Metals or ceramics.

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