FUTURE REPAIR AND MAINTENANCE FOR AEROSPACE INDUSTRY

Deliverable 2.9 **Draft specification of RepAIR scenarios**

Gereon Deppe, Christian Lindemann, Marco Plass
University of Paderborn
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Work Package 2

Project Coordinator
Prof. Dr.-Ing. Rainer Koch (University of Paderborn)

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Further contributors				
Authors		*Gereon Deppe, University of Paderborn (UPB)* *Christian Lindemann, University of Paderborn (UPB)* *Marco Plass, University of Paderborn (UPB)*		
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Short description		*In this document scenarios are developed that give an overview of the project's work packages. This document aims to form a common thread through the other work packages, to prepare for validation and demonstration and to give an overall overview of the project RepAIR. The scenario definition is based on the Description of Work and on the requirement analysis of work package two.*		
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Executive Summary

The European MRO business has to face increasing competition of the low wage countries. Nevertheless the complex maintenance work is still done in Europe. To keep the technological lead and to further reduce maintenance costs, the project RepAIR focuses on the integration of Additive Manufacturing in the MRO business. The complex repair and workflow processes require a deep understanding of the business to be able to develop applications and an IT system for the AM integration. This is why the deliverable tries to give an overview of the project plan and how the different topics of the project interact with each other. Therefore the processes and the work packages are divided into scenario modules that fit to each other and that are easy to understand. In a next step some scenarios are developed that put together the scenario modules with the help of the project's sample parts. Every scenario contains a special feature of the project.

The first scenario has the high batch repair of an engine part, the shroud, as its main characteristic. A semi-automatic repair process already exists, but it is analyzed how Additive Manufacturing can be implemented advantageous. The current deposit welding should be replaced by Additive Manufacturing (SLM/EBM). The difficult feature that has to be developed is to be able to apply material to an existing geometry and to the exactly correct position. To process the high number of items, several shrouds should be repaired at once within manufacturing run. As AM is much more precise than deposit welding, there is the opportunity to cut down on the number of the current process steps by two. Additionally the remaining process steps should all be conducted with the same platform the shrouds are mounted to. This reduces the manual handling of the parts significantly. Therefore the clamping devices are of considerable importance as they take care of the fixation on the platform.

There are three different events that start a repair process. There are line terminal checks that are performed at the airport to ensure the airworthiness of the aircraft for the next flight. The second trigger is the regular maintenance like the D checks where every assembly is examined for failures. The last option is the failure warning of an integrated vehicle health management where parts are monitored by sensors. There are two approaches that can be used to analyze the sensor's data stream. The data-based approach uses statistical patterns recognition to identify anomalies. They usually indicate that a part is going to have a fault and needs to be replaced. The time of the occurrence can be calculated so the maintenance action can be planned in advance. The sample part for this work package is the drive shaft of the Integrated Drive Generator. This is an assembly that is responsible for the power supply with a high rotation speed and a complex design.

The next scenario describes the usage of Laser Cladding for the repair of the impeller. This is also the scenario for a single part repair in contrast to the high batch repair. The Laser Cladding machine that is developed during the project runtime has the advantage of an integrated milling tool. It is able to post process every layer directly after its application. The benefit is that the post processing can take place when the treated area is still accessible for the milling tool. In addition to that Laser Cladding does not need a powder bed so it can add material to existing surfaces that are below the level other areas of the impeller. The SLM and EBM process needs a plain level so

that a straight powder layer can be dispensed. This restriction is not valid for Laser Cladding. Only the tool needs to be able to access the surface in an orthogonal angle.

Another scenario describes the process of the redesign of an Inconel housing. There are several reasons for a MRO provider to redesign a part. One reason is to save costs by optimizing the part for its application. A lower failure rate decreases the costs for maintenance. To be able to redesign the part it is necessary to know the form, function and fatigue of the part. Then it can be optimized for its function and the loads it is exposed to. Additive Manufacturing enables a completely new design that has almost no restrictions compared to the conventional manufacturing technologies. The buy-to-fly ratio as well as the mass-to-strength ratio are much better and thus enable a lightweight design. Further optimization for the available space or for the stress can be conducted easily as well as an integration of several parts into one. The certification effort for a major change in design is too high so only minor changes are usually undertaken.

The last scenario explains the IT Management Platform. This software is developed within the RepAIR project and supports all repair processes. The CAMO component processes the sensor data of the part monitoring and gives a failure warning in case of an anomaly. It helps to keep the aircrafts airworthy and gets information from the Operator component for the flight schedules to plan the maintenance. The software saves all necessary information in its database (vehicle number, flight hours, replaced assembly number etc.). The assembly is sent to the workshop and tested there. The identified defective part is handed over to the SRU workshop. There it is inspected with the help of the PARTS component that stores all available part data like CMMs, failure modes. The DECISION component calculates the repair with the lowest costs as it knows about the acquisition price and the repair costs. It is also able to calculate the costs for an AM repair as this technology is newly applied by the project. The MRO component prepares the work cards and plans the priority for the processing machines. Those get relevant data like CAD files or machine settings from the PART component. After the processing took place, generated data is saved by the software for example log files or errors. The Certification Component uses this information to control the quality of the processes and the parts as well as it supports the certification. The part is then put in storage and the software controls the inventory of the warehouses.