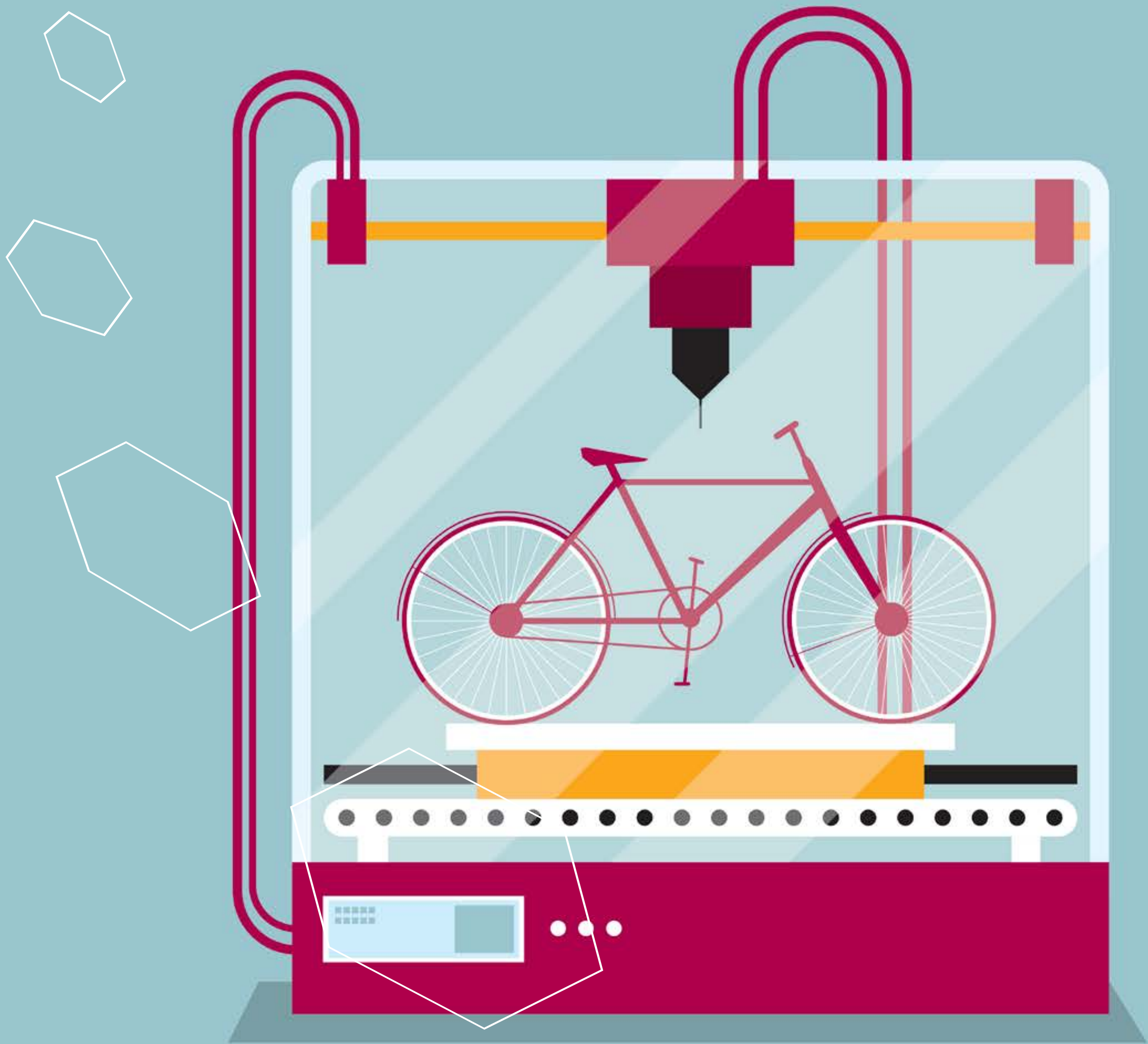
PLATTFORM INDUSTRIE 4.0

WORKING PAPER



# Application Scenario in Practice: Order-controlled Production of a Customised Bicycle Handlebar

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# Application scenario in practice: order-controlled production of a customised bicycle handlebar

## How do standards, research, security, law, labour and skills interact with each other? This cross-discipline brochure provides the answers.

For the first time Plattform Industrie 4.0 has combined the various aspects of Industry 4.0 that have been developed in its working groups into one comprehensive overall picture. On the basis of the “order-controlled production (OCP)” application scenario, this brochure shows how the various fields standards, research, law, security, labour and skills interplay with each other. It also demonstrates the practical impact of these aspects on companies – especially in the case of SMEs. The focus is on a custom-made and automatically manufactured bicycle handlebar for an E-bike.

# Content



# Introduction

Over the past years the manufacturing industry has undergone sustained transformation – and is facing diverse challenges in light of digitalisation and changing market requirements: Many products are changing at an ever-increasing rate, for instance in vehicle manufacturing. The range of materials used here is constantly increasing – aluminium, high-strength steels and fibre-reinforced plastics are all put to use. Time and again they require new, specific capabilities that are essential to manufacturing.

In addition to this, strong market dynamics and changing customer behaviour are increasing competitive pressure: Innovation and product cycles are becoming shorter and new production technologies are establishing themselves on the market. This means that companies are having to react quicker and make investment decisions on an ad hoc basis in order to remain competitive. This is not just the case for consumer goods but also for capital goods.

Thus, increasing numbers of industrial companies are starting to counteract this trend and to avoid protracted decision processes on investments. Their strategy: Better interlinking their capacities and production capabilities, for example the technologies available in their company or staff skills- including beyond company boundaries. This enables them to adapt quickly to a changing market and order conditions and to make the best use of capabilities and capacities of existing production facilities – not solely in terms of the machines but also with regard to the staff and the whole organisation. How? Companies offer their available production capacities to other companies and thereby increase the utilisation of their own machinery. Other companies may access these capacities, thereby temporarily expanding their own production spectrum.

In order to put these dynamic relationships into practice in a cost-efficient manner, external production capacities must be incorporated into a company's own production processes

### Order-controlled production: Moving away from rigid structures towards dynamic relationships

Order-controlled production means that manufacturers can also incorporate external production modules on a largely automated basis. They expand their own production capabilities and capacities ad hoc in line with demand. No investment is required for this process. This enables companies to react very flexibly to the changing market and customer demands. On the other hand, companies offering their capabilities and capacities on the market can optimise their production capacity utilisation. New business models are also possible when using flexible order-controlled production. This is closely related to the transition to the socalled platform economy in which, as described in the "value based services" scenario, services are offered via digital platforms in the B2B sector.

as independently and automatically as possible. This helps to combine individual process modules much more flexibly and earlier than previously possible and to make use of their specific capabilities. Today's relatively rigid and separately negotiated relationships between companies along the value chain are being transformed into a largely fragmented and dynamic value chain network that changes as required by the individual order.

This trend is described in more detail in the application scenario "order-controlled production",[1] developed by Plattform Industrie 4.0.

It includes all production facilities and steps and describes how orders are all planned, awarded and controlled completely automatically. This is a complex process which involves many various aspects and requirements: Ranging from technical requirements and a common machine code to a secure exchange of data through to legal requirements and new skill requirements for staff. Taking the key questions from the WGs of Plattform Industrie 4.0 (standards, research, security, law and labour) as a guide, we will illustrate and discuss by way of a concrete example what is needed in order to make "order-controlled production" suitable for practical application. The example we will focus on: Order-controlled production of a customised bicycle handlebar.

**Editor's note:** Given the complexity of all aspects associated with the production of a customised bicycle handlebar, the present brochure will focus on demonstrating how a suitable supplier is automatically found and selected and how the chosen supplier is incorporated into the manufacturer's production system via an automated system of awarding contracts.

1 Published in "Update of the application scenarios of Plattform Industrie 4.0", available to read on the Plattform Industrie 4.0 online library.

# The customised bicycle handlebar

In essence the application scenario "order-controlled production" looks at how a company, in this case a bicycle manufacturer, can automatically award contracts in order to incorporate capacities and capabilities of outside companies into its own production system. The example of a custom-made handlebar for an e-bike will demonstrate how this process could be implemented in practice

1. An e-bike manufacturer offers its customers a wide range of configuration options to put together their own customised bike. The manufacturer sources the individual components form suppliers in order to then use these to assemble the bikes.

2. In addition to standard parts, which the manufacturer sources from wholesalers, there are also other components which must be specifically produced in line with the customer's requirements.

3. For instance, the customer can choose from a range of bicycle handlebars. Alongside standard models, which are made from aluminium tube or carbon-fibre-reinforced plastic, there is also a model made by means of additive manufacturing. Instead of a tube that absorbs impacts, this handlebar has a structure with optimised force distribution inside the handlebar itself, which opens up new design possibilities. Whether the customer wants a particular handlebar geometry or additional operating controls for the electric drive system or for an electric gear-shifting system – thanks to the innovative manufacturing process, these requests can be taken into account during production.

4. Using the configuration tool provided by the bicycle manufacturer, customers can change the handlebar shape and the position of the controls. The configuration system ensures that the requests are feasible, compliant with component operational requirements and compatible with the other bike parts.

5. The design of the handlebar structure with the optimised force distribution illustrates the manufacturer's valuable expertise. The manufacturer's in-house software automatically draws the design based on the configuration.

6. As it is anticipated that there will be a strongly fluctuating demand for the type of handlebar designed by the customer, the manufacturer has decided not to invest in buying its own machines. Instead, whenever this kind of order is placed, the manufacturer outsources to an external supplier. In order to keep the costs for this custom procurement to a minimum, the entire process of awarding the contract and manufacturing the product itself must be automated.

An autonomous process can be achieved if everything is set up to function automatically: the configuration of the product by the end customer, awarding the contract to the supplier, the manufacturing process and the entire logistics. Only under these circumstances can the manufacturer make a customised product with a comparable price to a mass-produced product.

In this example, **three roles** will be considered:

1. **Bicycle manufacturer** (Client)

2. **Supplier** (Contractor for manufacturing and supplying the customised bicycle handlebar)

3. **Intermediary service** (intermediary between the client and contractor; service can be performed by client or by a third party. The following shows what would happen in a scenario where the intermediary service is provided by a third party and is a separate legal entity.)

**Figure 1: Roles and relationships in the order-controlled production of a customised bicycle handlebar**

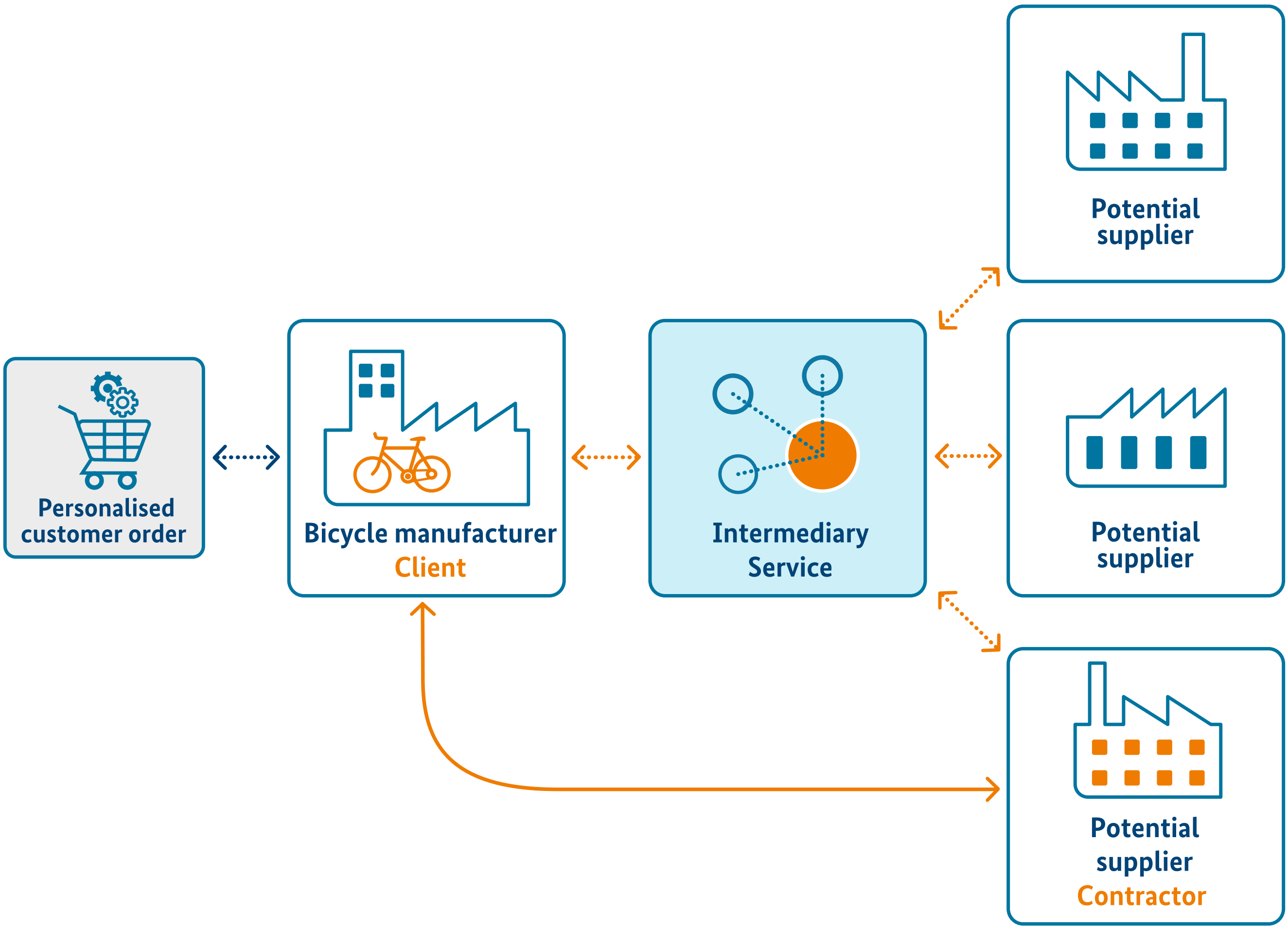


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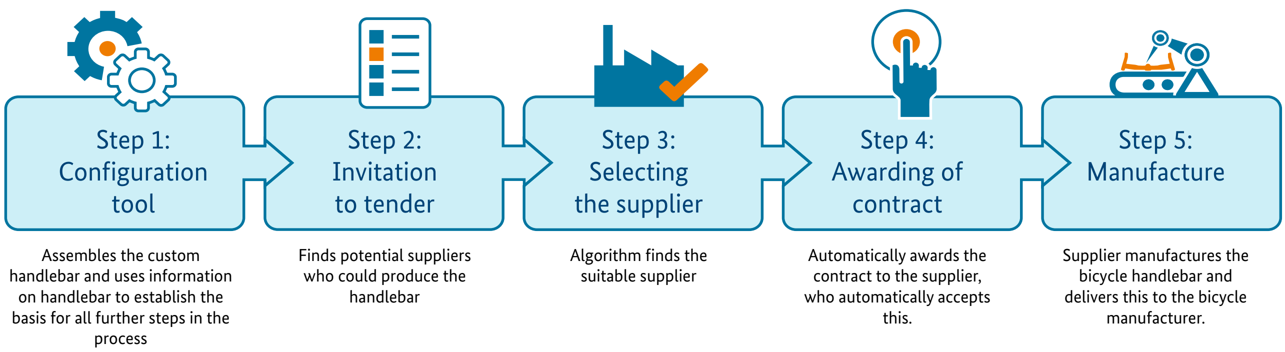
**Figure 2: An overview of the individual process steps:**

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# Overriding aspects

Before getting into the individual parts of the process, there are various aspects that must be considered as overriding, in particular safety and legal issues but also the current state of research and new staff skill requirements.

**Security** The integrity and authenticity of the electronic data exchanged and the protection of the intellectual property of the bike manufacturer (e.g. in the dataset of the design) are absolutely essential. Only once these are guaranteed can contracts be successfully awarded. Integrity and authenticity ensure that the agreements are verifiable. They are essential for the accurate technical manufacturing of the product. It is therefore important that all participants (bicycle manufacturers, suppliers and the intermediary service) and information exchanged are clearly and easily identifiable.[2] Since contracts are awarded within a very short time frame it is important that channels of communication are technically available across companies and protected from unauthorised access.[3] Only contractors who submit their offer on time and accept the order can be considered.

**Law** Another challenge associated with order-controlled production of the bicycle handlebar is the current legal situation: Statutory provisions are not yet tailored to Industry 4.0 and only apply at national level. Legal requirements of Industry 4.0 must be fulfilled through use of agreements and contractual arrangements. The manufacturer's ability to produce the order-controlled handlebar relies on them.[4] The essential content of these agreements can be split into three categories:

1. **Rules of participation** in the order-controlled production for all participants;

2. **Rules for bids by suppliers** and for intermediation by the intermediary service;

3. **Rules for the specific order** between client and contractor.

**Labour and skills** Order-controlled production of a bicycle handlebar does not only change the way machines and technologies communicate and work with each other in the production facilities. It also changes the skills and competencies needed by those people working there: The tasks go beyond the work that was previously required. In particular, the ability to operate abstract interfaces for digitalised machines is increasingly in demand at all levels. Thus, it is mainly interface skills that are needed even though particular production steps are automated or outsourced. Technical processes are increasingly converging due to the use of digital technologies. In order to implement these new and additional processes, it is necessary to have considerably more people working in IT infrastructure. Assembly processes are also changing due to the altering logic behind these. Machine operation, automation and flexibilisation are increasing – and so are the skills needed for these: all staff members in the company need a better understanding of production than they previously had and must assume more responsibility. The so-called "firefighters" will also continue to play an important role as highly-qualified employees who can quickly solve problems. But also "analogue" expertise is becoming increasingly important, for instance understanding and enhancing business models for the digital world. Advanced analytical skills are additionally called for in order, for instance, to process sensor and platform data appropriately. There is also a higher demand for skills in the field of security, but also the ability to communicate, cooperate and make decisions as well as personal responsibility in dematerialised and asynchronous remote operating processes. Finally, skills in customised design (i.a. for user interfaces) are also playing a greater role. To this end skills are already being taught today on design thinking and UX/UI design for IT applications. There has been an increase in demand in this field as companies try to ensure that customer needs are being considered during the entire production process. In order to shape the world of work of tomorrow it is necessary to conduct increasing research into how the kind of order-controlled production as described in our example impacts on work organisation, work processes and the skills required.

2 Further information can be found in "Technical overview: secure identities"

3 Further information can be found in "Technical overview: Secure cross-company communication"

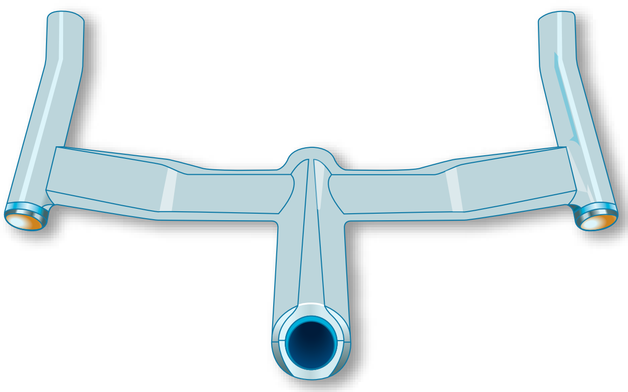
4 Details in "Industrie 4.0 – How well the law is keeping pace". All publications from the Plattform are available via the Plattform Industrie 4.0 online library: www.plattform-i40.de/I40/Online-Bibliothek

# Step 1: Configuration tool

**Assembles the custom handlebar and uses the information on the handlebar to establish the basis for all further steps in the process – right through to the manufacturing of the handlebar at the external supplier.**

Thanks to the extensive options in the configuration tool the bike manufacturer can offer the customer a handlebar that has been made according to his/her desired design and features. Long-standing customer Peter Meier is taking advantage of this opportunity and orders an e-bike with a customised handlebar. He enters all kinds of details on the bike handlebar, such as the measurements and desired geometry, into the configuration tool, which automatically compares these specifications with all of the available information. In this way, the tool is able to recognise during the ordering process whether Peter Meier's requests, for example the handlebar shape he has chosen, are physically possible and whether the handlebar is compatible with the other bike parts. The configuration tool simultaneously pools the data on the model and configuration of the handlebar, for instance the structure, steering design, mechanical strength, thereby providing the input data for the automated steps to follow, "invitation to tender", "supplier selection", "award of contract" and "manufacturing".

**Figure 2: Peter Meier's personalised handlebar**



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## The configuration tool in practice: From four angles

**Standards** & **Research** Configuration tools are already being used very widely in various sectors today – although with one notable difference to the configuration tool in the present example: Whereas bicycle manufacturers today choose and assemble relevant and customised handlebars from a list of models, the handlebar in the present example is a tailored product individual to the customer. The handlebar did not exist previously in this form and is manufactured automatically and autonomously by a supplier. Instead of a programmed code with previously conceived handlebar models, in this example more flexible rules must be applied in the configuration tool. This tool demands considerably more from the information it requires in order to produce a handlebar autonomously and individually. In the case of the customised handlebar there are no CAD drawings nor any precise instructions for the machines producing this. These machines can be CNC or PLC operated, they can also be robots and 3D printers.

The "reference architectural model for Industrie 4.0 – RAMI 4.0" and its administration shell provide an appropriate method for collecting data from the configuration tool and exchanging this between the bike manufacturer and supplier. Using the administration shell, the configured handlebar becomes an Industrie 4.0 component and is allocated a digital counterpart. This counterpart accompanies Peter Meier's handlebar configuration and the physical product throughout its life cycle.

It is of great importance that the information delivered with no further editing, refinement or additions made is clearly understood by all systems from the configuration tool all the way to the machine in the production facility.

### FYI: Using RAMI 4.0 for uniform standards

A key achievement of the Plattform Industrie 4.0 from the past months is the uniform “reference architectural model for Industrie 4.0 – RAMI 4.0”. RAMI 4.0 combines the important technological elements of Industrie 4.0 in a standardised model for the first time, thereby providing companies from different sectors – from manufacturing automation to mechanical engineering through to process engineering – with a standardised guideline framework. RAMI 4.0 creates a collective understanding of norms, standards and case studies for everyone working on the Industrie 4.0 standards. RAMI 4.0 also helps in identifying relevant standards – according to the application scenario and solution. If there is not yet a suitable standard, RAMI 4.0 helps to detect these gaps. At the initiative of working group 1, the reference architectural model RAMI 4.0 has been certified and published as a DIN standard, DIN SPEC 91345. Furthermore, a major step has been made towards international standardisation of Industrie 4.0 Recently RAMI 4.0 has also been a topic of discussion at the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

This means that perfect communication must also be ensured between the configuration tool and intermediary service in the next process step as this service has a key role to play: It serves as the intermediary hub between the bicycle manufacturer (client) and the supplier (contractor) throughout the entire automated process. Communication can only take place successfully if all data and information are machine-readable and the data and machines understand each other using a precise and unambiguous language. Syntax and semantics are therefore a particularly important consideration.

It is important that the description of the bike handlebar in the configuration tool is sufficiently precise. Only then can an automated production be ensured and the exact delivery date, quality and price be determined.

**Security** In order to protect the data collected and recorded in the configuration tool – particularly against third parties – information must be classified according to its confidentiality level, i.e. whether that information should be classified as sensitive or not. At the same time the data protection requirements of the potential suppliers must be included in machine-readable form. Confidentiality can only be guaranteed if there is exactly the right amount of technical data for contractors to place a bid and for the sensitive information to remain protected.

**Labour and skills** In order to develop this kind of configuration tool the bicycle manufacturer requires staff who do not only understand classic engineering. Product developers and the purchasing department must have their eye on the entire process, beginning with the configuration tool and ending at delivery. Staff who input data into the system must have a wide range of skills such as knowledge on technology and materials as well as data management, legal and commercial expertise.

### Configuration tools of the future: One language fits all

Information is classified and cross referenced in ontologies. These can be used for arriving at logical conclusions, adding information and identifying discrepancies. All participants have access to the same knowledge and vocabulary.

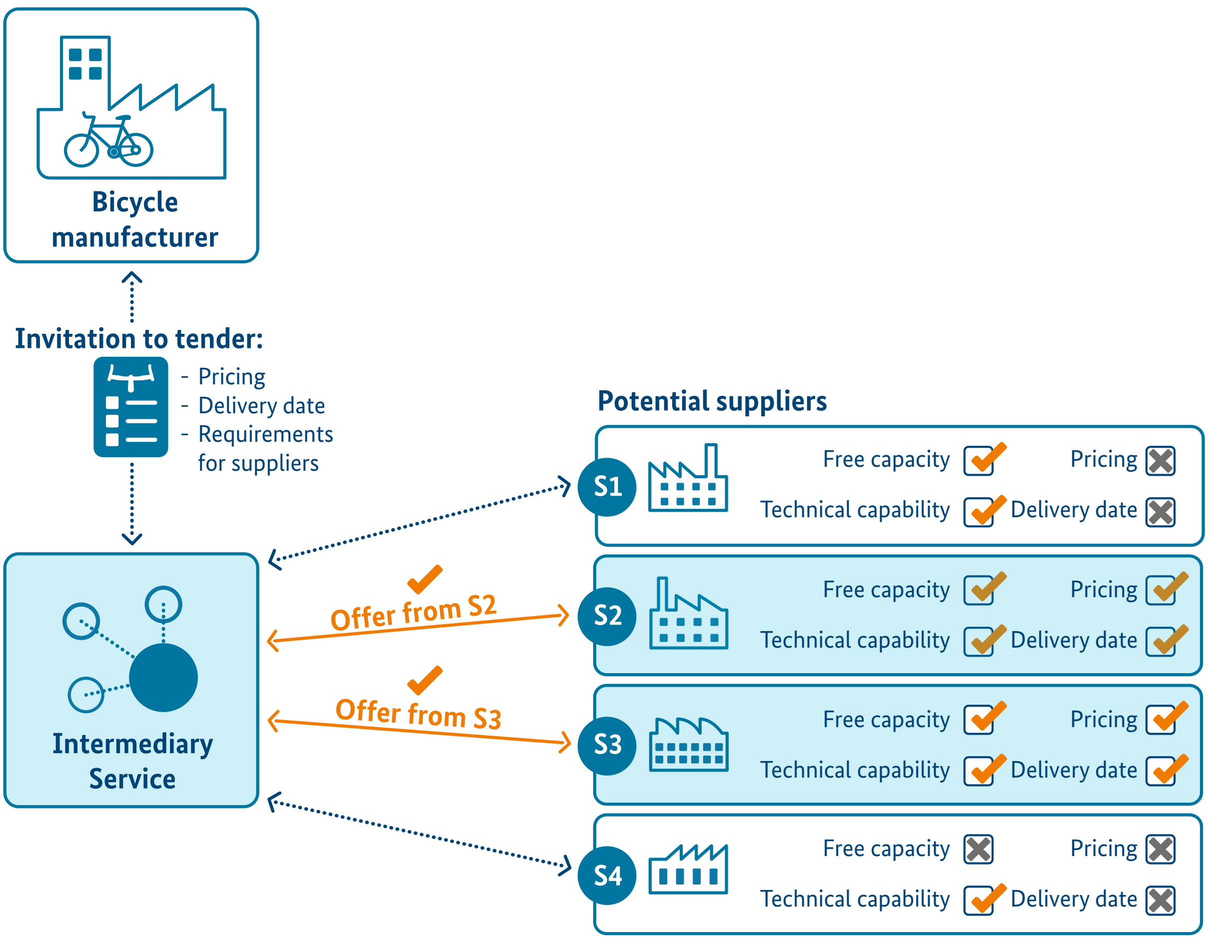
# Step 2: Invitation to tender

**Finds potential suppliers to produce the handlebar.**

In addition to the data from the customised configuration, in the second automated step the bicycle manufacturer's order management system provides potential suppliers with the necessary information for the tender process.
It is very important in this step that the data are machine-readable and are understood. This includes the anticipated price range and the desired delivery date. In the case of Peter Meier's e-bike, the handlebar should be delivered by the end of June at the latest for it to be assembled by the bike manufacturer by the time of his/her summer holiday to Lake Constance.

This is where the intermediary service comes into play: Using this information and the manufacturer's qualification requirements, the service automatically identifies suitable suppliers. Once the eligible suppliers have been determined, the intermediary service asks them to place a bid. Provided that suppliers have capacity and the necessary technical capabilities, an offer is automatically drawn up and sent to the intermediary service. Based on this, an algorithm identifies which suppliers meet the bicycle manufacturer's requirements and relays the selection of suppliers to the manufacturer. If a supplier makes an offer which is within the envisaged price range and delivery date then this supplier is classified as suitable – as long as the offer complies with all other requirements.

**Figure 4: A fully automated tendering process conducted by the intermediary service finds potential suppliers.**



## Invitation to tender in practice: From four angles

**Standards** & **Research** The aim of the example described here is an open (intermediation) platform. For this to occur it is essential that all involved-bike manufacturer, supplier and intermediary service – are able to cooperate as seamlessly as possible. This means that a standardised exchange of data and communication mechanisms are vital. At this early stage, in the second phase, the foundations are laid for all functions and for all of the later phases. This places very high demands on the content quality and level of detail in the information. The standards must include all necessary information for an enquiry via the intermediary service but also all the information pertaining to an offer by a potential supplier. This encompasses information on:

### Requirement meets property: Property-based description of Industrie 4.0 components in the administration shell

As part of numerous standardisation activities of factory automation and process automation, properties and property lists are drawn up and used to describe resources, processes and products.  As part of the Plattform Industrie 4.0 activities, the standardised administration shell uses this concept and describes Industrie 4.0 components based on their properties. This involves precisely characterising but also abstracting the desired properties. For instance, a CAD design and material characteristics can be abstracted using characteristic properties such as stiffness and radii of curvature. This ultimately protects the design – and thereby the intellectual property. At the same time this concept provides new freedoms with regard to technology, the manufacturing process and the product since a complete characterisation is no longer necessary.

- **Prequalification:** e.g. social standards for employees of the supplier
- **Order:** e.g. delivery deadline, delivery type such as "just in time" or "just in sequence", place of delivery, etc.
- **Technology and product, or more specifically, production:** e.g. material, shape, functionality, manufacturing technology
- **Optional, additional services provided by supplier:** e.g. production data, documentation or order status

Suitable models and description tools which can be automatically processed currently only partially exist in standardised form. Often vocabulary, protocols and interaction mechanisms are found scattered amongst different standards. This means that they are based on entirely different concepts and assumptions. Therefore: An intermediary service like the one described in the present example is currently unable to exist as there is still no shared, standardised language. All efforts must therefore focus on creating uniform standards and appropriate ontologies. Alongside the scattered standard components, larger holes are also evident, where even more intensive research must be conducted such as research into interaction mechanisms which enable systems to negotiate automatically (call for offers and submission of offers).

**Security** Bicycle manufacturers must guarantee the authenticity of the invitation to tender. This means that during secure transmission to the intermediary service, the manufacturer must be clearly identified as the client and the supplier contacted by the intermediary service as the contractor. The potential suppliers deliver their authenticated offers, which also contain an indication of the level of trustworthiness of the various trust and safety aspects of the supplier and his/her equipment. This shows the manufacturer to what extent the suppliers protect their own systems using IT and whether this fulfils the requirements.

**Law** Legally speaking it is necessary for all parties involved to make a (framework) agreement that establishes the basic rules of participation in digital order-controlled production. Possible content could include:

- Effectiveness of digital communication between machines ("machine declarations")


**Trustworthiness**

Environmental disturbances, human error, system failures and attacks – trustworthiness is the degree of assurance offered by the system with regard to these kinds of risks. All significant system features are included in this term such as security, privacy, safety, reliability and resilience. Both front office and shop-floor OT requirements must be fulfilled.

- Rights on information and technical descriptions
- Confidentiality, privacy, applicable law, place of jurisdiction

In practice the above-mentioned content is often already contained within preformulated contractual requirements (terms and conditions), which must be actively agreed between the parties involved. An agreement is also necessary on the role and tasks of the intermediary service as an intermediary for that order between the bicycle manufacturer and the supplier.

For a valid offer which the bicycle manufacturer is able to accept unamended, the information on the order must contain all legal agreements, technical requirements and any other requirements. This could include:

- Rules on the service provision (with quality requirements, quality assurance and quality documentation) with description of service to be supplied.
- Warranty, liability, applicable law, jurisdiction etc.

# Step 3: Selecting the supplier

**Algorithm finds suitable supplier.**

On the basis of the preselection delivered by the intermediary service, the bicycle manufacturer then uses an algorithm to automatically select the supplier who is to be commissioned. This process also takes into consideration the manufacturer's individual preferences. Therefore: The best offer that fulfils all the necessary requirements (legal, technical and commercial) is automatically awarded the contract.

## Selecting the supplier in practice: From four angles

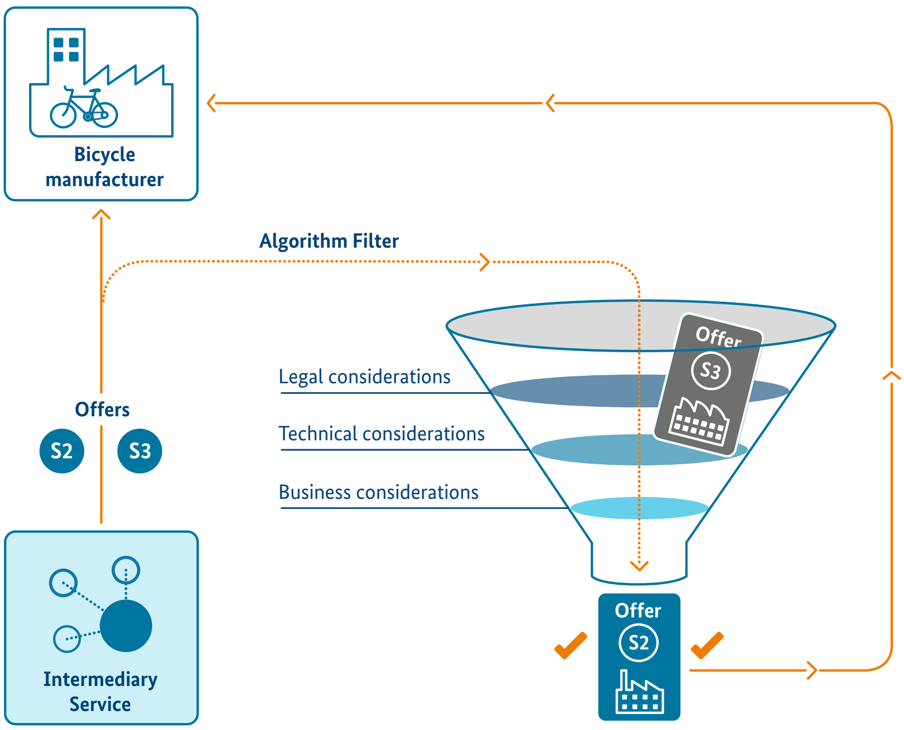
**Standards** All aspects have already been discussed in the second step "invitation to tender".

**Security** In this phase it should be ensured that the algorithm is running in the manufacturer's secured area or is protected appropriately against manipulation.

**Law** Whilst working within a platform economy the bicycle manufacturer should keep an eye on the extent to which the employees of the selected supplier enjoy basic social protection, for instance whether they have health insurance and receive the minimum wage.

**Research** If the offer should not just be verified to ensure it is suitable for the service required, but also service and price are to be automatically negotiated, research will be necessary on the topic of automated negotiation processes. Due attention must be paid also to the basic structure of the algorithms for the intermediation process, such as "broker" and "blockchain" based algorithms. Another aspect to be looked at is convergence during the selection and intermediation processes.

**Figure 5: The algorithm selects the offer of supplier 2.**

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# Step 4: Awarding the contract

**Automatically awards the contract to the supplier, who autonomously accepts this**

All information collected and prior agreements reached are taken into account when the contract is awarded and the selected supplier is automatically commissioned. The supplier is able to independently accept this order. An automatic contract is concluded between the IT systems. Subsequently the contract data and CAM data are transferred.

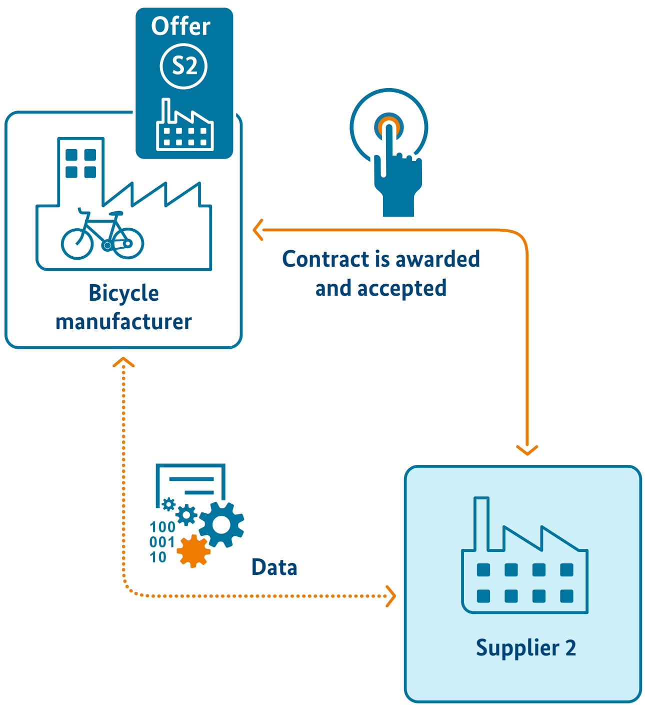
## Awarding contracts in practice: From three angles

**Standards** & **Security** In this fourth step it is important that all the required information is properly transferred in order to for the acceptance of order to become legally binding. Standardisation is imperative for this process and substantial progress has already been made in this respect. In addition to this it is essential that a standardised interface and uniform data formats exist in order to automatically exchange product and production data between the manufacturer and supplier and to use these data – also automatically – in both locations. Therefore: Information must be able to be used for configuring production directly without operator intervention. Particularly during the additive manufacturing of the bicycle handlebar, security plays a vital role before, during and after printing in protecting intellectual property, which can be safeguarded by means of digital rights management. Thus, it would be a good idea to technically safeguard how the specific custom design of Peter Meier's handlebar may be used by the supplier and, for instance, by the supplier's 3D printer (e.g. the quantity of bicycle handlebars).

**Security** Another important security aspect in this phase is that the order is authenticated, the contract verifiably awarded and successfully accepted. In this regard confidentiality must be ensured during the transfer of CAM data, which is sent directly to the 3D printer producing the bicycle handlebar. This is only possible, however, if clear and definite identification is guaranteed.

**Law** When a contract is awarded, a binding contract for the provision of a service is concluded with the supplier which the bicycle manufacturer has automatically determined as the most suitable provider. The message sent to the supplier from the manufacturer stating "the offer is accepted", shows the offer has been accepted without change. It is important to note that: If the order is automatically accepted, this can have a direct impact on the labour input of the supplier's employees. This can prompt a need for coordination between the supplier and its works council.

**Figure 6: Contract is automatically concluded between supplier 2 and the bicycle manufacturer.**

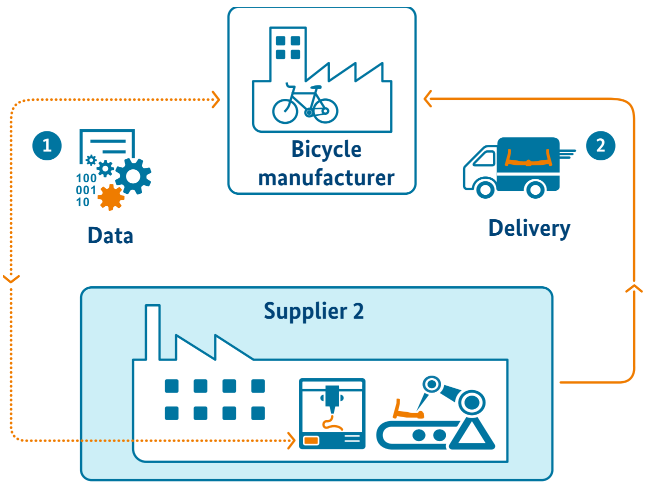


# Step 5: Manufacture

**Supplier manufactures the bicycle handlebar and delivers this to the bicycle manufacturer**

Finally, the supplier manufactures the desired bicycle handlebar. Here the client communicates all collected information that is relevant for manufacturing directly to the supplier's production facility – for instance to a robot or a 3D printer. The bicycle handlebar is identifiable over the entire course of production since the digital copy, or twin, of the handlebar contains all relevant data and information, also for quality assurance purposes. The bicycle manufacturer is kept informed about what stage the order is at and can see prior to delivery, for instance, whether the handlebar meets the quality requirements. Once the handlebar is finished, it is delivered directly to the bicycle manufacturer's production facility along with all of the agreed documentation data (product memory).

**Figure 7: The data flow between manufacturer and supplier production machine ensures accurate and transparent production with prompt delivery.**

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## Manufacturing in practice: From four angles

**Standards** The requirements or, more specifically, services which were described in the previous phases "invitation to tender" and "awarding of contract" – such as those regarding product tracking – must be met during manufacturing via appropriate, standardised information interfaces implemented by manufacturer and supplier. Furthermore, the requirements must be in a suitable format which enables them to be processed further automatically.

**Security** This phase is primarily about detecting quality deficiencies and manipulation. In order to do so it must be ensured that process data collected during the manufacturing process can be integrated into the product memory. Only the necessary and agreed data are sent to the bicycle manufacturer. Other data, which is subject to data protection regulations, for instance, must be safely removed whilst still in the supplier's hands. Confidentiality requirements must be observed if the product memory is sent to the bicycle manufacturer.

**Law** It is important to guarantee data protection during the manufacturing phase. During quality assurance, for instance, the supplier's employee data is processed and passed on to the bicycle manufacturer. There must be an agreement in the order that the contractor assumes full responsibility for the quality management of the handlebar with the appropriate documentation.

**Labour and skills** Certain roles may also be rearranged in the supplier's workplace and the classic conception of engineering, purchasing and the legal department undergoes changes. This leads to a demand for new skills such as skills in product development, buying and in the preparation and execution of 3D printing.

# Outlook

The present example shows a fully-automated process for finding and commissioning a supplier with the production of a custommade handlebar. This example intentionally focuses on a case that is as simple as possible to keep the example within reasonable complexity. The aim of this brochure is to demonstrate the considerations to be taken in implementing this scenario in the fields: standards, security, law, labour and skills. It also aims to show which solutions Plattform Industrie 4.0 offers in this regard.

Beyond the case looked at in this brochure, these kinds of application scenarios of Plattform Industrie 4.0 open doors to many further possibilities. It may be assumed, for instance, that whilst the order is being placed by the end customer, suppliers are already receiving the enquiry in realtime. This outcome then has an influence on the pricing in order to offer the customer different prices depending on the delivery date. In cases where the customer is granted great freedom in designing the product, the bicycle manufacturer might be taking on sub-stantial risk by naming the customer a price without having clarified his/her own costs for the delivery and the delivery date before-hand.

The example illustrates right from the outset that complex products, such as the individual bicycle handlebar, progressively intertwine supplier relations leading to the development of highly dynamic value creation networks. However, this will only become reality once contracts can be awarded automatically and independently.

At a technical level, communication protocols already exist for an exchange of information as in the example between the bicycle manufacturer and the supplier. But there is still more to do: Enabling order-controlled production means developing the automated negotiation of security requirements and measures as well as cross-company identity management.

What's more: The more complex the product, the more probable it is that one simple enquiry to be answered with "I will deliver for that price" or "I will not deliver" will no longer be sufficient in order to build supplier relations. A possible solution in these cases: a completely autonomous negotiating process to take into account the different interests of the bicycle manufacturer, or client, (e.g. price, delivery date, etc.) and supplier, or contractor, (e.g. production capacity).

Looking ahead we can see: The rapid development of digitalisation is placing high demands on all areas of industrial companies – on technology, security, law, overall organisation and: on their employees. Provided that there is a strategic longterm plan within the company and the sector itself (nationally and at European level) for the skills needed in the future, it will be possible to avoid shortages of employees with the right skills. Thinking long-term and being proactive ensures that the appropriate technical expertise and qualifications can be offered and obtained in time and that the employees greatly benefit from the digital transformation.

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