Interreg Sudoe

EUROPEAN UNION

ADDITOOL

European Regional Development Fund

D3.2.1: MOBILITY REPORT

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INDEX

1. INTRODUCTION 3

2. List of PhD, Equipment and Research axis 4

2.1. List of PhD per entity 4

2.2. List of equipment and software per entity 6

2.3. List of research axis per entity 10

3. Mobility organization 13

3.1. Mobility 1 and 2: Metallic material characterization / Collaborative development 14

3.2. Mobility 3, 4, 5 & 6: MAM processes / Collaborative development 15

3.3. Mobility 7: Characterization of porosity in copper alloys 16

3.4. Mobility 8: CFD Simulations (Computational Fluid Dynamics) 17

3.5. Mobility 9: Joint study of the Laser's caustic at Addimadour (Machine BeAM Magic 800 and PRECITEC CoaxPrinter) 18

3.6. Mobility 10: Discussions and experience sharing on W360 steel 19

3.7. Mobility 11: Sharing Computed Tomography and Digital X-Ray Equipment VJ 225-SE 20

3.8. Mobility 12: DED Wire Arc (WAAM) processes and collaborative development 21

3.9. Mobility 13: Monitoring of DED Wire Arc (WAAM) process and collaborative development 22

3.10. Mobility 14: MAM parts simulation 23

3.11. Mobility 15 & 16: Characterization of MAM parts 24

4. Conclusion 25

Table des figures

Figure 1 : All mobility carried out in the ADDITOOL project 13

1. INTRODUCTION

This deliverable aims to report on the transfer of knowledge between teachers, researchers, engineers, and doctoral students from each partner as part of the "Mobility" activity of the ADDITOOL project.

To have a common base of skills in Metal Additive Manufacturing (MAM) in the SUDOE area (Nouvelle-Aquitaine and Occitanie in France, Spain, and Portugal), a group of different experts was created, composed of researchers, engineers and doctoral students from the following centres:

- CEIT (San Sebastian, Spain)
- ENIT (Tarbes, France)
- ESTIA Addimadour (Bayonne, France)
- FADA CATEC (Seville, Spain)
- IPLEIRIA (Marinha Grande, Portugal)
- LORTEK (Ordizia, Spain)
- UPV / EHU (Bilbao, Spain)

The main activities of this task were the sharing of good practices in the SUDOE sector, an exchange of skills, as well as an exchange of equipment.

Indeed, the ADDITOOL consortium relies on various cross-functional skills and on a large fleet of machines, not only on the manufacturing part, but also on the entire value chain of the MAM: The control and monitoring, various software of trajectories generation, Non-Destructive Testing equipment, metallographic analysis equipment, etc.

To share the methods, the people who took part in the "Mobility" task had the opportunity to be welcomed in the different centres to present their work and exchange with the research community of each partner.

2. List of PhD, Equipment and Research axis

2.1. List of PhD per entity

First Name	Last Name	Entity	Research subjects
Aintzane	Fayanas	CEIT	New bronze alloys for additive manufacturing applied to the naval sector
Angel	Sota	CEIT	Advanced manufacturing of new soft magnetic components for next-generation devices
Flor	Schiopetto	CEIT	Repair of railway metallic components using additive manufacturing
Iñigo	Ramón	CEIT	Femtosecond laser PBF additive manufacturing of stainless steel
Anthony	TY	ENIT	Study of nickel-based alloys obtained by LPBF for high-temperature wear applications: process - microstructure - mechanical properties relationships
Pierre-Nicolas	PARENT	ENIT	Tribology of metallic alloys for aeronautics obtained by LPBF AM: Process - Macro/Microstructure - Durability Relationships
Nicolas	Chambrin	ENIT	Study of manufacturing conditions on the in-service behaviour and defect tolerance of aluminium alloys obtained by LPBF
Cécile	LEROY DUBIEF	ESTIA	Definition of design and manufacturing rules for DED processes
Alexia	ROLLAND	ESTIA	Integration of additive manufacturing in the company: development of skills and support for change
Laurent	TERRENOIR	ESTIA	Methodology for the development of an operating range in additive manufacturing: application to the LMD-P process
Camille	BUROS	ESTIA	Study of the behaviour under complex stresses of architectural metallic materials obtained by additive manufacturing processes
Fábio	GAMEIRO	IPLEIRIA	Automation in industrial systems and robotic control
António	SILVA	IPLEIRIA	FFF of filaments charged with inorganic powders

Renato	BATISTA	IPLEIRIA	Thermographic image processing of MAM processes
Olivier	GOUVEIA	IPLEIRIA	Topology Optimization for structural optimization of automotive components / Reduced Order Modelling for FEM simulations
David	SERRÃO	IPLEIRIA	DED process optimization using CFD
Paulo	FREITAS	IPLEIRIA	Heat sink optimization using CFD techniques
Daniel	SILVA	IPLEIRIA	Aircraft parts produced by FDM 3D printing with recycled polymers
Maider	Arana	LORTEK	New high strength Al alloys for WAAM
Amaia	Iturrioz	LORTEK	NiFe36 alloy development tailored for AM
Iñaki	Setien	LORTEK	Computationally efficient distortion prediction models for L-PBF
Raul	Gomez	LORTEK	Fe based shape memory alloy development by L-PBF
Jon	Aranzabe	LORTEK	Topological optimisation for SLM
Juan Carlos	Pereira	LORTEK	LMD powder
David	Aguilar	LORTEK	CAD-CAM DED
David	Marquez	LORTEK	Simulation
Jose	Exequiel	UPV/EHU	Design of a coaxial nozzle for the Laser DED of titanium alloys
Marta	Ostolaza	UPV/EHU	Analysis of the behaviour of the functionally graded materials (FGMs) deposited by Laser DED
Oihane	Murua	UPV/EHU	Process modelling of Metal Additive Manufacturing
Sara	Sendino	UPV/EHU	Surface roughness prediction on LPBF processing of IN718 parts

2.2. List of equipment and software per entity

Organization	List of equipment	List of software
CATEC	LPBF Renishaw RenAM500 Sflex to operate with Ti64	Manufacturing preparation metal: Renishaw Qantam
CATEC	LPBF Renishaw RenAM500 E to operate with Scalmalloy	Design: CATIA, FUSION 360
CATEC	LPBF Renishaw AM250 to operate with AlSi10Mg	Simulation: ANSYS, Matlab
CATEC	Renishaw RBV to operate with Scancromal, Astraloy, Invar, Nitinol	CT Analysis: VG Studio Max
CATEC	Roughness improvement post processing equipment's (sandblasting, Chemical etching...)	
CATEC	Laboratory (Polisher, circular saw, Microscope, arquimides, roughness profilometer, 3D scans...)	
CATEC	X-Ray Computer tomography and Digital radiography equipment VJ 225-SE	
CEIT	DED Powder Laser (Kuka KR30HA + DKP400 + LMD HEAD Kuka MWO-I)	Design: CREO Programming: Mastercam, Robotmaster
CEIT	Binder Jetting (P-1 Production System, Desktop Metal)	Simulation: Live Sinter
CEIT	Gas/water atomisation unit PSI (model HERMIGA 3VI), up to 3 kg of powder	Simulation: ANSYS
CEIT	Furnaces for post-build heat treatment under different atmospheres (Ar, H2, High vacuum), up to 1800 °C, option for gas quenching	Thermocalc
CEIT	Hot Isostatic Press (HIP) ASEA (model QIH-6) up to 2000 °C and 160 MPa	
CEIT	Powder Characterisation (PSD (Dynamic image analyser Sympatec QICPIC for particle size distribution and morphology), sieving, FT4 rheometer, Hall´s Flow, pycnometer, densities)	

CEIT	X ray diffractometer BRUKER D8 ADVANCE A25: phase identification and quantification, residual stresses, crystallographic texture,	
CEIT	Microstructural Characterisation (optical & electronical microscopes, SEM, FEG-SEM, FIB, EDS & EBSD)	
CEIT	Mechanical characterisation (INSTRON universal machines (tensile, fatigue, creep), Charpy, hardness (micro & nano))	
CEIT	Chemical Characterisation (Leco C/S & N/O; ICP-OES (Agilent 725-ES))	
ENIT	Microstructural Characterisation (optical & electronical microscopes, SEM, FEG-SEM, EDS & EBSD, AFM)	
ENIT	Mechanical characterisation (INSTRON universal machines (tensile, fatigue, creep), Charpy, hardness (macro & micro & nano), Gas launcher for impact testing, Drop tower (60 Joules))	digital image correlation (VIC and GOM software)
ENIT	study of phase transformations (ATD & TMA, quenching dilatometer)	
ENIT	*Gleeble® Thermal-Mechanical Simulators*	
ENIT	micro tensile and bending tests on SEM (-100°C - 500°C)	
ENIT	X ray diffractometer Panalytical: phase identification, crystallographic texture,	
ENIT	Furnaces for post-build heat treatment up to 1400 °C	
ENIT	chemical characterization (UV spark spectrometer)	
ENIT	optical characterization (Camera's acquisition frequency: 12Hz (can be used in a stereovision bench), - Fast camera, acquisition frequency: 120Hz, - High speed camera, acquisition frequency: 600kHz (can be used in a stereovision possible use in stereovision bench)	
ENIT	corrosion study (Kelvin probe microscope (KFM), Low current bipotentiostat, Electrochemical impedance spectroscopy, Climatic chambers)	
ESTIA	DED Wire Arc (Kuka KR100HA + Fronius TPS3200)	Design: 3D Experience, Siemens NX

ESTIA	DED Wire Laser (Kuka KR60HA + DKP400 + Meltio D1mm – 1.2kW Laser)	Programming: Siemens NX, Adaxis AdaOne, Rhino Grasshopper, Simplify 3D
ESTIA	DED Wire Laser (COMAU + Precitec Coaxprinter D1.2mm//D1.6mm – 6kW Laser)	Simulation: GeonX Morpheo (Virfac) + homemade solver for Thermal simulation
ESTIA	DED Powder Laser (Machine BeAM Magic 800 – 2kW Laser)	Topology Optimization: Ansys Workbench (for student)
ESTIA	FFF/FDM (Machine Lynxter S600D)	Control & Monitoring: CAVITAR C300 + WiDySens 640 V-ST
ESTIA	Laboratory (Enrober, Polisher, circular saw, microscope, micro durometer)	
LORTEK	LPBF MCP-Realizer SLM 250	Programming: QuantAM, Magics
LORTEK	LPBF 280 LH (from SLM Solutions).	Distortion simulation: ABAQUS
LORTEK	LPBF RenAM 500Q (2 fibre lasers 500 W) from Renishaw	Topology Optimization: INSPIRE Altair
LORTEK	LDED Powder	Path planning: SKM, PowerMill
LORTEK	Gantry de dimensions (7x3 metros)	
LORTEK	DED Wire Arc with PAW, TIG y CMT	
UPV/EHU	DED Kondia Aktinos 500+Coherent 1kW fibre laser with two Powder feeders and coaxial head	Design: Siemens NX, CATIA
UPV/EHU	DED Trumpf Trucell 300 + 3kW Disk laser. Powder feeder with coaxial head	Programming: Siemens NX, QuantAM
UPV/EHU	LPBF Renishaw AM400 to operate with Ni base materials	Simulation: ANSYS, MATLAB + homemade

		solver for Thermal simulation
UPV/EHU	LPBF Renishaw RenAM500 to operate with Inco 718. Full monitoring included	
UPV/EHU	Coordinate Measuring Machine with contact probe and laser scanning	
UPV/EHU	Surface roughness optical profilometer	
UPV/EHU	Xray Computer tomography GE X-CUBE compact 225	
UPV/EHU	Machining centres for pre- and post-processing	

2.3. List of research axis per entity

Organization	Research axis
CATEC	New LPBF metal alloys (Al, alloys SMAs-Shape Memory Alloys, Ni-base Alloys)
CATEC	Roughness improvement of LPBF Metal AM parts (Chemical etching)
CATEC	Mechanical behaviour of AM components
CATEC	New industrial/functional applications (multisectoral, e.g., Heat-Exchangers, medical applications)
CATEC	W-LDED (integration stage)
CATEC	AM defects- Behaviour and influence
CATEC	Computed tomography to improve AM process
CATEC	Powder (Quality assurance and monitoring)
CEIT	Design and production of gas atomised powders for additive manufacturing
CEIT	Sinter based additive manufacturing (Binder Jetting)
CEIT	Advance characterisation for AM materials
CEIT	Post AM Heat treatments
ESTIA	Process Simulation (standard approach for thermal and thermomechanical simulation)
ESTIA	Model reduction
ESTIA	Process monitoring & Instrumentation (thermal + geometric)
ESTIA	Process indicator (KPIs) - Comparison with conventional technologies
ESTIA	Advanced toolpath generation
ESTIA	Process robotization
ESTIA	Impact of the process on material health
ESTIA	Industrial Engineering
ESTIA	Architectural materials
IPLEIRIA	Additive manufacturing: SLM, DED, FFF metal, Selective Powder Deposition

IPLEIRIA	Characterization: Materials, Processes and Parts
IPLEIRIA	Design for AM - numerical simulation
IPLEIRIA	Design of Manufacturing systems
IPLEIRIA	Materials development for AM
IPLEIRIA	Post-processing (milling, thermal treatments)
IPLEIRIA	Quality control - non-contact inspection (micro-CT)
IPLEIRIA	AM technologies integration in shop floor
LORTEK	Optimisation of powder composition based on the characteristics of the SLM and LMD processes
LORTEK	Customised, ad hoc alignments for SLM technology.
LORTEK	Optimisation of process parameters for different AM processes
LORTEK	Numerical simulation models based on FEM (Finite Element Method) to predict distortions in process and offset to ensure quality and repeatability.
LORTEK	Post-processing stages: optimisation of heat and surface treatments, removal of supports, ensuring dimensional tolerances, etc.
LORTEK	Quality assurance: development of monitoring system to detect defects, non-destructive testing (NDT).
LORTEK	New Fe, Co and Ni alloys for high-temperature applications and resistance to wear, and mechanical fatigue for LMD process
LORTEK	Short series, customised parts. Repair of high-value parts
LORTEK	Digitalisation of industrial production processes
LORTEK	WAAM processes with higher deposition rates, due to incorporation of multi-wire technologies (e.g., CMT TWIN) and hot-wire technologies (e.g., TIGSpeed).
LORTEK	Research in process monitoring technologies for early detection of isolated defects (porosity, lack of fusion).
LORTEK	Research in non-destructive testing (ultrasound, X-ray, tomography) to detect defects.
LORTEK	Process simulation and CAD/CAM tools for automatic manufacture of parts in 2.5D and 3D.
UPV/EHU	Process Simulation: thermal, thermomechanical and mechatronics
UPV/EHU	Data driven AM processes: Monitoring of LDED and LPBF. Analysis of the signals

UPV/EHU	Integration of LDED processes in machine tools: Hybrid machines, CAD/CAM integration, collision avoidance, simulation, etc.
UPV/EHU	Digital Certification of AM process: Monitoring data for certification
UPV/EHU	Mechanical behaviour of AM parts
UPV/EHU	Machining of AM parts
UPV/EHU	Roughness improvement of LPBF Metal AM parts

3.Mobility organization

The mobility activity has been reviewed compared to the initial plan (revision of post-COVID activities) to best answer to the issues of knowledge sharing in the SUDOE space. The consortium was able to ensure mobility of doctoral students, engineers, and researchers for a defined time in the project's partner centres:

- CEIT (San Sebastian, Spain)
- ENIT (Tarbes, France)
- ESTIA Addimadour (Bayonne, France)
- FADA CATEC (Seville, Spain)
- IPLEIRIA (Marinha Grande, Portugal)
- LORTEK (Ordizia, Spain)
- UPV/EHU (Bilbao, Spain)

The objective of this mobility was the ability of sharing good practices between France, Spain, and Portugal in the field of research, in particular through doctoral students and also to have access in use to other equipment by sharing the resources:

- Advanced Metallography Laboratory
- Powder bed machines, DED Powder, DED Wire Arc, DED Wire Laser, etc.
- Software: Design of lattice structures, thermomechanical simulations
- Non-Destructive Testing Equipment
- etc.

In total, more than 16 mobilities took place between doctoral students, post-docs, engineers, and researchers. The duration varies between 2 days and several weeks depending on the programs and took place from October 2022.

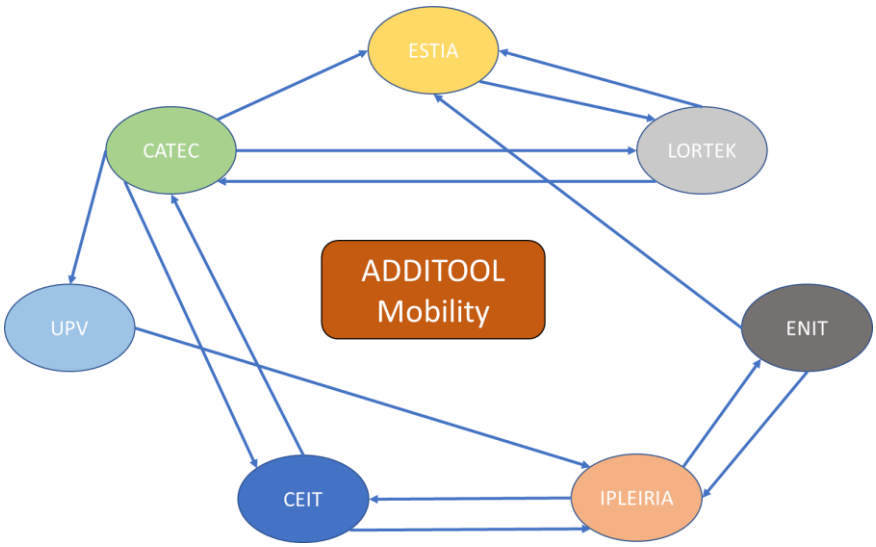
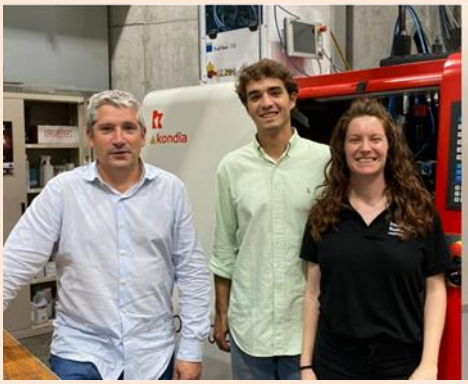


Figure 1 : All mobility carried out in the ADDITOOL project

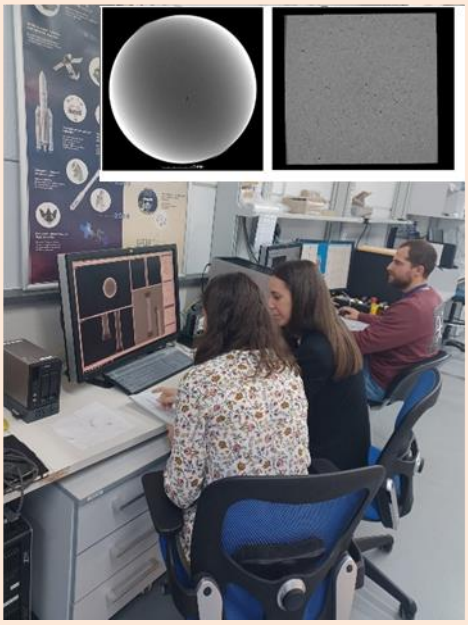
3.1. Mobility 1 and 2: Metallic material characterization / Collaborative development

From:	FADA CATEC
To:	CEIT // UPV/EHU
Name of the person:	Ignacio GONZALEZ-BARBA
Date of the mobility:	From 03rd to 07th October 2022
Short description:	Ignacio is one of the Additive Manufacturing Unit members at CATEC. He is in charge of material characterization of the parts produce by LPBF. He went to UPV and CEIT to share and acquire knowledge about different processes to characterize metallic materials produce by LPBF and DED.
Photos:	  

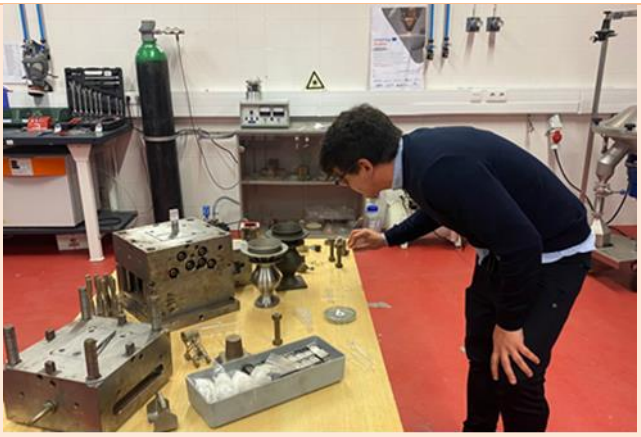
3.2. Mobility 3, 4, 5 & 6: MAM processes / Collaborative development

From:	FADA CATEC
To:	CEIT // ESTIA // LORTEK // UPV/EHU
Name of the person:	Carlos GALLEGUILLOS & Antonio PERINAN
Date of the mobility:	From October 17th to 21th 2022
Short description:	Antonio and Carlos have wide experience in LPBF processes and how to assure the quality of the components. They went to visit different ADDITOOL partners to share its experience and learn about DED processes.
Photos:	   

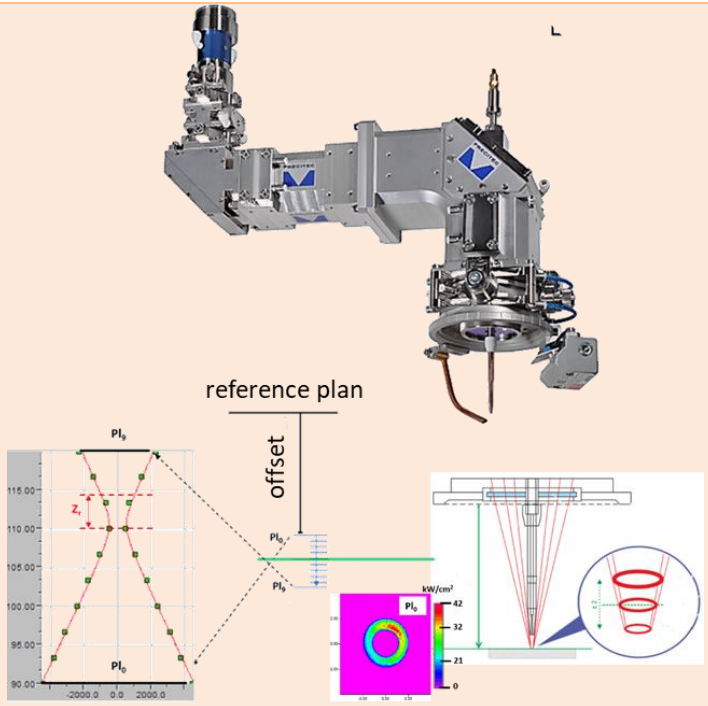
3.3. Mobility 7: Characterization of porosity in copper alloys

From:	CEIT-BRTA
To:	FADA CATEC
Name of the person:	Aintzane FAYANAS ALASTUEY
Date of the mobility:	From November 07th to 11th 2022
Short description:	Thanks to the ADDITOOL project, Aintzane was able to go to FADA CATEC to perform the characterization of porosities in copper alloys by computed tomography, focused on samples from additive manufacturing.
Photos:	 

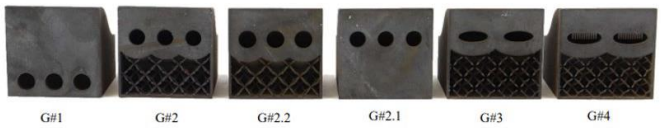
3.4. Mobility 8: CFD Simulations (Computational Fluid Dynamics)

From:	CEIT-BRTA
To:	IPLEIRIA
Name of the person:	Ernesto URIONABARRENETXEA
Date of the mobility:	From November 21th to 25th 2022
Short description:	The objective of this mobility was an opportunity for Ernesto to share with IPLEIRIA their experiences in CFD simulations for Additive Manufacturing and atomization processes.
Photos:	 

3.5. Mobility 9: Joint study of the Laser's caustic at Addimadour (Machine BeAM Magic 800 and PRECITEC CoaxPrinter)

From:	ENI de Tarbes
To:	ESTIA Addimadour
Name of the person:	Yannick BALCAEN & Jean-Denis BEGUIN
Date of the mobility:	October 14th 2022
Short description:	The mobility of ADDITOOL allowed an exchange of equipment and skills to study the caustic of the lasers present in Addimadour, namely: - Study of the power distribution of laser beams near the focal point or working distance (BeAM Magic 800 + PRECITEC CoaxPrinter) - Determination of caustics and Rayleigh length (Beam Magic 800 + PRECITEC CoaxPrinter).
Photos:	

3.6. Mobility 10: Discussions and experience sharing on W360 steel

From:	ENI de Tarbes
To:	IPLEIRIA
Name of the person:	Yannick BALCAEN & Joël ALEXIS
Date of the mobility:	February 01st and 02nd 2023
Short description:	This mobility allowed the ENI of Tarbes to go for the first time to the CDRSP centre of IPLeiria (Impossible to visit during the COVID-19 period). - Presentation of additive manufacturing activities and equipment of the CDRSP - Presentation and discussion of metallurgical studies carried out on W360 steel.
Photos:	 

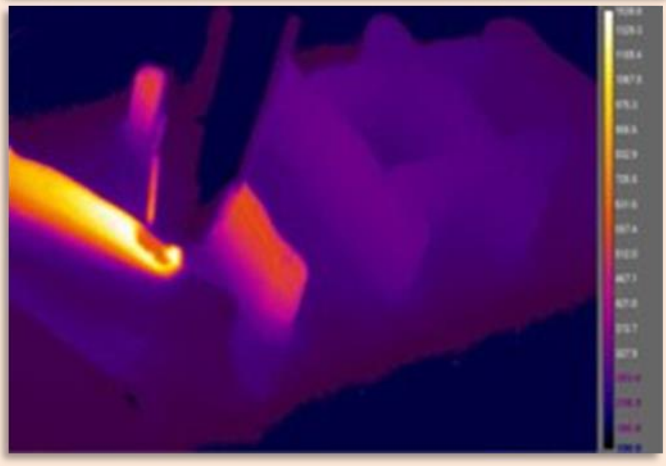
3.7. Mobility 11: Sharing Computed Tomography and Digital X-Ray Equipment VJ 225-SE

From:	LORTEK
To:	FADA CATEC
Name of the person:	Maider ARANA
Date of the mobility:	From November 07th to 11th 2022
Short description:	Acquisition of knowledge on NDT computed tomography applied to parts manufactured in Metallic Additive Manufacturing: - Different materials - Different equipment - Applicability - Operating concepts and training with specific software for results analysis.
Photos:	 

3.8. Mobility 12: DED Wire Arc (WAAM) processes and collaborative development

From:	LORTEK
To:	ESTIA Addimadour
Name of the person:	Amaia ITURRIOZ
Date of the mobility:	From October 03rd to 07th 2022
Short description:	Amaia is a PhD student at LORTEK working on the development of a NiFe36 alloy suitable for MAM. The mobility objectives for Amaia were threefold: - See in detail the process and manipulation of DED Wire Arc in Addimadour - See also the DED Wire Laser process (MELTIO equipment) + manipulation. - Manipulate another programming software (Adaxis AdaOne): Training on the programming of robotic trajectories for the manufacturing of metal parts using two different DED technologies: DED Wire Arc and DED Wire Laser.
Photos:	 

3.9. Mobility 13: Monitoring of DED Wire Arc (WAAM) process and collaborative development

From:	ESTIA Addimadour
To:	LORTEK
Name of the person:	Pierre DIAZ & Pierre SEZE
Date of the mobility:	October 10th and 11th 2022
Short description:	Pierre SEZE (Robotics Engineer) and Pierre DIAZ (Process & Mechanical Engineer) went to LORTEK during the manufacturing of the pilot part of the project (WAAM manufacturing) and brought monitoring equipment (SWIR thermal cameras) in addition to the equipment LORTEK monitoring tools to share data and compare different equipment.
Photos:	 

3.10. Mobility 14: MAM parts simulation

From:	UPV/EHU
To:	IPLEIRIA
Name of the person:	Oihane MURUA
Date of the mobility:	From November 14th to 27th 2022
Short description:	Thanks to this mobility, Oihane was able to carry out: - Thermal simulations of complex structures - Simulations for the design of complex geometries
Photos:	

3.11. Mobility 15 & 16: Characterization of MAM parts

From:	IPLEIRIA
To:	CEIT & ENIT
Name of the person:	Fabio SIMOES Pedro MARTINHO, Paulo NOVO
Date of the mobility:	February 13th & 14th 2022
Short description:	During this mobility, Fabio SIMOES Pedro MARTINHO and Paulo NOVO were able to go to the CEIT technological centre as well as to the ENI of Tarbes to discuss: - Mechanical characterization - Microstructural characterization (optical & electron microscopes, SEM, FEG-SEM, EDS & EBSD, AFM), Panalytical X-ray diffractometer: phase identification, crystallographic texture; study of phase transformations (ATD & TMA, quenching dilatometer); hardness (macro & micro & nano)
Photos:	

4.Conclusion

The “Mobility” part of the ADDITOOL project was very rewarding for all the partners who took part in this task.

It allowed those who wanted it to have access to very interesting equipment, often very expensive. This pooling has made it possible to go further in the various R&D subjects as well as the merging of skills without necessarily investing large costs.

Also, thanks to mobility, the partners were able to draw on each other's expertise and build skills on subjects related to their areas of research. The objective is to have a common base of knowledge in the SUDOE area, to share good practices between the different stakeholders, and to move forward jointly on the entire Metal Additive Manufacturing value chain (Design, Simulation, Programming, Process Control and Monitoring, Non-Destructive Testing, etc.).

Thanks to the ADDITOOL project, an important and strong collaborative network has been initiated, it must now continue over time with the will of everyone.

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