Interreg
North-West Europe
COTEMACO
European Regional Development Fund
EUROPEAN UNION

Success Story

Process Automation Opportunities

Imp & Maker Ltd., UK

Automation

Company description

Imp & Maker is a small food business that produces luxury hampers and experiences for their customers from expertly sourced products. They are based at premises in Holbeach, UK. Their products are mostly sold through eCommerce routes, and it is known that to continue to be competitive, they will need to expand at a rapid rate. They are currently expanding into other markets such as sub-contract packing for external companies and higher volume hampers for retailers. Imp & Maker see the luxury food and drink eCommerce market growing substantially. Their aim is to be market leaders through quality and value perspectives and understand the only way able to compete in the sector is to be able to handle and pack products efficiently. They have a choice: employ large numbers of staff or automate. Growth through automation is seen as cheaper and more sustainable in the longer term given the growing difficulties in finding employees.

Goal

The aim of this COTEMACO support is to assess the current production processes at Imp & Maker and provide an automation roadmap to underpin future business growth. This will provide multiple stages and options which take their current manual process towards a fully automated one.

Current processes

The current production is several hundred hampers monthly with the expectations of sales to increase 10-fold to several thousand per month over the next 2 years. Currently all packing is performed manually, and this is a major limitation to growth. As sales volumes are increasing, Imp & Maker engaged with the COTEMACO SME support programme to devise methods to increase hamper production capacity whilst limiting the number of people employed in unrewarding packing roles.

The current basic production operations are:

1. Product intake (and QA checks)
2. Wrapping of some products in paper hex wrap
3. Storage of products in individual stock containers in ambient, chilled, and frozen stores.
4. Formation of hamper box
5. Insertion of "Woolcool" insulation into the hamper box
6. For each batch of identical hamper boxes, collect products from the various stock stores and bring to central packing table.
7. Collect cool packs from frozen store
8. Packing of products to hamper box
9. Insertion of void fill and information flyers

10. Box taping and labelling.
In the current site configuration this involve substantial movement around the facility (Figure 1).

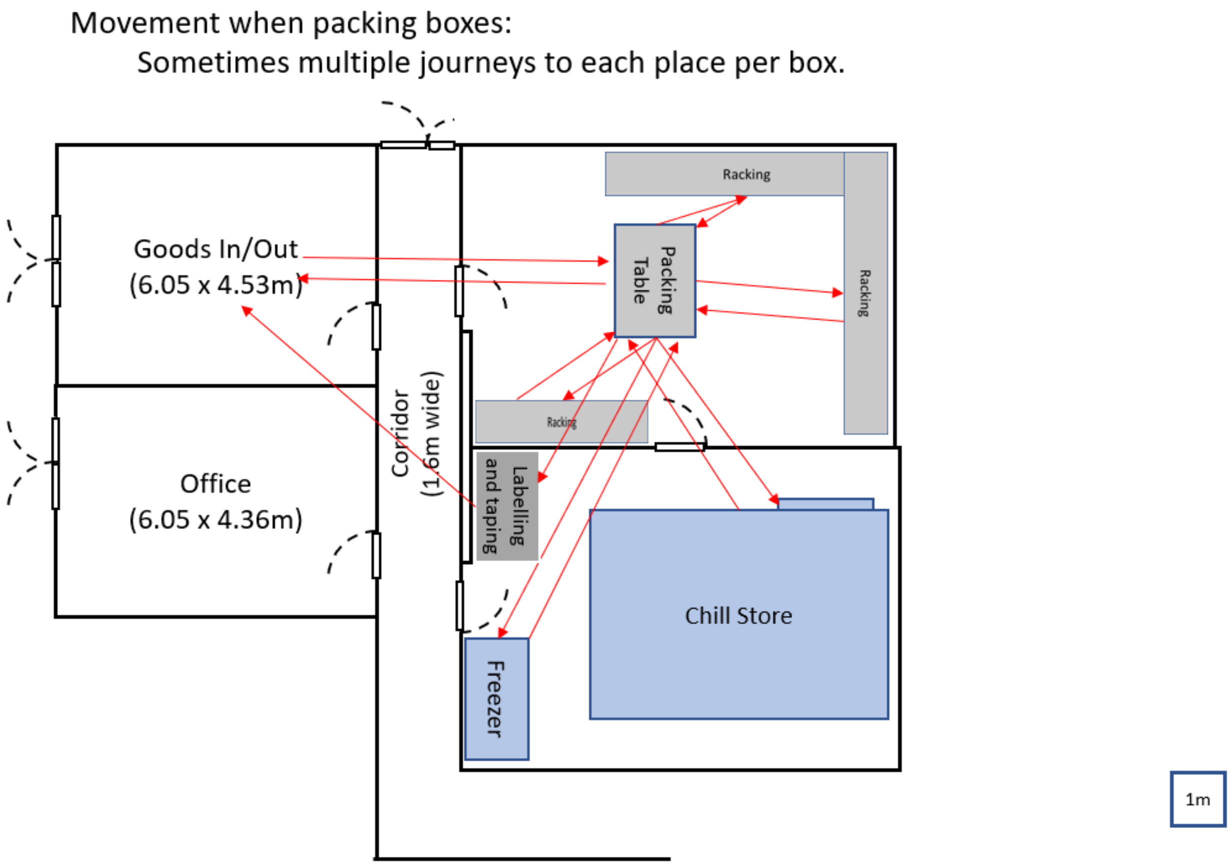

Figure 1. Movement of staff around the factory when creating a hamper box. Often multiple journeys are made between each location.

Several of the operations are ancillary, not in the main flow and could be initially performed manually and automated ad hoc at a later time. These ancillary operations are:

2. Wrapping of products in paper hex wrap;
4. Formation of hamper box;
5. Insertion of Woolcool insulation.

10a. Hamper box taping,
10b. Hamper box labelling;
Existing dedicated automation can be purchased for most of these ancillary activities.

SME Support Activities

An initial assessment of the production operations was carried out to identify bottlenecks, effort intensive operations, and issues where automation could provide business benefit.
The long-term objective of fully automated packing of hamper boxes poses several substantial technical challenges and it was deemed imprudent to attempt this as a first foray into automation for Imp & Maker. A staged automation roadmap with initial implementation of simpler automated equipment, but working towards the long-term objective was proposed. This would bring more immediate business benefits and

start building the technical skills within the business in readiness for the longer-term objective of fuller automation.
Fully automated co-/ro-botic packing is a non-trivial task and would require substantial R&D due to:

- Products to be packed are non-uniform and vary substantially in size, shape, and weight. The products' packaging materials and formats vary greatly requiring a range of grippers to handle all successfully.
- Requirements for tight packing of these products into a hamper box of fixed size with minimum dunnage limits space for gripper systems when placing products.
- Chilled products need to be kept cool by icepacks added on top, but not in such a manner that could cause drip damage to card/paper packaging.
- Any combinations of product could be in any hamper box.

Whilst solutions to all these requirements are possible, no off-the-shelf commercial automation systems could be located to perform these requirements and hence the staged approach building skills towards the long-term objective was adopted.

Initial Steps

Initial observations of the process showed that step 6 was the main time-consuming part of the operation. This involved multiple trips between stores for each hamper box, taking approximately 75-80% of the packaging time irrespective of box size. This non-value adding task took c.4 minutes for small simple hamper boxes, and c. 15 minutes for a larger more complex hamper box. This is the initial target for automated investment. If the products were fed to a packing station down a conveyor line fed by a robotic arm (revolute or cartesian) in each of the storage locations (Figure 2), this product collecting time would be substantially reduced allowing the staff member to focus on the value adding (and technically challenging for automation) packing of the products tightly into the hamper box.

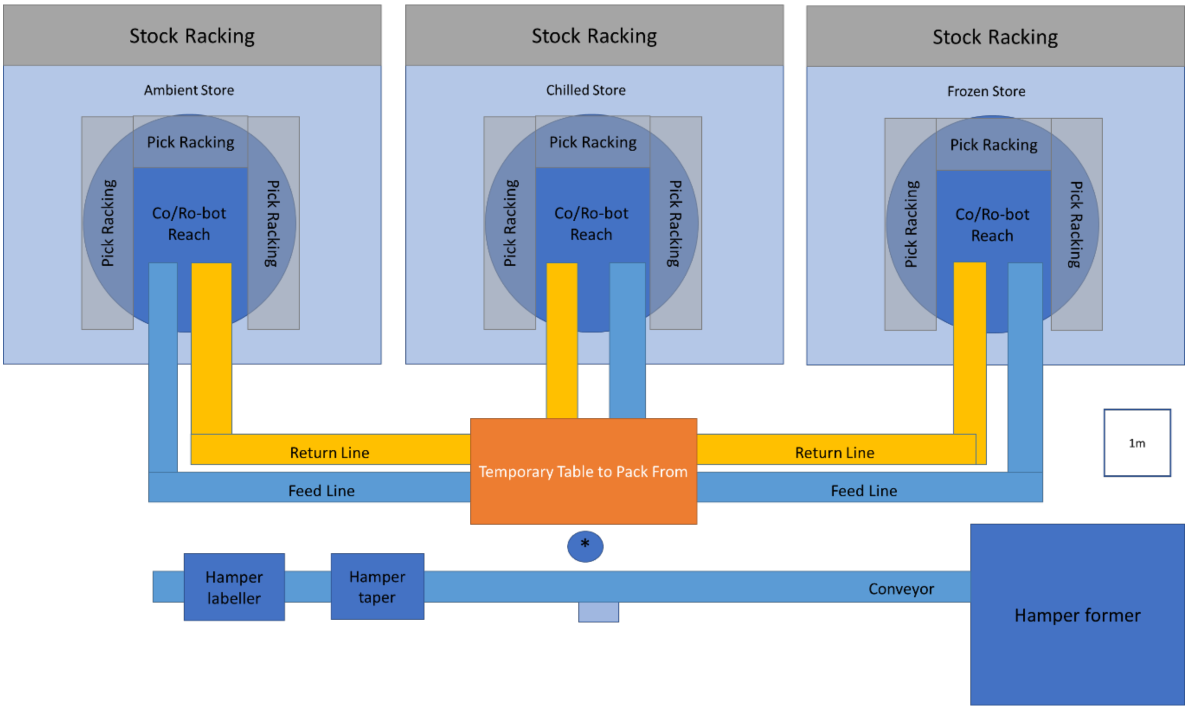

Figure 2. Stage 1 automated delivery of product to pack station.

In this scenario, the system would work thus:

1. Arriving products from suppliers received, logged to ERM, hex wrapped if required, and placed in stock.
2. Products in coded bins on pick racking within each store. Pick racking bins refilled manually from stock at start of shift (and if required mid-shift).
3. Customer orders from ERM system specifies products needed and order required at packing station to robot in each store.
4. Robots in stores place required product bins down feed line to pack station chosen using bin-coding (barcode, QR code, RFID, etc).
5. Product bins arrive at a pack station where they are manoeuvred by the packer into ergonomic position best to pack from.
6. Manually pack hamper boxes at the packing table with insertion of dunnage as required.
7. Once product bins are empty/finished with, the packer pushes them back onto the appropriate return line to be re-filled in the store.
8. Hamper former supplies hamper box to the packer. Woolcool is added.
9. Once packed, hamper boxes continue along the conveyor for taping and labelling.

As order volumes increase, the product bins could be fed onto a rotating conveyor with packer(s) around the rotating conveyor with a separate line feeding hampers, multiple hampers could be packed back-to-back without the packer(s) ever having to leave their station(s). Once the product bins in are empty, they would move back on the return line to be re-filled at respective store (Figure 3). Each of the 'packers' could, in time and with the required R&D, be a bespoke packing robot which would cope with packing all of Imp & Maker's products into a tight-fitting hamper. These technical challenges will be discussed in a later section.

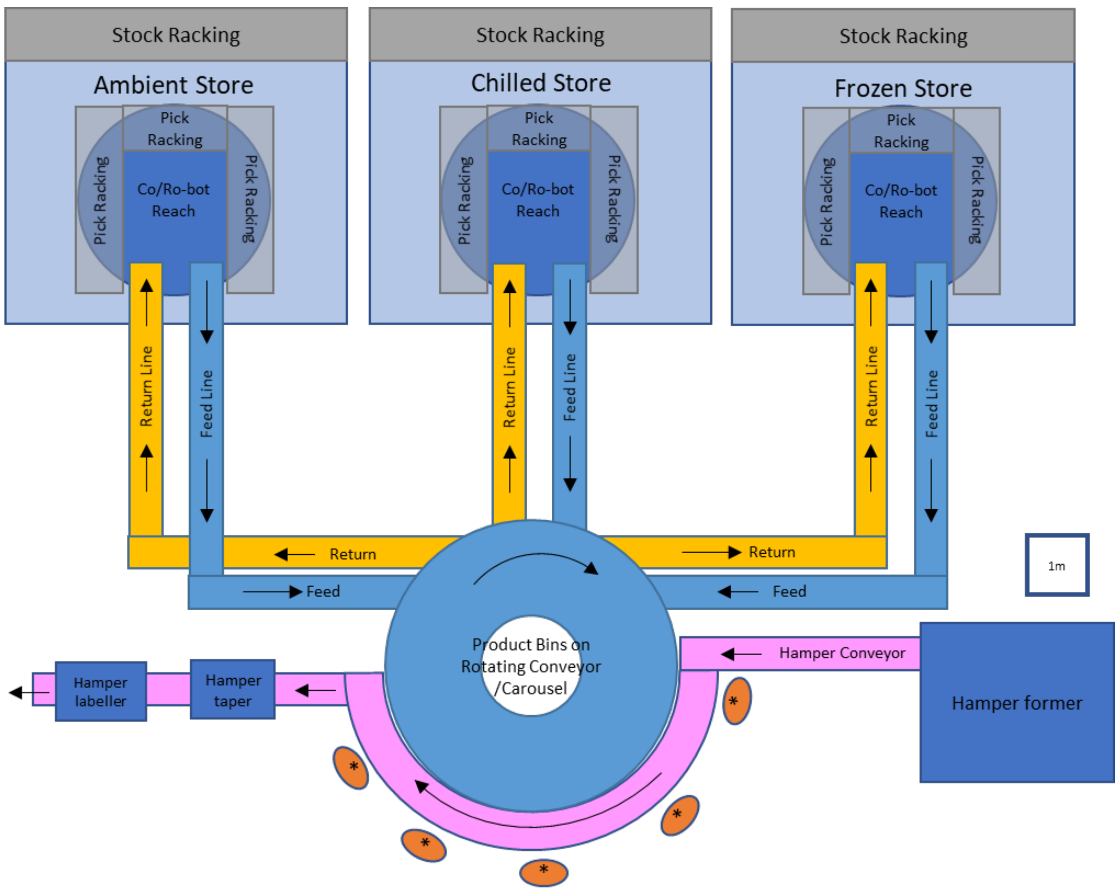

Figure 3. Packing from carousel of products.

Subsequent development of fully automated packing cell

The long-term objective of the automation roadmap would be to develop a packing robot which can grasp the wide range of products that Imp & Maker pack within their hampers and is also able to pack them accurately within the constrained space of the hamper. There are 3 key challenges

<u>Challenge 1: Gripper system for wide range of products</u>

The first challenge is in identifying a grasping system that can reliably pick a relatively random product (hex wrapped, flexible pack, and/or naturally variable biological produce) from a bin, and place it in the hamper where at times there will no clearance to either side. This limits the use of gripper fingers using closed-force or closed -form approaches as there will be no space to accommodate gripper fingers. 'Adhesive' grasping (vacuum, Bernoulli, etc) will not work for all products as some are naturally porous, and the required hex wrapping renders many other products effectively porous. The lay-up arrangements in hampers also varies with the same product being placed vertically in some hampers and horizontally in others. An anthropomorphic robot 'hand' mimicking the established manual process could perform the task, or a multi gripper type end effector is required. Whilst anthropomorphic robot hands are being developed, they have yet to reach full readiness for industrial deployment.
Some initial trials were carried out to investigate the range of Imp & Maker products that could be grasped with differing gripper types (Figure 4). These showed that the most viable end effector approach that could grasp the greatest proportion of the products would be a dual gripper head comprising inflatable closed form fingers and long bellows vacuum cups. Even then, not all products could be reliably grasped.

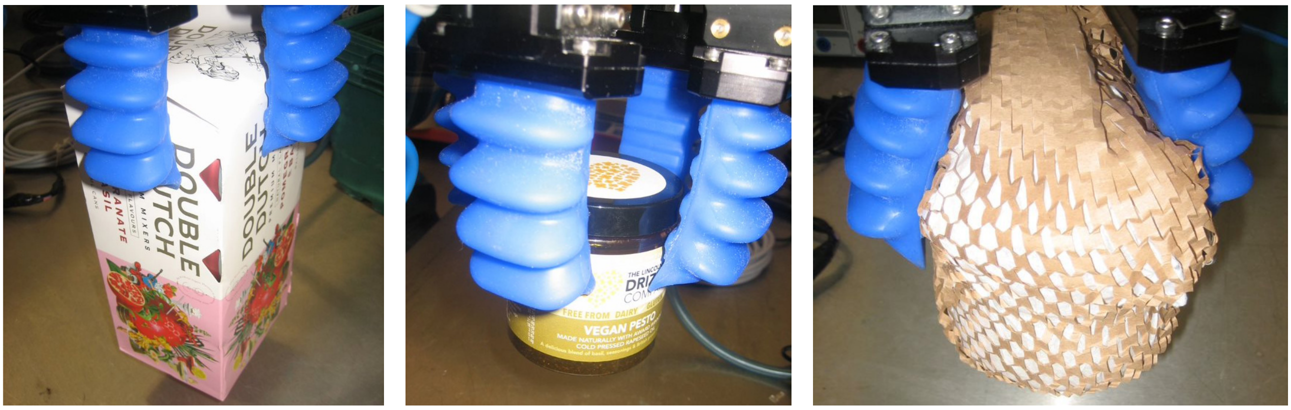

Figure 4. Images from initial gripper trials.

A second set of gripper trials were carried out with a more extensive range of gripper types, including Bernoulli grippers, vacuum cup grippers and a high-volume flow vacuum gripper. Six of Imp & Maker's products were used in the trials: a jar wrapped in hex paper (Bernoulli and vacuum cups failed to grasp, high volume air-flow vacuum gripper and four-finger soft gripper successfully grasped); mixer drinks in a cardboard outer cup (as on left in Figure 4) - Bernoulli grippers gave high pitched squealing noises as the packaging vibrated at high frequency, vacuum grippers (low-flow and high-flow) and 4-finger soft gripper successfully lifted; a small tin which all gripper types successfully lifted; a carton of fruit juice (both types of vacuum gripper successfully lifted); and a boxed Christmas pudding which no grippers could successfully lift (pictures in Figure 5).

A final gripper type that was not tested due to lack of availability, but which could be ideal for this application is the FormHand gripper. They claim to be universal grasping pads that can pick up many different products, whilst doing so using a low-pressure difference in combination with form-closure. Cost of this gripper system is c.€9,600.00. Trials would need to be undertaken with this gripper type to ensure that it would work on many of Imp and Maker's products prior to full recommendation. Marketing images can be seen in Figure 6.

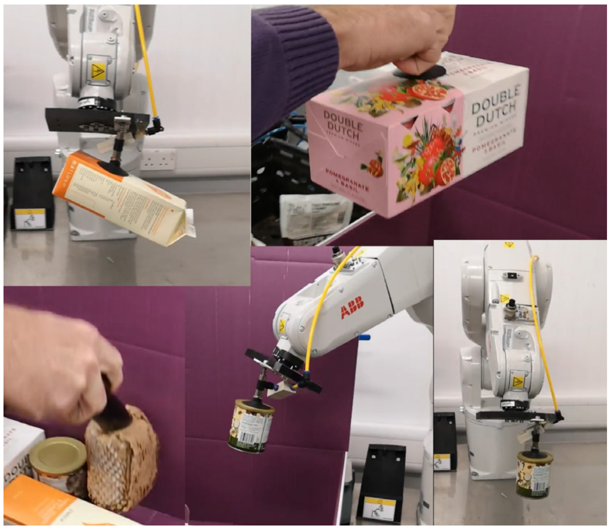

Figure 5. Images from second set of gripper trials.

<u>Challenge 2: Bin picking for non-uniform items</u>

Whilst bin picking algorithms and hardware are reaching commercial opportunity, these are mainly for known, often straight edged products with defined corners. Not all food products and/or packaging to be packed here exhibit those properties, but automated bin picking could be possible for un-hex-wrapped rigid products such as tins and tubs. The most pragmatic approach for the other products would be to use a spacer in the pick bins to separate and align products to a known position and orientation for simpler grasping.

Figure 5. Images from second set of gripper trials.

<u>Challenge 3: Packing of non-uniform items into constrained spaces</u>

The third challenge is in the algorithms to pack non-uniform products tightly into a constrained volume of fixed dimensions. There is some research work addressing this but majority in 2D, this application requires an extension into 3D techniques. One shorter term approach adopted so far is to have a predetermined packing arrangement for each hamper box type. The success of this is subject to the dimensional variations of the fruit, vegetable, meats and cheese block products.

The recommended implementation approach is to initially automate the packing of the simpler, lower product number, higher sales volume hampers to reduce complexity and degrees of variation to be dealt with, and to build techniques and expertise that can subsequently be applied to packing more intricate hampers.

Some products will remain difficult to pack automatically and may need some manual input.

The longer-term factory layout would be broadly the same with this robot, which would be deployed alongside human packers at the carousel (Figure 3). These cobot packer systems would be multiplied up as demand required.

The complexities of fully automated packing with a wide range of variable products into a constrained space are substantial and may require a future academic-industry partnership to create an industry-leading bespoke system. This may create additional intellectual property (IP) for Imp & Maker to exploit but is not in the core business and should be approached cautiously.

Ancillary automation

The previous sections deal with automation of the core challenge of packing products tightly into hamper boxes. As the long-term goal for this business is to fully automate the entire process, the ancillary operations must also be assessed for readiness of automation.

Figure 7. Hexcel-wrap paper dispenser.

Receipt of goods will remain manual as QA checks for incoming goods requires visual inspection of products, and the process also has to deal with a disparate range of possible incoming packaging arrangements including damaged in transit products.

Hex wrapping of some products could be performed robotically but this will pose similar handling/grasping challenges for the wide range of products as the core robot packing operation. As not all products are wrapped this is considered best dealt with later when grasping challenges of the products range is better understood and automation skills have increased within the business. In the shorter term, a wrap paper dispenser (Figure 6) would ease the manual task.

Hamper box erection could be automated with bespoke dedicated automation (hamper box design dependent) or a robot folder could be developed.

The Woolcool insulation needs to be placed into the hampers in a very specific way to provide the best presentation, thermal insulation, and physical protection of products. Initial searches showed no current off-the-shelf systems are available to make this an automated process. As with hex wrapping this is an operation that could be automated, but is considered best left to later in the evolution of the automated systems at Imp & Maker. Current manual processes place Woolcool in c.15s, so this is not currently a bottleneck process.

Paper void fill to prevent movement of products within the hampers is one of the final additions to the hampers before taping. Dedicated automated void fill dispensers (Figure 7) could save a small amount of time instead of creating this manually.

Hamper box taping and labelling can be performed with off the shelf dedicated taping and labelling automation (Figure 8, Figure 9). Automation of these operations would only save a small amount of time per hamper box, so are lower priority in the roadmap, but do form part of the long-term objective of a fully automated process.

Finally, to operate the robotic system described in the sections above, an inventory management system would be required, ideally driven by, and reporting to, the eCommerce digital systems/ERM.

Figure 8. Paper void fill dispenser.

Figure 9. Semi-automated case sealing machine

Figure 10. Automated Case labelling system.

Implementation

At the time of writing, Imp & Maker are considering the automation roadmap and preparing to implement initial stages. Further steps will be reviewed and implemented as time progresses and the enterprise grows. Business growth will be both the driver and financial enabler for adoption of further automation.

Interview

Impact of COTEMACO support on the Business

The owner commented: The COTEMACO project has provided a roadmap which is a great start towards the full automation that the business needs in order to expand in line with the business plan; it was great to work with the COTEMACO team; the next steps are to get quotes for the exact kit that is needed, and the business is eager to get this implemented.

How could COTEMACO support you?

Via the SME support programme, COTEMACO engages with SMEs from the automotive and food sectors through field labs. These regional field labs in the UK, the Netherlands, Belgium and Germany are showcasing key production steps in the automotive and food industries, in order to tackle current low sectorial awareness and knowledge gaps. The field labs will exchange knowledge on different manufacturing tasks, such as handling and (un)loading.

With the COTEMACO programme, manufacturing SMEs are guided through the process of adopting collaborative robotic and shop floor digitalisation technologies, from the exploration of technological opportunities to the detailed definition of a business plan.

What is COTEMACO?

The project, which is an initiative of Interreg North-West Europe, aims to support around 60 SMEs in the automotive and food manufacturing industries with so-called „test environments“ and to encourage them to integrate collaborative robotic systems and digital technologies into their business. Accordingly, in addition to increasing production flexibility, the relocation of production abroad will be curbed and the number of jobs in manufacturing increased, which will generally lead to an improvement in the competitiveness of the companies involved.
In the project new technologies are implemented in application examples - the aim is to move from the prototype in the laboratory environment to the transfer to production, taking into account the legal situation and certifications.

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