

Robotic Challenges in Manufacturing for the First Open Call for ESMERA Experiments (ESMERA-FOCE)

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Glossary/ Acronym Terms

ESMERA: European SMEs Robotics Applications

SME: Small and Medium-sized enterprises form a specific target group for the experiments and the CCs in ESMERA. The term is used in exactly the same way as defined by the EC (<http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/>).

Experiment: An experiment is a small to medium sized scientific research and/or technology development project carried out by a team of at least one SME and potentially additional research institutions, robot manufacturers and robot and automation users, which typically lasts no longer than 9 months.

CC: Competence Centre is a physical infrastructure supporting different user groups by providing state-of-the-art hardware, software components, and support in form of experienced staff.

RTD: Research and Technology Development

ICT: Information and Communication Technology

Robotic Challenges in Manufacturing for the First Open Call for ESMERA Experiments

The ESMERA project calls for contributions that propose solutions to three given real-life challenges in the manufacturing area defined by industrial end users. Such technologies may involve fully/nearly autonomous robots or human-robot collaboration applications which should be able to be demonstrated in real-world scenarios. In the first challenge, we ask SMEs to develop a solution to “**Wire Harness Assembly Tasks**” problem in the assembly area with “**ESMERA-M.1**” Challenge ID. The problem description, desired robotic technology and the supports from the Challenge Provider, [ELVEZ Doo](#), is explained in Section 1.

In the second challenge in manufacturing area, we ask SMEs to find a solution to “**Dishwasher Door-Gasket Assembly**” problem in assembly area with “**ESMERA-M.2**” Challenge ID. The problem description, desired robotic technology and the support from the Challenge Provider, [Arçelik](#), is explained in Section 2.

In the third challenge in the manufacturing area, we ask SMEs to find a solution to “**Paint Quality Check**” problem in the processing area with “**ESMERA-M.3**” Challenge ID. The problem description, desired robotic technology and the supports from the Challenge Provider, [TOFAŞ Türk Otomobil Fabrikaları A.Ş.](#), is explained in Section 3.

1. ESMERA-M.1 – Wire Harness Assembly Task

1.1. ESMERA-M.1 challenge description

Introduction

Information Communication Technology (ICT) is entirely dependent on the exchange of signals and information through a chosen medium. In the future, the physical medium in the form of wire, cable and cable harness cannot be completely avoided. Cables as the central power and signal interface element of the ICT establish links between several devices and electronic systems. Since the complexity of ICT systems is growing rapidly, the manufacturing techniques of cable harnesses become more and more important and sometimes even critical.

The current process

Production of cable harnesses is a very time-consuming work that is mostly performed manually. Existing manual or semi-automated manufacturing techniques for wiring harnesses are characterised by highly labour-intensive operations and thus are very sensitive in terms of quality assurance. All these circumstances significantly impact the productivity and economic factors. Solving the problems by outsourcing the manufacturing to countries with cheap labour is no longer acceptable. To avoid this, the producers are looking for a fully automated production of wire harnesses to replace the manual one. However, production trends in the field of ICT are going in the direction of smaller lots characterized by the continuous variability and the need for rapid adaptation to market requirements. However, the low flexibility of the fully automated production process is not able to react quickly to the market changes and the product variability. Furthermore, the production efficiency strongly depends on the connector technology that is used. The current scenario can be seen in [here](#).

Challenge scenario

In this call, we are looking for a robotic system which is able to fulfil the taping of the wire harness with insulation tape while collaborating with a human or another robot. It is expected from the robotic solution to perform the following tasks:

STEP 1: A worker first inserts first wires with connectors into assembly jig as in Figure 1.1.

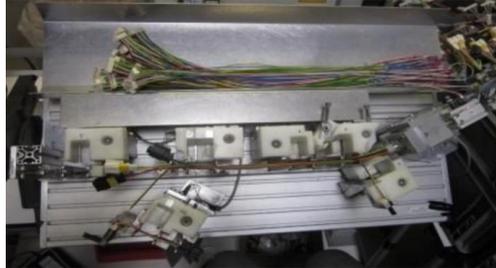


Figure 1.1. Insertion of the first wires into the assembly jig

STEP 2: Collaborative system spot tapes with insulation tape the wire harness on 1 spot as in Figure 1.2.

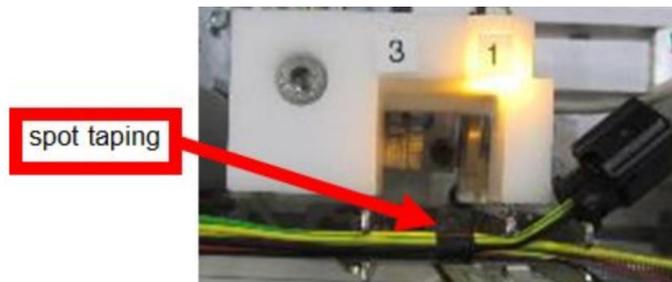


Figure 1.2. The spot taping procedure

STEP 3: The worker inserts first wires with connectors into assembly jigs as in Figure 1.3.



Figure 1.3. Assemble of wire harnesses and the spot taping process

STEP 4: The collaborative system spot tapes the wire harness with isolating tape on 7 spots shown in Figure 1.4.

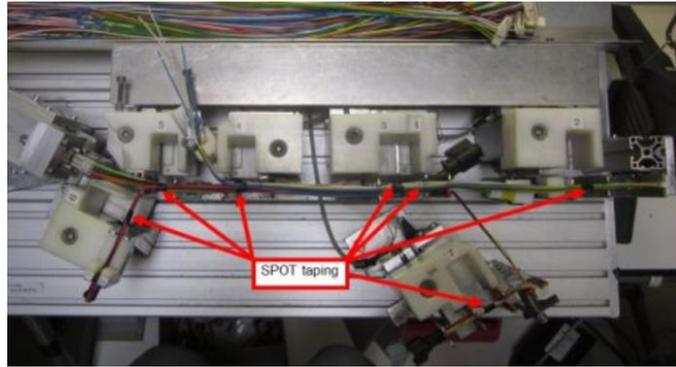


Figure 1.4. The spot taping process

STEP 5: A worker spot tapes the blue and white wire during the time when the robot is spot taping as in Figure 1.5.

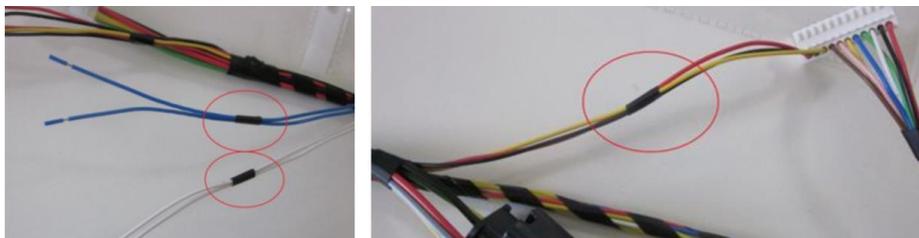


Figure 1.5. Spot typing process done by a worker

The cable assembly with marked taping spots can be seen in Figure 1.6.

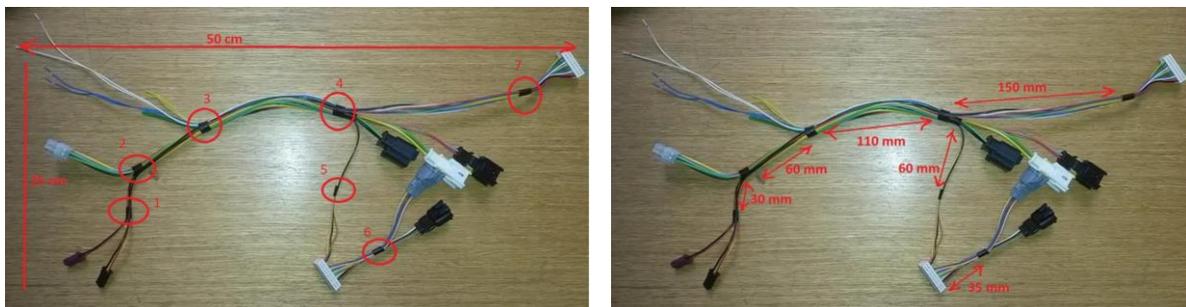


Figure 1.6. Cable assembly with marked taping spots and with dimensions between taping spots

For spot taping, the taping pistol in Figure 1.7 is used.



Figure 1.7. Taping pistol

General requirements

The following list describes important requirements for the end user that will be evaluated positively for each proposal.

1. **Standardization:** Process will be evaluated according to the following automotive standards: Production Part Approval Process (PPAP), Measurement System Analysis (MSA), Failure Mode and Effect Analysis (FMEA), Special Characteristics (Cmk, Cpk).
2. **Lean manufacturing adaptability:** The system allows the end user to apply lean manufacturing methods (POKA-YOKE, Single-Minute Exchange of Die (SMED) method, Value-Stream Mapping (VSM)). The expected takt time is 500 parts per shift in 22 secs with 10% tolerance.

Performance metrics

In addition to other metrics specified by the experiment consortium to demonstrate the efficiency/performance of the solution, the following metrics by the Challenge Provider will also be evaluated:

1. **Cycle time:** Same or shorter cycle time when compared to human (for current process 25s/part to 20 s/part).
2. **Ergonomy:** It is expected from the system to put less strain on worker.

Worker needs a lot of time to perform the taping of harness. In case that a cobot is used for the taping task and the taping task is done simultaneously, it may save up 4 secs. To show the importance of the time, it should be noted that 1 second corresponds to 1€ in wire harness process.

1.2. Support to the experiment

Support from the Competence Center

The TUM CC is responsible for the challenge and the currently available equipment list can be seen in our [website](#). The environment for the experiment is set in TUM CC and the selected proposals can test/develop their solutions in TUM CC (other CCs are also able to support the development).

Support from the Challenge Provider

The Challenge Provider will provide a layout of the production of the cable harness and the specification of the taping gun for a robot (3 kg weight, 270x150x50 mm dimensions, 6-bar compressed air). In addition, the Challenge Provider will provide testing fixtures for assembly of wires harness. In the end of the product development process, the company will provide their production line to test the developed solution.

2. ESMERA–M.2 - Dishwasher Door-Gasket Assembly

2.1. ESMERA-M.2 challenge description

Introduction

In dishwasher production, the assembly of door gasket is an important and critical process. The gasket is used for preventing water leakage between the door and the inner tube which may not only cause a mass but also may cause dangerous situations such as electrical hazards. The assembly of the gasket is done by hand since it is a critical operation and it is hard to robotize it due to the elastic nature of the gasket as can be seen in Figure 2.1. Moreover, the model of the product changes in approximately 1-year periods and it is preferred to use robot because of the model variability.



Figure 2.1. Dishwasher schematic and its inner gasket detail

The current process

In every assembly line, one person is allocated for the gasket assembly process. Pre-cut gaskets are delivered to gasket-door assembly area. In the current process, an operator takes the gasket from the container and firstly pushes the beginning of gasket against to surface to place the beginning part of gasket into the canal which is specially designed for the gasket placement in the inner wall of the dishwasher. After that the operator pushes gasket upwards through the canal instead of pushing against the surface. The operator applies force until the gasket is placed. The general view of the station can be seen in Figure 2.2.



Figure 2.2. General view of the station

Every dishwasher is tested after they are produced.

If the gasket is not properly assembled, it causes a water leakage and the dishwasher has to be turned back to the production and a new gasket is assembled instead of the previous one. After reassembling process, the dishwasher is checked again for all tests. Rework causes material cost, handling cost, extra energy and water consumption for testing. The layout of the process can be seen in Figure 2.3.

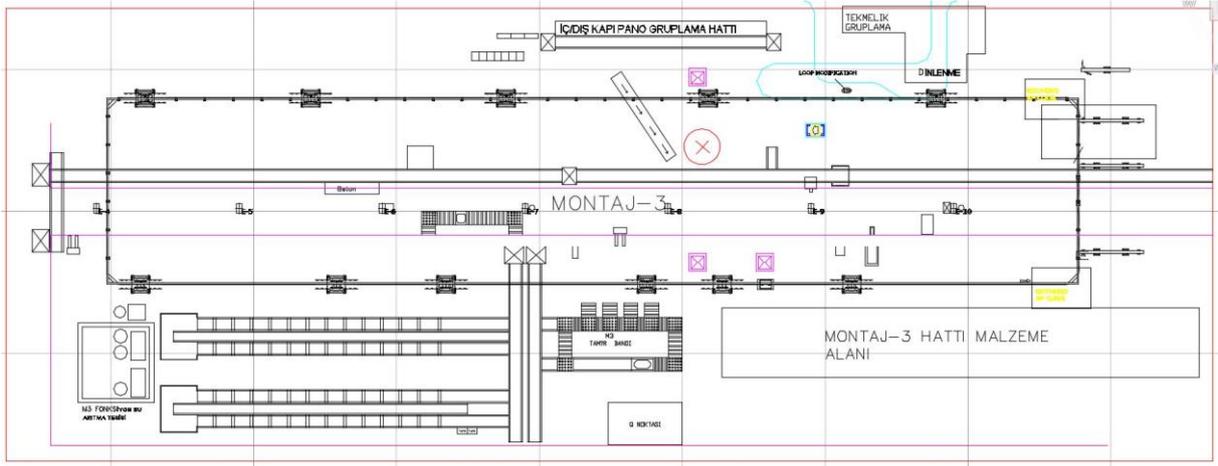


Figure 2.3. Layout of the production line (x shows where the station is)

Challenge scenario

Task sequence: The current process is manually done by an operator. In this call, we are looking for a robotic system which can perform the following tasks:

STEP 1: The inner surface is soaked with soapy water as in Figure 2.3.



Figure 2.4. Brushing soapy water process

STEP 2: A gasket is picked from the gasket storage area.

STEP 3: The gasket is assembled on the inner tube as the manual operation in Figure 2.4.



Figure 2.5. Assembling the gasket on the inner tube
The current process can be seen in the [video](#).

General requirements

The following list describes important requirements for the end user that will be evaluated positively for each proposal.

1. **User friendliness:** The robot should be easily calibrated/operated with intuitive user interfaces.
2. **Easy and fast setup:** The solution should be easily set and can be easily reprogrammed for task reallocation.
3. **Collaborative and safe:** If the solution involves a collaborative robot then it should be able to work with a human or another robot without any safety risks. The developed solution should consider requirements of international standards.
4. **Supporting OPC UA:** The final solution should satisfy the conditions or provide compatibility for Object Linking and Embedding for Process Control Unified Architecture (OPC UA) which is a machine to machine protocol for industrial automation developed by [OPC Foundation](#). Although this is not explicitly required for the proof of concept, it should be considered for the later stages of the experiment.
5. **Space restrictions:** Due to the current shop floor layout there is limited movement and working area in the gasket assembly workstation.

Performance metrics

In addition to other metrics specified by the experiment consortium to demonstrate the efficiency/performance of the solution, the following metrics by the Challenge Providers will also be evaluated:

1. **Cycle time:** The target cycle time of the process is 15 secs.
2. **Minimum water leakage failure incidents:** There should not be any leakage in the system after the assembly of the gasket. The percentage of OK/NOK accurate detections could be used for the evaluation. Other metrics may also apply.
3. **Flexibility:** The system should be able to handle three different gaskets for four different dishwasher models (45, 60, 90 lt and built-in).

2.2. Support to the experiment

Support from the lead Competence Center

The LMS CC is responsible for the challenge and the currently available equipment list can be seen in our [website](#). The replicated manufacturing environment will be prepared by the LMS CC in their premises and will be available for the selected experiments to test/develop their solutions. Other ESMERA CCs will also be available to support the experiment development process.

Support from the Challenge Provider

The Challenge Provider will provide the required parts (dishwasher door, gasket, etc) for LMS CC. In addition, the Challenge Provider may also provide an assembly station environment in their production technologies lab, Atölye 4.0, for testing purposes in the end of the Phase I. Moreover, the company may provide some expert personnel in the area of automation who will be able to guide the SMEs during their solution development.

The ESMERA project calls for contributions that propose solutions to three given real-life challenges in the manufacturing area defined by industrial end users. Such technologies may involve fully/nearly autonomous robots or human-robot collaboration applications which should be able to be demonstrated in real-world scenarios.

In the third challenge in the manufacturing area, we ask SMEs to find a solution to “**Paint Quality Check**” problem in the processing area with “**ESMERA-M.3**” Challenge ID. The problem description, desired robotic technology and the supports from the Challenge Provider, [TOFAŞ Türk Otomobil Fabrikaları A.Ş.](#), is explained in Section 3.

3. ESMERA–M.3 – Paint Quality Check

3.1. ESMERA-M.3 challenge description

Introduction

Paint application is one of the most demanding aspects of automobile manufacturing. It not only considers the paint as protection coating for the body surface, but also enhances visual appearance by adding colour and gloss which are important from a marketing point of view. The painting process is done by electrostatic principle via automated robots in ex-proof, conditioned paint booths where the paint coating thickness must be between 84-280µm. Besides the thickness, levelling (orange peel) and colour measurement, gloss rate are the other important factors that affect the car paint quality. After painting process, the previously mentioned measurements are performed by an operator manually. For the measurement, the devices in Figure 3.1. are used.

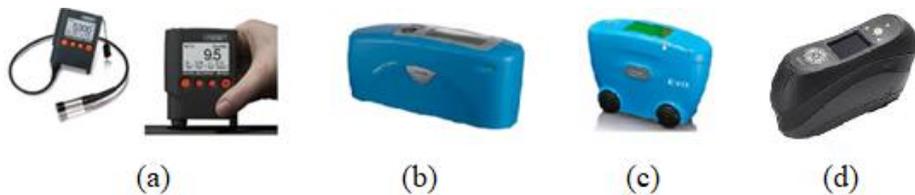


Figure 3.1. Equipment used for paint (a) thickness, (b) gloss, (c) levelling and (d) colour check

Besides the automobile industry the solution can be used in any sector to check paint quality such as white goods.

Challenge scenario

In this call, TOFAS is looking for a robotic system which can perform these quality checks automatically in painting process for commercial and passenger car produced in their production line. It is expected from the solution to give warning to the operator for rework/scrap process and to perform the following tasks:

- **Thickness measurement** via special probe: the robot checks the thickness of the paint on several defined points of a car body (around 30 points) using the thickness sensor whose details can be seen in [1],
- **Levelling measurement** via special probe: the robot checks the levelling on several defined points of a car body (around 20 points) using the levelling measurement sensor whose details can be seen in [2],

- **Gloss measurement** via special probe: the robot checks the gloss rate on several defined points of a car body (around 20 points) using the device whose details can be seen in [3],
- **Colour measurement** via special probe: the robots checks the colour on several defined points of a car body (around 30 points) using the sensor whose details can be seen in [4].

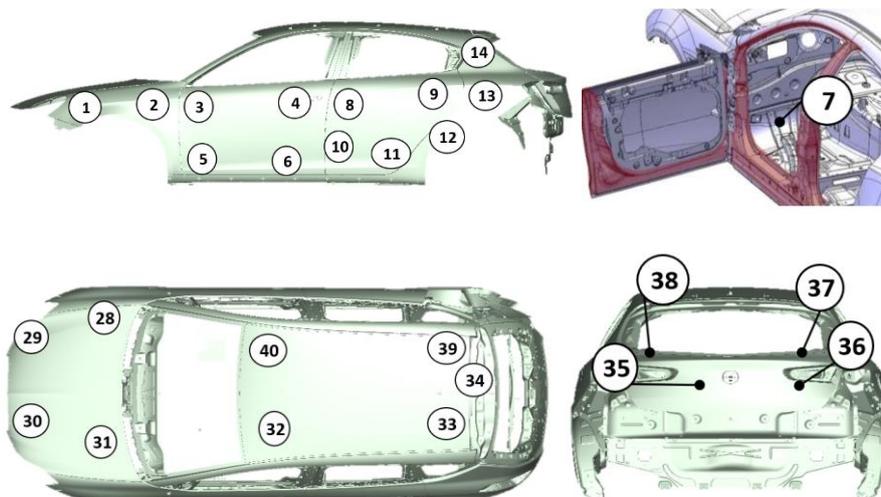
The current process

The system will be placed between the end of the paint shop and the beginning of the assembly shop where it will work in a protected cell. Figure 3.2 shows the station where the developed solution will be installed.



Figure 3.2. The place where the robot is placed in the production line

The measurements are done while the body is moving with 4.8 m/min speed and the system must measure the whole body with doors. For each measurement, sensors are used and the system takes measurements from predefined points which are scattered to whole car body as in Figure 3.3 and Figure 3.4 using the given sensors and the system should only touch the body with applying maximum 30-40 N forces. The same procedure is also done for the other types of the cars produced in TOFAŞ Bursa plant (e.g. light commercial vehicles).



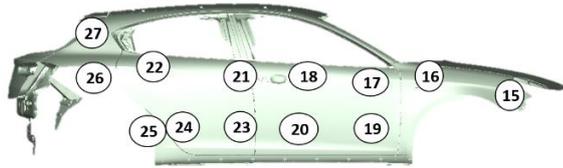


Figure 3.3. The predefined external points to measure the thickness of the paint in Sedan type cars

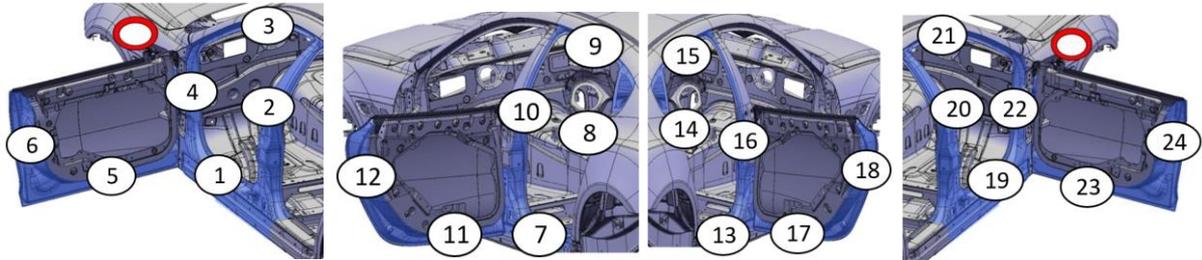


Figure 3.4. The predefined internal points to measure the thickness of the paint in 356 Sedan type cars

Currently, the process is done manually as in Figure 3.5, and 16 cars/day from each model are checked with manual control equipment. One operator is working per shift.



Figure 3.5. The current process

General requirements

The following list describes important requirements for the end user that will be evaluated positively for each proposal.

1. **Flexibility:** In the current process, 10 different car body should be checked in which the predefined points are distributed differently. It is expected from the system to be easily reprogrammed for task reallocation when changes are required.
2. **User friendliness:** The developed solution should have user friendly interface, and maintainability. The calibration may be done by a self-calibrating system for a robot.
3. **Data Storage:** The robot should have a data storage system for all controls/measurements. It will count positive if it is integrated with RFID system for car information up to 0.5 million autos.

Although the requirement of performing the process on a moving vehicle is of importance, the possibility of testing the solution in a static vehicle may also be considered if the complexity of the proposed experiment justifies this decision.

Performance metrics

In addition to other metrics specified by the experiment consortium to demonstrate the efficiency/performance of the solution, the following metrics by the Challenge Providers will also be evaluated

1. **Operation time:** The target duration of the task completion is 45 sec. (around 100 points in 45 secs.).
2. **Reliability:** The robot should have 100% OK/NOK decision capacity.
3. **Efficiency:** The robot should not affect the technical efficiency of the line (complete line technical efficiency is 98% which means there should not be more than 8.4-minute break in 7 hours).

3.2. Support to the experiment

Support from the lead Competence Center

The LMS CC is responsible for the challenge and the currently available equipment list can be seen in our [website](#). LMS CC will be responsible for replicating the manufacturing environment (in terms of dimension and weight) so that it will be available for the selected experiments to test their solutions. Other ESMERA CCs will also be available to support the experiment development process.

Support from the Challenge Provider

The Challenge Provider (CP) will provide the test parts (car body, etc) and the required information about the devices that are currently being used, in order to create the replicate environment. Moreover, the CP may provide their manufacturing line after a certain TRL level in Phase II. Finally, the company may also provide personal for the solution evaluation.

References

- [1] <http://www.fischer-technology.com/en/united-states/products/coating-thickness-measurement/>
- [2] <https://www.byk.com/en/instruments/products/index.php?a=1&b=14&c=&f=0&action=15&direct=1>
- [3] <https://www.byk.com/en/instruments/products/index.php?a=1&b=3&c=&f=0&action=15&direct=1>
- [4] <https://www.xrite.com/categories/portable-spectrophotometers/ma98>