DELIVERABLE T2.1.4

Modular transdisciplinary training programme on 3 AVM knowledge dimensions acc. to SME needs in CE

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1. Aim of this report

Within the course of developing a novel InnoPeer AVM qualification programme, the aim of this report is to define the content und structure of the training modules for basic, advanced and practical trainings in the three knowledge dimensions advanced manufacturing (AVM)-related technology, AVM-rel. business model development and AVM-rel. human resource & organisational management.

This document is designed as a comprehensive summary and contains the curriculum of the modular qualification programme on all three knowledge dimensions acc. to SME needs in CE in one document. This document correlates in form and content to the deliverables D.T2.1.1, D.T2.1.2 and D.T2.1.3, while being not as detailed and thus giving more of an overview on the complete content of the training programme. For a more detailed description of each topics, the respective deliverables should be used.

2. Overview on Content and Structure of the Trainings

The basic training is the first training in the InnoPeer AVM Qualification Programme and has the goal to introduce the topic of AVM (AdVanced Manufacturing = Industrie 4.0) in general as well as the three knowledge dimensions AVM-rel. technology, human resource and org. mgmt. as well as business model development & strategy. The basic training has a duration of three days and will be held as a local course in each region.

As shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**, the basic training consists of four modules: A general introduction to Industrie 4.0, a part for business model development & strategy, a part for human resource & org. mgmt. and a part for technology. As the whole topic of Industrie 4.0 can be described best with technological innovations, this deliverable will cover some general introduction to Industrie 4.0 with the focus on technical aspects as well as the specific topics for the technology module of the basic trainings. There are two possible options on how the basic training can be split up:

- 0.5 days for the general introduction and 0,83 days for each of the 3 knowledge dimensions including the elaboration of one short teaching case per dimension
- 0.5 days for each of the 4 modules within the basic training plus 1 day for the first 3 teaching cases in each knowledge dimension

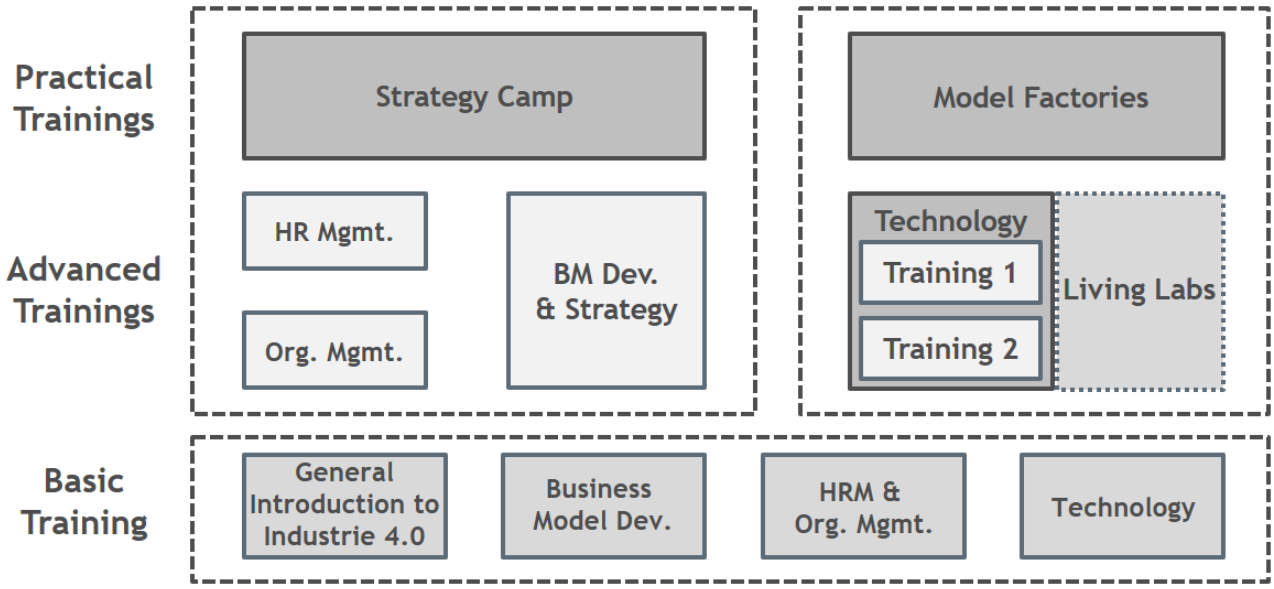

Figure 1: Overview of the InnoPeer AVM Training Modules

Regarding the advanced trainings, five trainings are held with a duration of two days each. There will be two trainings for technology, one training for human resource management (HRM), one for organisational management and one for business model development in conjunction with business strategy. These trainings will be held as webinar. In the advanced trainings, 1-2 teaching cases per training will be used to further impart the knowledge on the different topics. It is possible to do the elaboration of the teaching cases in local workshops instead of web-based.

Following the advanced trainings on technology, the living labs will be held web-based with a maximal duration of 0.5 days. In the living labs the newly developed teaching cases will by elaborated and the assignments that will further be tested practically in the Model Factory are prepared jointly.

The practical test runs for AVM-rel. technology will be done in Model Factories run by PP11 (FHG), PP10 (WRUT) and PP9 (DEMO), which are based on the results of the living labs. Examples on what can possibly be tested are given in this deliverable.

The practical trainings for business model development in conjunction with business strategy as well as HRM & org. mgmt. will be held as a strategy camp with a duration of up to one week while the practical test runs for technologies will be done in Model Factories.

3. Modules for Basic Trainings

3.1. Modules for Basic Training on AVM-rel. Technologies

As mentioned before, the basic training will be split up into four different modules with one general introduction to I4.0 and three modules on the different knowledge dimensions. In this chapter, the technological aspects of the introduction as well as the specific content for the module on AVM-rel. technologies is being elaborated. A detailed description of this chapter can be found in D.T2.1.1 chapter 3.2.

3.1.1. Module for Basic Training on General Introduction to Advanced Manufacturing / Industrie 4.0

It was decided within the development of the training programme that the basic training will start with a general introduction to advanced manufacturing, which is to be treated equally with the German term “Industrie 4.0” (I4.0). One of the main aspects in the definition of I4.0 are the digitally networked systems needed to realise a world, where everything from machines to people are connected to each other. These intelligent connected devices can also be called cyber-physical Systems or CPS, since it consists of information technology / software and physical mechanical and electrical parts. These CPS are able to communicate with each other for exam,,ple over the internet. Two of the main factors leading to the development of I4.0 are:

- Generally shorter product lifecycles, especially in electronic products
- Growing demand for individual products (mass customisation)

Since these are only general trends in the context of I4.0, an example should be presented as storyline, in which a possible implementation in SMEs is shown. A concept, which should also be mentioned in the context of I4.0, is the Reference Architecture Model Industrie 4.0 (RAMI 4.0).

3.1.2. Modules for Basic Training on AVM-rel. Technologies

This chapter describes the training modules and topics, which should be covered in the basic training for AVM-rel. technologies. Since all of the technology topics can be covered very detailed, the basic training

has the goal to just give an overview with the most relevant information in addition to the technology-focused introduction in general. This also leads to a broad overlap between the basic and advanced trainings, since most topics are covered more detailed in the advanced trainings.

3.1.2.1. General Technological Trends in I4.0

In the first part of the basic training, general technological trends have to be covered, which are the direct result of the reasons for the Industrie 4.0 initiative stated in the introduction to the basic courses. These topics are treated separately since they are not directly related to unified connectivity, which is typically one of the main aspects in I4.0.

Additive Manufacturing / 3D Printing

Due to the demand for individualised products, new manufacturing processes, which are able to produce a high variant diversity up to batch size one, are needed. As a result of this development, the technologies summarised with 3D printing or additive manufacturing have developed to the most promising manufacturing processes to produce batch size one. Generally, there are three processes that can be distinguished: Manufacturing out of a liquid state (e.g. stereolithography), manufacturing out of a plastic state (e.g. Fused Deposition Modeling) and manufacturing out of a powdered state (e.g. SLM, SLS, EBM).

For the InnoPeer basic training, these three manufacturing processes should be elaborated very shortly with examples for their practical application.

Flexibility and Changeability

As a result of smaller batch sizes and shorter product life cycles, production systems have to be adapted to new products in a very short time to be cost efficient. In this context, the two terms “flexibility” and “changeability” are used very often to describe this kind of adaptability.

The concepts of flexibility and changeability should be covered in the InnoPeer basic training by explaining these two terms and their difference. They should be elaborated with suiting examples from existing production lines as well as research demonstrators that can show new concepts in this field.

Simulation, Digital Twins and Virtual Commissioning

To achieve shorter set up times in production lines, simulation can be used for creating or testing the configuration virtually before setting it up in reality. In this context, the terms “Digital Twin” and “Virtual Commissioning” are also used very often. Another term that has to be mentioned in direct correlation to virtual commissioning is Hardware in the Loop (HiL).

The basic training should impart knowledge about general application of simulation models with focus on virtual commissioning/ HiL and show how these models can be created and integrated.

Human Machine Collaboration / COBOT

Human machine collaboration describes generally a coordinated, synchronous activity between a human and a machine that is the result of a continued attempt to achieve a common goal. This means that the machine and the human are directly working together on one task. The term “COBOT” is short for collaborative robot and a specialisation of human machine collaboration. It refers to (industrial) robots working together with humans and supporting them in their tasks.

For the InnoPeer basic training, the different types of collaboration and cooperation between human and machines/robots should be explained by giving short examples out of practical application. It should also be mentioned that current research shows that a cooperation is a more realistic scenario in the near future than collaboration.

3.1.2.2. Connectivity

While chapter 3.1.2.1 covered general trends correlated with I4.0, this chapter shell focus on one of its main aspects, which is connectivity. The topic connectivity is split up into the three aspects *Connectivity Technologies*, *Data Models* and *Security*.

Connectivity Technologies

In the introduction to Industrie 4.0 it was elaborated that the connectivity between all machines to form a digitally networked system can be considered as one of the main aspects. However, in today's automation systems, there are many different interfaces and protocols present for connectivity, which are often also preferred or developed by certain manufacturers. To connect every machine to each other, a full interoperability and thus a unified communication needs to be established.

In the InnoPeer basic training should elaborate the general problematics with proprietary interfaces in relation to the goals of I4.0 and also provide a brief description of the relevant I4.0 connectivity technologies. Detailed examples on the application of these standards will be given in the advanced trainings.

Data Models

While unified interface standards are important to connect machines to each other, this does not necessary mean that a full interoperability is provided. It is still possible to transfer proprietary data by bits and bytes without any common understanding about its semantic meaning. It is therefore necessary to create common data semantics, which are known by all participants in an I4.0-Network. These data models can be based on existing standards, but have now to be adapted to the new communication technologies like OPC UA.

The basic understanding on why data models are as important as common network standards for I4.0 should be presented in the InnoPeer basic training by showing a few selected use cases, especially in terms of processing a lot of data from different types of machines for condition monitoring, predictive maintenance or online process optimisation.

Security

While more and more machines will be connected over the Industrial Internet of Things (IIoT), the aspect of security becomes especially important. For security reasons, most production systems are currently heavily protected by firewalls or completely closed off from the outside world and are therefore not able to transmit any data to the IIoT.

The topic of security in IoT networks should be covered in the InnoPeer basic training by giving an overview on the topics' importance in a connected world and showing the biggest security risks that we are facing today. Since security is also directly connected to the communication technologies, brief but concrete examples should be given how these technology tackle this topic (for example the build in security system of OPC UA especially designed for industrial application).

3.1.2.3. Data Collection and Analysis

This chapter focuses on how this data can be collected effectively and how it can be analysed to get a concrete benefit out of the connectivity.

Data Collection via Cloud and Big Data

While interfaces and data models are the basis for data collection, mechanism and technologies have to be found to collect and store this data efficiently. Since most of the IIoT-Standards covered in chapter 3.2.2.1 of D.T2.1.1 are not capable of deterministic real time communication, they are currently used to collect data for use cases like condition monitoring or online process optimisation. These use cases are elaborated in the following chapters.

In the InnoPeer basic training, the most common examples on how to collect data from different devices to a cloud service should be elaborated shortly. Hereby, the different technologies and cloud platforms should be presented shortly as well as the possible architectures to get data from devices up to the cloud.

Condition Monitoring and Predictive Maintenance

As stated in previous chapters, the lack of real time capability in modern IIoT-Standards makes them prominent for use cases that are based on data collection. Very common examples are Condition Monitoring and Predictive Maintenance. These terms do also have a relation to each other, since Condition Monitoring is the basis for Predictive Maintenance.

In general, the following different types of maintenance can be distinguished:

- Preventive Maintenance: The date of maintenance is being determined by time or condition
- Corrective / Breakdown Maintenance: Maintenance is performed if a machine has already broken down

In the InnoPeer basic training the different types of maintenance should be elaborated while stating why predictive maintenance is the best strategy regarding costs and availability and thus justifying the higher investment costs.

Intelligent Sensors / Retrofit of existing machines

Often very old machines can be found in production system, which have no connectivity options or even computer control. In these cases, sensors have to be added to utilise the use cases of condition monitoring and predictive maintenance. If a machine already has sensors but is missing connectivity, it is possible to fit adapters or gateways to get from proprietary data formats and connectivity options to standardised I4.0 protocols and data models. This process can also be called “retrofitting”.

In the InnoPeer basic training the addition of smart sensors and retrofitting of existing machines in terms of sensors and connectivity should be elaborated by giving different examples like the one stated above with the ABB Ability Smart Sensor. These examples should cover different types of devices and machines like Motors, Drives, CNC-Machines or injection moulding machines.

3.2. Modules for Basic Training on AVM-rel. Human Resources Management and Organisational Management

This chapter gives an overview on the topics of the training modules for the basic training on AVM-rel. HRM and Org. Mgmt. A detailed description of these modules can be found in D.T2.1.2 chapter 3.1.

3.2.1. Implications of AVM for Human Resources and Org. Mgmt.

Firms are embedded in a wider context. This context has become more dynamic and competitive over the last years (“Hypercompetition”). Besides general changes in technology (e.g. digitalisation), the introduction of Advanced Manufacturing. technologies is determined by further factors of the context. The context can be distinguished in the industry and a wider societal context.

Regarding the wider societal context there exist six factors influencing changes towards Advanced Manufacturing:

1. Technology: New technologies and the ongoing digitalisation
2. Socio-cultural factors: Demographics, Digital Natives
3. Economic factors: Low interest rates, shortage on skills
4. Political factors: Digitalisation agenda, innovation support programmes, incubators

5. Law: Changes in data law, privacy, etc.
6. Environemtal factors: Climate Change

Generally, speaking in Central European countries, demographics lead to a shortage of labour and states have been starting digital transformation agendas.

Regarding the industry further factors influencing adoption of Advanced Manufacturing can be distinguished:

1. Customers and their needs
2. Competitors
3. Suppliers
4. Potential entrants

In the last years industries have been disrupted by so called Internet giants (e.g. Amazon, Google, Tesla, etc.) threatening existing structures of value chains and businesses.

Against this background manufacturing firms start to work on their strategic goals (Positioning markets and resources in order to gain a competitive advantage), influencing their business models (combination of value proposition, value added model and revenue model) and finally their execution architecture (organisational design, work design and production system design). Central for the transformation of firms towards Advanced Manufacturing is a fit between strategic goals (based on resources and competencies), business model, and execution system with future demands resulting from the wider societal context and the industry context. Should there be a misfit, resources and competencies have to be aligned to the future demands.

3.2.2. Module for Basic Trainings on AVM-rel. Human Resources and Org. Mgmt.

3.2.2.1. Aims and Learning Goals for Basic Training on HRM and Org. Mgmt.

The basic course on HRM and org. mgmt. has the overall goal to allow general managers and innovation managers to get a first introduction on the way these topics are affected by changes through Advanced Manufacturing. Specifically, the basic training aims at the following learning goals:

1. Describe and understand the interactions between environment, organisational structure and technology regarding Advanced Manufacturing
2. Describe and understand the changes for Human Resource Management and Org. Mgmt. design brought by Advanced Manufacturing
3. Describe and understand barriers and enablers of change towards Advanced Manufacturing on the individual and organisational level

Based on these basic topics, practitioners should understand the importance of Org. Mgmt. and Human Resource Management for successful changes towards Advanced Manufacturing.

3.2.2.2. Content for Basic Trainings on HRM and Org. Mgmt.

Based on the learning goals, the 0.5 days for the basic training should comprise the following topics and content:

1. Interactions of environment, structure and technology
    a. The law of requisite variety: Mechanistic vs. organic organisational forms, complexity and dynamic of context
    b. Technology, Size and Industry as context: Fit between organisational form, institutional and context factors

2. Changes for HRM and Org. Mgmt. design
    a. Allocating human resources according to future needs of the organisation: Allocating will & skill according to the strategic needs
    b. Organising work as a service and for flexibility: Innovative HRM, team-based work, virtual forms of collaboration
    c. Designing organisations for openness and continuous change
3. Barriers and Enablers of change towards Advanced Manufacturing
    a. Individual level: Competencies of employees, mindset of employees (technology acceptance, openness, empowerment & motivation), leadership
    b. Organisational level: Trade-off between flexibility (innovation) and efficiency (routine), culture & mindset as barrier, fit with strategy

3.3. Modules for Basic Training on AVM-rel. Business Model Development and Strategy

This chapter gives an overview on the topics of the training modules for the basic training on AVM-rel. Business Model Development and Strategy. A detailed description of these modules can be found in D.T2.1.3 chapter 3.

3.3.1. Introduction: Description of Business Models and Strategies

3.3.1.1. Description of a Business Strategy and its Relation to a Business Model

Starting a new business requires careful planning to maximise the chances of success. Many small businesses are unable to make profit and fail within the first few years of operation. The terms "business strategy" and "business model" describe related concepts that are key to the processes of planning and managing a business.

The business strategy for a company defines the path that the business will take to achieve its goals. These goals include the elements of the business model, along with any additional mission or goals. It explains the steps, processes and changes that the business will follow and it identifies the strategies the business will use to counteract potential upsets and hurdles. Achieving the business strategy requires the efforts of every employee. The business strategy should be contemporary, if not advanced, to meet the current industry demands, as well as the forecasted demands. In chapter 2.2.1.1. of D.T2.1.3 the terms Business Strategy, Business Model and their relation to each other are described in detail.

In general, a business model makes no statements about the competitive situation. In contrast, a strategy describes how a company can differentiate itself from the competition and develop a sustainable competitive advantage.

3.3.1.2. Different Components of Business Models

A business model is a plan for how a company is going to make money. This can be simple or very complicated. The business model should include details on all operations, as well as short- and long-term visions for the business' growth. Without a business model, investors and owners will not have a clear idea of how to best grow the business, and it will be much harder to create a stable and sustainable concern. In chapter 2.2.1.2. of D.T2.1.3 the following terms are described: Value Proposition and Market Segment, Value Chain Structure, Revenue Generation, Market Position and Strategy.

3.3.2. Impact of Industrie 4.0 on the Business Model

The fourth industrial revolution brings with it a wealth of possibilities; things can be done now that were never possible before. This gives organisations in the manufacturing industry the freedom to make the leap from supplying a product to delivering a service. An interesting example of this is the German company Kaeser Compressors. It transformed from being a supplier of compressors and being quite active both inside and outside manufacturing into being a supplier of compressed air.

This transformation was realised after Kaeser started up a large-scale project to integrate business processes. To do this, the Internet of Things (IoT) – the motor that runs Industrie 4.0 – was put into place to connect processes and devices via sensors. As a consequence, Kaeser got great insight into the entire production chain, a starting point from where service levels could be raised. Service is therefore central in the revamped business model.

3.3.2.1. Benefits of Business Models

The best business idea is usually not sufficient if it is not based on a well thought-out and functioning business model, which covers the key pillars of future success.

Making a business model serves several purposes, firstly the people involved in authoring the model engage very intensively with all the important aspects of the business, which can help to better understand it. On the other hand, the unique selling point can be worked out even more clearly and thus a better positioning in the market can be made possible. In addition, a mature business model provides a better estimate of the scalability of a business idea.

3.3.2.2. Description of Business Model will be provided with Canvas

The "Business Model Canvas" method is based on a specific, process-oriented approach to the content development of the various business model components. The method supports the analysis of the market potential of business ideas and business models in order to make the relationships and influences on a business model tangible and comprehensible. Using special visualisation and creativity techniques and templates, nine essential building blocks of potential business models (customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure) are developed in several workshop settings. Future developments can be structured and played through with different variants.

3.3.3. Describing different new I4.0-Business Models

3.3.3.1. Existing Models that can be developed in direction of I4.0

In this chapter, the development of existing models in direction of Industrie 4.0 is outlined. Especially three models should be named and described: “Principal of E-Business in B2B market”, “Extreme Integration of Suppliers and Customers (value chain gets more connected)” and “Mass Customisation is getting easier with I4.0”.

All this requires an IT system with the capacity to compute an enormous amount of data. All mutations must be recorded and accessible, day and night. That necessitates a powerful database. But then, all the information you need is available in real time, and you can respond even better to your customers’ requests.

3.3.3.2. Newly developed and models possible only with I4.0 - Service-based Business Models

The digitalisation of plants and mechanical engineering enables many new business areas. Most of these Industrie 4.0 business models affect service providers in the IT industry (such as software developers, software providers, data processors, service providers, web and app designers), and there are many new value-added opportunities for plant and machine builders, as providing Infrastructure as a Service with pay-per-use / pay-per-hour models. These new business models shift the classic services of the plant and machine manufacturer to IT-based services. A detailed description of newly developed business models such as pay-per-use or predictive maintenance can be found in D.T2.1.3 chapter 3.3.2.

3.3.4. Development of a Business Model

A business model typically contains a description of the customers, how customers use the product, how the company distributes the product and details about how to promote that business. The model also describes key operational tasks, staffing and other resource requirements as well as details about how business is conducted.

4. Modules for Advanced Trainings

4.1. Modules for Advanced Trainings on AVM-rel. Technologies

As stated in chapter 3.1, the Advanced Trainings are generally overlapping with the modules of the Basic Trainings. All topics of the basic course should be also included in the Advanced Trainings and covered in detail. Since some modules gave only an overview on a broad variety of technologies (e.g. Additive Manufacturing or Connectivity Technologies), the specific technologies, which should be focussed on in the advanced trainings, are specified in this chapter. In addition to that, new modules are specified, which were generally too complex for the basic trainings. A more detailed description of the modules on advanced trainings for AVM-rel. technologies can be found in the corresponding deliverable D.T2.1.1 chapter 4.

4.1.1. General Technological Trends in I4.0

The general technological trends from the basic training are further detailed in this module of the advanced training. Due to the diversity in processes for additive manufacturing, a recommendation on which processes should be focussed on in the advanced trainings is given in this chapter. The focus for the topics of flexibility and changeability, simulation, digital twins and virtual commissioning as well as human machine collaboration / COBOT is specified in chapter 3.1 of this document with a more detailed version in D.T2.1.1 chapter 3.2. Since further detailing of these topics heavily depends on the individual competences of the partners, only suggestions for the main focus of the advanced trainings is given in the following chapters.

4.1.1.1. Additive Manufacturing / 3D Printing

The most important processes[1] regarding additive manufacturing should be briefly explained and specific benefits of of the following processes together with examples for practical application are to be highlighted: Powder Bed Fusion process, Material Extrusion and Vat Photopolymerisation.
For the InnoPeer Advanced Trainings, the applications and benefits of the abovementioned Additive Manufacturing processes are even more important than the technical background. The overview of Additive Manufacturing processes given in the basic courses should be elaborated in detail with examples for practical

[1] https://kreatize.com/de/welche-unterschiede-gibt-es-bei-den-verschiedenen-fertigungsverfahren/

application. The description of specific advantages and disadvantages completes the presentation of Additive Manufacturing as a general technological trend in I4.0.

4.1.1.2. Flexibility and Changeability

As stated in the introduction to chapter 3.1.2.1 of D.T2.1.1, in the advanced training this topic should be continued from the basic training (chapter 0 of D.T2.1.1) by going further into detail. Therefore, examples on how flexibility and changeability can be achieved which could not be covered due to lack of time are covered in this module of the advanced training.

4.1.1.3. Simulation, Digital Twins and Virtual Commissioning

As stated in the introduction to chapter 4.1.1, in the advanced training this topic should be continued from the basic training (chapter 3.1.2.1) by going further into detail. This can be achieved by going further into the different applications of simulation models and possible hardware configurations including the necessary software for virtual commissioning. The focus of this module heavily depends on the partner's expertise in this topic.

4.1.1.4. Human Machine Collaboration / COBOT

As stated in the introduction to chapter 4.1.1, in the advanced training this topic should be continued from the basic training (chapter 3.1.2.1) by going further into detail. The examples stated in the basic training should be extended and the current challenges further elaborated. This especially refers to the problems in safety and certification as well as the problems with true Human Robot Collaboration.

4.1.2. Connectivity

Similar to chapter 4.1.1, the connectivity topics in the advanced trainings should be based on the basic training and go further into detail. Since only an overview on technologies is given, the advanced training should elaborate the most important technologies and their application extensively.

4.1.2.1. Connectivity Technologies

Regarding the connectivity technologies, an overview over the most important standards was given in the basic training. In the advanced courses the technologies OPC UA, MQTT and 5G should be covered in detail, while the other technologies can also be elaborated further if possible in terms of time.

In the InnoPeer Advanced Trainings, the basis as well as the different application of MQTT should be elaborated in detail. It should also be pointed out, that it is completely different to OPC UA, since it does not offer an architecture or any kind of standardised information modelling. It should also be pointed out, that many benefits of MQTT are based on the publish-subscribe interaction pattern and not on the protocol itself.

4.1.2.2. Data Models

As stated in the introduction to chapter 4.1.2.1, in the advanced training this topic should be continued from the basic training (chapter 0) by going further into detail. The examples stated in the basic training should be extended and the current challenges be further elaborated. The different possibilities of data modelling and the problems on finding a universal information model should be in focus. In the advanced training the link to standardising activities like the standardisation of OPC UA Information Models as Companion Specifications should also be covered in detail.

4.1.2.3. Security

As stated in the introduction to chapter 4.1.2.1, in the advanced training this topic should be continued from the basic training (chapter 0) by going further into detail. The examples stated in the basic training should be extended and the current challenges be further elaborated. Since the advanced training goes more into detail regarding technologies, it should be focussed on how these different technologies handle the requirements on industrial security. The integration and differences between different architectures, especially with the integration of I4.0-connectivity into existing production systems, should be treated as one of the main challenges.

4.1.2.4. Data Collection and Analysis

As stated in the introduction to chapter 4.1, the topics of the basic trainings will be elaborated in detail in this advanced training, which is also the case for all topics that cover data collection and their analysis.

Especially the topics Data Collection via Cloud and Big Data, Condition Monitoring / Predictive Maintenance and Intelligent Sensors / Retrofit of existing machines should be elaborated. In the InnoPeer advanced training, examples from different component manufacturers as well as cloud providers and their respective available connectivity technologies should be given. The different types of architecture and especially the difference between hierarchical connections which still use PLC and MES systems as gateways as well as more direct connections from sensors and actuators to the cloud should be presented in detail. The algorithms needed to perform a calculation for predictive maintenance should also be a topic of the advanced trainings.

4.1.2.5. Advanced Manufacturing Control Systems

The concepts presented so far are key elements to realise the vision of Industrie 4.0. However, connectivity and standardisation is not enough for a truly intelligent production. The components themselves have to get more intelligent and less dependent from centralised control systems and the hierarchical structure of the automation pyramid, which leads to a completely networked and CPS-based automation. The kind of intelligent component, in which physical and software components are deeply intertwined and connected to the industrial IoT, is called cyber-physical system or CPS.

For the InnoPeer advanced trainings the different levels from a classical hierarchical and centralised control system to a fully autonomous self-organising production, which is based on CPS, should be elaborated. This also includes an outlook on current research and practical applications that were already realised.

4.2. Modules for Advanced Trainings on AVM-rel. Human Resources Management and Organisational Management

As described in chapter 2, there will be one advanced training for human resource management and one for organisational management with a duration of two days each. The content of these trainings is described in the following chapters.

4.2.1. Modules for Advanced Trainings on Human Resources Management (HRM)

This chapter gives an overview on the topics of the training modules for the advanced training on AVM-rel. HRM. A detailed description of these modules can be found in D.T2.1.2 chapter 4.1.

4.2.1.1. Aims and learning goals for the Advanced Trainings on HRM

The advanced courses on the HRM competencies are part of several webinars comprising additionally the technological and business model competencies. The advanced courses build on the basic course and further refine the implications for HRM. They aim at developing a thorough understanding of topics regarding HRM in the context of Advanced Manufacturing.

For the HRM course, there are four main learning goals, as conducted in chapter 2.4.1.1 of D.T2.1.2. In sum, based on these basic topics, practitioners should understand the importance of Human Resource Management for successful changes towards Advanced Manufacturing.

4.2.1.2. Content for the Advanced Trainings on HRM

Based on the learning goals, each course comprises about 16 hours of content. There is one course for HRM compromising at least 4 webinars, which are detailed in chapter 2.4.1.2 of D.T2.1.2. The main topics are:

- Traditional vs. innovative human resources management
- Execution work systems vs. high performance work systems
- Leadership for change
- Individual competencies and learning

4.2.2. Modules for Advanced Training on Organisational Management

This chapter gives an overview on the topics of the training modules for the advanced training on AVM-rel. organisational management. A detailed description of these modules can be found in D.T2.1.2 chapter 4.2.

4.2.2.1. Aims and Learning Goals for the Advanced Trainings on Org. Mgmt.

The advanced courses build on the basic course and further refine the implications for org. mgmt. They aim at developing a thorough understanding of topics regarding org. mgmt. in the context of Advanced Manufacturing. For the course on org. mgmt., there are four main learning goals, as described in chapter 2.4.2.1 of D.T2.1.2.

In sum, based on these basic topics, practitioners should understand the importance of org. mgmt. for successful changes towards Advanced Manufacturing.

4.2.2.2. Content for Advanced Trainings on Org. Mgmt.

Based on the learning goals each course comprises about 16 hours of content on the following topics. There is one course for org. mgmt. compromising at least 4 webinars, which are detailed in chapter 2.4.2.2 of D.T2.1.2:

- Environment, Capabilities, Resources and the Organisation
- Context and Industry as a resource for organising in Advanced Manufacturing
- Basic organisational designs for Advanced Manufacturing
- Organisational design and innovative behaviour in Advanced Manufacturing

4.3. Modules for Advanced Trainings on AVM-rel. Business Model Development and Strategy

This chapter gives an overview on the topics of the training modules for the advanced training on AVM-rel. Business Model Development and Strategy. A detailed description of these modules can be found in D.T2.1.3 chapter 4.

4.3.1. Identification of Opportunities for New or Changing Business Models Made Possible by I4.0

In the past years, many different methods in developing Business models have been carried out by consulting companies. The most common methods in developing business models in terms of digitalisation are the following:

4.3.1.1. Business Model Canvas

Business Model Canvas (BMC) is a strategic management template for developing new or documenting existing business models. It is a visual chart with elements describing a companies' or product's value proposition, infrastructure, customers, and finances. It assists companies in aligning their activities by illustrating potential trade-offs.

The tool can be printed out on a large surface so groups of people can jointly start sketching and discussing business model elements with post-it note notes or board markers. It is a hands-on tool that fosters understanding, discussion, creativity, and analysis. The Business Model Canvas is also available in web-based software format.

The blocks on the BMC are:

- **Customer segments:** for whom do we aim to create value? Who are our most important customers?
- **Value Propositions**: what do we offer to whom? What value do we deliver to a customer in a given segment? What needs do we satisfy?
- **Channels:** how do we reach each customer segment? What is easiest for the customer?
- **Customer Relationships:** how do we build and maintain these? How do they fit effectively in both the customer's world and our own?
- **Revenue Streams:** for what will our customers pay? How much? How would they prefer to pay?
- **Key Resources:** what resources are essential to deliver our Value Propositions through the Channels and maintain our Customer Relationships?
- **Key Activities:** what are the most important things you must do to make your business work?
- **Key Partnerships:** who are our Key Partners and why? What Key Resources do they provide and what Key Activities do they carry out? What's in it for them? What relationship should we have?
- **Cost Structure:** what costs are implied by our Business Model? Which are largest? What is fixed and what is variable? What drives them?

Each of these blocks needs to be accurately filled in, and revised regularly to ensure the business model is still accurate. In the following image the business model of google is illustrated.

4.3.1.2. Design Thinking

Design thinking is an innovation method for working with predominantly interdisciplinary teams. Design Thinking was developed by David Kelley, founder of the well-known design agency Ideo. The term design in "design thinking" refers to the deliberate design of interactions, processes and objects that are strictly oriented to the needs of their future users. By using Design Thinking at the beginning of product and project development, process risk is significantly reduced by early validation of various approaches. The design thinking process is divided into three major phases of development: inspiration and user research, creative idea development, prototyping and testing. This approach is further enhanced by the further strategic design of the solutions developed and their implementation in the company.

4.3.2. Describing different new I4.0-Business Models

This section is giving a recap of already mentioned aspects of opportunities to develop digital business models. There are 3 approaches for business development.

The first one aims to optimise an existing business model. The technical possibilities outlined above for the automation of processes make it possible to reduce costs, and most of all, to react faster to changes in the market and of course specific customer inquiries.

The second approach is to conquer neighboring business models. The "Outcome Economy" forms blueprints for this, among other things with its "as-a-service" models, but even in the traditional industry, products are no longer thought of. Why not sell truck tires per trouble-free kilometer instead of one piece? Or jet engines per flight hour? And that's not science fiction, it's already reality.

The third approach aims to build entirely new business models - and here, in particular, digitalisation has drastically lowered entry barriers.

If you already have the data - you can offer your customers data-based consulting services for their business. After all, data primarily conveys knowledge and insights that, in addition to products and services, can become a further pillar of your business. The customer receives better and more comprehensive services, learns how to optimise his own business - and the provider benefits from higher margins than he would ever receive for the pure product.

For a better understanding the field of new I4.0 business models, teaching cases are discussed within the advanced training module.

5. Modules for Practical Trainings

5.1. Overview on Content and Structure

The training modules for practical trainings are split in two groups. On the one hand, there are model factories in which the practical test runs in the technological trainings will be held. On the other hand, strategy camps offer the possibility to practice use cases in business model development and strategy as well as HRM and organisational management.

5.2. Model Factories

The practical test runs in the technological trainings will be done in Model Factories, which are organised by PP11 (FHG), PP10 (WRUT) and PP9 (DEMO). Since this deliverable is very early in the project, the concrete topics for the Model Factories are not set yet and will be worked out further in D.T2.2.5 based on the AVM assignments developed by SME trainees. Therefore, the following chapter will only give an outlook which

technologies and trainings could be realised based on already available technologies and trainings at the project partners. A more detailed description of the model factories can be found in D.T2.1.1 chapter 5.

5.2.1. Model Factory FhG

One possibility in the Model Factory at Fraunhofer IGCV is to show the benefits of a networked production in manual assembly. In general, the concept of a paperless production is being imparted at the example of a RC car production with different manual assembly stations. The course is built up in three rounds. In the first round, all the order slips are presented digitally with tablets and no confirmation when an assembly step is done. In the second round, the worker confirms his step manually by pressing a confirmation button on the tablet while in the third round even this confirmation is automatically done by the networked system over RFID.

Other examples that can be shown at Fraunhofer are use cases of human machine interaction with augmented reality. In this example, a worker is guided on how to interact with a CNC machine by using an augmented reality glass.

As mentioned in chapter 0 of D.T2.1.1, virtual commissioning is an important technology in the context of Industrie 4.0. At Fraunhofer, a demonstrator can show how virtual commissioning can be used to test a PLC configuration. A simulation model is therefore connected to the PLC and simulates all the values of actuators and sensors. It is then possible to directly switch to the corresponding real production line to see that the virtual commissioning was correct.

Another example that could be built up for the InnoPeer practical trainings is a demonstrator for IIoT connectivity. As pointed out in chapter 3.1.2.2 of D.T2.1.1, modern connectivity standards like OPC UA as well as unified data models of machines are important to achieve full interoperability. A demonstrator could show how data models are created within a PLC by using the built in OPC UA functionalities, which are available from most vendors. This also refers to the topic of retrofit, since existing sensors can be used to transfer data to the cloud by only replacing the PLC or adding a smaller PLC on top of the existing production line as a gateway (chapter 0 of D.T2.1.1).

All these topics are only examples on what can be done at Fraunhofer. As mentioned in the beginning, the concrete assignments for the Model Factory are worked out in D.T2.2.5.

5.2.2. Model Factory WRUT

The first option of the Model Factory at Wroclaw University of Science and Technology is to present possible applications of additive manufacturing technologies in production generally. The practical test run will be focused on explaining how and when to replace conventional manufacturing process with additive manufacturing, which process an SMEs should consider for changing and the known cases studies in the world. This study will include process preparation and integration into existing manufacturing infrastructure as well as a cost analysis to compare both ways of producing and the most important factors supporting the conversion. The participants will be familiarised with different technologies and the newest applications in different branches of industry such as aerospace, automotive or polymer components production.

As described detailed in chapter 5.2 of D.T2.1.1, other practical applications that could be developed for the Model Factory can be based on the following ideas:

- “The integration and adaptation of scanning and rapid prototyping device prepared for I4.0 – “Scan™”
- human-robot interaction and human-robot cooperation (UR10 collaborative robot and/ or the two-arm and highly flexible collaborative robot ABB YuMi)
- mobile robots in production (automated guided vehicles (AGV) based on the mobile platform MiR100)

The training could include issues connected to map creation and navigation, task planning, programming and configuration as well as safety and security. A program for the MiR robot can easily be created in a user friendly graphical web-interface using a smartphone, tablet or computer connected to the WiFi network. The connectivity possibilities of the mobile robot with external devices can also be shown using REST API.

The topics mentioned above are rough ideas and will be stated more clearly later in D.T2.2.5.

5.2.3. Model Factory DEMO

Through the infrastructures of the Technopole of Modena coordinated by the Foundation Democenter-Sipe, it is possible to organize practical exercises of I4.0-solutions, which are described in detail in chapter 5.3 of D.T2.1.1. These topics are:

Additive manufacturing:

For example, the equipment at disposal (e.g. conoscopic microscope, three-dimensional microscope, metallographic sample preparation, static testing machine, hydraulic fatigue testing machine, resonant fatigue testing machine, electro-chemical machining, micro-electro punching) can be used to explore the characterization of metal products obtained through additive manufacturing processes.

Simulation and Digital Twins:

Thanks to a simulation lab, it is possible to deepen the understanding for digital product-process design and intelligent manufacturing by leveraging hardware/software/model/human-in-the-loop simulations. To do so, the lab exploits advanced simulation and virtual prototyping with high performance computing and GPU computing, virtual reality and Human in the Loop design and advanced robotics and reconfigurable intelligent manufacturing, with more than 5 industrial robots.

Human-Machine Collaboration / COBOT:

Another laboratory can make available equipment to deepen the issues connected to industrial automation, for example, working on human-robot collaboration, advanced robot simulation and programming, design and manufacturing knowledge-based engineering.

Intelligent Sensors:

Through another lab devoted to the development of sensors and instrumentations for biomedical and industrial applications, it is possible to carry out tests for sensor calibration, working more specifically on subjects such as calibration of electrical sensors or optical sensors testing/characterisation.

5.3. Strategy Camps

The strategy camps will be held in up to one entire week. Within this module the so-called “Mega-case” will be solved by the participants, which includes the knowledge dimensions:

- Business model development and strategy
- Human Resource Management
- Organisational management

The overall aim of this training is to enable the participating SME representatives to apply learned methods and gained experience from the Mega-case to develop useful strategies for their own companies, as well as to set up a transnational value chain especially together with other SME.

5.3.1. Strategy Camp on HRM and Org. Mgmt.

The following chapters describe the goals for strategy camp regarding HRM and org. mgmt..

5.3.1.1. Aims and Learning Goals for the Strategy Camp on HRM and Org. Mgmt.

For the practical part of the training the HRM and Org. Mgmt. competencies are part of the strategy camps. The strategy camp encompasses up to 40 hours of guided self-work on business model development, organisational and human resource topics. About the half of the time spent in the strategy camp should be devoted to HRM and Org. Mgmt. topics.

The strategy camp has the overall goal that managers and innovation managers apply the topics learned in the advanced and basic training on problems and questions of their own firms and thereby, develop strategies to deal with changes induced by Advanced Manufacturing

Main learning goals for the HRM and Org. Mgmt. topics are:

1. Evaluation of current practices, structures, strategies, organisational design, capabilities, leadership as well as other Org. Mgmt. and HRM issues and their implication on employees behaviour and change towards Advanced Manufacturing
2. Developing procedural knowledge on how to identify problems in change towards Advanced Manufacturing regarding HRM and Org. Mgmt. issues, developing procedural knowledge on how to develop a strategic action plan for implementing changes in HRM and Org. Mgmt. towards Advanced Manufacturing.
3. Creation of strategic actions for adapting identified issues in HRM and Org. Mgmt. to Advanced Manufacturing based on knowledge from the advanced and basic trainings
4. Creation of a roadmap and milestones for implementing strategic actions in their own organisation

5.3.1.2. Content for the Strategy Camp on HRM and Org. Mgmt.

Based on the learning goals and the results of the practical training on business model development the course draws on concrete topics from the participants and applies knowledge developed in the advanced trainings. Therefore, the concrete topics are a result of the interaction within the respective strategy camp. However, as a guideline for developing business models, the following topics are described and comprise up to 20 hours of content:

1. Guided evaluation of the involved firm, its current practice, structures, strategies, organisational design, capabilities, leadership as well as other Org. Mgmt. and HRM issues as well as development of aims for these dimensions
2. Guided development of specific goals for changing towards Advanced Manufacturing in the dimensions Org. Mgmt. and HRM
3. Guided development of strategic action plan, plan of measures and based on the current situation of the firm, knowledge of the basic and advanced trainings and the goals for changing towards Advanced Manufacturing
4. Guided creation of a roadmap for implementing strategic actions and measures in the participant’s firm.

5.3.2. Strategy Camp on Business Model Development and Strategy

The following chapters describe the goals for strategy camp regarding business model development and strategy.

5.3.2.1. Development of digital business strategy

In the practical trainings, participants shall apply the knowledge that they received in the first two training modules. A first step will be the application of design thinking for the development of a digital business strategy.

Alternatively, participants are encouraged to apply business model canvas to develop new business models for their individual company.

5.3.2.2. Development of a transnational value chain – SME + customer + supplier

The second part of the strategy camps focuses on developing a transnational value chain

As most companies are searching for emerging markets for their products, they are forced to go beyond the borders of their country. On the other hand, this offers the opportunity to create higher value for their own business.

The typical value chain includes activities such as research and design, production, marketing, distribution, and support to the final consumer. Research and development, production, distribution, sales and service are all business processes which most companies consider to be integral aspects of their business strategy, which shall also be part of this practical training.

By managing the value chain's activities strategically, a company can create a competitive advantage for itself. This means ensuring that supply meets projected demand effectively and efficiently, with maximum consumer satisfaction. Productivity, innovation, flexibility and responsiveness to the consumer become critical attributes of the value chain and SME must choose the most effective solution for each link in the chain. This requires expanding SME’s vision outside the walls of their country, morphing their previously domestic/internal value chain into a transnational, or even global one.

With developing a global value chain business model the participating SME shall be enabled to organise operations in innovative ways which deliver greater value to their customers through reduced costs and increased product and service quality. By focusing on what they do best, and using strategic relationships with other partner companies to fill in the gaps, these companies are able to strengthen their competitive advantage in ways which would not have otherwise been possible.

5.3.2.3. Individual coaching

The overall aim of this training is to enable the participating SME representatives to apply learned methods and gained experience from the Mega-case to develop useful strategies for their own companies, as well as to set up a transnational value chain especially together with other SME.

The participants are encouraged to bring current difficulties and challenges from their own company, and to discuss these topics with the other participants. They shall be guided by the trainer(s) with developing their own business model or strategy and the according HR and organisational change issues.