FUTURE REPAIR AND MAINTENANCE FOR AEROSPACE INDUSTRY

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Final

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Work Package 1

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1 Introduction

This report responds to generic requirements as stated in the Grant Agreement. It summarises all outputs and outcomes of the project from M1 to M36. It is based on the Periodic Reports submitted after each reporting period.

More detailed information can be retrieved from the website (URL www.rep-air.eu). For direct contact, please refer to Jens Pottebaum, pottebaum@cik.upb.de, acting as project manager for the RepAIR project.

1.1 Relation to other documents

[1] RepAIR Grant Agreement N 605779, Specific Programme 'Cooperation', Theme 'Transport', Topic 'AAT2013.4-4.: Maintenance, repair and disposal', Brussels/Paderborn, 2013.

[2] RepAIR Grant agreement N 605779, Annex I – 'Description of Work', Brussels/Paderborn, 2013.

[3] RepAIR Consortium Agreement, based on the DESCA model, Paderborn, 2013.

1.2 Target audience

The final report will be public, targeting a wider audience while still including the European Commission, related projects and stakeholders.

The report does not include any confidential information, whose publication might undermine the protection of commercial interests, including intellectual property, or privacy and the integrity of the individuals, in particular in accordance with Community legislation regarding the protection of personal data.

1.3 Glossary

Additive manufacturing terminology used in this document and the table below are given in ISO/ASTM 52900-2015 "Standard Terminology for Additive Manufacturing — General Principles — Terminology".

Abbreviation	Expression	Explanation
AAT	Aeronautics and Air Transport	Domain description used, e.g., by the EC in its FP7 framework programme. In this domain of the Transport work programme the RepAIR project was evaluated.
AB	Advisory Board	Board of advisors for the RepAIR project and specific WPs. All AB members sign a NDA.
AM	Additive Manufacturing	Technology to manufacture products by adding material layer by layer and, at the

Abbreviation	Expression	Explanation
		same time, create the intended material structure. Opponent to subtractive or 'conventional' technologies.
ARD	Assessment Repair part and processes Document	Contains all data that must be evaluated to ensure the quality of the part and all processes (EASA)
DMD	Direct Metal Deposition	Also known as directed energy deposition, additive manufacturing process in which focused thermal energy is used to fuse metals by melting as they are being deposited.
DOW	Description of Work	Annex I of the Grant Agreement, [2]
EBM	Electron Beam Melting	Additive manufacturing process in which an electron beam selectively fuses regions of a powder bed. The term EBM is a registered trademark of Arcam AB.
EC	European Commission	Providing funds for RepAIR
GA	Grant Agreement	Contract between the EC and UPB representing the RepAIR consortium (being assigned to it by Annex IV of the GA), [1]
IDG	Integrated Drive Generator	Sample part selected by WP4
IPR	Intellectual Property Rights	
IT	Information Technology	Enabling technology including software and hardware components.
IVHM	Integrated Vehicle Health Management	Foundations for WP4
KDB	Knowledge Data Base	Database as defined by WP8 including

Abbreviation	Expression	Explanation
		procedural knowledge for AM in MRO
LRD	Legal Requirement Document	Contains all registers that must be stored related with the legal aspect (EASA)
MOE	Maintenance Organisation Exposition	Describes and specifies all the procedures followed by an organization when it carries on approved maintenance operations
MRD	Manufacturing Requirement Document	Contains all manufacturing parameters to be stored like material, AM process parameters, machining parameters (EASA)
MRO	Maintenance, Repair and Overhaul	Service to ensure airworthiness of aircrafts.
MS	Milestone	Each project year (i. e., each reporting period) is completed by achieving a milestone as defined in [2].
N/A	Not applicable	
NDA	Non-Disclosure Agreement	Agreement to be signed by AB members and the Project Coordinator UPB on behalf of the consortium to agree on, e.g., confidentiality regulations.
NDT	Non-destructive testing	Type of methods to test a part (or indirectly a manufacturing process)
PB	Project Board	Board of all RepAIR consortium members where strategic decisions are taken.
PDB	Part Data Base	Database as defined by WP8 including part knowledge (synonym: “Part Library”)
P/N	Part Number	Identifier for an individual part
RTD	Research, Technology	Type of activities in FP7

Abbreviation	Expression	Explanation
	and Development	
SLM	Selective Laser Melting	Additive manufacturing process in which a laser beam selectively fuses regions of a powder bed. The term SLM is a registered trademark of SLM Solutions GmbH.
TB	Technical Board	Board of all WPLs where tactical and operative decisions are taken. All consortium members are allowed to participate.
TL	Task Leader	Project management role as defined in [2] (level of tasks, reporting to WPL).
TRD	Technical Requirement Document	Contains the technical requirements and specifications of a particular part (EASA)
TRL	Technology Readiness Level	Scale to assess the maturity of a technology.
UML	Unified Modelling Language	Language to specify functionality, behaviors and structures of software (and hardware) systems
WP	Work Package	Part of the project structure, subsuming logically connected tasks.
WPL	WP Leader	Project management role as defined in [2] (level of WPs, reporting to the Project Manager).

1.4 List of figures

1.5 List of tables

2 Executive summary

The goal of the RepAIR project with twelve partners from all over Europe and the US is the onsite maintenance and repair of aircrafts by integrated direct digital manufacturing of spare parts. Cost efficient and lightweight but robust reliable parts are obligatory for aircrafts. Additive Manufacturing allows completely new approaches for this requirement. The main objective of RepAIR is therefore to shift the 'make-or-buy' decision towards the 'make' decision by cost reduction in the remake and rework of spare parts and thus to improve cost efficiency for maintenance repair in aeronautics and air transport.

The project aims to reduce the Maintenance, Repair and Overhaul (MRO) costs with the help of the Additive Manufacturing (AM) technology as its crucial advantage is the flexible availableness allowing on-time maintenance. Through the integrated vehicle health management parts can be monitored constantly and thus the prediction of the remaining lifetime can be realized. Consequently, maintenance events can be harmonized with the flight schedule. When defect parts arrive at the workshop a multi-criteria decision support has been developed to compare different repair solutions on the basis of their costs, time and environmental impact. To adapt the AM technology to the needs of aerospace a high batch repair has been developed allowing the repair of a high quantity of identical parts such as turbine parts with an integrated in-situ quality system. In addition to that, a 5 axis Direct Metal Deposition machine and its control software has been engineered. It automatically determines the geometrical deviation between the existing part and its original geometry and reestablishes the required shape with multiple tools. To be able to provide high quality parts by AM extensive research has been put into testing of influence factors for surface, accuracy and part quality to determine optimized parameters. In this context a sample part has been topology optimized to fully exploit the technology's potentials.

As a crucial requirement for the application of AM in aerospace is a defined QA and certification concept. Therefore, a quality assurance IT component has been specified and a certification procedure composed. Due to the fact that knowledge and experience are essential in this industry a knowledge management library has been prepared. As RepAIR aims for the direct digital manufacturing a constant IT support is the basic concept of the project. Hence, an existing MRO and CAMO IT system has been extended and significantly improved by the integration of the developed IT Components. So, the complete MRO process is supported by one integrated IT system architecture increasing the automation level and reducing lead time and costs.

The different research and development activities in the project have been evaluated and presented to a broad audience of end-users from various branches to receive feedback and determining the exploitation of the subsystems. The project's progress and results have been published according to the dissemination strategy while the exploitation plan has continuously been synchronized with the individual exploitation plans of each partner.

New business models have been identified for this prospective technology. In order to achieve the project's objectives a roadmap for the further progress and research needs of the considered technologies has been generated as further improvements of the technology are foreseeable.