Project no. 314739

HEPHESTOS

Hard Material Small-Batch Industrial Machining Robot

Collaborative Project

WP 7

Deliverables D7.2

Final Workshop Report

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RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	X

Document information

Abstract: This deliverable provides information about the Hephestos Final Workshop. It corresponds to deliverable 7.2: Workshop II (actually the Final Workshop corresponds with Workshop III). The Final Workshop was organized by the Hephestos project participants at MAG facilities in Oulu (Finland) on 16th of October 2015.

This deliverable contains restricted information and it has been classified as confidential.

All Authors/Organisations:

- Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (Fraunhofer IPK)
- ME Messsysteme GmbH (MEM)
- Comau SPA
- G-Robots
- Easy-Rob
- Teknologian Tutkimuskeskus (VTT)
- JOT Automation OY (MAG)
- Universidad Politecnica de Madrid (UPM)
- Universitetet i Agder (UiA)

Reviewer: Dr. Claus Risager, Blue Ocean Robotics

Dr. Erwin Prassler

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Table of Contents

Table of figures

Introduction

Workshops have been considered a very appropriate way to disseminate the project results not only to the scientific community but also to the industrial community, allowing to receive feedbacks from a large spectrum of potential industrial users.

Initially the project "Description of Work" foresaw the celebration of two workshops (months 6 and 36), but finally the project partners organized three workshops, including and new one in the European Robotics Forum (ERF) 2014. For this reason, the Final Project Workshops is actually Workshop III.

The main objective of Workshop I (Figure 1) was to present the current situation of the use of robots in the Machining World and to present the Hephestos Project objectives to the scientific and industrial community. It was held at IPK facilities in Berlin on 5th of April 2013 (Project month 8). It included ten presentations from different industrial companies and research institutions, a panel/roundtable discussion and scientific encounters.

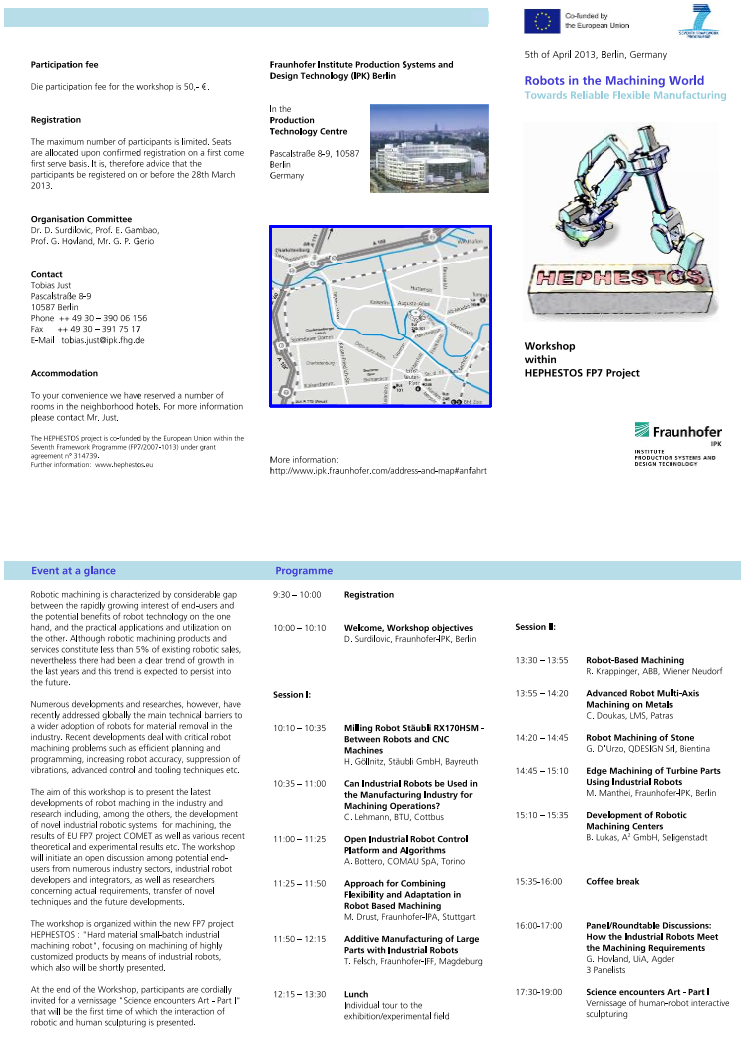

Figure 1: Hephestos Workshop I flyer.

Workshop II was held at the 5th European Robotics Forum 2014 in Rovereto (Italy). Under the title "Advances in robot machining", the project partners presented the research achievements in a two hours session. The session had 29 attendants (from 22 different institutions).

1 Final Workshop Objectives

The main objective of the Final Workshop was to show an integrated demonstration of the most important technical results obtained in the project. The project includes two different demonstrators denominated Demonstrator 1 and Demonstrator 2 (see Deliverable 6.1). Demonstrator 1 was selected as a demonstrator for the Final Workshop since it includes the possibility of integration of most of the work developed in the technical Workpackages for several representative operation scenarios:

- WP2: Sensory system
- WP3: Programming and simulation
- WP4: Advanced control
- WP5: Human-machine interfaces and interaction

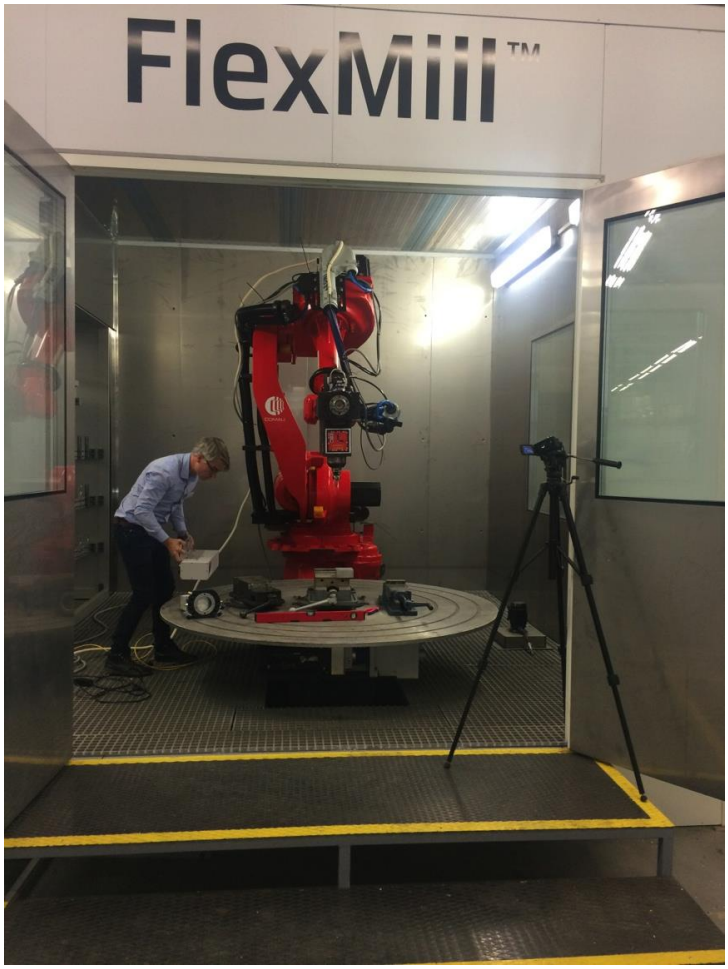

Figure 2: Hephestos use case 1 Demonstration Cell.

Demonstrator 1 consists of a complete flexible robotic machining cell and it has been installed at MAG facilities in Oulu (Finland) (see Figure 2). This demonstration includes four different demonstrations: two milling cases (Aluminum and Inconel milling), drilling and polishing. These four demonstrations were designed to show the different technological capabilities developed in the project:

1. Localization of parts for programming and simulation:
   Laser profilers are used to acquire 3D profiles data from objects allowing to get a user coordinate frame.

2. Programming and simulation with path compensation:
   A prototype wireless sensor module is used for teaching machine paths for the industrial 6-axis robot using an impedance robot controller. Alternatively, the HRI application (Hammer) can be used to build robot trajectory points and paths.
   Easy-Rob robot simulation is used for robot programming including off-line path corrections based on robot elasticity and process material cutting models.
   Hammer application can be used to build robot programs in a very simple way and for a first simulation of robot paths.

3. Compliance control for robot machining:
   Improvement of the robot position controller for better machining performances based on model based control system. An external RT controller implements a position based compliance control.

4. Monitor program execution in real robot using augmented reality techniques:
   Hammer application provides augmented reality algorithms to show useful information about the task the robot is executing.

The consecutive execution of the four demonstrations in the Final Workshops allowed to see the different capabilities of the systems developed in the project.

2 Workshop organization

2.1 Previous work

After the selection of Demonstrator 1 to show the project technological results, the Final Workshop had to be organized at MAG (integration leader) premises in Oulu since the Flexible Robotic Cell was difficult to translate due to its size and weight.

NH3 Comau robot and the main parts of the robotic machining cell were installed in Oulu at the beginning of project year 3. The technological developments (WP2 to WP5) were developed by the project partners during years 1 and 2 in collaboration, but it was necessary to integrate them in the Demonstrator 1 single robotic cell. For this reason, an "integration week" was organized from 22 to 26 of June. All the project participants worked in cooperation to develop the different scenario demonstrations. All the partners thoroughly prepared this integration work, however, several unexpected technical problems appear during the integration mainly due to the incompatibility of the different necessary equipment. Additionally, since there were only one available robot it was necessary to organize its shared use. After the integration week, most of the systems were ready for the final demonstration but some refinements were still needed.

2.2 Workshop technical preparation

To do a final integration of all the systems and to prepare the presentations and demonstrations, the project partners worked again together on the Workshop site during the four days before the Final Workshop. The last versions of the different systems where tested an integrated in the four demonstration cases.

Figure 3: Hephestos Final Workshop preparation at Oulu.

2.3 Workshop Schedule

The Workshop flyer including the agenda is shown in Figure 4.

Figure 4: Hephestos Final Workshop flyer.

Fraunhofer IPK distributed the invitation flyer to possible interested technology users and developers. Due to the long travel to Oulu for non-Scandinavian participants, the Workshop had not participant fee and transport between selected hotels at the city of Oulu and MAG facilities (10 km) where arranged.

The final Workshop receives 17 attendants from 10 different institutions.

After the participants welcome by MAG, the Hephestos project was presented at a glance. Following, four technical presentations (Figure 5) presented the main technological work.

Figure 5: Technical presentation.

After a short introduction to the system demonstrator, the attendants moved to shop floor to see the field demonstrations (Figures 6 and 7). The four use cases were consecutively presented and after the demonstrations the attendants where free to see every system closer and to ask questions. Some attendants test several systems by their own like the programming system, virtual robot teach pendant or augmented reality glasses (Figures 8 and 9).

A final roundtable discussion allowed common questions and definition of possible future work and the Workshop was concluded with the final remarks and farewell.

The Final Workshop was filmed and a short video was prepared and distributed.

Figure 6: Field demonstration.

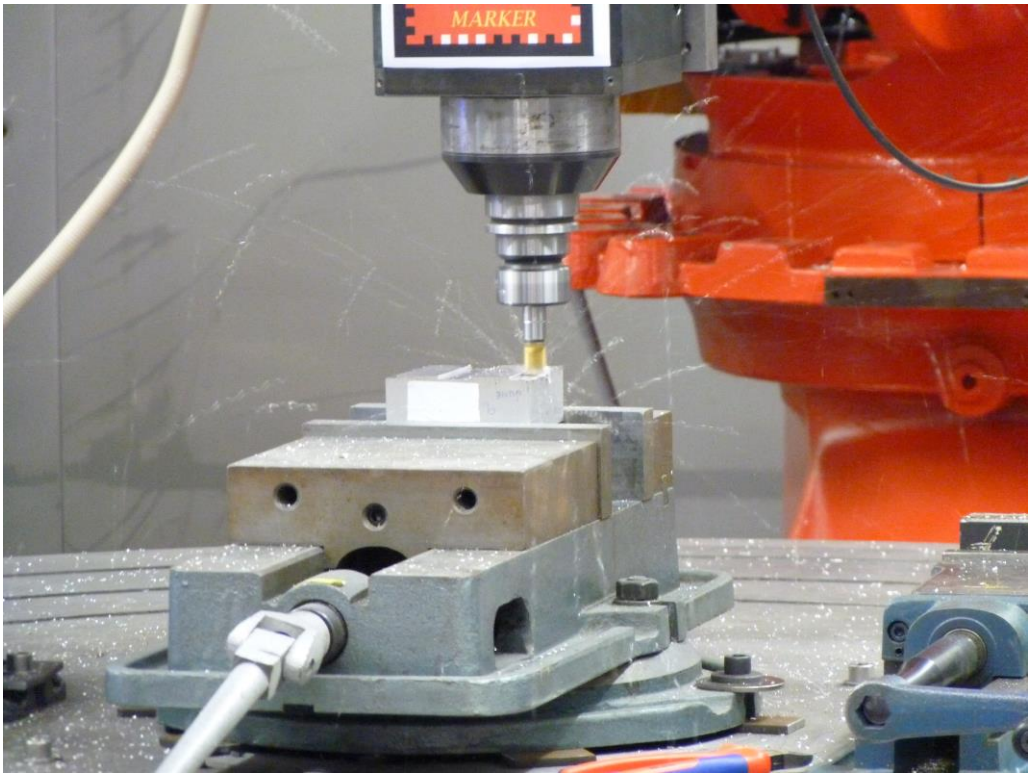

Figure 7: Robot machining during the Final Workshop.

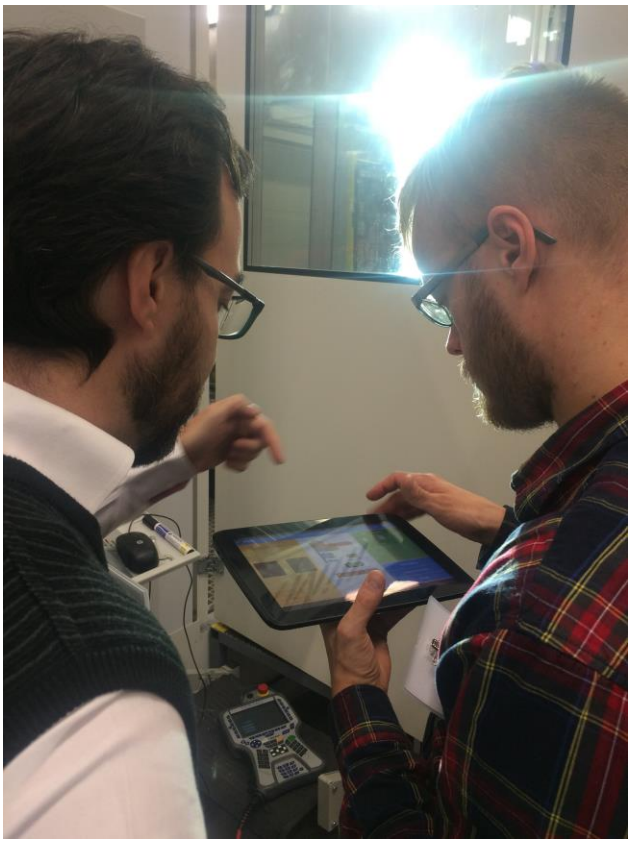

Figure 8: Robot programming demonstration.

Figure 9: Augmented reality.

3 Workshop Results and Obtained Feedback

3.1 Results

Spite the several mentioned difficulties, it was possible to show the four different demonstrator and the different sub-systems performance to the attendants with no significant errors. The robotic system demonstrates its machining capabilities with both, no hard and hard materials. Although it was not foreseen during the Workshop preparation, several attendants had the opportunity to personally test several sub-systems and it was very interesting to get their comments.

The Workshop agenda was maintained with no important delays. The general roundtable discussion was reduced since most of the comments were directly done during the field demonstrations.

3.2 Obtained feedback

The technical presentations and the filed demonstrations opened several questions and comments from the attendants allowing to receive a feedback of the system performance in general and the different developed subsystems. Not all this feedback was directly received during the Final Workshop day; the project partners have also received interesting feedback after the Workshop and during direct contacts with possible customers or end-users in fairs and private conversations. It has been considered interesting to include this feedback in this deliverable.

1. Complete robot machining cell feedback:
   Since the project beginning, as it was confirmed in Workshop I, many possible customers and the technical community showed a big interest in the project objective of using a robot for machining hard materials for small-batch production and even in general to use machining robots. The machining industry expressed its interest in this possibility, not only for machining of industrial pieces but also for machining of artistic sculptures with robots, reducing the costs and augmenting ease of use. The robot manufacturers also showed their interest in the Hephestos technological way of solving the inherent difficulties.
   After the project finalization we conclude that this initial interest is still alive. We consider that the selected procedure is still valid (several attendants presented other methodologies). However, it is still necessary to increase the reliability of the software and hardware of the robot control system. Comau will use the project experience to improve the capabilities of the G5G Open Robot Controller.
   Some attendants also express their interest to collaborate in future projects.
   One of the attendant pointed that the field demonstration did not cover all the topics presented in the technical presentations.
   In general, the attendants were happy about the demonstrations, we receive only some remarks about typical small demo errors. The technical presentations received very good comments.
   Many of the attendants also expressed that it was nice to know the project in detail and the project partners.

2. Sub-systems feedback:
   Of course, not all the participants were interested in the robot machining system as a whole. Some of them were interested in robot machining, but not necessarily including all the sub-systems presented in the demonstrations. We received several questions about the possibility of applying some of the technological achievements to other systems or applications.
   Some customers were only interested in specific developments of the project that could have their particular application to the market.
   3D vision based localization receive a great interest form one of the participants in the Final Workshop since it matches very good with their current interest. VTT is in direct contact for near future collaborations.
   The Hammer application received also big interest from several participants, specially the monitoring capabilities. Internally, there are conversations between Easy-Rob and UPM for possible commercialization of this application. Additionally, Comau is also interested in this technology for HRI and there will be a common meeting to share the technology.
   MEM force sensor received also great interest in the market. A workshop to check the possibility of its use in medical robots was organized on 9 of October 2015 and MEM has received some comments about possible improvements of the sensor increasing modularization and offering electronic component with ProfiNet Industrial bus.

4 Conclusions

The Final Workshop required a big effort of all the project participants. Field demonstrations are always complex but after the work developed in WP2-WP5, the workshop preparation effort was underestimated and one work of on-site collaboration was not enough to have everything completely ready. This forced the consortium to spend four more collaboration days in Oulu before the demonstrations. However, the acquired experience and collaborative work was one of the best and satisfactory experiences in Hephestos projects and after the Final Review Meeting in Berlin some of the partners expressed it.

Since MAG was the leader of the integration WP and Demonstrator 1 was installed in MAG facilities in Oulu, the Final Workshop had to be organized there. Due to the difficulties of travelling to Oulu this fact increases the efforts of the Workshop organization and also reduced the number of attendants. For this reason, the project partners decided to participate in the Deburring Expo 2015, to continue their common participation in future fairs, their participation in Robo Business 2016 at Odense (Denmark) and a new workshop organization has been proposed for the 7th European Robotics Forum at Ljubljana (Slovenia) under the title "How interactive robots may support small-batch machining in industry".