ReCaM— Rapid Reconfiguration of Flexible Production Systems through Capability-based Adaptation, Autoconfiguration and Integrated tools for Production Planning

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D6.1: Demonstration of Use Case I
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Table of Contents

Executive summary ................................................................................................................. 3

1 Introduction ......................................................................................................................... 4
  1.1 General ............................................................................................................................. 4
  1.2 Use Case Introduction ..................................................................................................... 4
  1.3 Use-Case independent demonstrations ........................................................................... 4

2 Main Demonstration HoP2 ................................................................................................. 5

3 Implementation of Localization and Fixation ................................................................. 9
  3.1 Production of bearing pulleys ......................................................................................... 9
  3.2 Sample Shop at Bosch Electronics Factory ................................................................. 11

4 Implementation of Fixation system in sensor assembly ................................................. 12

5 Conclusions and Consequences ....................................................................................... 14

List of Figures ...................................................................................................................... 15
Executive summary

1. Issues (situation, motivation and tasks)
This document summarizes the multiple demonstrations around the Bosch Use Case and documents the results. At a pint in time, where the duration of the project is almost over, this document helps to gather all different relevant results and summarize them as an input for the Final Report.

2. Results
The results of this task are the demonstrations realized in the last months and years. This document gathers this data and provides the references to the documents describing the technological background.

3. Conclusions and Consequences
The results of ReCaM do not only contain the architecture and so called ReCaM-system, but also various technologies which are demonstrated in different applications. Of cause this single results cannot proof all KPIs and objectives claimed in the Grant Agreement, but they increase the impact by having a simple and fast deployment in industrial scenarios. Examples are the matured localization technology in combination with the fixation of mechatronic objects or the adaptive intake.
1 Introduction

1.1 General

This document summarizes the multiple different demonstrations around the Use Case I.

1.2 Use Case Introduction

The description of the Use Case is based on D1.1. The main Use Case of Bosch is based on the assembly of hydraulic valves for different industrial applications. Figure 1 shows a representative part as well as a exemplary process required to assembly this product. As the initial plan documented in the proposal was to use a different line producing part for Automobiles, multiple different contacts within Bosch were approached in order to generate the new Use Case mentioned before. During this process various people got interested in the topics of ReCaM and enabled multiple partial implementations beside the Use Case. Due to the relevance for the impact of the project, these Use Cases are mentioned in the subsequent document, although they are not directly linked to the primary Use Case I.

![Figure 1: Description of reference Use Case I taken from D1.1](image)

1.3 Use-Case independent demonstrations

This document summarizes the main demonstrations implemented around Use Case I. Multiple other demonstrations of main ReCaM results took place. These are documented in the following deliverables:

- D3.5 – Matchmaking method and Rules
- D4.1 – Flexible Systems Engineering Platform and system visualization tool
- D4.3 – Installation and testing of the designed solutions
- D4.4 – Reconfiguration Management Platform: implementation and testing
- D5.2 – Module Controller
- D5.4 – Engineering Integration and auto-programming methods and tools
- D5.5 – Plug-and-Produce HMI framework

The content of the previously listed documents will not be reused / rephrased in this deliverable.
2 Main Demonstration HoP2

The main demonstration of Use Case I is implemented in the plant HoP2 in order to proof the applicability and benefits in the industrial use. The motivation are a high number of different products and variants, which needs to be produced on one single workbench, the high reconfiguration effort as well as the retirement of experienced workers.

The state before ReCaM was characterised by a high effort for setting up the workbench for actual orders, high engineering effort in case of new products. The structure of the workbench pictured from above can be seen in Figure 2. The implementation of the ReCaM results for this Use Case has to follow the specific requirements towards the context in the production and to improve the core production processes in the same time. Integrating new products and processes to the old workbench could take between 6-12 months. This time has been reduced by ReCaM massively, with the demonstrator shown in Figure 3 and Figure 4. This could be achieved due to the systematic description of the resources and the resulting knowledge on which products were able to be produced on the existing system as well as the plug-and-produce technologies enabling fast integration of new processes.

![Layout of the workbench before ReCaM](image)

*Figure 2: Layout of the workbench before ReCaM*

Therefore, together with the colleagues of production planning ReCaM defined different MOs to be realised in the demonstration. These can be seen in Figure 3.
Figure 3: Concept of Demonstration including all different MOs

Figure 4: Workbench including final Design
The functional development of the workbench as core element of the demonstration was done steadily during WP6. The realization of the design however was pushed to a later state of the implementation. This is why there are no physical pictures of the final workbench including all elements and the designed covers to the time where this document has been uploaded. Figure 4 shows the final design to be realized for the workbench and Figure 5 shows the current state to the time the document has been written. In the next weeks, the covers of the workbench will be finalized and it will be installed at the final location inside the plant.

![Figure 5: Disassembled workbench including the raw metal covers](image1)

![Figure 6: Main MOs integrated in the workbench (from left to right: NEXO Screwdriver “Angled”, NEXO Screwdriver “Pistol”, Adaptive Intake and Screwing Spindle)](image2)
Besides the physical demonstration and implementation which can be seen in the figures above, the main implementation is based on the execution part, which enables the identification of the MOs as well as the work-flow-based programming. Figure 7 represents the Component explorer, described also in D5.4, which is listing all MOs being integrated in the system as well as their properties and operations.

![Figure 7: Component explorer (representing the MOs in the Execution Platform)](image)

All this different components and tools described in the previous slides increase the technological complexity of the workbench massively in comparison to the “Pre-ReCaM version” shown in Figure 2. This complexity can only be managed by the suitable support of various different tools that were developed in other WPs like the capability-based description, matchmaking and Editors in WP3, the planning tools of WP4 and the control technology in WP5. As these results are described in separate reports, deliverables and demonstrations their use will not be described in more detail in this document.
3 Implementation of Localization and Fixation

3.1 Production of bearing pulleys

The demonstrator described in this chapter is not representing an official ReCaM demonstration but it is utilizing major results of ReCaM and therefore described briefly.

The use case is the assembly of bearing pulley for conveyor belts. Two examples of six produced on this cell are shown in Figure 8.

![Figure 8: Bearing Pulleys of plant StP](image)

The design of the cell is based on a closed system (for safety reasons) and Mechatronic Object that can be arranged gridless (green in Figure 9). The process conducted is the assembly of the pulley by pick and place operations as well as the application of grease between the rolls and the discs. The productive cell is shown in Figure 10.

![Figure 9: Design of versatile demonstrator at StP utilizing ReCaM-technologies](image)
The operator can arrange the MOs freely inside the cell according to the optimal layout for this process. Additional functionalities like layout optimization are not integrated in this demonstrator, but the data is there and it can be deployed as further steps. Figure 11 shows the digital representation of the MOs within the cell, the operator is using for rearranging the MOs. This picture is the digital representation of the physical plant layout built from the different MOs and their capabilities.
3.2 Sample Shop at Bosch Electronics Factory

![Demonstrator utilizing ReCaM results at plant RtP2](image)

Besides the productive main demonstrator and the demonstrator represented in chapter 3.1, another versatile production system was implemented utilizing ReCaM results. This can be seen in Figure 12 and is used within the sample shop of a plant producing electronic control units. Therefore, there are multiple different processes implemented and to be implemented on this cell. The results of ReCaM towards connectivity, localization and fixation are easing this integration of new processes massively.
4 Implementation of Fixation system in sensor assembly

The demonstration presented in this chapter is very much focussed on the fixation. The use case was identified during discussions with the production planners of HoP2. Within the manual workplace of the sensor assembly, heavy assembly devices and intakes have to be rearranged multiple times during the day. Reasons are:

- Different requirements for different products
- Different ergonomical requirements of different workers

Therefore, a simplified implementation was chosen, being focussed on the fixation and the easy rearrangement of the objects on the table. Figure 13 shows the CAD-design of the base plates and Figure 14 shows the main internal components.

![Figure 13: CAD-Model of simplified MO Base](image)

![Figure 14: Showing the components in the MO base: Vacuum ejection, Micro-PC and wiring](image)
The workplace was equipped with three MO-bases, which allow a free arrangement and fixation of the different devices and intakes required. The whole workplace can be seen in Figure 15. Figure 16 shows the front part of the base with the easy interface for the worker based on two buttons.

Figure 15: The workplace inside the sensor assembly utilizing the MO bases as fixation for fast adaption of the working positions

Figure 16: Front part of the MO base with the buttons for fixation and releasing of the base
5 Conclusions and Consequences

This document summarizes the main demonstration of Use Case I as well as the multiple different demonstrations which were utilizing ReCaM results already during the project’s runtime. The main demonstration will be given live during the Final Review Meeting also having the designed covers finished around the operative workbench.

The KPIs achieved in the production by using the project’s results will be described in D6.3.
List of Figures

Figure 1: Description of reference Use Case I taken from D1.1 ......................................................... 4
Figure 2: Layout of the workbench before ReCaM .................................................................................. 5
Figure 3: Concept of Demonstration including all different MOs ............................................................. 6
Figure 4: Workbench including final Design ............................................................................................ 6
Figure 5: Disassembled workbench including the raw metal covers ......................................................... 7
Figure 6: Main MOs integrated in the workbench (from left to right: NEXO Screwdriver “Angled”, NEXO Screwdriver “Pistol”, Adaptive Intake and Screwing Spindle) ......................................................... 6
Figure 7: Component explorer (representing the MOs in the Execution Platform) ........................................ 8
Figure 8: Bearing Pulleys of plant StP ....................................................................................................... 9
Figure 9: Design of versatile demonstrator at StP utilizing ReCaM-technologies ...................................... 9
Figure 10: Productive demonstrator at StP for bearing pulley assembly utilizing ReCaM technologies ...... 10
Figure 11: Digital representation of versatile cell’s layout ....................................................................... 10
Figure 12: Demonstrator utilizing ReCaM results at plant RtP2 ................................................................. 11
Figure 13: CAD-Model of simplified MO Base ............................................................................................. 12
Figure 14: Showing the components in the MO base: Vacuum ejection, Micro-PC and wiring .................. 12
Figure 15: The workplace inside the sensor assembly utilizing the MO bases as fixation for fast adaption of the working positions ......................................................................................... 13
Figure 16: Front part of the MO base with the buttons for fixation and releasing of the base ................. 13