Project acronym:	Lasers4MaaS
Project title:	Laser-as-a-Service Digital Platform with Dynamic Beam Shaping for Acceleration of Smart, Decentralised and Sustainable Factory of the Future
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Owner:	WMG
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Type		
R	Document, report (excluding the periodic and final reports)	x
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filling, press & media actions, videos, etc	
DATA	Data sets, microdata, etc	
DMP	Data management plan	
ETHICS	Deliverables related to ethics issues	
SECURITY	Deliverable related to security issues	
OTHER	Software, technical diagram, algorithms, models, etc	

Dissemination level		
PU	Public, fully open, e.g. project website	x
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified R-UE/EU-R	EU RESTRICTED under the Commission Decision No2015/444	

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HISTORY OF CHANGES

Version	Publication date	Change
1.1	10/02/2025	First draft
1.2	17/02/2025	Second draft with addition of unstructured training
2.0	23/02/2025	Final document

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TABLE OF CONTENT

LIST OF TABLES

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
F2F	Face-To-Face
FEM	Finite Element Method
KPI	Key Performance Indicator
ML	Machine Learning
OCT	Optical Coherence Tomography
PC	Personal Computer
R&D	Research and Development
TRL	Technology Readiness Level

1. Executive summary

This deliverable constitutes the initial plan of training activities within the exploitation and dissemination activities planned for the first reporting period. The proposed training activities are divided into structured and unstructured activities. The former contain well-defined training events such as courses, where prerequisites, methods, outcomes and duration are clearly defined and measurable. The latter encompasses training, mentoring and skill development that people directly (or indirectly) involved in the project receive continuously, which is mostly – but not limited to – concerning the training of PhD and MSc students working on the project. The variety of planned training activities are chosen in a way that valuable knowledge transfer and skill development opportunities are offered for both researchers and industrial practitioners, both at entry level without significant prerequisites (BSc students, engineers without prior domain knowledge in, e.g., laser welding) and at the highest level (PhDs, industry experts). Due to the nature of training being a core responsibility of universities, most of the structured and unstructured training will take place at university partners, with some courses being held in collaboration, and some being conducted by industrial partners. Furthermore, with the progress of the project and generation of new results to be disseminated, existing training activities will be reviewed continuously, and new ones will be designed accordingly. This deliverable is also aligned with the D17.4 (initial plan of knowledge transfer activities) and will evolve into D18.2 (report on completed training activities) due at month 36 of the project.

2. Introduction

The training activities laid out within this document serve as a first starting point to start continuous dissemination and skill development already at the project start. With progress of Lasers4MaaS, new knowledge gained from the project will continuously be integrated into the courses and training activities outlined in this document. Furthermore, regular evaluation of held training courses and feedback surveys with participants will ensure a high quality and efficient knowledge transfer. These insights will especially be important for suitable design of training activities in later phases of the project (reporting periods 2 and 3), when more project-related results have been generated and can be used for design of new training activities.

While naturally the majority of training is conducted by university partners, the variety of trainings offered is designed in a way to offer valuable training opportunities equally to engineers from industry, at different skill levels.

In the following sections, structured and unstructured training activities are listed, containing both existing courses that have been and will be continuously adapted to integrate knowledge gained from Lasers4MaaS, and completely new activities which are being created within Lasers4MaaS. Structured training contains events, such as courses, with well-defined prerequisites, methods, outcomes and duration, while unstructured training encompasses the continuous training and skill development of people involved directly or indirectly in the project.

3. Structured training

Table 1 provides an overview of proposed training courses, where the dissemination of project outcomes of Lasers4MaaS plays a significant role in the course contents.

Table 1: Proposed training courses in Lasers4MaaS

Course proposed by: WMG
Proposed course name
Laser-as-a-Service digital platform for manufacturing servitisation
Course duration
One semester
Course level
MSc and PhD level, and professional
Course knowledge outcomes
This is a research-led module which aims at bridging the relationships between research and industry and how these serve both sides' needs in introducing advanced manufacturing and digital technologies. A number of case studies from industry-led projects and use cases.
Course skills outcomes
Appraise the methods and practices for Laser-as-a-Service technologies. Critically evaluate the strengths and weaknesses of the latest technologies/methods.
Overall outcomes (what will this course enable participants do do)
Students will be expert in the Laser-as-a-Service paradigm for the manufacture “on demand” of a large choice of customised products, with high flexibility and short lead time, by using distributed facilities as a service and exploiting unused production capacities, also by rapid re-purposing of laser welding machines.
How will the participant learn?
Lectures (face to face blended with on-line delivery for some of the lectures) and hands-on sessions in labs (laser welding lab and PC lab).
Mode of learning
Blended (lectures and hands-on sessions) – F2F and/or online

Any pre-requisites
Students must have followed the course on *Advances in laser beam welding systems* and any other Lasers4MaaS training needed to operate the system.
Target audience
This course is suitable for industry practitioners such as product designers, process engineers/researchers, system engineers/researchers. The course is also well suitable for innovation managers, program managers and technology officers with responsibility for the introduction of new process/technology.
How many times per year
One per year
Max no. of participants per session
N/A
Course proposed by: WMG (with guest lectures from all Lasers4MaaS partners)
Proposed course name
Advances in laser beam welding systems
Course duration
Across 2 weeks and covers 4 modules: *(1) laser welding landscape; (2) welding engineering; (3) control engineering; (4) system engineering.*
Course level
MSc and PhD level, and professional
Course knowledge outcomes
(1) Understand the recent developments in laser beam shaping welding technology and current applications. (2) Define strategies to weld similar and dissimilar materials. (3) Select sensors and control systems for weld quality management. (4) Troubleshooting of typical weld defects. (5) Risks assessments and safety when working with class 4 lasers. (6) Predictive maintenance and remote monitoring.
Course skills outcomes
(1) Operation of key components (welding heads, laser interface) for laser beam welding. (2) Installation, calibration and operation of sensors (photodiodes, OCT, high-speed cameras) for weld quality inspection as well as beam profiling (caustic measurements). (3) Implementation/coding of machine learning/artificial intelligence techniques for smart control of process parameters. (4) Fundamental of system maintenance and safety measures. In-class lectures and hands-on sessions will be offered to attendees.
Overall outcomes (what will this course enable participants do do)
(1) In-depth knowledge of laser welding systems which are essential for product designers, welding/process engineers and system engineers during R&D projects, technology validation and prototype, and pre-production setup. (2) Demonstrate the technology on typical applications. (3) Have opportunities to establish long-term relationship with WMG staff for collaborative work on fundamental research (TRL 2/3), applied research (TRL 4/5) and technology development (TRL 6/7).
How will the participant learn?
Lectures (face to face blended with on-line delivery for some of the lectures) and hands-on sessions in labs (laser welding lab and PC lab).
Mode of learning
Blended (lectures and hands-on sessions) – F2F and/or online
Any pre-requisites
Basic knowledge of fusion welding technologies.
Target audience
This course is suitable for industry practitioners such as product designers, process engineers/researchers, system engineers/researchers. The course is also well suitable for innovation managers, program managers and technology officers with responsibility for the introduction of new process/technology.
How many times per year
2 times per year (we may increase to 3 times pending demand from attendees)
Max no. of participants per session

10 to 15
Course proposed by: ULEI
Proposed course name
Sustainability and cost evaluator training tutorial
Course duration
<2 hours
Course level
Professional
Course knowledge outcomes
Use and interpretation of the Sustainability and Cost Evaluator
Course skills outcomes
Ability to operate the Sustainability and Cost Evaluator
Overall outcomes (what will this course enable participants do do)
Use of the Sustainability and Cost Evaluator
How will the participant learn?
On demand and guided online tutorial to operate the Sustainability and Cost Evaluator
Mode of learning
Blended (lectures and hands-on sessions) – F2F and/or online
Any pre-requisites
Students must have followed the course on *Advances in laser beam welding systems* and any other Lasers4MaaS training needed to operate the system
Target audience
Operators and other application users
How many times per year
On demand
Max no. of participants per session
Unlimited
Course proposed by: TUW
Proposed course name
Laser-assisted manufacturing
Course duration
The course runs over the course of 2 semesters and consists of 5 modules: *(1) Laser Technology; (2) Laser Processing Technology (3) Precision Machining with Lasers; (4) Laser Systems; (5) Laboratory Tutorial.*
Course level
BSc, MSc and PhD level
Course knowledge outcomes
(1) Fundamental principles of optics, lasers, beam propagation, laser-material interaction, and processes like welding, cutting, drilling, etc. (2) Design and components of high-power lasers for manufacturing, including beam shaping; process monitoring and control. (3) Modern trends and applications of laser technology in manufacturing. (4) Laser systems in industrial applications. (5) Experience of operating high power lasers (including beam shaping laser with industrial robot-mounted welding head) in a laboratory environment.
Course skills outcomes
(1) Understanding of fundamental physical principles of laser material processing. (2) Ability to critically assess laser system design for specific material processing applications. (3) Ability to choose optical components and laser specifications for concrete task. (4) Operate lasers safely. (5) Operate a modern laser system, such as a robot-mounted, multi-kW laser capable of beam shaping to facilitate a given welding task.
Overall outcomes (what will this course enable participants do do)

In-depth theoretical knowledge of laser material processing across a broad range of materials and applications, and the ability to apply the knowledge in practice using modern laser machines (both high-power cw lasers and ultra-short pulsed lasers) will enable participants to conceptualize new and optimize existing laser-based manufacturing processes across a broad range of TRLs in both industrial and academic R&D setups in a safe manner.
How will the participant learn?
Lectures (face-to-face or hybrid face-to-face/online) lectures, interactive seminars, and hands-on sessions in labs. Interactivity and high degree of individual attendee support is ensured through small groups (typically, less than 10 attendees per session, lab sessions are delivered in smaller sub-groups of 2-3 attendees).
Mode of learning
Blended (lectures, seminars and hands-on sessions) – F2F and/or online
Any pre-requisites
Basic physics and manufacturing knowledge is advantageous, but not strictly required.
Target audience
This course is part of the curriculum of the master's degree courses "Mechanical Engineering", "Industrial Engineering" and "Material Science" at TUW; it is open also to interested students (BSc., MSc., PhD) of other disciplines.
How many times per year
Starting Bi-yearly at beginning of each semester (October/March), lasting 2 semesters.
Max no. of participants per session
Lab sessions are divided into 2 – max. 3 attendees per session.
Further notes
This is an existing course, into which knowledge and results generated during Lasers4MaaS will directly and continuously be integrated, ensuring a direct dissemination of project results to future laser welding experts.
Course proposed by: TUW and CIVAN (joint)
Proposed course name
An introduction to simulation-based optimization of laser beam shaping strategies
Course duration
The course is held in the form of a pre-recorded webinar of approx. 1 – 2 hours duration, which will be free and open for the public.
Course level
BSc to MSc level
Course knowledge outcomes
(1) Fundamentals of coherent beam combining and dynamic beam shaping; (2) Fundamentals of physics-based simulation of laser welding; (3) Physics of laser-material interaction and process behaviour in welding with dynamic beam shaping; (4) Strategies of how to use simulations and hybrid experimental-simulative approaches to understand cause-effect relationships and to solve real-world manufacturing challenges via beam shaping.
Course skills outcomes
(1) Understanding of dynamic beam shaping and its possibilities to influence welding processes; (2) Understanding of potential and limitations of physics-based simulations of laser welding. (3) Choose suitable beam shaping strategies to achieve desired welding process outcome with the help of simulations and experiments. (4) Ability to abstract and idealize welding processes for efficient setup of simulations. (5) Ability to critically analyse simulation results.
Overall outcomes (what will this course enable participants do do)
Participants will have a basic understanding of dynamic beam shaping in laser welding, and the potentials, limitations and application cases for physics-based simulations. They will be able to abstract

a real-world manufacturing process into an idealized simulation and to critically assess the results of a simulation. They will furthermore gain insight into the cause-effect chains in laser weldng with beam shaping (parameter-KPI links) by studying selected examples from practice.
How will the participant learn?
Pre-recorded webinar (presentation with slides, including many practical examples from real welding tasks, and illustrative videos and images). Interested participants will furthermore be directed to material for self-study.
Mode of learning
Online webinar and independent self-study
Any pre-requisites
Basic knowledge of laser welding
Target audience
Welding engineers, R&D engineers and technical project managers from industry.
How many times per year
N/A
Max no. of participants per session
N/A
Course proposed by: USTUTT
Proposed course name
System technology for laser-based manufacturing
Course duration
The course runs over the course of 1 semester and consists of 15 to 16 lectures of 1.5h length
Course level
BSc, MSc and PhD level
Course knowledge outcomes
Impact of process parameters on system design for industrial laser applications. (1) The effect of the basics of laser material processing on the design of systems and the laser tool (contents: applications, absorption, heat conduction, energy balance) (2) The laser tool: laser source basics, laser types and beam propagation (content includes Beam guidance, focussing, axis dynamics and the corresponding components) (3) Supplementary: System and unit cost calculations and laser safety in systems
Course skills outcomes
To know the interdependencies between needed laser parameters to fulfil a laser application and the subsequent design of a machining system for laser material processing. Fundamental knowledge of the physics which define the needed process parameters.
Overall outcomes (what will this course enable participants do do)
Independent assessment of the design of laser machining processes for a given application. This means being able to answer questions such as ‘what does the system look like’, ‘which laser, optics... do I need to carry out the application...’, “Can I fulfil the requirements of the application with my system?”, ’What does it cost to manufacture a part?’
How will the participant learn?
Lectures (face-to-face), interactive seminars, and hands-on exercises. Interactivity and high degree of individual attendee support is ensured through small groups typically, less than 10 attendees per session.
Mode of learning
Blended (lectures, seminars and hands-on sessions) – F2F and/or online
Any pre-requisites
Basic physics and knowledge of laser material processing is advantageous, but not strictly required.
Target audience

This course is part of the curriculum of the master's degree courses "Mechanical Engineering" at USTUTT; it is open also to interested students (BSc., MSc., PhD) of other disciplines.
How many times per year
Starting Bi-yearly at beginning of each semester (October/March), lasting 1 semester.
Max no. of participants per session
Lectures are open up to 25 participants.
Further notes
This is an existing course, into which knowledge and results generated during Lasers4MaaS will directly and continuously be integrated, ensuring a direct dissemination of project results to future laser experts.

4. Unstructured training

Throughout the project, PhD students (approx. 2 per university partner) and MSc Students (approx. 1-2 per year per university partner) directly involved in the project will receive continuous training through working on the project-related tasks and collaboration with partners. They will be well-trained experts in the methodology developed throughout Lasers4MaaS; typically, students will move to industry or different academic institutions upon completing their degree, hence ensuring dissemination of project results and know-how and adoption of methodologies across industry and academia. Engineers involved with the project at industrial partners will receive continuous training and skill development, similar to students at universities.

Furthermore, researchers collaborate closely at the respective research groups and institutes, and over the course of the project also researchers (MSc students, PhD students, PostDocs) not directly involved in Lasers4MaaS will receive continuous informal training:

- TUW holds monthly internal seminars where researchers present and discuss their ongoing project results within the institute, hence the Lasers4MaaS project outcomes will be disseminated to and discussed with a group of approx. 30 scientific researchers regularly within TUW, further enhancing the long-term effects of knowledge transfer via unstructured training beyond people directly working in the project.

- ULEI/CML holds a weekly seminar where ongoing research projects are presented and discussed. Lasers4MaaS ongoing work will be features in these seminars as well, reaching the 100+ employees at the Institute of ULEI where the Lasers4MaaS project is hosted (i.e., CML).

- USTUTT holds several bi-weekly seminars for PhD, MSc and BSc students (Lasers in Manufacturing, Process Fundamentals of Laser Material Processing, System technology for laser-based processing), where the results of Lasers4MaaS will be presented and discussed.

- WMG holds regular quarterly training sessions for MSc and PhD students on topics related to FEM programming, computer coding, statistics/data processing and ML/AI laser process monitoring. Lasers4MaaS project outcomes will be disseminated and discussed during those training sessions.

- WMG will align the training activities via the Lasers4NetZero training platform[1] to foster further dissemination and networking.

5. Outlook into subsequent reporting periods

Throughout the course of reporting period 1, the effectiveness of the chosen training activities and their implementations laid out in Sections 3 and 4 will be monitored by surveying attendees and monitoring

[1] https://cordis.europa.eu/project/id/101119711; https://www.lasers4netzero.com/

participation metrics. This information, and the contents of the offered courses will be reviewed by the consortium yearly to identify needs for modification of content (e.g., choice of content, level of detail), mode of training (e.g., size of participant groups, F2F vs. online) and reach (e.g., how are courses advertised, how can interested participants be reached effectively).

The project results generated during each reporting period will be integrated into existing activities, and lead to creation of new activities implemented in the respective subsequent funding period. Newly proposed activities will be reviewed by the consortium before implementation to ensure effectiveness.