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Theoretical Training Materials Piloting Report

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Contents

1. Overview:

The AR/VR for Aerospace PBF-LB Operators (AREOLA) project is a part of the Erasmus+ program and involves a consortium of organizations, namely EOS, EWF, FA, IDONIAL, LAK, MakeReal, and MTC, listed alphabetically. One of the project's purposes is to develop educational materials that leverage technology to enhance vocational training in the field of additive manufacturing.

The emergence of the Covid-19 pandemic has stimulated online education and the integration of technology into education. This has increased the importance of more innovative education methods compared to traditional education methods. As technological advancements continue to reshape the landscape of education and training; various methods have emerged to enhance the learning experience. In response to this transformation and to make vocational education and training more appealing and aligned with the modern era, the AREOLA project has dedicated itself to developing digital educational content. However, the project goes beyond just producing digital content; it also investigates the pedagogical implications of adopting these technologies.

To achieve this, the project developed online materials for theoretical training and Extended Reality (XR) materials for practical training. These materials were also tested by means of pilots in the project result 4 namely comparison between the different learning and teaching strategies. In this report, the pilot result of online theoretical materials is presented. The pilot results of the Extended Reality materials have also been published in the "Extended Reality (XR) and Hands-on methods comparison report".

The pilot testing phase was undertaken in order to obtain valuable insights from the identified target groups regarding the quality of both the structure and the content of the developed training materials. The aim of this step was to collect feedback from participants to measure the effectiveness and relevance of the materials. The overarching goal was twofold: to assess the overall quality of the training materials structure and content, and to ascertain whether the materials, in their current form, successfully align with the specific needs of the intended target groups. Through this, we sought to refine and optimize the training materials, ensuring they not only meet but exceed the expectations of our participants.

In the pilot testing phase, we focused on trying out various online training materials. These materials include presentations, teaching notes, lesson plans, and case studies. The presentations are visual guides to help understand the topics better. Teaching notes provide additional information for instructors to gain a deeper understanding of the context. Lesson plans outline what will be covered during the training. Lastly, case studies present practical examples for a hands-on learning experience. By testing these materials, we aimed to ensure they are effective, easy to understand, and meet the needs of those using them for learning and development.

This report is intended for a diverse audience, including VET (Vocational Education and Training) providers, VET trainers, researchers in the field of educational technology, as well as trainers and training developers in the aerospace sector and other industries that utilize additive manufacturing technology.

2. Pilot Participants:

A total of 104 participants took part in the national pilot events across Portugal, Spain, Germany, and the UK. The participants represented diverse backgrounds and perspectives, contributing to a comprehensive evaluation of the training materials. The engagement and feedback provided by these participants played a vital role in shaping the effectiveness and applicability of the training materials on a national level.

The participants in the pilot testing represented a diverse spectrum within the aerospace and manufacturing sectors, encompassing both employees and apprenticeships. Furthermore, individuals came from various industry segments, including aerospace, defence, automotive and more. This eclectic mix ensured a broad range of perspectives and experiences, contributing to a comprehensive assessment of the training materials.

3. Pilot Design:

The pilot testing phase comprised a total of five sessions, with Portuguese, Spanish, and English (x2) partners conducting online pilots, while the German partner delivering a face-to-face . Each online pilot, on average, spanned eight hours, during which partners introduced the main training materials. The partners devoted an average of two days to the comprehensive implementation of the entire course.

During the sessions, the partners presented the developed content through engaging presentations and the inclusion of case studies made the courses even richer by encouraging the participation and interaction of the participants. Recognising the need for engaging activities in the online format, the trainers strategically used assessment questions and use cases to increase participation. For the online courses, partners preferred to use Microsoft Teams. Assessment questions were strategically integrated into the training using various software features provided by Teams, including polls and Microsoft Forms. This allowed trainers and participants to experience variety of different digital tools during the training.

The details of the pilot sessions conducted by the partners are presented below in Table 1.

Table 1: The details of partners' pilot event

Country	Partner	No. Trainees	Delivery methods	Date
Germany	LAK	17	Hybrid	30th June, 3rd-4th July 2023
Portugal	FAN	13	Online	19th-20th July 2023
Spain	IDONIAL	22	Online	20-22-23rd of June 2023
UK	MTC	36	Online	4-5th July 2023
		20	Online	13 July 2023

4. Aims of Pilots

The pilot tests had three objectives. First of all, the consortium wanted to evaluate the overall effectiveness of the training materials in conveying key concepts and facilitating learning. Secondly, the consortium aimed to gather detailed feedback from participants to identify strengths, weaknesses, and areas for improvement in the training materials. Finally, to evalauate participant satisfaction with the overall learning experience, content relevance, and the level of interaction facilitated during the pilot testing. Based on the findings of the pilot test, the developed materials were reworked and optimized to increase the satisfaction of users.

5. Feedback Collection:

Following each pilot testing session, participants voluntarily provided valuable feedback through a satisfaction questionnaire (see Annex I) crafted by the Quality and Evaluation Manager with input from all project partners. The questionnaire utilized a 4-Likert scale to quantify responses (strongly disagree to strongly agree), offering a structured approach. Additionally, participants had the opportunity to share insights through two open-ended questions. The feedback, organized into four distinct sections, encapsulates participant perspectives on various aspects of the training program.

- Structure and theoretical contents: Within this section, participants were asked to evaluate the efficiency and quality of the presented materials, specifically the presentations. They were also consulted on the overall design and presentation of the course. The section comprised nine Likert-type questions, providing a structured assessment of participants' perceptions regarding the effectiveness and design coherence of the course materials.

- Practical content and assessment questions (Quiz): This section focuses on the evaluation of the developed and implemented content, in particular the case studies and the assessment questions. The participants were asked to evaluate the quality of the delivered content and the compatibility of the assessment tools through Likert-type questions.

- Trainers' performance: This section focused on participants' assessments of the trainers' performance during course lectures and their teaching approach. Likert-type questions were employed to gather feedback on how participants perceived the effectiveness of the trainers.

- Suggestions and comments: In this section, participants were provided with an opportunity to share their suggestions and comments through open-ended questions. They were encouraged to highlight areas where the course could be improved, offering valuable insights to enhance future iterations.

  Additionally, besides the participants' perception, the pilot trainers' perception was also sought. Each trainer filled a feedback report at the end of training session.

6. Feedback Analysis:

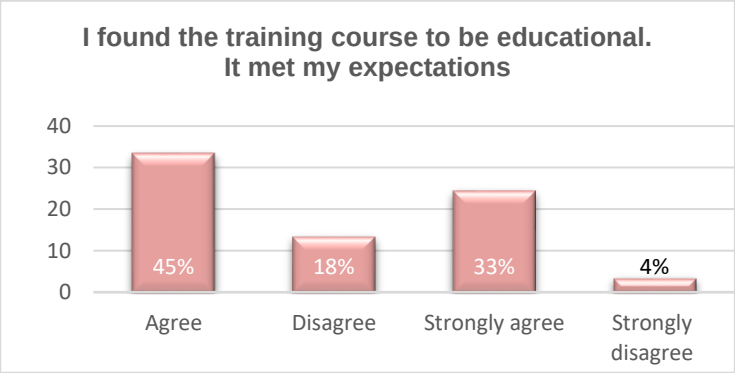
The analysis in this chapter is derived from pilot participants' feedback, and the results are presented accordingly. As the completion of the questionnaire is voluntary, some participants decided not to fill out the form. A total of 73 participants' results were utilized in the analysis.

6.1. Structure and Theoretical Content

The average score of 3.00 out of 4.00 was found for this section of the questionnaire. More detailed analysis was also conducted to comprehensively understand the point of participants.

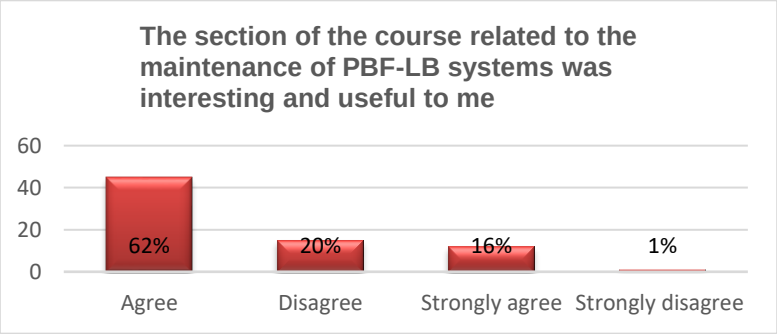
In response to the Likert scale survey, majority of participants indicated that the training course was both educational and aligned with their expectations. In contrast, a few participants reported a less positive experience, pointing out areas where the course could be improved. Please see Graphic 1.

Graphic 1. Responses regarding overall course content satisfaction with the training course



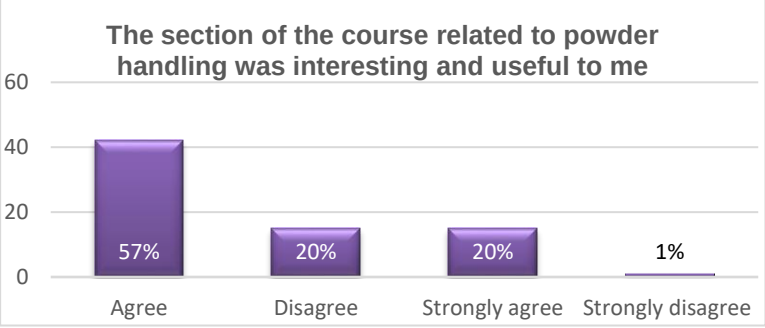
In response to the question, a significant number of participants highlighted 'maintenance of PBF-LB systems' as particularly interesting and useful. However, some of the participants stated the opposite as presented in Graphic 2.

Graphic 2. The distribution of responses regarding the training materials on maintenance of PBF-LB systems



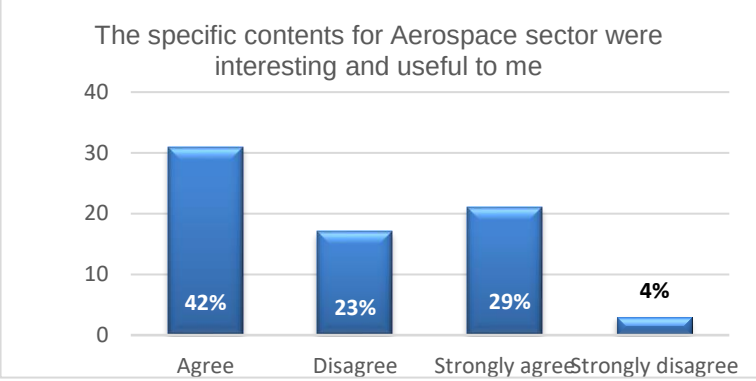
The majority of participants found “the powder handling” section of the course interesting and useful. However, some of the participants held opposing views (see Graphic 3).

Graphic 3. The distribution of responses regarding the powder handling content



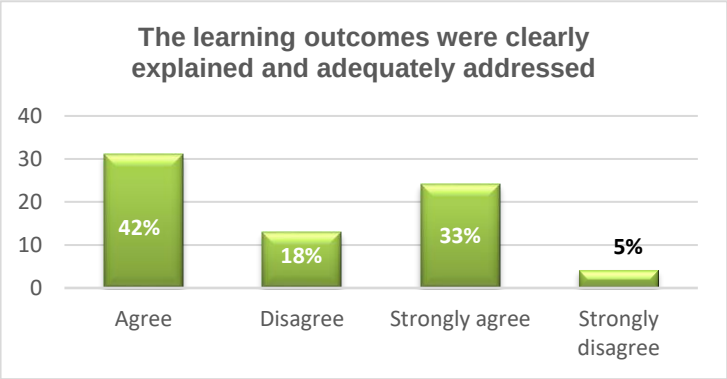
The majority of the participants reflected that the aerospace sector specific contents are useful and interesting as indicated in Graphic 4. However, some of them stated the opposite.

Graphic 4. The distribution of responses regarding specific contents for aerospace sector



Graphic 5 reveals that most participants positively acknowledged the clear and thorough explanation of learning outcomes during the piloting implementation. However, it's important to acknowledge that a subset of participants held differing views.

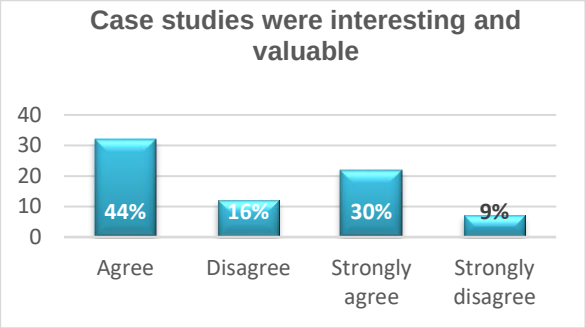
Graphic 5. The distribution of responses regarding the clarity in explaining learning outcomes



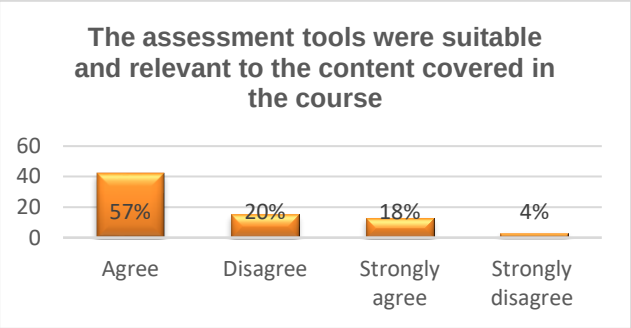
6.2. Practical Contents and Assessment Questions (Quiz)

In this section, we sought participants' views on the practical content, specifically the case studies and assessment questions. The average rating was 2.9 out of 4.0. While participants found this section valuable overall, a more in-depth analysis is available in Graphic 6 and 7 below.

Graphic 6. The distribution of responses regarding the case studies

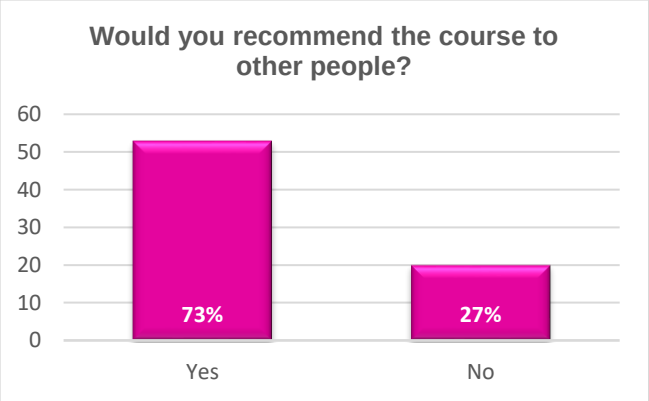


Graphic 7. The distribution of responses regarding the assessment



Finally, participants were asked whether they would recommend the course to others. Most participants expressed a positive inclination, stating that they would indeed recommend the course. However, it's noteworthy that a subset of participants had a different perspective. The detailed analysis presented below in Graphic 8.

Graphic 8. The distribution of responses regarding the recommendation of course to other people



6.3. Suggestions and Comments

To enhance the developed materials and training, participants were asked to share the most positive aspects they identified and to highlight points for improvement. The responses yielded valuable insights into the strengths of the materials as well as areas that participants felt could be enhanced. The detailed analysis of these answers, presented below, offer a comprehensive understanding of the aspects that resonated positively with participants and provideguidance for potential adjustments and enhancements in future iterations of the developed materials.

6.3.1 Positive Aspects

At the conclusion of the pilot sessions, participants were asked to share their most positive aspects about the overall course. Common themes emerged in their reflections, with participants frequently highlighting aspects such as material, content topic and quiz as can be seen in the Picture 1 below.

Picture 1: The common themes of positive aspects

This feedback not only serves to recognize the strengths of the course, but also provides valuable information about participants' impressions of the developed training materials.

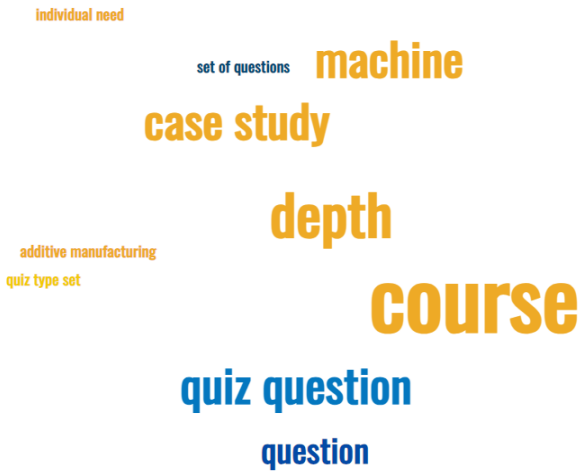
- "Content was interesting & applied to what I was looking for"
- "The course provided **valuable and comprehensive information**, making it accessible to individuals who are new to the subject matter. The incorporation of **videos and photos** throughout the course added an engaging element."
- "Very **interesting material** which enhanced my knowledge"
- "Very **informative overview** of all metal AM processes. PBF process **explained in detail covering all aspects"**
- "Very **informative and interesting"**
- "Practical maintenance and safety practices were detailed. The whole training gave a good insight into what the actual practice might look like"
- "Course was very concise and provided a **good overview of Additive Manufacturing**. Presented multiple different AM techniques with advantages and disadvantages of each. **Quizzes** provided helped assess and **reinforce what was learnt"**

- “I liked the case study and videos”
- “The quiz activity”
- “Content was good”
- “Interesting topic”

6.3.2 Points for Improvement

Participants generously shared points for improvement, shedding light on aspects for potential adjustments to enhance the developed materials and training. Common themes emerged in their reflections, with participants frequently highlighting specific areas such as lack of access to machine, case study, depth, and course parts, as illustrated in Picture 2 below. This feedback offers valuable guidance for refining and strengthening these elements in future iterations of the developed materials and training program.

Picture 2: The common themes of points for improvement



The participants quotes are given below;

- “More **videos** and **real cases** help understanding”
- “I would have liked a bit more **content on manufacturing strategy”**
- “More **concise explanations”**
- “Training should be more interactive, promoting the involvement of participants. We attended the mere exposition of the contents, which at least could have been complemented with examples that were beyond the ppt; correct small typos that appear in the ppt (PT materials)”

- "Topics covered (some covered **too superficially** and others **too deeply**)."
- "Questions & practical case study was more challenging & in depth than what we covered on the course. "
- "In order to cater to a general audience and fulfill the course's objective of introducing a new area, it may be beneficial to reduce the amount of detailed information presented. This would prevent overwhelming participants who are not already familiar with metal AM"
- "I am very new to additive manufacturing and was a little too advance for my understanding"
- "Once the course (part 2) got more in depth it became harder to follow and became less relevant for my individual needs."
- "Case study from day one needs to be altered, it reads more of another quiz type set of questions rather than a case study (in my opinion)."

6.4 Trainers' Reflection on the Training Materials

After delivering the training, trainers offered valuable insights in their feedback, pinpointing specific areas in the developed materials that, in their real experience, require modification or fine-tuning. The trainers recommended reworking the following materials within the AREOLA project, as detailed in the table below.

Table 9. Trainers' recommendations on the developed materials

Materials	Evidence supporting the decision	Improvements required
Teaching notes	Definition of maintenance and servicing was not matching the German latest standards.	The text on maintenance and servicing has been adapted to the latest German standards in the German slides used in the pilot course.
Presentations	Some of the contents may require certain adjustments or additional recommendations/warnings to trainers, as their current length or configuration could potentially lead to an extension of training time or repetition of certain aspects.	Review the content to identify adjustments or recommendations that could be provided to trainers.
	Inconsistent terms are used.	The terminology in the slides should be harmonized.
	Some slides have too much text and some just aren't very engaging. Some sections referred standards without any link to them	Rework these slides.
Case studies	The case studies are not consistent in their presentation, or even in their potential use. It would be necessary to standardize this presentation or establish the recommended use for each of them. Specifically, the case study on the material dispenser system may not have sufficient support in the developed slides.	Review the developed case studies and identify their preferred mode of use.
	Some case-studies were hard/impossible to pilot effectively due to lack of engagement possibility. Some required materials that were not possible to make available for the students (EOS manuals)	Provide material to give trainees during training
Assessment questions (Quiz)	Some of the evaluation questions have excessively long wording, either in the questions or in the answers. It would be appropriate to establish a recommended methodology for using these questions.	Establish a recommendation for their use.

This direct input from trainers provides actionable guidance for refining the materials and further optimizing the developed training materials. While most participants provided positive feedback about the AREOLA training materials, there is still room for improvement to enhance the quality of the materials by the end of the project. Therefore, we carefully considered every piece of feedback and information to address issues and ensure the efficiency and relevance of the materials. Since we specifically inquired about each material in the feedback questionnaire, we were able to fine-tune each of them in the refinement of the training materials. The following section outlines the action plan for fine-tuning the materials.

7. Implementation

The insights gathered from participant and trainer feedback have shaped a comprehensive action plan to enhance specific aspects of the AREOLA project's training materials. Notably, the pilot activities revealed the adaptability of theoretical materials for versatile training delivery, whether online or face-to-face, with a particular emphasis on the pivotal role of interactive content in sustaining engagement during online courses. Table 10 shows the actions taken in response to this feedback to improve AREOLA's theoretical training materials.

Table 10: Actions for revision of the theoretical materials

Materials	Actions
Teaching notes	The feedback underscores the need for a review of teaching notes. A review process was initiated to ensure alignment with the latest German standards.
Presentations	• Actions in this category concentrated on refining the presentation materials. • Redundant slides were identified and removed, missing information was supplemented, and efforts were made to minimize text for enhanced clarity. • Inconsistencies in terminology and the length of some slides were addressed to create more engaging and harmonized presentation content.
Case studies	• Case studies underwent a standardization process to ensure consistency in presentation and recommended usage. • Missing information was added to the presentation to create a bridge with case study. • The training manual incorporated explicit recommendations on the effective utilization of case studies.
Assessment questions (Quiz)	• The action plan for the assessment tools included addressing concerns about the length of questions and answers. A suggested methodology for using these tools to facilitate the evaluation process was provided in the trainers manual.

This comprehensive approach aimed to refine teaching materials systematically, acknowledging their significance as references for trainers. The overarching goal is to enhance the overall effectiveness and applicability of the AREOLA training materials, aligning them more closely with the needs and expectations of both trainers and participants.

8. Conclusion

Amid the Covid-19 pandemic and the growing reliance on online education, the AREOLA project has strategically responded by creating online deployment materials for theoretical training and extended reality materials for practical training. In this report we focused on the pilot testing phase, involving 104 participants across Portugal, Spain, Germany, and the UK, representing diverse backgrounds in the manufacturing sector especially with AM background, including aerospace, defence, and automotive.

The pilot design comprised five sessions, with online and face-to-face approaches, where partners presented engaging contents such as presentations, case studies and assessment questions (quiz). The feedback gathered from participants guided the refinement of the training materials, emphasizing the suitability of theoretical content for both online and in-person training. The importance of interactive materials in online education, ensuring student engagement, was highlighted.

In conclusion, the valuable insights and recommendations from both participants and trainers have guided us in mapping out necessary actions to refine the training materials. The analysis of the feedback led to the identification of actions for instance to enhance the presentation, the partners identified and eliminated repetitive slides, supplemented any missing information, and minimized text for improved clarity. Recognizing that the materials serve as reference sources for trainers, an additional recommendation was incorporated in the training manual. Trainers were advised to tailor their own materials based on the AREOLA training material, considering the proficiency level of the target audience.

One of the most significant outcomes of the pilot, stemming from activities conducted both online and face-to-face, indicates that the theoretical materials developed in the AREOLA project are suitable for use in both online and in-person training. Additionally, it's crucial to highlight that interactive materials play a vital role in online training, capturing students' attention and ensuring engagement throughout the course.

9. Appendix I

The purpose of this questionnaire is to evaluate your satisfaction with the theoretical online training you have received. We want to assure you that your responses will be completely anonymous and confidential, and will only be used to improve the quality of the training. Please take the necessary time to respond with sincerity and accuracy.

Section 1. Structure and theorethical contents. Please, rate the following aspects:

	Strongly disagree	Disagree	Agree	Strongly agree
I found the training course to be educational. It met my expectations	☐	☐	☐	☐
The section of the course related to the maintenance of PBF-LB systems was interesting and useful to me	☐	☐	☐	☐
The section of the course related to powder handling was interesting and useful to me.	☐	☐	☐	☐
The specific contents for Aerospace sector were interesting and useful to me.				
The training course was well-organized, and each section complemented the others well	☐	☐	☐	☐
The learning outcomes were clearly explained and adequately addressed	☐	☐	☐	☐
The topics were covered at an appropriate depth	☐	☐	☐	☐
The length of the training was adequate	☐	☐	☐	☐
The learning materials met my expectations in terms of content and quality	☐	☐	☐	☐

Section 2. Practical contents and assessment tools. Please, fill out every question:

	Strongly disagree	Disagree	Agree	Strongly agree
Case studies were interesting and valuable	☐	☐	☐	☐
Sufficient time was devoted to the presentation of the case studies	☐	☐	☐	☐
The assessment questions were suitable and relevant to the content covered in the course	☐	☐	☐	☐

Section 3. Trainer´s performance. Please, rate the following aspects:

	Strongly disagree	Disagree	Agree	Strongly agree
The trainers were highly organized and well-prepared.	☐	☐	☐	☐
The trainers made efficient use of time	☐	☐	☐	☐
The trainers presented the course material in a clear manner	☐	☐	☐	☐
The trainers contributed to stimulate my interest in the subject matter	☐	☐	☐	☐
The trainers actively encouraged audience participation and interaction.	☐	☐	☐	☐
The trainers provided helpful feedback that improved my understanding of the material	☐	☐	☐	☐

Section 4. Suggestions and comments. Please, feel free to comment on the most positive aspects and/or points for improvements of the Train the Trainers event:

Most positive aspects:

Points for improvement:

Thank you very much for your contributions, they are highly valuable for improving future training activities in the context of Additive Manufacturing.