PROJECT PERIODIC REPORT

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Project acronym: **STAMINA**

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Sustainable and Reliable Robotics for Part Handling in Manufacturing Automation

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1 Publishable summary

1.1 Summary description of project context and objectives

Part handling during the assembly stages in the automotive industry is the only task with automation levels below 30% due to the variability of the production and to the diversity of suppliers and parts. The full automation of such task will not only have a huge impact in the automotive industry but will also act as a cornerstone in the development of advanced mobile robotic manipulators capable of dealing with unstructured environments, thus opening new possibilities in general for manufacturing SME's. The STAMINA project uses a holistic approach by partnering with experts in each necessary key fields, thus building on previous R&D to develop an autonomous and mobile industrial robot with different sensory, planning and physical capabilities that can be part of a fleet of robots and which can solve two logistic and handling tasks: De-palletizing, and Kitting. The robot and orchestration system is developed in a lean manner using an iterative series of development and validation testes that will not only assess the performance and usability of the system but also allow goal-driven research. STAMINA gives special attention to the system integration promoting and assessing the development of a sustainable and scalable robotic system to ensure a clear path for the future exploitation of the developed technologies. In addition to the technological outcome, STAMINA allows to give an impression on how a sharing of work and workspace between humans and robots could look in the future.

The core and specific objectives of this proposal are

1. to solve the above mentioned use-cases with a mobile robot
2. where
    a. the robot has the set of skills needed for the use-cases,
    b. the solutions are reliable and sustainable, i.e., the STAMINA robot works in all use-cases on-the-fly,
    c. normal shop-floor workers and the ERP system of the company can interface with the robot and,
    d. the system complies as much as possible with the safety requirements,
    e. the robot can function within a fleet of other robots

1.2 Description of work performed and main results

During the first project period, the STAMINA project was successfully started by the consortium. The STAMINA project is built on a number of test sprints that are regularly executed during the project duration. The first test sprint was scheduled for the months M7-M9 with the aim of getting the available technologies to work with early prototype components of the STAMINA robot. Consequently, the first steps focused on

3. a clear analysis of the key use-cases *de-palletizing* and *kitting*
4. pre-selection of the car parts to deal with from the start of the project
5. early prototype definition of the stamina robot
6. testing the available picking, placing, localisation and navigation technologies using the prototype stamina robot components during the first test sprint, and evaluate the results.
7. implementing the first draft of the Skill-based software infrastructure
8. analysis of the kitting process at PSA as it is running now and suggesting strategies for a mission planner that could automate the kitting process.

1.2.1 Use-case and part selection

The very first step the partners took was to put the available technologies into the context of the use-cases. PSA gave an exact account of the layout of the kitting area in the PSA plant in Rennes[1]. PSA took several hundred photos of different car parts within the kitting area with the aim of pre-selecting those parts that can be handled already in the first test sprint. The car parts were either photographed in the boxes from which the robot has to pick them, or in locations where the robot needs to put them. Based on the available grasping expertise in the consortium, choices for grippers and sensory devices were made so that a large number of car parts could be grasped already for the first test sprint.
After the pre-selection, PSA had sent the most relevant parts as well as typical boxes and pallets to the partners.

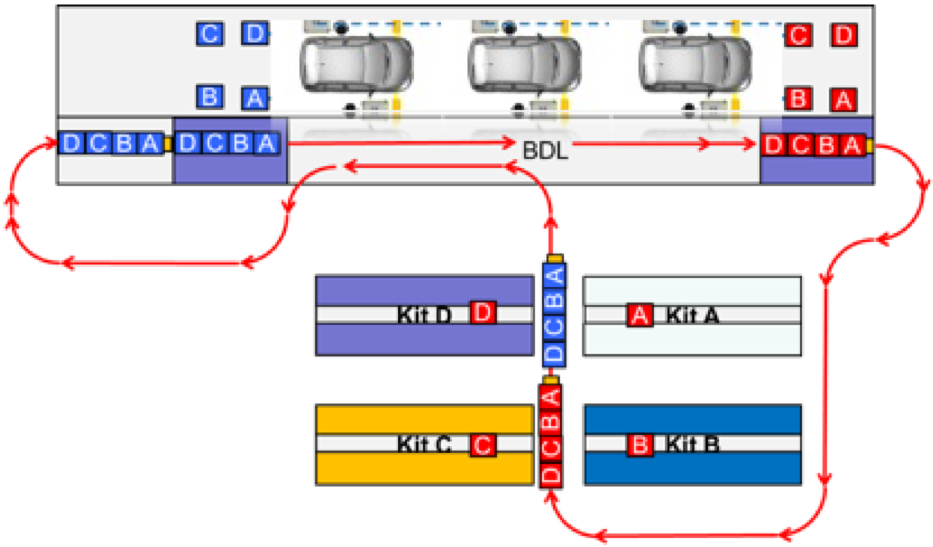

Figure 1 This figure sketches the idea if kitting: a robot drives around a kitting zone where it collects the various parts into a kit. Then, it delivers the kit to the assembly site.

1.2.2 STAMINA robot prototype

A first STAMINA robot prototype was outlined based on the use-case description provided by PSA. A first prototype was designed by BA-Systèmes (BAS). It considers the input from all partners, in particular the choice and location of sensors for navigation and for the picking, the size of the robot arm, the gripper and the necessary safety considerations.
BA-Systèmes provides a complete process that includes designing the prototype, building it, testing, quality control, documentation and marketing and industrial dissemination.
The STAMINA robot consists of two parts: the mobile platform which is an autonomous BA-Systèmes forklift AGV, and a picking platform. The picking platform contains all necessary robotic and sensory components for part picking.

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[1] The manufacturing plant where the stamina robot will be tested is located in Rennes.

1.2.3 First test sprint experiences

The first test sprint used the design suggestions for the STAMINA robot as the starting point. The aim of the first test sprint was to

1. implement the available software techniques and test them: The picking for de-palletizing as well as placing were successfully tested with the available parts from PSA on a first test setup, the localisation and navigation was implemented and tested on the available AGV from BAS.
2. revise the STAMINA robot design choices in light of the experiments: The picking setup was re-designed and improved during the picking test sprint, sensory devices on the AGV were moved and added to improve localisation and navigation.
3. revise the available AAU software infrastructure for robot skills to improve its usability for the project partners. As the skill software infrastructure will be used to integrate the software components from all partners, it is very important that the software is easy to use.
4. Based on the first test sprint experiences the next steps were outlined, shortcomings identified and the activities until the second test sprint planned.

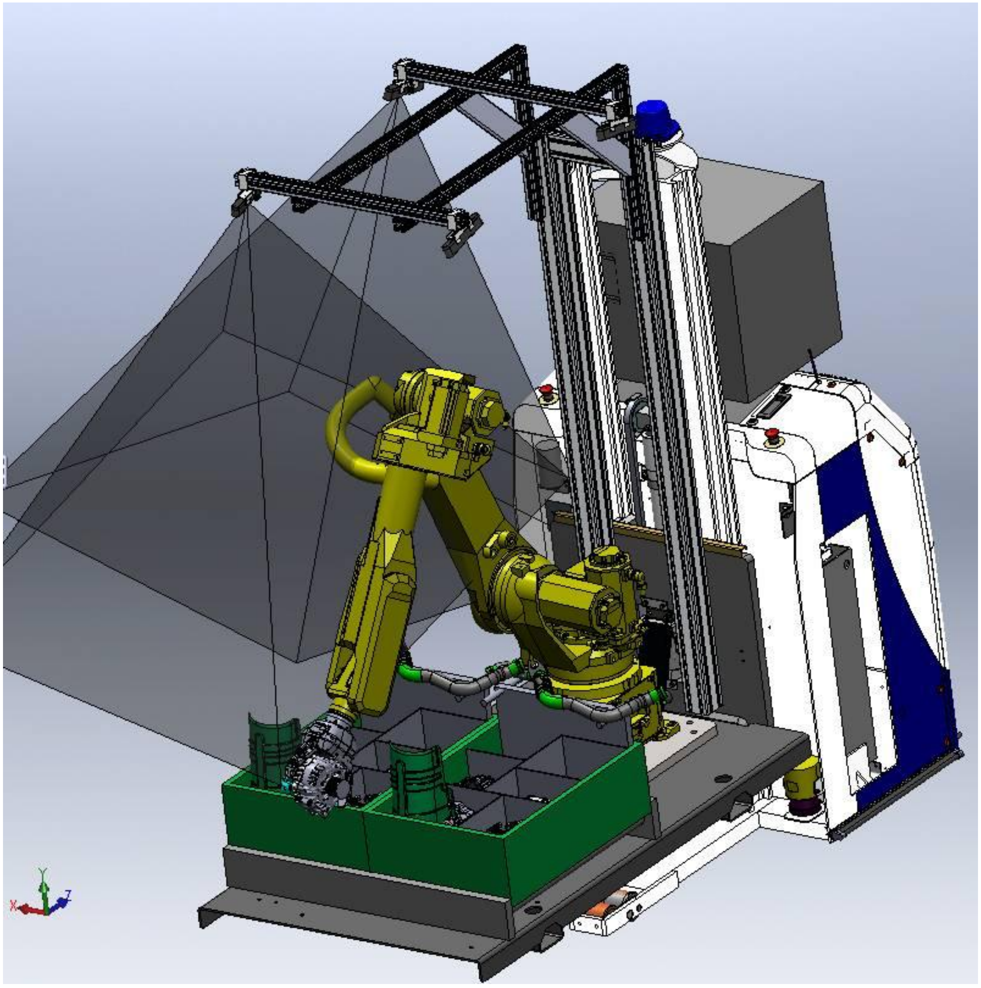

Figure 2 This figure shows the CAD model of the present prototype. The FANUK robot is yellow, the kitting boxes are green. The BAS-AGV is white/blue and the gantry with the cameras is black. The viewing angles of the cameras are visualized.

1.2.4 Integration of the Robot with the MES

In order to truly integrate the STAMINA robot into the manufacturing process, the Manufacturing Execution System (MES) must be able to communicate with the STAMINA robot. Consequently, the relevant processes were analysed and documented by the partners from INESC and PSA. Based on that a complete communication infrastructure was designed by INESC, PSA and UEDIN that integrates requests from a MES, a Mission planner and a Logistic planner to process these requests and commissions them to potentially several STAMINA robots. This communication infrastructure is, among other things, meant to

- provide the necessary information such as kit orders, part locations, number of requested parts, etc. to the different robots
- take and process requests from the MES, generate an action plan, collect the necessary information and forward it to the robots
- communicate with robots to track successful executions and failures and initiate the right actions upon error messages from the robots.

1.3 Expected final results and potential impacts

The final result of this project will be a mobile manipulator prototype that is able to solve the use-cases without major re-programming. The robot will have all necessary skills to perform tasks that are requested by a shop floor worker or by the MES, and will be able to automatically deal to changes in the environment by using highly advanced robot skills and mission and task planning.

Our use-cases, together with their end-user requirements, are highly relevant tasks because they are typical examples of hundreds of similar tasks not only for car manufacturers but in general for the manufacturing industry, for SMEs as well as for LSE. In fact, a survey by Fraunhofer Institute for Systems and Innovation Research ISI (2006) states that approx. 11% of the SMEs in EU expect to invest in robots if technically and financially suitable solutions existed in order to improve their competitiveness with regards to low-wage economies where “suitable” contains in particular “ease of use”. Considering that manufacturing industry in Europe covers about 2.5 mio companies and that 80% of those are SMEs within the manufacturing industry (MANUFUTURE, 2004), this makes 220.000 SMEs. Independently from that survey, the international robot statistics (IFR) estimates a market potential of 10.000 robots p.a. of the type to be developed in this proposal.

More information can be found under www.stamina-robot.eu.