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3D4VET
3D FOR VET STUDIES

IO1 Report

DEFINITION OF THE 3D EXPERT COMPETENCE

Project Title	3D4VET 2017-1-ES01-KA202-03800
Output	IO1 – Definition of the 3D Expert Competence
Date of delivery	30.09.2018
Author(s)	INCOMA

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IO1 FINAL REPORT

INTRODUCTION TO 3D4VET

3D4VET project aims at developing innovative curricula based on the usage of new digital technology to implement in the additive manufacturing industry, in line with the priority related to open and innovative education, training and youth, imbedded in the digital era.

Furthermore, the new curricula will be adapted to the ECVET point system to guarantee an easy recognition in all partner countries, thus contributing to the transparency and recognition of skills and qualifications to facilitate learning, employability and labour mobility.

On the other hand, project activities will also enable the production of 3D printers, which will allow VET providers to create their own equipment. This promotes the sustainable investment, performance and efficiency in education and training, improving the quality and innovation of the learning process.

The project will also contribute to improve the knowledge of learners in one of the Key competencies defined by the European Commission (ICT), thus it will allow final beneficiaries to increase their employability.

IO1 REPORT RATIONALE

The first step to achieve the abovementioned objectives of 3D4VET is the "Definition of the 3D Expert Competence". That is why this first output is aimed to define the 3D expert competence through the collection of evidences and information about the skills, knowledge and competences relevant and necessary for professionals working in 3D printing in partners' countries. This is the previous step that will lead to the IO2, which is the design of the training, as IO1 pretends to provide detailed information about the requisites for the 3D printing professional from different perspectives, thus allowing a comprehensive view of the profession and ensuring that the training encompasses all these perspectives and needs.

This report presents a gathering of the main results and evidences obtained during the implementation of this IO, as well as an explanation of the methodology followed to obtain the different results. So, this report is going to:

- describe the activities carried out, target groups and stakeholders involved, and results achieved;
- report the matrix of knowledge, skills and competences of the 3D Expertise that will be adopted by 3D4VET and will serve as the basis for the training.

METHODOLOGY

This Intellectual Output has been carried out between the beginning of the project in December 2017 and September 2018. It has been a slight deviation of one month in the output implementation due to the school summer holidays, as most of the partners come from this kind of institutions.

Regarding the methodology adopted to develop this first output, during the Kick-off meeting held in Seville in December 2017 there was a discussion about the terminology used, as they considered that "3D Expert" as stated in the project form did not fit so good in the project objectives as "3D expertise". Therefore, partners agreed that the partnership should focus on a 3D EXPERTISE conceived as a transversal competence to be taught in different studies.

In order to achieve the main objective of the output, BIOAVAN and CEP have developed a table containing a framework with the main characteristics of a "standard" 3D Expertise Profile and then a common questionnaire evaluating the table's contents. This methodology has been very useful to homogenise the experts' responses and to analyse and study the results.

As a second step, CEP has elaborated 4 Qualifications containing the main characteristics of the four levels of Professional Qualifications, contributing to the objectives of the IO2.

RESULTS

This intellectual output contains 4 activities to be developed, being the second and the third ones the longer and the forth the current final report. So, the results achieved in each of the 3 first activities are the following:

A1 – Operative Plan

INCOMA was in charge of the development of the Operative Plan (Annex 1) with the inputs from the other partners, specially CEP and BIOAVAN. This plan included the schedule of activities as well as the way of implement them. The chronogram with the tasks planning is copied here below:

ACTIVITY	DEADLINE	TASKS TO BE DEVELOPED	PARTNERS INVOLVED
IO1-A1 Operative Plan	April 2018	Drafting of the **operative plan.**	INCOMA
IO1-A2 Desk and field research on the 3D Expert Competence	January-March 2018 March 2018 April 2018	Gathering a 3D experts committee (10 per country) to elaborate the basic structure of the professional profile. Sharing with partners the conclusions of the first experts committee so that they will analyse and contribute to them. Gathering a committee of a minimum of 10 experts per country to analyse and propose changes in the basic structure of the professional profile.	BIOAVAN and CEP BIOAVAN and CEP All partners
IO1-A3 Definition of the 3D Expert Competence	April 2018 April 2018 April 2018 April 2018 May 2018	Study and update all the proposals of changes made by the partners to design the definitive of the 3D expert professional profile. Share the definitive proposal with all the partners to decide the final structure of the 3D expert profile. Gather the 3D experts committee to develop the structure and the final qualifications of the 3D experts' professional profile. Share with the partners the final structure of their analysis about the 3D experts' profile. Gathering the committee of 10 experts per country to analyse and propose the last changes of the final document of the professional profile.	BIOAVAN and CEP All partners BIOAVAN and CEP BIOAVAN and CEP All partners
IO1-A4 O1 Report	May 2018 May 2018	Share the final proposal and agree on the definitive structure of the 3D experts' profile by all the partners. Elaborating a Report containing the results of IO1 activities, including: a description of the activities carried out, target groups and stakeholders involved; reporting the matrix of knowledge, skills and competences adopted by 3D4VET.	BIOAVAN and CEP BIOAVAN and CEP

At the very beginning, the chronogram established some deadlines that were not finally respected, but the description of tasks was scrupulously followed.

A2 – Desk and field research on the 3D Expert competence

Partners followed the next steps, which are related with the tasks of the chronogram:

First of all, CEP and BIOAVAN sent all partners a glossary (Annex 2) to clarify the meaning of all terms that would be used in the description of the 3D expertise competences. After this, they prepared a table containing the 3D Expertise general profile, their general competences, professional qualifications, units of competences and proposed formative modules:

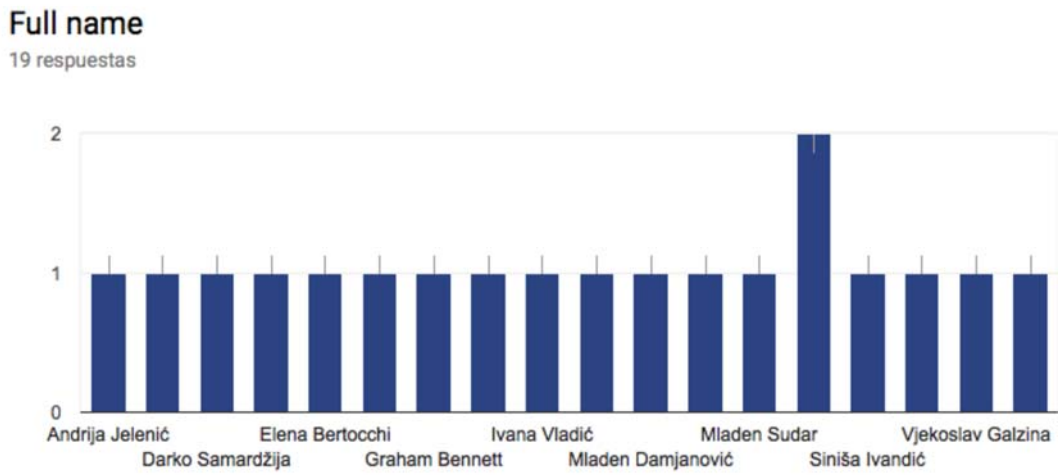
General Profile	General Competences	Professional Qualifications	Units of competence	Formative Modules
The professional profile of the Expert in 3D Designing, Scanning and Printing Systems (ESDEI3D) is decided by his/her general competence, his/her professional, personal and social competences and by the relationship of the National Catalogue of Professional Qualifications included in the grade.	The general Competence of this expert consists of developing 3D designing, scanning and printing projects, as well as managing and supervising the design, assembly and maintenance of the 3D printing and scanning systems, from the technical documentation, the regulations and established procedures, guaranteing its working out, quality, safety and the environmental conservation.	Management and Supervision of Designing Systems of 3D models, in professional environments.	Design and repair 3D models meshes through rapid prototyping.	Design of 3D models.
			Elaborate the technical documents of 3D designing models.	Technical documents in 3D designing.
		Management and Supervision of Scanning systems in 3D models, in professional environments.	Manage and supervise the assembly and maintenance of 3D scanning systems, in industrial, personal and social environments.	Assembly and maintenance of 3D scanning systems.
			Use 3D scanners to obtain the physical model.	3D scanning.
			Reconstruction of 3D models from clinical images (DICOM) or photographs throughout software of inverse engineering.	3D modelling and inverse engineering.
		Management and Supervision of 3D printing systems, in professional environments.	Manage and supervise the assembly and maintenance of 3D Printers, in industrial, personal and social environments.	Assembly and maintenance of 3D scanning systems.
			Use 3D printers to obtain final products.	3D printing.
		Development of Designing Projects, Scanning and 3D printing, in professional environments	Develop, Plan, Programme, Control of times, Supply the production, Supervise the start up, as well as the maintenance of 3D scanning and printing system, considering the installation conditions and the manufacturer's recommendations, guaranteing precaution, safety, environmental and quality conditions.	Management of 3D printing and scanning projects.

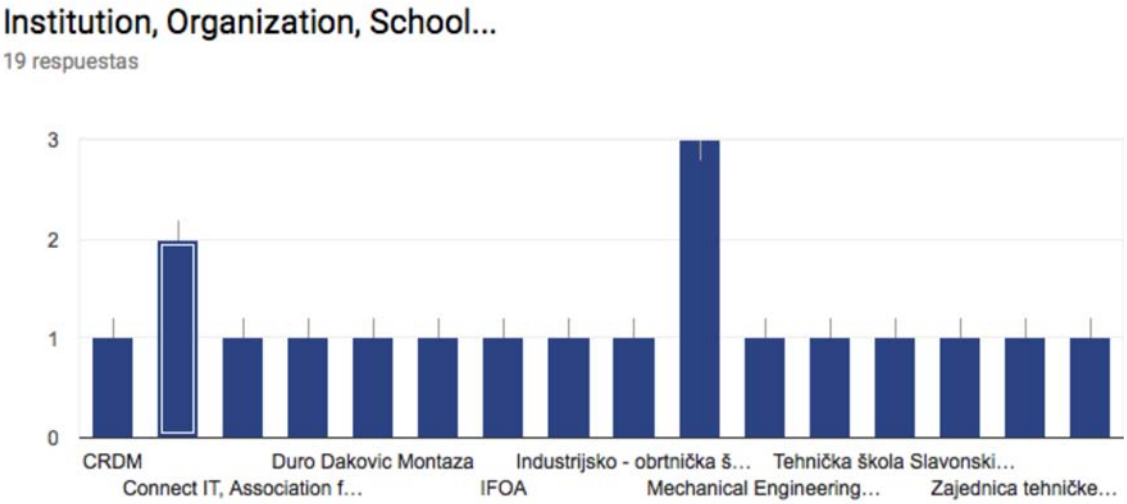
This table was used as the basis for each partner to conduct a desk and field research aimed at collecting information and evidences related with the objectives of this activity. For that purpose, a complete questionnaire was prepared to guide the national experts interviewed and obtain the required information.

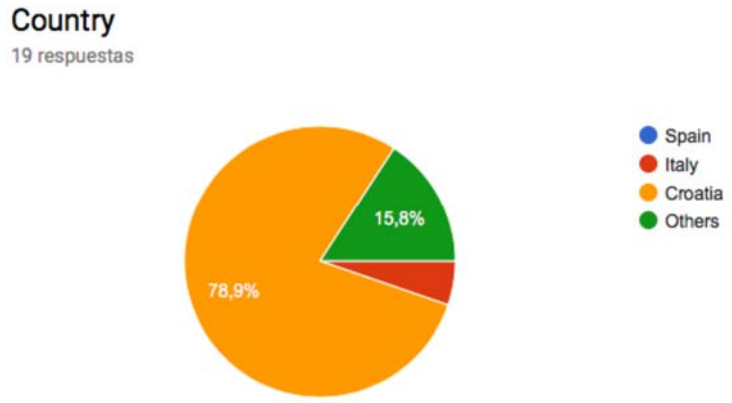
All partners carried out their desk and field research in each partner country. Taking into account that in the project form was stated that 10 experts must be involved in each national panel of experts, it was given to the partners the option to realise this research in 2 different ways:

- organising a panel of 10 experts in just one or a couple of session, answering in common the questionnaire;
- sending the document and the form to the 10 experts so they will analyse the structure, will reach to some conclusions and will make contributions.

A total of 19 questionnaires were filled in: 15 experts from Croatia have participated, 1 conclusion report of 7 experts from IFOA and other response from Sergio González from CadMan Do (who filled in 3 questionnaires by mistake). These are the most important graphics of the experts who have participated filling in the questionnaire:







A report containing the results of the questionnaire regarding the table originally proposed was produced (Annex 3). Some experts made different comments to the content proposed and a revised table was created:

		Professional Qualifications	Units of competence	Formative Modules
General Profile The professional profile of the Expert in 3D Designing, Scanning and Printing Systems (ESDE13D) is decided by his/her professional, personal and social competences and by the relationship of the National Catalogue of Professional Qualifications included in the grade.	**General Competences** The general Competence of this expert consists of developing 3D designing, scanning and printing projects, as well as managing and supervising the design, assembly and maintenance of the 3D printing and scanning systems, from the technical documentation, the regulations and established procedures, guaranteing its working out, quality, safety and the environmental conservation.	Management and Supervision of Designing Systems of 3D models, in professional environments.	Design and repair 3D models meshes through rapid prototyping.	Design of 3D models.
			Elaborate the technical documents of 3D designing models.	Technical documents in 3D designing.
		Management and Supervision of Scanning systems in 3D models, in professional environments.	Manage and supervise the assembly and maintenance of 3D scanning systems, in industrial, personal and social environments.	Assembly and maintenance of 3D scanning systems.
			Use 3D scanners to obtain the physical model.	3D scanning.
			Reconstruction of 3D models from clinical images (DICOM) or photographs throughout software of inverse engineering.	3D modelling and reverse engineering.
		Management and Supervision of 3D printing systems, in professional environments.	Manage and supervise the assembly and maintenance of 3D Printers, in industrial, personal and social environments.	Assembly and maintenance of 3D scanning systems.
			Use 3D printers to obtain final products.	3D printing.
			Technologies and knowledges of materials for 3D printing	3D materials
		Research, Development, Innovation and Management of Designing Projects, Scanning and 3D printing, in professional environments	Investigate, Develop, Plan, Programme and innovate, Control of times, Supply the production, Supervise the start up, as well as the maintenance of 3D scanning and printing system, considering the installation conditions and the manufacturer's recommendations, guaranteing precaution, safety, environmental and quality conditions.	Research and Management of 3D printing and scanning projects.

A3 – Definition of the 3D Expert competence

According to the results of the previous activity, all partners contributed to update all the proposals of changes to design the definitive version of the 3D expert professional profile. The final proposal was shared among all the members of the partnership to decide the final structure of the 3D expert profile (the above-mentioned document).

This document was informally validated by the same group of experts contacted in the previous activity, who did not have anything else to add. It was also sent to the members of the Advisory Board in order to obtain another qualified vision of the 3D Expert Competence. Both experts considered that the structure used for the purpose of the outcome was appropriate and that the contents were relevant for the project's activities.

Asked about giving any input, idea or feedback they may have about this outcome, the experts gave the following recommendations:
- Sergio Tassani has proposed a short-term implementation in education professionals and teaching centres;
- Lorenzo Bernieri noticed that there was a mistake in the last column where, in the 3D Printing Formative Modules was written again "Assembly and maintenance of 3D scanning systems" instead of "Printing". From his points of view, the project's structure was clear, although the last Module (Research and Management) could be better detailed. For example, requesting to formally document the different projects or innovation histories could create a good portfolio and help to refine the planning for future projects.

In addition, Bernieri considered that the different modules require very different durations, and that some addition themes such as different scanning technologies, slicer software, etc. should be introduced.

Taking these issues into account, CEP developed the four "professional qualifications" proposed in the analysed table with the objective of completing this IO1 and contribute with the design of the training in IO2:

1. Management and supervision of designing systems of 3D models in professional environments (annex 4);
2. Management and supervision of scanning systems in 3D models in professional environments (annex 5);
3. Management and supervision of 3D printing systems in professional environments (annex 6); and
4. Research, development, innovation and management of designing projects, scanning and 3D printing in professional environments (annex 7).

These professional qualifications were informally validated by the same experts that contributed in the previous activities, as well as by the Advisory Board.

CONCLUSIONS

The main objective of this IO aimed to define the 3D expert competence by collecting evidences and information about the skills, knowledge and competences relevant and necessary for professionals working in 3D printing partners' countries.

Within the framework of 3D4VET project's IO1, a common and agreed definition about the 3D Expert Competence was created after completing the different activities proposed in this output. To achieve this goal, BIOAVAN and CEP created a basic table and a questionnaire in Google Forms to be filled in by all partner's experts, so each partner invited their national experts to complete de questionnaire.

After this step, a report with the first conclusions was written and some modifications were realised to the table following the comments and suggestions of the questionnaire. Then, in order to make the fine-tuning of the definition of the 3D Expert competences, the national experts were invited to give their advice once again and the Advisory Board made some comments and suggestions that were took into account.

Finally, CEP developed the four "Professional Qualifications" contained in the table to close this IO1 and contribute to the implementation of the training foreseen in IO2.

ANNEXES

ANNEX 1.- OPERATIVE PLAN

ANNEX 2.- GLOSSARY

ANNEX 3.- EXPERTS CONCLUSION ON THE CONTRIBUTIONS TO THE BASIC SKELETON OF THE 3D PRINTING EXPERT PROFILE

ANNEX 4.- PROFESSIONAL QUALIFICATION 1

ANNEX 5.- PROFESSIONAL QUALIFICATION 2

ANNEX 6.- PROFESSIONAL QUALIFICATION 3

ANNEX 7.- PROFESSIONAL QUALIFICATION 4

ANNEX 1.- OPERATIVE PLAN

3D4VET – IO1

Definition of the 3D Expert Competence

OPERATIVE PLAN

Project Title	3D4VET 2017-1-ES01-KA202-03800
Output	IO1-A1
Date of delivery	20/04/2018
Author(s)	INCOMA

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1. DOCUMENT DESCRIPTION

INCOMA, supported by the output leader and project coordinator BIOAVAN, has defined this Operative Plan, including the timeline, milestones, deliverables, support activities foreseen, responsibilities and expected contributions from each partner.

This Operative Plan will be shared among all the project partners in order to foreseen the distribution of tasks and activities, as well as their deadlines.

2. OUTPUT OVERALL DESCRIPTION

This first intellectual output aims at defining the 3D expert competence by collecting evidences and information about the skills, knowledge and competences relevant and necessary for professionals working in 3D printing in partners' countries.

It is an essential step prior to the design of the training (O2), and it will provide detailed information about the requisites for the 3D printing professional form different perspectives, thus allowing a comprehensive view of the profession and ensuring that the training encompasses all these perspectives and needs.

This will be done by conducting a desk and field analysis according to the methodology, timeline and formats defined by BIOAVAN (O1 coordinator) and CEP, and that each partner will apply. Evidences collected will be shared and further enriched in order to define the 3D Expert competence and the different related knowledge, skills and competences.

This profile will later be validated by stakeholders at national level. Partners will set up a panel of national experts from different fields that are involved in 3D printing, including companies, teaching staff, professionals and institutions with expertise on 3D printing and/or the norms applicable at national level.

Results obtained will support the fine-tuning of the 3D Expert competence. The main results and evidences obtained within O1 will be gathered in the O1 Report. The final version of the 3D Expert competence will serve as the basis for the design of the training (O2).

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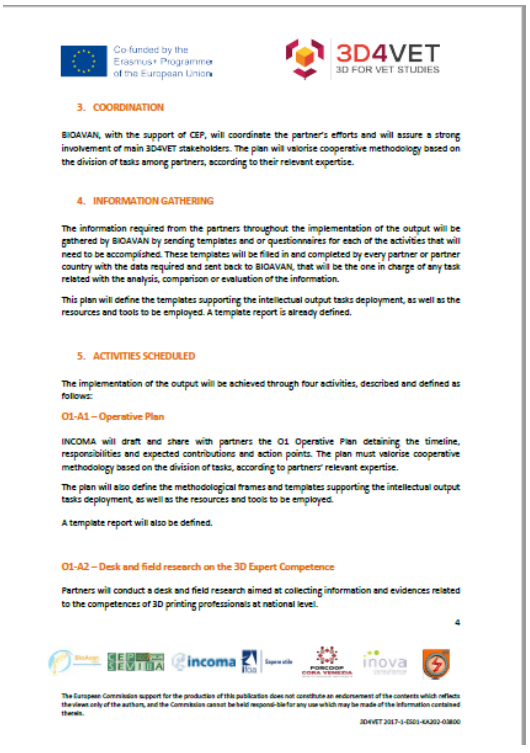

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3. COORDINATION

BIOAVAN, with the support of CEP, will coordinate the partner's efforts and will assure a strong involvement of main 3D4VET stakeholders. The plan will valorise cooperative methodology based on the division of tasks among partners, according to their relevant expertise.

4. INFORMATION GATHERING

The information required from the partners throughout the implementation of the output will be gathered by BIOAVAN by sending templates and or questionnaires for each of the activities that will need to be accomplished. These templates will be filled in and completed by every partner or partner country with the data required and sent back to BIOAVAN, that will be the one in charge of any task related with the analysis, comparison or evaluation of the information.

This plan will define the templates supporting the intellectual output tasks deployment, as well as the resources and tools to be employed. A template report is already defined.

5. ACTIVITIES SCHEDULED

The implementation of the output will be achieved through four activities, described and defined as follows:

O1-A1 – Operative Plan

INCOMA will draft and share with partners the O1 Operative Plan detaining the timeline, responsibilities and expected contributions and action points. The plan must valorise cooperative methodology based on the division of tasks, according to partners' relevant expertise.

The plan will also define the methodological frames and templates supporting the intellectual output tasks deployment, as well as the resources and tools to be employed.

A template report will also be defined.

O1-A2 – Desk and field research on the 3D Expert Competence

Partners will conduct a desk and field research aimed at collecting information and evidences related to the competences of 3D printing professionals at national level.

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For that purpose, they will set-up and hold meetings/focus groups with national/local stakeholders and experts from different fields, such as: companies with experience in working with/applying 3D printing; teachers and professors that teach 3D printing; 3D printing professionals; and institutions with expertise on 3D printing and/or norms applicable at national level.

A panel of experts with 10 members will be created in each country (Italy, Croatia, Spain and United Kingdom).

O1-A3 – Definition of the 3D Expert Competence

Based on the outcomes of O1-A2, partners will analyse the results at national level and integrate the information obtained, further enriching and valorising these results by providing additional comments and inputs.

Activity outputs Will include a matrix of knowledge, skills and competences that will serve as basis for the definition of the training.

It will be informally validated by the same group of stakeholders and by the members of the Advisory Board.

O1-A4 – O1 Report

The results of the O1 activities will be reported in a comprehensive report:

- Describing the activities carried out, target groups and stakeholders involved, and results achieved;
- Reporting the matrix of knowledge, skills and competences of the 3D Expert that will be adopted by 3D4VET and serve as the basis for the training.

The O1 report will be prepared in English and an Executive Summary will be translated in all partners' languages.

BIOAVAN will be responsible for developing the O1 operative plan and report, as well as coordinating partners' efforts. All partners will actively contribute to the research and definition of the 3D Expert competence according to the methodology, timeline and formats defined.

6. CHRONOGRAM

The activities of O1 are scheduled within the period running from January to May 2018, as described in the chart below.

The dated mentioned in this plan are approximate. The setting of the concrete dated will be done by agreement among all the partners and according to the on-going assessment of the project progress.

ACTIVITY	DEADLINE	TASKS TO BE DEVELOPED	PARTNERS INVOLVED
IO1-A1 Operative Plan	April 2018	Drafting of the operative plan.	INCOMA
IO1-A2 Desk and field research on the 3D Expert Competence	January-March 2018	Gathering a 3D experts committee (10 per country) to elaborate the basic structure of the professional profile.	BIOAVAN and CEP
	March 2018	Sharing with partners the conclusions of the first experts committee so that they will analyse and contribute to them.	BIOAVAN and CEP
	April 2018	Gathering a committee of a minimum of 10 experts per country to analyse and propose changes in the basic structure of the professional profile.	All partners
IO1-A3 Definition of the 3D Expert Competence	April 2018	Study and update all the proposals of changes made by the partners to design the definitive of the 3D expert professional profile.	BIOAVAN and CEP
	April 2018	Share the definitive proposal with all the partners to decide the final structure of the 3D expert profile.	All partners
	April 2018	Gather the 3D experts committee to develop the structure and the final qualifications of the 3D experts professional profile.	BIOAVAN and CEP
	April 2018	Share with the partners the final structure of their analysis about the 3D experts profile.	BIOAVAN and CEP
	May 2018	Gathering the committee of 10 experts[1] per country to analyse and propose the last changes of the final document of the professional profile.	All partners
IO1-A4 O1 Report	May 2018	Share the final proposal and agree on the definitive structure of the 3D experts profile by all the partners.	BIOAVAN and CEP
	May 2018	Elaborating a Report containing the results of IO1 activities, including: a description of the activities carried out, target groups and stakeholders involved; reporting the matrix of knowledge, skills and competences adopted by 3D4VET.	BIOAVAN and CEP

[1] Please, note that only one contribution to the form should be made by country/partner, while the attendance list will be provided to the partners in order to state that the experts' committee has met, analysed the structure and reached a conclusion. Nevertheless, there is also the possibility to send the document and the form to the 10 experts so they will analyse the structure, will reach to some conclusions and will make contributions (we strongly recommend this second option).

7. TEMPLATE

Report template for IO1-A4:

DOCUMENT NAME

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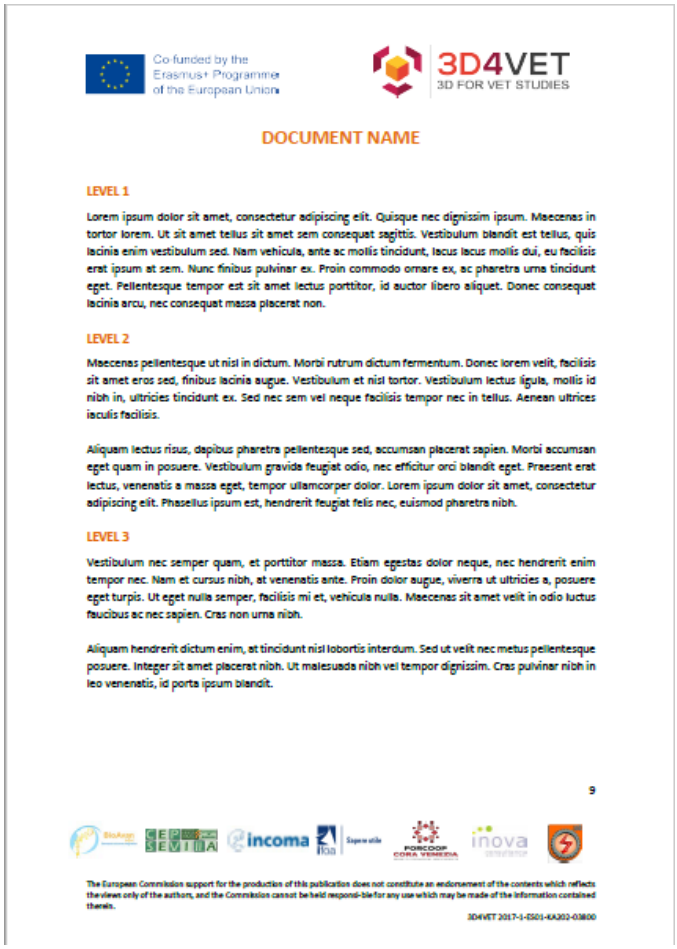

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DOCUMENT NAME

LEVEL 1

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ANNEX 2.- GLOSSARY

GLOSSARY PROPOSAL

1. Professional field
2. Observational field
3. Competences
4. National Catalogue of Professional Qualifications (CNCP)
5. General competence
6. Personal competences
7. Professional competences
8. Social competences
9. Professional context
10. External contrast
11. Achievement criterion
12. Professional qualification
13. Employability
14. Professional environment
15. Professional community
16. Productive process phase
17. Professional figure
18. Education associated with the grade
19. Function
20. INCUAL
21. Formative module
22. Level of qualification
23. Occupation
24. Professional profile
25. Process/Subprocess
26. Technological process
27. Professional achievement
28. Productive sector
29. Unit of competence

1. Professional field	Professional place where the owner of the qualification or grade is able to develo phis/her working activity
2. Observational field	Unit of processes/subprocesses plus the one dealing with functions/subfunctions identified in a productive sector/subsectorand which are characteristic of it. It sums up the whole of productive or services activities
3. Competences	Revelation of the expected results from the learning community at the end of the formative module
4. National Catalogue of Professional Qualifications (CNCP)	Mechanism through which the National System of Qualifications and Vocational Education structures those professional quialification susceptible of recognition and certification
5. General competence	Most significant professional functions of the grade, taking as reference the unit of qualifications and, where appropiate, the units of competence
6. Personal competences	Those related to employability. They must respond to the competences which allow to find, keep and change a job. They must also provide functional and technical polyvalence. They can be classified as : 1. Those applicable to different sectors. 2. Those using the same technological process, only diferentiated in the observational field. 3. Those related to leadership, teamwork, change management, initiative, business culture, identification and solving of problems, creativity, etc.
7. Professional competences	Those corresponding to the relevant steps of the technological subprocess. The main subfunctions of every step and their implementation field are specified.
8. Social competences	Those related to social cohesion. They must respond to those competences which favour the good working of the society. It deals with the values people must have in their relations and which ease common and professional life. They are related to responsibility, tolerance, respect, honesty, and, in general, those values of democratic citizenship.
9. Professional context	It describes, as a guide, the means of production, products and results of the job. Used or generated information and the elements of analogous nature necessary to frame the

	professional achievement
10. External contrast	Stage in the development of qualifications to validate the qualification as a whole. Social agents, professional organisms and associations take place
11. Achievement criterion	Acceptable level of the professional achievement that satisfies the objectives of the productive organizations. It sets up a guide for the evaluation of the professional competence
12. Professional Qualification	Set of professional competences significant for employment
13. Employability	Global set of competences of the workers that allow them to find, keep and change their job and which are kept throughout all their professional life
14. Professional environment	Set of elements that help and guide to define the sociolaboral frame of the possible handling for the owner of the qualification
15. Professional community	Each of the 26 sections in which the grades are structured and the National Catalogue of Professional Qualifications, classified due to affinity views of the professional competence
16. Phase of the productive process	Each of the successive stages that form the technological process of an industrial production system or a service provision
17. Professional figure	The concrete professional area selected from the observational field and which is liable to form the professional core of a vocational training grade
18. Education associated with the grade	It is structured in formative modules which take as a reference the units of competence and which form the minimum aggregate to establish the training dealing to professional grades and certificates
19. Function/Subfunction	Homogeneous set of productive activities or services directed to achieve a production objective or a service provision. It corresponds to each essential stage of the activities of "company Type"
20. INCUAL	The National Qualifications Institute (INCUAL) was created by Real Decreto 375/1999, 5th of March. It is the technical instrument with criterion independence capacity that
	supports the General Council of Professional Education to achieve the ojectives of the National System of Qualifications and Vocational Education. The Law 5/2002 of Qualifications and Vocational Education conferres on INCUAL the responsibility to define, elaborate and keep updated the National Catalogue of Professional Qualifications and the respective Vocational Education Modular Catalogue
21. Formative module	The minimum unit of vocational education to establish the learning to lead to obtain Vocational Education Grades as well as professional certificates
22. Level of qualification	It deals with the professional competence required by the productive activities according to criterion of knowledge, initiative, autonomy, responsibility and complexity of the activity due to develop. According to RD 1128/2003, annexe II, there are 5 levels of qualification, being the first one the relatively basic working activities and the fifth one the assigned to great complexity, autonomous, responsibility tasks
23. Occupation	Generic term used for a set of jobs, roles and any job situation with affinity in the competence
24. Professional profile	Description of the general competence, formulation of professional, personal and social competences and the inclusion of qualifications and units of competence of CNCP. Complemented with general data, related to the professional environment, the functional relations, types of occupation, as well as the prospective of the sector
25. Process/Subprocess	Activities banded together in obtaining a product or give a service, using technology or "ways of doing" typical of the sector where the professional activity takes place
26. Technological process	Successive stages of an industrial productive system or provision of services showing the relations among the different parts of the whole. It is prefereably represented by a flowchart
27. Professional achievement	Part of the competence which establishes the expected behaviour of the person as the consecuences or results of the activities he/she accomplishes
28. Productive sector	Economical-productive activity where grades and

	qualifications are established
29. Unit of competence	Minimum aggregated of professional competences, susceptible of recognition and partial accreditation

ANNEX 3.- EXPERTS CONCLUSION ON THE CONTRIBUTIONS TO THE BASIC SKELETON OF THE 3D PRINTING EXPERT PROFILE

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CONCLUSION ON THE CONTRIBUTIONS TO THE BASIC SKELETON OF THE 3D PRINTING EXPERT PROFILE

INTRODUCTION:

I would like to start congratulating and saying thank you to everybody who is contributing and working in this Project, as the tasks developed towards objective 1 are not easy to achieve. I would like to point out as an important difficulty finding experts with the necessary formation so as to contribute to the Project. We are aware it is a very young profession with only a few years of life, and the concretions are so specific that we understand it has been an added difficulty for each of the participating countries. Although I would like to point it as a positive opportunity for all the participating countries to elaborate a much richer and valid material.

Before starting with the analysis and summary of the contributions obtained from the questionnaires sent to the platform in Google, I would like to clarify some issues. A brief introduction to the Project might had been made to the people surveyed explaining the objectives, the agreements, what we expected from the survey, etc. I am saying this because there are contributions made where the minimum contents are questioned and which will be necessary in order for the outline to be approved in the Professional Qualifications Institute in Spain.

I would like to remember that we agreed in the first meeting to make a basic skeleton, which accomplished with the rules of the accreditation bodies, to which we would be providing the peculiarities of each country. In Spain, to obtain the degree of a formative module, the students must develop the professional competences as well as personal and social ones, and so it is not a matter of questioning the results so far, but to continue adding and building the professional profile with the singularities of the other countries and which have not been taken into account in the basic profile.

In the first meeting we stated the writing shall accomplish the requirements of wording and verbalization needed to fulfil the parameters and patterns used in the writing of the Professional Qualifications Institute in Spain, and that way, we could speed its possible presentation and approval of these organisms.

ANALYSIS:

As for the questionnaires, we have made two surveys: one in Spanish, for the Spanish experts; and, the other one, in English, which is the one we sent to the partners. They have been useful for us as a revision, as a way to provide and validate the documents elaborated by the chosen people in order to make the basic draft of the 3D expert profile. Both surveys have had as an objective to check the elaborated documents and to try to add the singularities of each country.

Statistical Data:

19 questionnaires have been made, 15 experts from Croatia have participated, 1 conclusion report of 7 experts from IFOA Italy and 3 from other country which the same person completed, Sergio Gonzalez from CadMan Do:

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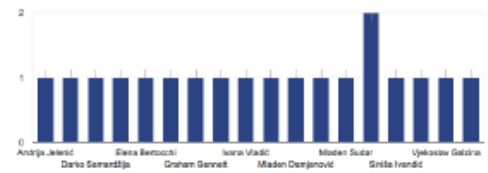
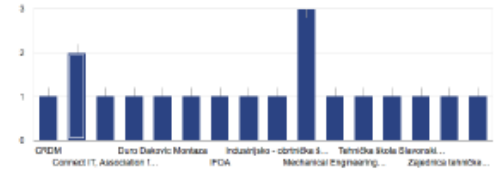
Full name

19 respuestas



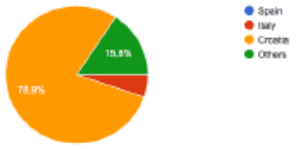
Institution, Organization, School...

19 respuestas



Country

19 respuestas



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1.- As for the definition of the general profile: "The professional profile of the Expert in 3D Designing, Scanning and Printing Systems (ESDEI3D) is decided by his/her general competence, his/her professional, personal and social competences and by the relationship of the National Catalogue of Professional Qualifications included in the grade."

- We refer to the fact that some of the units of competences are already redacted and included in the national catalogue of professional qualifications and could be considered in the development of this new profile. For instance, the unit of competence "Elaborate the technical documents of 3D design models" is based in other unit of competence present in the national catalogue of qualifications, "Elaborate the technical documents of the products of mechanical manufacturing."

-As for the composition in robotics, it is not related to the language used, but to the fact that it must comply with the standardized format demanded by the Institute of Qualifications in order to approve any professional profile, and, for this reason, it seems a little concrete sentence as the more it develops the more concrete it comes.
(Comment by Mladen Sudar, from the company Helior Technologies d.o.o. from Croatia)

-As for the experience it is always gathered in the personal competences.

2.- As for the general competences: ""The general Competence of this expert consists of developing 3D designing, scanning and printing projects, as well as managing and supervising the design, assembly and maintenance of the 3D printing and scanning systems, from the technical documentation, the regulations and established procedures, guaranteeing its working out, quality, safety and the environmental conservation."

-There is a contribution that questions the suitability of the inclusion of the part of the assembly and maintenance of the equipments in the development of this profile. I would like to remember we are talking about the knowledge an expert should have in this matter in a maximum level, and it is not a personal conviction, it is that actually the most expert people in this subject, not only they design their own printers or scans but they also manufacture, assembly and maintain them.

-The situation is that a professional profile is being defined in its maximum level, upper-level. If it is able to develop 3D design, scan and printing projects, we understand the management and oversight will be included, for obvious reasons.

-When it is stated it must be able to develop design projects, the knowledge the materials needed to do the design is included. It would be included in the unit of competence dealing with 3D models design, but it will be consulted with the experts whether to give more importance to the materials in order to include a unit of competence and a specific formative module in Qualification 1.

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-Clarify again in this section that the composition in robotic is not related to the language used, but to the fact that it must comply with the standardized format demanded by the Institute of Qualifications to approve any professional profile in Spain. Remind you it was already explained in the meeting in Seville and the patterns to be used were shown. I would also like to give my support to the translator, who is an approved translator, and though of Spanish birth, much of her academic and professional life was developed in London and she received her Bachelor of Arts in English philology in Cambridge.

Professional Qualifications:

89% agrees with the first qualification, 78% with the second one, 94% with the third one, and 89% with the last one.

-To clarify the issues that raise:
In the first qualification, we refer to 3D models design, not to systems design. Regarding the management and oversight of the 3D systems design, it would cope all the work dealing with the design of 3D models and that we later concrete much more in the units of competences and their formative modules, and the further we go the greater is the concretion, going from the general to the concrete.
In the second qualification, we are drafting a professional profile of a 3D expert. In these cases, it is essential to be able to scan to get 3D models, and in fact, this is developed in companies engaged in 3D printing. In this sense it is not someone who only works in one working environment where basic activities are developed, but we believe he/she could work in an important wide range of jobs.
In the third one, only improve English.
In the fourth one, only improve English…

-As a final conclusion, they all seem to agree these four qualifications will be enough to achieve the 3D expert professional profile.

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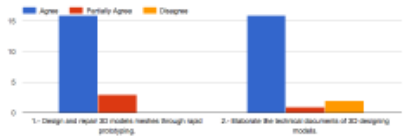
Units of competence (1PQ):

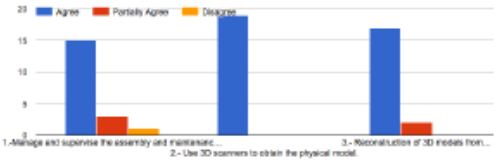


84% agree with the first unit of competence, and, 84% with the second one.

- To clarify the issues that raise:
In the first unit of competence they all seem to agree with it.
In the second unit of competence they all seem to agree with it, although there is a contribution that raises that in some cases another person could be the one to do that job, but we suggest if someone should have to do it, a 3D printer expert should be the person.

As for the contributions of new units of competence, knowing all kind of materials to be used in 3D printing will be part of the contents to work in the unit of competence of design, and experts should be asked whether it would be a unit of competence by itself or linked to its formative module.

Units of competence (2PQ):



79% agrees with the first unit of competence; 100%, with the second one and, 89%, with the third one.

- To clarify the issues that raise:

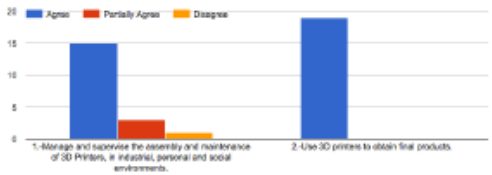
In the first unit of competence they all seem to agree with, although as I said before, the purpose is to define the profile of an expert in an upper level and these nowadays design, manufacture and maintain these equipments, as if it not so, it would be impossible to print in them. In respect of comparing it with a page printer, it is not possible, as they have nothing to do one to the other, as experts say. To the question made of what the personal environment is, just point out the sentences cannot be fragmented without loosing their meaning. What we want to gather is that it is sable to make those operations not only in professional environments but in any other environment, personal or social. It is true that administering and managing could be synonymous in this case, and could be exchanged without problem, though we chose manage because we believe this verb includes much more tan administration.

In the second unit of competence they all seem to agree with, although there is a contribution that comments : "It does not obtain the physical model by 3D scanning, it obtains a digital model of physical object" while it is true what we obtain is a digital file of the physical model, the pursued aim with the scanning is the attainment of a copy of that item in a printed and physical form, no professional scans a physical item just to stop in the step of getting the file of the model.

In the third unit of competence, they all seem to agree with, although there is a contribution that states: "I would add at the end, "in cooperation with experts" (I refer to medicine) as it is a sensitive area". I would agree with this collaboration if, in order to achieve that work, other experts were compulsory, but in this case each professional does his part of the work. The experts in achieving the medical images do their job, and the 3D expert with these images and a specific software is capable to build a real model and print that item in 3D. Although as a conclusion to the query, when this unit of competence is developed the know-how to work in a team with other experts will be reflected as a personal competence of a 3D expert.

As for the contributions to new units of competence, in this professional qualification there is none.

Units of competence (3PQ):



79% agrees with the first unit of competence, and 100% with the second one.

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- To clarify the issues that raise:
In the first unit of competence they all seem to agree with, although as I said before, the purpose is to define the profile of an expert in an upper level and these nowadays design, manufacture and maintain these equipments, as if it not so, it would be impossible to print in them. In respect of comparing it with a page printer, it is not possible, as they have nothing to do one to the other, as experts say. Also to be said, these equipments are not manufactured in series production and most that exist are prototypes assembled by the experts, so it is compulsory they can manufacture, set up and maintain them…
The few equipments there are which were manufactured in mass production do not comply with quality printed items.

In the second unit of competence, they all seem to agree with. As for the contributions of new units of competences, in this professional qualification the following proposal has been made "Administer the usability of the materials in 3D printing" and, as stated at the beginning of this report, the study of the specific materials for 3D printing would be contents to learn in the first unit of competence of design. Though it would be a proposal we should present to the experts, explore if it could be of entity enough to have a unit of competence and a specific materials formative module.

Units of competence (4PQ):

89% agrees with the first unit of competence.

- To clarify the issues that raise:
In this first unit of competence, they all seem to agree with. Although in this unit of competence we intend to gather the competence to do, develop and manage the design projects, 3D parts scanning and printing, as stated before, we describe the profile of an expert in an upper level, and these currently design, manufacture, assemble and maintain these equipments, as if not so 3D printing with them would be impossible. In respect of comparing it with a page printer, it is not possible, as they have nothing to do one to the other, as experts say. We do not understand either the comment "Develop, plan, program, control the times, supply the

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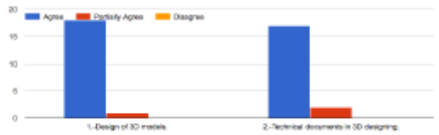
production, the terms used here could be confusing because both are standards and could lead to confusion"
We do not understand which standards are referred to or what we could be misleading.
As for the contributions to new units of competence, in this professional qualification there is none.

-To the question "If you propose a different professional qualification not included in the schems, please write here the units of competence the qualification should include." As for the proposal of adding a new qualification: "Administer the usability of the materials in 3D printing" the study of the specific materials for 3D printing would be contents to learn in the first unit of competence of design. Though it could be studied with the experts.

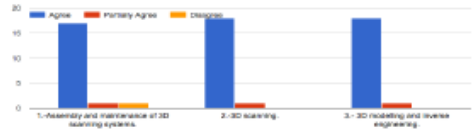
Formative Modules (1PQ):



94% agree with the first formative module, and 89% with the second one.

- To clarify the issues that raise:
Regarding the first formative module, they all seem to agree with and there is no contribution to it.
Regarding the second formative module, the contribution "The 3D design is already a technical document" the result towards the way to get to it are being confused, the way is what would be constructed in the design.
As for the contributions of new formative modules, not included in this qualification, "Material usage documentation" has been reflected. As stated before, these contents would be included in the design module. The experts will be asked whether it is feasible including it as separate from the design.

Formative Modules (2PQ):



89% agree with the first formative module, 94% with the second one and 94% with the third one.

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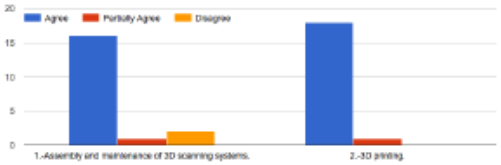
- To clarify the issues that raise:
As for the first formative module, they all seem to agree with, although the continue insistence on the fact that the expert must have knowledge of manufacture, assembly and maintenance of these equipments is justified. Thus, this contribution is already answered.
As for the second formative module, there is no contribution and they all agree with it.
As for the third formative module, they all seem to agree with although the following contribution is made "I believe REVERSE engineering is a better wording, commonly effective used." To this contribution we must answer that contribution could be made in the English version, but in the Spanish version reverse engineering would be more correct.
As for the contributions of new formative modules, not included in this qualification, no contributions have been provided.

Formative Modules (3PQ):



84% agree with the first Formative module, and 94% with the second one.

- To clarify the issues that raise:
As for the first formative module, they all seem to agree with, although the continue insistence on the fact that the expert must have knowledge of manufacture, assembly and maintenance of these equipments is justified. Thus, this contribution is already answered.
As for the second formative module, there is no contribution and they all agree with it.
As for the contributions of new formative modules, not included in this qualification, no contributions have been provided.

Formative Modules (4PQ):

89% agree with the first Formative module.

- To clarify the issues that raise:
As for the first formative module, they all seem to agree with although the continue insistence on the fact that the expert must have knowledge of manufacture, assembly and maintenance of these equipments is justified. Thus, this contribution is already answered.
As for the contributions of new formative modules, not included in this qualification, no contributions have been provided.

- As for the contributions of adding new formative modules to the profile, we take note of the contribution making reference to add a formative module that considers the investigation in the printing processes.

With this last contribution the summary report of the questionnaires received will be finished.

We would like to thank all the contributions made to the 3D printing basic skeleton. Pending consulting and arranging with partners and experts that have been drafting in the meeting.

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ANNEX 4.- PROFESSIONAL QUALIFICATION 1

ANNEX 5.- PROFESSIONAL QUALIFICATION 2

ANNEX 6.- PROFESSIONAL QUALIFICATION 3

ANNEX 7.- PROFESSIONAL QUALIFICATION 4

Professional Qualification: MANAGEMENT AND SUPERVISION OF DESIGNING SYSTEM OF 3D MODELS, IN PROFESSIONAL ENVIRONMENTS.

Related professional groups: (Electricity-Electronics, Computing, Mechanical manufacturing)
Level 3
ESDEI3D Code_1
Version 1
Situation: Review

General Competence
Carry out the processes of Management and Supervision of Designing Systems, monitoring the obtained 3D models, with quality, safety and respect to environment criteria

Units of competence
UC0001_3: Design and repair 3D models meshes through fast prototyping.
UC0002_3: Elaborate the technical documents of 3D designing models.

Professional Environment

Professional field
Its activity deals with the designing and supervision of fast prototyping 3D models as well as with the elaboration of the appropriate technical documents.

Productive sectors
This qualification is located in the subsector related to designing and development of 3D models, placed in industrial, architectonical, civil engineering, clinical, food and agriculture, artistic, educative, sports, domestic and other scientific-technological sectors.
Machinery construction, mechanical equipment and industrial products in the different production sectors.

Employment and relevant job positions
3D models designer.
Researcher of mechanical topology of 3D models.
Technical consultant in 3D designs.
Assistant for technical documents in 3D designs Projects.
Related Education (... h)

Formative Modules
MF0001_3: Designing of 3D models (... h)
MF0002_3: Technical documents in 3D design (... h)

UNIT OF COMPETENCE 1: Design and repair 3D models meshes through fast prototyping

Level 3
Code UC0001_3

Professional achievements and carrying out criteria

RP 1: Define fast prototyping 3D models, providing constructive solutions and stating specifications, characteristics, materials and costs, complying the regulations for occupational hazards prevention as well as environmental protection rules.

CR1.1 3D models are designed considering the features, limitations of the processes, means used to obtain results and criteria to optimize their output and economy of the post process of the prototypes.
CR1.2 3D models definitions will be determined taking into account the amount of material used, the needed supports, their functionality, and the costs for their manufacture.
CR1.3 The base materials, for the design of these 3D products, are chosen guaranteeing their resistance, terminations, costs and established quality.
CR1.4 The parameters for 3D printing equipment's must be linked to the prototypes of the designs according to their technical specifications.
CR1.5 The design of the 3D models are corrected considering the results of the tests, simulations, experimentations and post processing of the prototypes.
CR1.6 The features of the final product will be decided regarding its specifications and, in particular, its official approval.

RP2: Measure the elements designed in 3D from the established data and according to the results obtained from the required technical calculations.

CR2.1 The requirements of effort or load are determined analyzing the phenomenon that cause them.
CR2.2 The resistance of the product to torsion, flexion, shear, compression, break, among others, is established dealing with the requirements the product is subjected to.
CR2.3 The safety coefficient (break, life, among others) applied to the calculation of the elements are decided due to the technical specifications.
CR2.4 The shape and dimension of the designed elements are set depending on the results of the calculus.

RP3: Establish the verification and assurance procedure of the quality of the design of the product, guaranteeing its reliability, the fulfilling of the technical specifications and the applicable regulations for occupational hazards prevention as well as environmental protection rules.

CR3.1 The verification and assurance procedure of the quality of the product is determined focusing on the aspects dealing with quality of the product, specific regulations, functionality, safety and occupational hazards prevention, costs, tools, manufacturing viability, human resources and available material, as well as design and updating of AMFE, rules and quality management systems and CE regulations.
CR3.2 The types of tests and analysis (breaking resistance, fatigue, among others) are established knowing the degree of compliance of the product regarding to the applicable regulation or to the demand of the customers.
CR3.3 The testing or essay parameters are decided in relation to the services conditions (life, environmental, among others) which the product must bear.
CR3.4 The limit of the designs and meshes is compared with the technical features or with the representations of the product as a whole, checking the 3D printing process the component must be complied with have been taken into account.
CR3.5 The production of the prototype is supervised to verify the feasibility of the manufacture and to propose changes in the design.

Professional context

Means of production

Specific computer assisted 3D design, CAD applications.
Specific computer applications for calculus and simulation of mechanisms and tests of the 3D models physical properties.

Product and results

Constructive solutions for products obtained by 3D printing (industrial, architectonical, civil engineering, clinical, food and agriculture, artistic, educative, sports, domestic, other scientific-technological sectors elements, among others). Lists of materials. Guidelines for control.

Product manufacturing viability reports. Verification procedure.

Used or generated information

Digital files of elements or 3D sets that form the 3D printing draft blueprint. Technical specifications. Design manual.

Technical documents of standard components. Commercial catalogues. AMFE of the product and the design. 3D printing procedures. Homologations specifications. Regulations for occupational hazards prevention as well as environmental protection rules.

UNIT OF COMPETENCE 2: Elaborate the technical documents for the 3D design models.

Level 3
Code UC0002_3

RP1: Obtain the digital maps of the product designed in 3D, from the files of the elements or sets, taking into account the 3D printing process and respecting the applicable regulations for occupational hazards prevention as well as environmental protection rules.

CR1.1 The designed product is defined guaranteeing its printing, maintenance, assembly and dismantling (easiness, accessibility, and use of standardized tools, among others).
CR1.2 The designs are made in any kind of file that permits import its meshes to 3D printing models in order to accomplish the drawing rules (blueprint drafts, drawing lines, dimension, tolerances, views, sections, tooling symbology, among others)
CR1.3 The adjustments and tolerances are established according to the function of the different parts and to the type of the expected manufacture.
CR1.4 The element will be defined allowing its safety printing and handling, determining the maximum dimensions of printing, among others.

RP2: Definition of 3D printing operative parameters depending on the equipment and the materials used in the process.

CR2.1 The documents are made implementing the characteristics and variable parameters of the printing equipments (Parameters tables and features of the equipments according to the manufacturer, among others).

RP3: Elaborate the technical dossier of the Printing product, gathering instructions for use, assembly drawings, outlines, list of spare parts, among others.

CR3.1 The documents dealing with the product (reports, list of spare parts, manual, outlines, overall drawings, manufacturing drawings, installation drawings, among others) are organised and completed guaranteeing the disponibility of the information.
CR3.2 The technical reports dealing with the feasibility of the design of the product are written adding the modifications occurred during the process.
CR3.3 The conclusions achieved during the steps of the design, process automatization, manufacture of the prototype and tests are gathered in the reports, easying later designs.

RP4: Keep up-to-date and organised the technical documents needed for the development of the 3D design final product.

CR4.1 The designs are revised and updated complying the established guidelines needed for the impletion of amendments in the final product.
CR4.2 The technical dossier is updated and ordered addind systematically the amendments, assuring its force.
CR4.3 The technical documents are classified according to the established rules allowing its easy location and access.
CR4.4 The guidelines for the revision and updating of the designs and documentation are set describing the impletion of amendments, responsibility and management, among others.

Professional context

Means of production

Specific computer assisted 3D design applications, (CAD) and specific computer applications in the Office environment.

Products and results

Sets of designs and 3D products sawing. List of materials. Technical dossier and technical reports and users manuals.

Used or generated information

Drawing rules. Technical documentation of standard components. Design of draft parts. Technical specifications. Design manual. Commercial catalogues. Design and product AMFE.

Procedures and printing techniques. Outlines and sketches. Applicable regulations for occupational hazards prevention as well as environmental protection rules.

FORMATIVE MODULE 1: Design of 3D models.

Level 3
Code: MF0001_3
Associated to UC: Design and repair 3D models meshes through fast prototyping.
Duration: hours

Capacities and evaluation criteria

C1: Design sets and 3D elements through fast prototyping, on the basis of the required specifications and requests of drafts phases.

CE1.1 Relate the different printing techniques to the shapes and qualities that ca be obtained.
CE1.2 Identify and determine the parameters to consider in the different 3D printing procedures.
CE1.3 Describe the limitations of the different techniques and 3D printing procedures.
CE1.4 Relate the different prototypes to build with the different 3D printing equipments.
CE1.5 Select the best type of material according to the required different specifications and requests.
CE1.6 3D design software, types, scad source files, stl 3D type dimensional files and gcode file generation, through laminators.
CE1.7 3D design, by additive manufacturing, through the use of topological optimization.
CE1.8 A practical example in which 3D printing parts has to be designed and with the required specifications information, must:

- Identify the technical specifications to guarantee the building of the prototype.
- Propose various constructive solutions for the parts that have to be designed, depending on the different demands, taking into account the limits of the 3D printing process.
- Size the different 3D prototypes, applying calculations, rules, tables, considering the safety coefficients of the design.
- Determine the necessary information for the calculus and simulation of specific computer applications and interpret the results.
- Represent in an outline the stress the different 3D prototypes undergo.

C2: Determine the adjustments, geometrical and dimensional tolerances and superficial qualities, linking the different 3D parts to their functioning.

CE 2.1 Relate the adjustments-types to the various demands of the 3D printing parts in accordance with the stresses they are subjected to.
CE 2.2 Calculate the tolerance fields for the adjustments, according to rules, from the nominal dimension and specific tolerance.
CE 2.3 Evaluate the choice of the kind of adjustment and its effect regarding the manufacturing cost, based on the printing process.
CE 2.4 Relate the geometrical tolerances to the required accuracy in the different 3D prototypes.
CE 2.5 Represent, through standardized symbology, different types of adjustments and geometrical tolerances

C3: Analyse the impact of the different materials used in the 3D parts prototyping, in order to determine the specifications of their design and finish.

CE 3.1 Describe the different behaviours of the 3D prototypes according to the materials used in their design.
CE 3.2 Identify the materials to be used in the 3D printing as well as in the finish treatments, which improve the behavoiour and look of the designed items.

C4: Verify and guarantee the quality of the design of the 3D printing prototypes.

CE 4.1 Describe the procedure of assurance of the quality in the design.
CE 4.2 Describe the AMFE design technique.
CE 4.3 Describe the standards and quality management systems from the point of view of the Product Design Process.
CE 4.4 Describe the CE regulation for 3D printed products.

Capacities whose adquisition must be completed in a real working environment

C1, C2 y C3

Other capacities:

Be responsible for the job he/she is carrying out and for the fulfillment of objectives.
Demonstrate creativity in the development of the job which is being delivered.
Propose alternatives with the aim of improve the results.
End the work attending to suitability, quickness, economy, and effectiveness criteria.
Demonstrate certain grade of autonomy in the resolution of contingencies related to his/her activity.
Learn new concepts or procedures and make effective use of the training using the acquired knowledge.

Contents:

1. - CNC introduction. Numerical Control Machines.

- **1.1. -** Components and Architecture.
- **1.2. -** Classification.
- **1.3. -** Operating Principle.
- **1.4. -** CAD / CAM system (Computer assisted Design and Manufacture).

2. - 3D Printers:

- **2.1. - 3D Printing Technologies: (Printing by addition).**
- **2.2. - Evolution and type of 3D Printers.**
- **2.3. - 3D Printers applications: Application Areas:**
- **2.4. - 3D printing Process and Steps.** STL attainment:
  - **2.4.1. -** 3D Design.
  - **2.4.2. -** Design Shceduled 3D design. SCAD**.**
  - **2.4.3. -** 3D scanning.
  - **2.4.4. -** From STL to G-Code. Mills.
  - **2.4.5. -** G-Code 3D printing.
- **2.5. - STL fixing.**
  - **2.5.1. -** Introduction to repair of meshes.
  - **2.5.2. -** Netfabb basic.
  - **2.5.3. -** MeshMixer.
  - **2.5.4. -**3D models design advices.

3. - Software of 3D Modules Designs.

- **3.1. -** CAD: Software Actual Design.
  - **3.1.1. -** Openscad. Parts design, through programming; parameterable Designs. Source files. *.scad
  - **3.1.2. -** Freecad.
  - **3.1.3. -** Tinkercad.
  - **3.1.4. -** Google Sketchup.
  - **3.1.5.-**Autodesk applications: 123D Design; 123D Make**;** ThingMaker (TinkerPlay).
  - **3.1.6. -** Others: IntelliCAD, LibreCAD, DraftSight, Blender, 3Dtin, etc.
- **3.2. -** Other applications of 3D design: Autodesk, SolidWorks, Sketchup, etc.
- **3.3. -** 3D Graphic files standards: *.SCAD**;** *.STL: Standard Tessellation Language. (Standard Patchwork language)**; ***.AMF: Additive Manufacturing Format.
- **3.4. -** Software of topological optimization of the complex parts of 3D models, through the improvement of the design according to its physical properties, lightening the final product.

4. - Geometry and 3D settings:

- **4.1. -** Geometric and Dimensional regulation; Settings and tolerances
- **4.2. -** Dimensional accuracy in 3D printing:
  - **4.2.1. -** 3D printer resolution. (Layer thickness). (ppp)
  - **4.2.2. -** Printing tolerance.

5. - 3D Printing Materials:

5.1. - Materials: characteristics and typology.

5.1.1. - Suitability and selection of the type of material according to its design.

6. - Verification and Quality of 3D products:

6.1. - Considerations to be taken into account:

6.1.1. - Cost of the printer.

6.1.2. - Cost of the printing materials. Price per Kg.

6.1.3. - Printing Speed.

6.1.4. - Cost of the printed prototype.

6.1.5. - Colour printing.

6.1.6. - Post-printing work.

6.1.6.1. - Support material removal.

6.1.6.2. - Hardening of materials with waxes and with thermoplastic polymers.

6.1.6.3. - In ABS, use of acetone.

6.1.6.4. - Sanding, Polishing by abrasion (Bronze), varnish (wood), etc.

6.2. - Endings.

6.3. - Additives.

6.4. - Other physicochemical characteristics: Hardness, Flexibility, Resistance, Opacity, Transparency, Rigidity, high temperature, de colours. Etc.

7. - Applicable regulations for occupational hazards prevention as well as environmental protection rules.

7.1. - Applicable regulations for occupational hazards dealing with the products design.

7.2. - Applicable regulations for environmental protection rules dealing with the products design.

Parameters of training context

Areas and facilities

The areas and facilities will respond, in the form of a classroom, classroom workshop, training workshop, laboratory or similar area, to the formative needs, according to the Professional Context detailed in the associated Unit of Competence, taking into account the applicable regulation of the productive sector, hazards prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1. Command of the knowledge and techniques dealing with the design of 3D printed products, which will be certified by one of these two ways:

- Level 3 academic education, Technical Engineering, higher studies in Design, or others of a higher level related to the professional field.
- Minimum 3 years professional experience in the area of the competences of this formative module.

2. Pedagogical Competence in accordance with what the competent Administrations establishes.

FORMATIVE MODULE 2: Technical documentation in 3D design

Level 3
Code: MF0002_3
Linked to UC: Elaborate the technical documentation of the 3D Design Models.
Duration: hours

Capacities and evaluation criteria

C1: Design in the appropiate format with IT mediums the 3D sets and parts, gathering the necessary technical information for its later printing.

CE 1.1 Choose the graphic design system for each of the sets or parts.
CE 1.2 Represent according to the applicable regulation, the elevations, units, sections and details, that take part in the graphic information the plans contain.
CE 1.3 Limit the dimensions of the designed parts depending on their procurement process and applying the proper regulation.
CE 1.4 Specify in the designs the technological data of the sets or developed parts (materials, standard components, superficial qualities, applicable rules, among others).

C2: Elaborate the technical dossier of the design of 3D prototypes.

CE 2.1 Elaborate the instructions and manuals needed for the use and maintenance of the printed product.
CE 2.2 Elaborate the dossier of the project incorporating the files, memories, plans, outlines, installation drawings, maintenance instructions, among others.
CE 2.3 Describe the updating procedures of the graphic information of the project, as well as the document management.

Capacities whose adquisition must be completed in a real working environment

C1 complete.

Other capacities:

Be responsible for the job he/she is carrying out and for the fulfillment of objectives.
Demonstrate certain grade of autonomy in the resolution of contingencies related to his/her activity.
Propose alternatives with the aim of improve the results.
Prove being flexible to understand changes.
Ability to adapt to new situations or contexts.
Learn new concepts or procedures and make effective use of the training using the acquired knowledge.

Contents:

1. - Representation of 3D prototyping parts.

- **1.1. -** Graphic representation regulations.
- **1.2. -** Sights, cuts and sections.
- **1.3. -** Limits according to the manufacturing process.
- **1.4. -** Surface state.
- **1.5. -** Dimensional tolerances.
- **1.6. -** Form and position tolerances.
- **1.7. -** Sketching.
- **1.8. -** Sets.
- **1.9. -** Standardization.
- **1.10. -** Representation of standard components.

2. - General representation system

- **2.1. -** Representation perspective.

3. - Office automation

3.1. - Word processor.
3.2. - Publishers.
3.3. - Databases.
3.4. - Spreadsheets.
3.5. - Presentations.

4. - Document management

4.1. - Organization of the information dealing with the projects management.
4.2. - Procedure of updating of documents.

5. - Plans computer-aided design

5.1. - Specific computer applications of 2D and 3D design.

Context parameter of the training

Areas and facilities

The areas and facilities will respond, in the form of a classroom, classroom workshop, training workshop, laboratory or similar area, to the formative needs, according to the Professional Context detailed in the associated Unit of Competence, taking into account the applicable regulation of the productive sector, hazards prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1. Command of the knowledge and techniques dealing with the design of 3D printed products, which will be certified by one of these two ways:
   - Level 3 academic education, Technical Engineering, higher studies in Design, or others of a higher level related to the professional field.
   - Minimum 3 years professional experience in the area of the competences of this formative module.
2. Pedagogical Competence in accordance with what the competent Administrations establishes.

Professional Qualification: MANAGEMENT AND SUPERVISION OF 3D SCANNING SYSTEMS, IN PROFESSIONAL ENVIRONMENTS.

Associated Vocational Families: (Electricity-Electronics, Computing, Mechanical Manufacturing)
Level 3
Code ESDEI3D_2
Draft 1
Situation: Final

General competence
It performs the processes of management and supervision of systems for scanning and reconstruction of 3D elements through the scanning equipment of these elements or inverse engineering (reverse), with criteria of quality, safety and respect for the environment.

Units of competence
UC0003_3: Manage and supervise the assembly and maintenance of 3D scanning systems, in industrial, personal and social environments.
UC0004_3: Use 3D scanners, to obtain final products.
UC0005_3: Reconstruction of 3D models, from clinical images (DICOM) or photographs using reverse engineering software (reverse).

Professional field

Professional context
Its activity is organised in functions or supervision of assemblies, maintenance and use of 3D scanning equipment, as well as the reconstruction of 3D elements through the application of inverse engineering software (reverse).

Productive Sectors
This qualification is located in the subsector of specific industries of scanning or reconstruction of 3D elements through the application of reverse engineering (reverse) for the development of 3D models, framed in the industrial, architectural, civil engineering, clinical, agri-food, artistic, educational, sports, domestic and other scientific-technological sectors. Construction of specific scanning machinery, mechanical equipment and industrial products in the different production sectors.

Main jobs and employments
3D scanners technician.
3D scanning technician.
Expert in reconstructing 3D models by applying reverse engineering software (reverse).

Associated training (... h)

Formative modules
MF0003_3: Assembly and maintenance of 3D scanning systems (... h)
MF0004_3: 3D Scanning (... h)
MF0005_3: 3D modeling and reverse engineering (or reverse.)(... h)

UNIT OF COMPETENCE 3: Manage and supervise the assembly and maintenance of 3D Scanning, in industrial, personal and social environments.

Level 3
Code UC0003_3

Professional achievement and implementation criteria

RP1: Condition the work area, prepare equipment, tools, instruments and EPIs, to join the elements and structures of 3D scanners, complying with the rules of prevention of occupational and environmental risks.

CR1.1 In the conditioning of the work area, the 3D scanner dimension, the necessary auxiliary spaces, the weights to be supported and the maneuvers to be performed have been taken into account.
CR1.2 The materials, machines, useful equipment, work tools and accessories necessary for the development of the specified work are selected in compliance with the instructions and standards of prevention of occupational risks established.
CR1.3 Machines or equipment are kept operational by applying user maintenance procedures.
CR1.4 Securities of equipment and personal media are prepared according to the requirements of the required safety standards.

RP2: Join elements and components of 3D scanners according to the specifications, complying with the rules of prevention of occupational and environmental risks.

CR2.1 The assembly and positioning of the elements or constructions, is done following the sequence of operations indicated in the technical documentation and within the admissible tolerances for their assembly.
CR2.2 The assembly is carried out according to the specifications of the construction drawings and the connection points are made in the appropriate place and with the established procedure.
CR2.3 The handling of the means and auxiliary tools of assembly, is done without interference and complying with the rules of prevention of occupational risks.
CR2.4 The union of elements and materials, is made with the taking of necessary measures and complying with the specifications.
CR2.5 The use of safety equipment and means is done according to the requirements of safety regulations.

RP3: Carry out the start-up and functional tests of the equipment and all its elements of the 3D scanning systems, according to the technical documentation, instructions given and manufacturer's standards, applying the established procedures, in conditions of quality and safety, and complying with current regulations.

CR3.1 The assembly, anchoring and leveling of the machinery has been carried out following established procedures, using the tools and tools specified in each case, ensuring the absence of damage and the functionality of the equipment.
CR3.2 Connections to the networks of energy fluids and services are made with the kind and type of elements described, accessories, devices and materials required by the technical specifications is done:
- Complying with the applicable regulations.
- Using the type of electrical conduit, layout and fastening specified in the assembly documentation, avoiding mechanical stresses and complying with the technical specifications.
- With the conductors of section, insulation, rigidity and protection specified, without changing their characteristics during assembly.
- Using the required terminals and connectors, connected to the necessary pressure and identifying the conductors in accordance with the scheme.
- Supervising the protection of the food, complying at all times with the requirements of the regulations applicable to low voltage.
- The power values are correct for the electrical, hydraulic or pneumatic elements.

CR3.3 The start-up is made:
- Following the sequence of commissioning according to what is indicated in the project.
- Loading control programs and operating the 3D scanning machine following the established procedures, with the guards and quality systems activated.
- Visualizing the information provided by the screens (if any) which is appropriate and corresponds to the actual state of the machine or equipment.
- The correct functioning of mobile systems and the absence of elements that interfere with it.
- Regulating the operating parameters within the established ranges of action, adjusting them if necessary and following the procedures indicated in the corresponding manuals.
- The safety systems of the equipment act correctly, according to the manufacturer's instructions and current regulations of application.

CR3.4 The functional verification of the system is carried out according to the technical documentation.

CR3.5 The work developed and the modifications introduced are included in the assembly report or work order.
CR3.6 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

RP4: Implement the program of preventive and predictive maintenance of 3D scanning equipment, revising the operating conditions of the installation and its components, in the established deadlines and times, in conditions of quality and safety, and complying with current regulations.

CR4.1 The technical manuals of the equipment, installation and accessories are consulted, when necessary, in maintenance interventions.
CR4.2 The technical means, tools and measuring devices are adequate and are used according to the requirements of each intervention, and must be adjusted and with the corresponding calibration certificate in force when required by regulations.
CR4.3 Preventive and predictive maintenance operations are carried out following the maintenance plan.
CR4.4 Maintenance is carried out following established protocols and taking into account, among others:
- External cleaning and absence of deformations in equipment, installation and accessories.
- Connections and continuities of cables, connectors, power strips, among others, both power and communications.
- The functionality of the control equipment of the safety devices of the system, of the electrical, pneumatic and hydraulic elements and of the field elements.
-The adjustment and calibration of equipment and system elements.

CR4.5 The work order of the intervention carried out is completed in the corresponding format indicating the elements replaced, the modifications introduced and the actions carried out, among others, for their incorporation into the history of the installation, as well as the communication to the person in charge of the impediments observed in maintenance.
CR4.6 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

RP5: Diagnose and repair the dysfunctions or breakdowns found in the field of its competence, applying it to 3D scanning systems, based on the symptoms detected, manufacturer information and history of breakdowns of the equipment, meeting the established deadlines, under quality conditions and security, and complying with current regulations.

CR5.1 The initial tests or observations allow to verify the symptoms of dysfunction or breakdown collected and are contrasted with the history of the equipment.
CR5.2 The possible dysfunction is checked according to instructions, performing the usual starting sequence and acting in a routine way to gather information about it.
CR5.3 The initial hypothesis and the plan of action developed allow to diagnose and precisely locate the damaged device as well as the cause that produces it, evaluating the possibilities of repair or its transfer to the person in charge, as well as establishing priorities according to the level of risk of repair and availability of use of the installation.
CR5.4 The diagnosis and location of the malfunction or breakdown is made using the technical documentation of the installation, when necessary, with the appropriate tools and measurement devices, applying the established procedure.
CR5.5 Replacement of the damaged element is carried out using the disassembly and assembly sequence recommended by the manufacturer, ensuring that the element, component or part of the equipment, installation or accessory replaced is identical or compatible with the damaged one and does not alter any mandatory regulation. Fulfillment.
CR5.6 The waste generated is collected according to the waste management plan.
CR5.7 The extensions and updates carried out verify that they do not alter the intended purpose, the conditions of the equipment nor the initial quality conditions set by the manufacturer.
CR5.8 The work developed is included in the repair report.
CR5.9 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

Professional context

Means of production

Measurement and verification instruments. Tools and supplies for assembly and installation. Fixing systems, manual tools for mechanical work (pliers, screwdrivers, among others). Manual tools for electric-electronic works (crimping pliers and fiber cutters, among others). Lifting and transport means. Review equipment. Machines for pneumatic and hydraulic works. Machines for mechanical works. Equipment for electrical, electronic, pneumatic and hydraulic tests, as measuring instruments (phase tester, network certifier, manometer, multimeter, oscilloscope, wiring tester, among others). IT tools Equipment for the prevention of occupational risks. Maintenance management software. Fault history. Team book.

Warehouse book.

Products and results

3D scanning systems installed and diagnosed. Maintenance in 3D scanning systems. 3D scanning systems start-up.

Used or generated information

Plans and assembly diagrams and work instructions, electrical, pneumatic, hydraulic, situation and connection diagrams. Lists of materials. Assembly sequences. Machine manuals. Installation manual, user maintenance and technical service. Quartering. Project documentation. Work orders. Failures reports. Technical protocols of action. Rules for equipment maintenance, standards for quality control, regulations for prevention of occupational and environmental risks and applicable regulations. Assembly report. Breakdowns historic report. Team book.

UNIT OF COMPETENCE 4: Use 3D scanners to obtain final products.

Level 3
Code UC0004_3

Professional achievement and implementation criteria

RP1: Prepare prototypes and/or 3D models for 3D scanning.

CR1.1 The digital files containing the model to be scanned in 3D are received, applying the rules established for the process.
CR1.2 The digital files that contain the model to be scanned in 3D are protected by backing up the file according to established procedures.
CR1.3 The 3D models are prepared by checking that it corresponds with the technical specifications of the work order and according to the chosen 3D scanning process.
CR1.4 The type of material to be scanned in 3D is verified and identified.
CR1.5 The type of surface of the 3D model is checked by determining its degree of transparency, refraction, reflection, and brightness.
CR1.6 The morphology of the 3D model to be scanned is taken into account, determining the degree of complexity of all the surfaces that compose it.
CR1.7 Surface markers are conveniently set and placed to improve 3D scanning.
CR1.8 Environmental factors are checked, indoors or outdoors, for 3D scanning:
- Illumination; Wind; Fog; Smoke; Contaminants; Humidity...etc.

CR1.9 Equipment, tools and instruments are chosen to perform the 3D scanning process according to the established procedure taking into account all the factors and parameters above.
CR1.10 The condition of materials and environmental factors are guaranteed and maintained throughout the entire process according to the established plan.
CR1.11 The necessary resources are applied to achieve the objectives of the prevention plan throughout the process of preparation and manipulation of 3D models, identifying and adapting the real needs of working and environmental conditions, participating in the determination and election of them.

RP2: Prepare the equipment, adjust the parameters and make the scanning of the elements and/or 3D models.

CR2.1 The element to be scanned is verified by checking that it corresponds to the one established in the scanning order.
CR2.2 Auxiliary systems are prepared by adjusting to obtain the established quality.
CR2.3 The type of material of the 3D model is taken into account for the scanning process.
CR2.4 The physical properties of the surface of the 3D model (transparency, refraction, reflection, and brightness) are verified to adjust the environmental and scanner parameters.
CR2.5 The type of scanning process is established, according to the morphology of the 3D model, according to the degree of complexity of the surfaces that make it up.
CR2.6 The surface markers of the 3D model are taken into account during the scanning process.
CR2.7 Environmental factors are controlled and established, indoors or outdoors, for the correct 3D scanning process:
- Illumination; Wind; Fog; Smoke; Contaminants; Humidity...etc.

CR2.8 The control of the parameters during the scanning process of the 3D model is done visually and / or through the management software of the scanning process, according to the control plan established.
CR2.9 The anomalies detected during the scanning process, movements of the model in the support, imbalances in the quality of the obtained image, and others, are corrected until reaching the required scanning parameters.
CR2.10 The digitized element is verified by the specific software: comparing the obtained dimensional and / or geometrical data, colors, defects and others, with the starting prototype.
CR2.11 The variables of the process are modified, according to the evaluation and the results obtained during the scanning process.
CR2.12 The correction and adjustment of the scanning process is carried out by acting on the elements, parameters and/or control mechanisms to alleviate the errors detected during the scanning process.
CR2.13 The 3D scanning equipment adjustments are made in compliance with the applicable regulations for the prevention of occupational and environmental risks.
CR2.14 The quality control of the scanning process is carried out according to the established method, both in terms of the characteristics to be controlled and how to do it, applying the established quality procedures.
CR2.15 The results of the verification of the scanning process are arranged in the control sheets, indicating the incidents and errors captured during the process, for analysis and improvement.
CR2.16 The scan parts are filled in to check the agreement between the model and the digitized file obtained.
CR2.17 The safety devices of the 3D scanning machine are checked, checking their correct operation, following established procedures.

CR2.18 The maintenance plan of the 3D scanning equipment is carried out following the instructions of the machine manufacturer and the established procedures.
CR2.19 The elements of the 3D scanning equipment comply with the cleaning levels established in the maintenance regulations.

RP3: Interpret and manage the digital information generated in the process of 3D scanning of prototypes and/or 3D models.

CR3.1 All the digital information generated by the 3D scanning devices is received through the appropriate computer applications.
CR3.2 The digital files containing the scanned model are archived and protected by backing up the file according to established procedures.
CR3.3 Digital files are opened using specific computer applications.
CR3.4 The digitized information is checked by checking that it corresponds to the specifications and technical characteristics of the model.
CR3.5 The correction parameters of the digital file are made on specific programs.
CR3.6 Corrected scanned files are saved using specific computer applications.
CR3.7 The data corresponding to the corrections of the scanned files are related to the adjustment parameters in the scanning process, obtaining a digital model that meets the required quality specifications.
CR3.8 The compatibility between computer programs is checked by pre-checking, verifying that the scanned and corrected files are compatible with the control and management software of the 3D scanning device.
CR3.9 The digital information management operations are carried out in compliance with the applicable regulations for the prevention of occupational and environmental risks.

RP4: Management of safety and environmental protection in 3D scanning processes

CR4.1 The information and training provided is verified to be adapted to the needs established in the risk assessment and to the planning of the preventive activity.
CR4.2 The resources necessary to achieve the objectives of the prevention plan in the 3D scanning section are identified and adapted to the real needs of the working and environmental conditions, participating in the determination and election of the same.
CR4.3 The own operations of the processes of 3D scanning are supervised verifying that they respect the norms and procedures of work in matter of security and environmental protection established in the general plan of prevention.
CR4.4 The use of personal protective equipment (safety footwear, hearing protection helmets, protective gloves against mechanical, chemical and/or thermal aggressions, protective goggles, masks with the appropriate filters, safety belts and others), is certified by checking they are used according to the current regulations.
CR4.5 The security devices of 3D scanning equipment and machines, (apartabodies, fixed or mobile guards, sensitive control, interlocking devices, emergency stops, photocells or other devices), are checked periodically, verifying their correct operation and adaptation to the applicable regulations, according to the current prevention and safety plan.
CR4.6 The security devices of 3D printing equipment and machines, (apartabodies, fixed or mobile guards, sensitive control, interlocking devices, emergency stops, photocells or other devices), are periodically checked, verifying their correct functioning and adaptation to the applicable regulations, according to the current prevention and safety plan.
CR4.7 The signaling of the risk areas in the 3D scanning section is checked by verifying its correct visibility and that the requirements established in the current regulations are met, notifying the prevention service of any anomaly.
CR4.8 Cleaning and maintenance operations in the 3D scanning equipment, (fastening systems, rails and guides, auxiliary elements, replacement operations of interchangeable elements, cleaning and greasing of all the elements), are supervised verifying that the products are used appropriate and that the established work procedures are met.
CR4.9 The incidents or anomalies detected in issues related to environmental protection in 3D scanning processes are solved, in collaboration with the technician responsible for prevention, taking corrective measures that allow their solution immediately.
CR4.10 The proposals for improvement in preventive matters are applied in collaboration with the responsible superior for the improvement of safety and health.

Profesional context

Means of production

Computer equipment, capture and digitization equipment. Image processing software. Software for 3D scanning. 3D scanners and digital process simulation systems. Drivers Servers of repositories and elements of communication. Work desk with normalized light. Software for the evaluation of occupational risks in 3D scanning processes. Personal protection equipment (EPIs). Collective protection equipment. Safety systems for machines and transport equipment. Portable safety detectors. Emergency devices for first aid or emergency response. Fixed and mobile emergency equipment. Fire ladders, extinguishers, hoses,

emergency lighting, warning signs. Environmental detectors Security signage or labels for all types of risks. Selective waste containers.

Products and results

Received files, optimized for processing or reproduction of 3D models. Digital information treated. Control and maintenance documentation. Elements scanned in 3D. First level maintenance. Occupational risk and environmental protection plan. Evaluation of occupational and environmental risks linked to 3D scanning processes. Reports of incidents and accidents analyzed in scanning processes. Proposed preventive measures to carry out in 3D scanning processes. Tokens of each job with associated risks. Product safety sheets. Action protocols applied in different emergency situations. Environmental management of the 3D scanning section. Waste management in the printing process.

Used or generated information

Technical documentation of equipment. File management manuals. User manuals. Work order. Applicable regulations for the prevention of occupational and environmental risks. Manufacturing order Technical documentation of 3D scanning equipment, applicable regulations for prevention of occupational and environmental risks. Standards and quality standards. Preventive maintenance plan. Control plan. Plan for the prevention of occupational risks and environmental protection. Self-protection plan. Documentation required in environmental matters. Manuals of the scanning process. Drawings or schemes of scanning machines and equipment. CE mark standards. Manuals and standards of safety, health and environmental protection. Recommendations and instructions for the use of personal protective equipment. Risk sheet for each job. Printed forms and forms. Manuals of use of consoles or computer terminals used in the different scanning systems. Technical safety sheets of materials, products and raw materials used during the scanning process. Plans of the facilities. Product handling standards. Occupational risk prevention plan.

UNIT OF COMPETENCE 5: 3D models reconstruction, based on clinical images (DICOM) or photographs through reverse engineering software.

Level 3
Code UC0005_3

Professional achievement and implementation criteria

RP1: Study and manage medical images of soft and hard tissues to obtain a 3D digital model.

CR1.1 Digital files containing images taken from soft and hard tissues (computed tomography (CT) or magnetic resonance imaging (MRI), ultrasound or any other means of non-invasive image acquisition that generates digital files) are received, applying the rules established for the process.
CR1.2 The digital files that contain the images (TC), (MRI) or those coming from any means of non-invasive image capture, are protected by making a backup copy of the file according to established procedures.
CR1.3 The digital information is checked by verifying that the parameters of the CT, MRI images or those from any non-invasive imaging means correspond to the technical specifications of the work order and comply with the standardization of the the images with the Hounsfield units.
CR1.4 Digital files are opened using specific computer applications such as: - DICOM (Digital Image Communications in Medicine), - 3D SLICER, - INVESALIUS, - MANGO ... etc.
CR1.5 Check the compatibility between computer programs, by pre-checking, verifying that the validated digital files are compatible with the three-dimensional reconstruction and fabric modeling software.
CR1.6 The operational status of the computer equipment, software, and applications are kept updated by the established plan.
CR1.7 The documents of the processes used are formalized according to the correct use of the specific terminology and lexicon.
CR1.8 The digital information is sent to the three-dimensional reconstruction and modeling devices, using the appropriate computer applications.

RP2: Apply techniques of medical image processing, and their methods for obtaining and generating three-dimensional models of human tissues.

CR2.1 The images (TC), (MRI) or those from any non-invasive image taking means, are preprocessed in the specific computer applications (DICOM, 3D SLICER, INVESALIUS, MANGO, ... etc.) to perform a 3D reconstruction and 3D modeling.
CR2.2 The images (CT), (MRI) or those from any means of non-invasive imaging, are pre-processed applying the following techniques:
-Equalization of the histogram; Negative of the images; Noise reduction; Enhanced edges.
CR2.3 The images (CT), (MRI) or those from any means of non-invasive imaging, are segmented by applying the techniques of:
-Manual segmentation; Segmentation based on thresholds; Growing regions (Region Growing); Segmentation of watersheds (Watershed); Methods Level Set.
CR2.4 Statistical analysis of the textures of the images (TC), (MRI) or those from any means of non-invasive segmented image taking.
CR2.5 The images (CT), (MRI) or those from any means of non-invasive imaging, during their analysis are applied techniques of:
- Half; Moment of second order (standard deviation); 3rd Order Moment (Asymmetry); Moment of 4th order (Homogeneity); Average entropy
CR2.6 The three-dimensional model generation methodology follows the established routines, applying the required quality procedures (3D reading and reconstruction routines, preprocessing routines, segmentation routines, resampling routines, export routines of geometric models and discretization with the numerical methods and routines of statistical analysis of geometric models obtained).
CR2.7 The quality control of the process is carried out according to the established work method.
CR2.8 The results of the verification are arranged in the control sheets in this regard, indicating the incidents for analysis.

RP3: Generation of three-dimensional models of hard and/or soft tissues using statistical descriptors of textures

CR3.1 The images (TC), (MRI) or those from any non-invasive image taking means are preprocessed applying the methodology of generation of three-dimensional models according to the established routines, discriminating the hard tissues.

CR3.2 The images (CT), (MRI) or those from any non-invasive image taking means are preprocessed applying the methodology of generation of three-dimensional models according to established routines, discriminating the soft tissues.
CR3.3 Analysis of the geometric models obtained, using statistical descriptors of textures.
CR3.4 Export of the results to CAD (formats * .vtk, * .stl, *. Sat, *. Iges).
CR3.5 Files exported to CAD are discretized (FEM) applying the required quality procedures.
CR3.6 The digital files containing the reconstructed three-dimensional models are archived and protected by backing up the file according to established procedures.
CR3.7 The quality control of the process is carried out according to the established work method.
CR3.8 The results of the verification are arranged in the control sheets in this regard, indicating the incidents for analysis.

RP4: Management of safety and environmental protection in the reconstruction processes of 3D models.

CR4.1 The use of the necessary personal protective equipment is checked by checking that they are used in accordance with current regulations.
CR4.2 The corrective measures proposed for the prevention and elimination of the identified risks are evaluated in collaboration with the prevention technician, to assess their feasibility and compatibility of the three-dimensional reconstruction work of the images (CT), (MRI) or the from any means of non-invasive imaging.
CR4.3 The security devices of computer equipment, electrical networks, particle emission controllers, chairs and other elements are periodically checked, verifying their correct operation and adaptation to the applicable regulations, according to the current prevention and safety plan.
CR4.4 The cleaning and maintenance operations of the work areas are carried out in compliance with the established regulations.
CR4.5 The proposals for improvement in preventive matters are applied in collaboration with the responsible superior for the improvement of safety and health.

Professional context

Means of production

Computer equipment, equipment or files made by computerized tomography (CT) or magnetic resonance imaging (MRI) equipment. Image processing software. Drivers Servers of repositories of files, and elements of communication. Work desk with normalized light. Verification elements. Software for the evaluation of occupational risks in processes of reconstruction of 3D models. Personal protection equipment (EPIs). Collective protection equipment. Emergency devices for first aid or emergency response. Fixed and mobile emergency equipment. Fire ladders, extinguishers, hoses, emergency lighting, warning signs. Environmental detectors

Products and results

Files received, and optimized for obtaining three-dimensional models by reverse engineering software (reverse). Digital information treated. Control and maintenance documentation. First level maintenance. Occupational risk and environmental protection plan. Proposed preventive measures to carry out in the processes. Tokens of each job with associated risks. Action protocols applied in different emergency situations.

Used or generated information

Technical documentation of equipment. File management manuals. User manuals. Work order. Applicable regulations for the prevention of occupational and environmental risks. Standards and quality standards. Preventive maintenance plan. Control plan. Plan for the prevention of occupational risks and environmental protection. Self-protection plan. Recommendations and instructions for the use of personal protective equipment. Risk sheet for each job. Printed forms and forms. Manuals of use of consoles or computer terminals used in the different systems of three-dimensional reconstruction from images (CT), (MRI) or those from any means of non-invasive imaging. Plans of the facilities. Occupational risk prevention plan.

FORMATIVE MODULE 3: Assembly and maintenance of 3D scanning systems.

Level 3
Code: MF0003_3
Associated to UC: Manage and supervise the assembly and maintenance of 3D scanning systems, in industrial, personal and social environments.

Lenght: Hours

Capacities and evaluation criteria

C1: Analyze the technical information required for the assembly of the 3D scanners, extracting the necessary information to carry out the same, complying with the required technical and security specifications.

CE1.1 Identify and interpret the symbology and technical characteristics that are related to the assembly process of 3D scanning systems.
CE1.2 Identify the different views and sections of the elements and assemblies of 3D scanning equipment constructions.
CE1.3 Describe the assembly process and the means, tools and tools to be used in it.
CE1.4 **In a practical case**, from a plan or assembly process of a representative 3D scanning system, we should:
- Identify and interpret the technical specifications provided by the plan.
- Identify and interpret the cutting plans, characterizing the different elements that make up the set and its dimensions and dimensions.
- Evaluate the quality requirements and tolerances required for assembly.
- Define the relative position of the elements and sets and identify the functionality of the set.
- Identify and characterize operations and processes involved in the assembly by determining the means and equipment necessary to carry out the assembly.
- Establish the order or sequences of the assembly to be made.
- Establish the aspects required by the occupational and environmental risk prevention plan.
- Establish a distribution plan in the plant: provision of auxiliary means, storage areas and, in general, how many needs must be met to prepare the assembly area.
- Establish access needs according to the assembly to be made.
- Evaluate the assembly process defined
- Present the information necessary for assembly in an orderly and sequenced manner.

C2: Prepare the work area for the assembly of 3D scanning systems (equipment, tools, auxiliary means and work protections), based on the technical information provided, applying the plan for the prevention of occupational and environmental risks.

CE2.1 Describe the machines, equipment, accessories and auxiliary services necessary to carry out the assembly work.
CE2.2 Identify and characterize the materials necessary for the assembly work.
CE2.3 Characterize the work areas according to the type of assembly to be made.
CE2.4 Describe the plan for the prevention of occupational and environmental risks.
CE2.5 **In a practical case** where there is a documentation that defines the assembly of a representative 3D scanning system, it must be done to perform this:
- Gather the necessary material to make the assembly.
- Select the necessary equipment, tools, tools and auxiliary services.
- Check that the equipment, tools and tools are in good condition and perform maintenance of use.
- Select the location of the assembly according to its dimension, the auxiliary means, its position and orientation in the work area.
- Apply environmental prevention and protection measures during the entire process.

C3: Assemble and install 3D scanning systems: Align, position and assemble elements and structures from the "assembly process", complying with the prevention plan for occupational and environmental risks.

CE3.1 Describe the means and equipment of measurement and leveling that are used in the assemblies.
CE3.2 Describe the different auxiliary means of assembly and repair, specifying their constitution and use.
CE3.3 Identify, interpret and use the control signals used in the handling of equipment and auxiliary means.
CE3.4 Relate the elements of the installation with the function they perform and their applications.
CE3.5 Identify the location of the elements of the installation according to the areas of application and using the appropriate symbology, from the execution process.

CE3.6 **In a practical case** where a process of assembly or repair of a representative 3D scanning equipment is available, and once the work area is prepared to proceed with the assembly and installation of the whole or part of it, the following should be done:

- Apply communication and collaboration techniques to perform team work.
- Identify the referential elements of position and shape of the set.
- Rethink the elements and sub-assemblies according to the assembly process.
- Select the necessary measurement and leveling elements.
- Select equipment, and auxiliary assembly tools.
- "Apply" and level the elements of the structure of the scanner, leaving them presented according to specifications.
- "Rigidize" the assembly appropriately, maintaining specified limits and tolerances.
- Verify that the measurements of the assembly coincide with those indicated in the drawing and the dimensions and tolerances are as specified.
- Select and install the necessary auxiliary means to carry out the assembly.
- Use the standard command signals when handling the equipment and auxiliary means.
- Handle the machines, tools and auxiliary means used in the assembly.
- Verify the parameters, alarms, securities, interlocks, movements, among others, of the installation by contrasting the values obtained with those specified in the technical documentation.
- Describir la lógica de funcionamiento de la instalación en función de los elementos que componen cada circuito, utilizando los esquemas eléctricos y comprobándolo mediante el análisis funcional de la instalación.
- Verify that the sensors, control equipment, actuators and auxiliary elements that make up the installation meet the requirements established in the documentation of the same.
- Determine the variation that occurs in the operation of the installation assuming changes in the parameters of the elements and checking functionally on the installation.
- Use the means of personal protection and the environment required by the plan for the prevention of occupational and environmental risks.
- Apply the rules of use of equipment and media.

C4: Perform operational tests and start-up operations of equipment and elements of a 3D scanning system, based on the technical documentation.

CE4.1 Select the necessary documents for the start-up of the equipment and elements of the installation (start-up protocols, manufacturer's manual, among others) from the technical documentation.
CE4.2 Describe the phases to be followed in the start-up of different equipment and elements of the installation according to their technical complexity.
CE4.3 **In a practical case** of start-up of equipment and elements of a 3D scanning system, based on the technical documentation:

- Check that the installation complies with what is indicated in the technical documentation.
- Carry out commissioning according to the technical manual.
- Prepare a report of the activities developed and results obtained.

C5: Analyze and apply predictive or preventive maintenance techniques in 3D scanning systems, based on technical documentation and acting under personal safety rules and the materials used.

CE5.1 Identify the parts and elements that make up the facilities analyzing the operation, characteristics, maintenance needs and applicable regulations.
CE5.2 Relate the elements of the installation with the function they perform and their applications.
CE5.3 Describe the parts of the installation that can be maintained, as well as the types of maintenance of each part of a 3D scanning installation.
CE5.4 Select and prepare the materials, equipment, tools and documentation necessary to perform the tasks of predictive or preventive maintenance and monitoring depending on the element to be maintained.
CE5.5 Describe the procedures of each of the predictive maintenance operations that must be performed on the equipment and elements of an installation according to the 3D scanning system to be maintained and according to the maintenance plan.
CE5.6 **In a practical case** of preventive maintenance of a type 3D scanning installation, based on the technical documentation:

- Identify the elements on which preventive maintenance operations should be carried out.
- Identify the waste management plan.
- Identify the risk factors, the associated risks and the measures to be adopted.
- Prepare the work area according to the requirements of the operation according to established procedures.
- Check the general condition of supports, fixings, protections, elements, insulation, among others.
- Carry out cleaning operations and check the absence of deformations in equipment, installations and accessories
- Check the power supply of the equipment and the connections and continuities of cables, connectors, power strips, among others, of electrical and communication systems of the 3D scanning installation. - Check the performance of the safety elements and protections.

- Check the status of the infrastructure of the installation (electrical, pneumatic and hydraulic).
- Check the parameters of the system and the equipment and compare the measurements obtained with the technical documentation, checking its correct operation.
- Review and maintain the equipment and tools used in maintenance in the operating state.
- Replace the element or component indicated in the maintenance plan, making the necessary interventions for this replacement.
- Carry out the necessary tests and adjustments according to the specifications in the technical documentation.
- Complete the action report from the actions made and in the established format.

C6: Apply corrective maintenance techniques in 3D scanning systems based on the technical documentation.

CE6.1 Describe the common faults that occur in 3D scanning systems, determining the cause of them and their effects on the system.

CE6.2 Describe the procedures of each of the corrective maintenance operations that must be performed on the equipment and components of the facilities in the most common faults.

CE6.3 Describe the tools and equipment used in corrective maintenance operations, indicating the manner of use and precautions to be taken into account.

CE6.4 **In a practical case** of diagnosis and troubleshooting of a type 3D scanning facility, based on the technical documentation:

- Interpret the symptoms of the fault by relating it to the elements of the system.
- Carry out hypotheses of the possible causes of the fault describing the relationship between the effects described and the causes of them.
- Carry out an intervention plan to detect the cause or causes of the breakdown.
- Identify the waste management plan.
- Indicate the tests, measurements and verifications that should be carried out, specifying the procedures, equipment and technical and safety means that must be used.
- Replace the element or component responsible for the fault, making the necessary interventions for this replacement.
- Carry out the necessary tests and adjustments according to the specifications of the installation documentation.
- Prepare a report of the activities carried out and the results obtained.

Capacities whose adquisition must be completed in a real working environment

C1 regarding CE1.4; C2 regarding CE2.5; C3 regarding CE3.6; C4 regarding CE4.3, C5 regarding CE5.6; C6 regarding CE6.4.

Other Capacities

Adapt to the organization of the company by integrating into the system of technical-labor relations.
Correctly execute the instructions you receive, taking responsibility for the work you do, communicating effectively with the right person at all times.
Show an attitude of respect towards the companions, procedures and rules of the company.
Assume responsibility for the work that is carried out and the fulfillment of the objectives.
Propose alternatives with the objective to improve results.
Recognize the productive process of the organization.
Participate and collaborate actively in the work team.
Getting used to the pace of work of the company.
Adapt to the organization, to its organizational and technological changes as well as to new situations or contexts.

Contents

1.- Graphic interpretation for the assembly of constructions of structures and elements of the 3D scanning system.

1.1.- Interpretation of plans and diagrams in the installations of specific assemblies and sub-assemblies. Electric schemes. Pneumatic and hydraulic diagrams. Process diagrams (P & I). Sketch of distribution and implementation plans.

1.2.- Assembly manuals of equipment and elements.
1.3.- Quality regulations, waste management and safety and prevention of occupational risks.
1.4.- Symbology used in the technical documentation in assembly of structures and elements of 3D scanning systems.

2.- Elements and equipment for leveling elements and subassemblies, tools and standard tools for the assembly of 3D scanning systems.

2.1.- Leveling equipment; plumb equipment; Leveling and plumb processes.
2.2.- Positioning elements; tools; auxiliary assembly elements; lifting and transport machinery; cats, tensioners; tools for screwing, riveting ... etc.
2.3.- Analysis and study of the structures of 3D scanners.

3.- Elements and pneumatic, hydraulic, electrical and electronic equipment for the assembly of 3D Scanning systems.

3.1.- Pneumatic and hydraulic elements:

- Tires: air production and treatment, distributors, valves, pressure switches, cylinders, pneumatic motors, vacuum, among others. Standardized symbology.
- Hydraulic: Hydraulic group, distributors, hydro-valves, servo-valves, pressure switches, cylinders, hydraulic motors, accumulators, among others. Standardized symbology.

3.2- Electrical and electronic elements:

- Power supply network, electrical cabinets, command and control desks, wiring, sensors, actuators, among others Technologies applied in automation: wired logic and programmed logic.
- Types of controls of a process: open loop or closed loop.
- Types of applicable industrial processes.
- Electrical switchgear: contactors, switches, relays, among others.
- Detectors and sensors. Field instrumentation: instruments for measuring flow pressure, level and temperature, among others.
- Control equipment: analog regulators and digital regulators. Actuators: starters, variators, regulation and control valves, motors, among others.
- Cables and driving systems: types and characteristics. Elements and electrical safety equipment. Standardized symbology.

4.- Assembly techniques.

4.1.- Assembly of machine elements:

- Transmission elements. Couplings Bearings Clutches and brakes. Belts, pulleys, chains, cogwheels, among others. Control cables. Manual and mechanical tools standard Manual and mechanical specific tools of the specialty. Equipment and tools.

4.2- Assembly of pneumatic and hydraulic circuits:

- Pneumatic elements. Structure of pneumatic circuits. Types of controls in pneumatic circuits. Sequential hydraulic and pneumatic circuits. Assembly of the different elements of the pneumatic circuit: tanks, valves, actuators, pipes, accumulators, among others.
- Hydraulic elements Structure of hydraulic circuits. Types of controls in hydraulic circuits. Hydraulic circuits. Assembly of the different elements of the circuit: tanks, valves, actuators, pipes, among others.

4.3.- Assembly of mechanical and electrical mechanisms:

- Assembly of: reducers, linear to circular motion transformers and vice versa, clutches, brakes, gear trains, pulleys, couplers of transmission shafts, bearings, bearings, cams, springs, connecting elements, control cables, among others. Sliding surfaces: Guides, columns, bushes,

trolleys. Sealing gaskets. Assembly of mechanical, electrical, hydraulic, pneumatic equipment or assemblies, among others. Installation of cable bundles. Connection of terminals and wire bundles.

4.4.- Fixation and joining techniques:

- Techniques of manual and machine machining. Braking. Sealed. Joints between rigid/flexible pipes. Curved and flared tubes. Placement of electrical terminals. Normalization and specific identification of the elements of union. Bolts, nuts bolts and bolts. Washers and pins. Flanges and broaches. Fittings. Separators, electrical terminals. Special binding elements.

5.- Functional tests and start-up of 3D scanning systems.

5.1.- Measurement, adjustment and control devices.

5.2.- Verification of:

- Parameters; Alarms, securities and interlocks; Monitoring and visualization system.

5.3.- Protocols of:

- Tests, Adjustments and regulation; equipment and field elements; Start-up of control and visualization equipment.

5.4.- Protection equipment.

5.5.- Assembly and start-up reports.

6.- Types of maintenance of 3D scanning systems.

6.1.- Predictive and preventive maintenance: - Established procedures.

6.2.- Substitution of elements due to their average life:

- Corrective maintenance; Scheduled repair: (Established procedures).

7.- Maintenance techniques of 3D scanning systems.

7.1.- Breakdowns types.

7.2.- Tools, equipment, measuring instruments and auxiliary technical means.

7.3.- Diagnostic techniques: - Tests, measures and procedures.

7.4.- Maintenance ranges

7.5.- Protection equipment.

8.- Regulations for prevention of occupational risks and protection of the environment applied to the assembly of 3D scanners.

8.1.- Risks evaluation.

8.2.- Techniques and protection elements.

8.3.- Environmental management: - Waste treatment.

8.4.- Legislative and regulatory aspects.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a classroom, classroom-workshop, practice workshop, laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1.- Mastery of knowledge and techniques related to the assembly and maintenance of 3D scanning systems, which will be accredited by one of the following forms:

- Technical Engineer degree or similar studies, or any other of a higher level linked to this professional field.
- Professional experience of at least 3 years in the field of competences related to this training module.

2.- Certified pedagogical competence according to what the competent administrations establish.

FORMATIVE MODULE 4: 3D Scanning

Level 3
Code: MF0004_3
Associated to UC: Use 3D scanners to obtain the physical model.
Lenght: hours

Capacities and evaluation criteria.

C1: Recognize and analyze the main properties and physical characteristics of prototypes and/or 3D models for their digitization.

CE1.1 Receive prototypes and / or 3D models applying the rules established for this process.
CE1.2 Store prototypes and / or 3D models protecting and manipulating according to established procedures.
CE1.3 Recognize and describe the main characteristics, physicochemical properties and structure of prototypes and / or 3D models.
CE1.4 Locate and mark the main defects and alterations of the prototypes and / or 3D models to be scanned.
CE1.5 Relate the properties of the materials with the proper scanning process.
CE1.6 Identify the risks and level of danger involved in handling the different materials and products used in the 3D scanning process.
CE1.7 **In a practical case** of assessment of the quality of the obtained digital file, from different equipment and scanning processes check:
- The characteristics of the scanned elements regarding the final file.
- The quality of the digitized model corresponds to the results of measurements, precision, and others.
- Determine the optimal storage conditions of the digitized files and the prototypes and/or of the 3D models to be scanned.

C2: Recognize and analyze the variables and environmental factors in 3D scanning processes.

CE2.1 Recognize and describe the most optimal environmental factors, indoors or outdoors, in 3D scanning processes:
- Illumination; Wind; Fog; Smoke; Contaminants; Humidity ... etc.

CE2.2 Relate the main defects and alterations in the digital files of the 3D models with respect to the different environmental factors.
CE2.3 Relate the different types of scanning processes with the most suitable environmental factors to the process.
CE2.4 Identify the risks and level of danger posed by the manipulation of the different models and tools during the 3D scanning process.
CE2.5 **In a practical case** of evaluation of the quality of the digital file obtained, based on environmental factors and the scanning equipment and processes used, check:
- The characteristics of the scanned elements with respect to the file obtained.
- The quality of the digitized model corresponds correctly with the results of measurements, precision, and others.
- Determine the optimal conditions of environmental factors, in the different scanning processes.

C3: Perform the operations of commissioning and start-up of the main machines and 3D scanning equipment, to perform the digitization process of prototypes with the required quality.

CE3.1 Describe the different 3D scanning systems currently used.
CE3.2 Analyze the regulatory operations necessary to adjust the 3D scanning process, according to the type of machine to be used.
CE3.3 Explain the different methods of checking and regulation in 3D scanning machines.
CE3.4 In a practical case of adjustment of a 3D scanning machine, from a work order properly characterized, regulate all configurable parameters.
CE3.5 **In a practical case** of maintenance of 3D scanner, from the maintenance sheet of the machine:
- Identify the elements that must be maintained.
- Define the appropriate first level maintenance plan for the 3D scanning machine.
- Carry out the maintenance operations methodically: greasing, cleaning dry grease, cleaning dust remains, following the manufacturer's instructions.
- Carry out methodical cleaning of the machine complying with the applicable regulations for the prevention of occupational and environmental risks.

CE3.6 Identify the appropriate way to arrange the prototypes and / or models in the scanners, in order to obtain the optimal results and times.
CE3.7 Describe the defects of the 3D scanning system.

CE3.8 **In a practical case** of adjustment of elements of 3D scanning machines, from a scan type job:
- Relate the causes and effects of the readjustment of the parameters on the obtained digital file.
- Start the parameters either manually or using computers, due to the needs.

CE3.9 In a practical case of 3D scanning, from the original design and prepress tests:
- Obtain the digital file with the required quality in relation to the original 3D prototype.
- Compare the digital element with respect to its prototype, by means of the corresponding software verifying and measuring with the intention of readjusting the parameters correctly.
- Relate the scanning speed with the machines and the complexity of the prototype to be scanned.

CE3.10 **In a practical case** of measuring the quality variables of the elements scanned in 3D:
- Relate the different elements that intervene in a series of control with the deviation of the required quality parameters.
- Identify, describe and, where appropriate, represent the defects that must be controlled during the scanning process.
- Identify the control devices that must be used.

CE3.11 Identify the risks and level of danger posed by the handling of the different materials, products and equipment used in 3D scanners.

CE3.12 Relate the products and materials used in the 3D scanning process, with the environmental regulations, considering the substitutes of the products traditionally used that adapt to said regulations.

CE3.13 **In a practical case** of 3D scanning characterized by the operations that must be performed:
- Identify and describe the security mechanisms of the scanning machines: stop buttons, protections, housings, grids, as well as the means of protection and clothing that should be used.
- Describe the safety conditions in the preparation and maintenance operations of the machines.
- Establish the safety and precaution measures that must be adopted, according to the applicable regulations for the prevention of occupational and environmental risks and the specific instructions of the equipment applicable to the different operations.
- Relate and describe the appropriate preventive measures and methods of prevention established to avoid accidents.

C4: Determine and apply the methods of processing digital information, using software appropriate to the needs of the 3D scanning process.

CE4.1 Interpret the methods and rules established in the reception of the files generated in the 3D scanning process.

CE4.2 Verify that the content of the digital files corresponds to the technical specifications of the scanned model.

CE4.3 **In a practical case** of receiving files generated by the 3D scanning process, check:
- Whether the files generated include: file names, if there are no duplicate files, if the file formats are adequate, others (resolution, mode and color).
- Whether the media storage information: CDs, DVDs, hard drives, virtual spaces, servers, among others.

CE4.4 Identify the specific computer equipment and software required to handle the digital design information.

CE4.5 Interpret the operation and characteristics of computers and computer programs from the scanned model.

CE4.6 Determine the causes that motivate the deviations of the characteristics of the digitized model, in relation to the process followed, to take timely corrective measures that allow us to obtain the quality specified in the given work order.

CE4.7 **In a practical case** of processing information from different files:
- Identify the computer format and characteristics to adapt it to the technical specifications, by using the appropriate software.
- Establish the appropriate file formats.
- Optimize the parameters of the scanners in relation to the digitized files in 3D.
- Store the optimized digital files, using the available software that guarantees the inalterability of the content.

CE4.8 Recognize the content of the digital file with respect to the 3D scanning machine that generated it.

CE4.9 Relate the current 3D scanning systems with the different 3D models to be scanned.

CE4.10 **In a practical case** of valuation of different 3D scanning systems, from a given 3D models:
- Establish the most suitable type of scan according to the model and environmental conditions of the process.
- Set the calibration of the selected scanning system, adjusting the environmental conditions for the optimization of the process.
- Relate the quality of digitized files in 3D with respect to the different existing 3D scanning systems.
- Contrast the relationship between the files obtained and their real models.

C5: Analyze occupational and environmental risk prevention plans and applicable regulations for the correct use of media, equipment and materials in 3D scanning processes.

CE5.1 Relate and describe the rules regarding the cleanliness and order of the work environment in 3D scanning processes.

CE5.2 Describe the properties, uses of clothes and personal protective equipment most used to perform 3D scanning processes.

CE5.3 Identify and describe standards for stopping and manipulating 3D scanning systems and machines.

CE5.4 Relate the materials used in the 3D scanning processes with the environmental regulations, considering the

substitutes of the products used.
CE5.5 **In a practical case** of security assessment in a 3D scanning process, based on a number of prevention plans for occupational and environmental risks of companies in the sector:
- Identify and describe the most relevant aspects of each plan, included in the documentation that contains it.
- Identify and describe the factors and situations of risk to health and safety in the plans related to that activity.

Capacities whose adquisition must be completed in a real working environment

C1 regarding CE1.7; C2 regarding CE2.5; C3 regarding CE3.4, CE3.5, CE3.8, CE3.9, CE3.10 y CE3.13; C4 regarding CE4.3, CE4.7 y CE4.10, C5 regarding CE5.5.

Other capacities

Assume responsibility for the work that is carried out and the fulfillment of objectives.
Demonstrate a certain degree of autonomy in the resolution of contingencies related to their activity.
Propose alternatives with the aim of improving results.
Demonstrate flexibility to understand changes
Adapt to new situations or contexts.
Learn new concepts or procedures and take advantage of training effectively using the knowledge acquired.

Contents:

1.- Introduction.

1.1.- Introduction:
- Background; history of the laser; laser equipment scanner and laser scanning; applications of laser scanning.

1.2.- The laser scanner fundamentals:
- The electromagnetic spectrum and light; lasers; important properties of laser light; laser security.

2.- Classification of laser scanner equipment.

2.1.- Classification by contact: - In contact with the object; without contact with the object.
2.2.- Classification by measurement system:
- Passive scanners:
  - Stereoscopes and Silhouette.
- Active scanners:
  - Measurement based on triangulation.
  - Time-based measurement:
    - Scanners based on pulses (flight time, incoherent detection).
    - Scanners based on the phase
    - Interferometry (coherent)

2.3.- Classification by sweeping system: - Chamber; panorama; hybrid.
2.4.- Classification by position: - Static equipment and dynamic equipment.
2.5.- Metrological aspects, error analysis:
- Instrumental errors; errors related to objects; environmental conditions; methodological errors.

2.6.- Equipment, technical specifications and auxiliary materials of a laser scanner:
- Equipment; Technical specifications; accessories.

3.- Metodology.

3.1.- Overwiew

3.2.- Planning:

- Determine the objectives of the work; analysis of the area to be lifted; determination of the optimal positions of the laser scanner; determination of the optimal positions of the reference points; Data management

3.3.- Previous work in the field:

- Preparation of the survey; scanner parking; scanner connection; scanner settings.

3.4.- Data collection:

- Scanning of a prototype and / or model.
- Scanning of targets or other reference points.
- Measurement of reference points or targets.
- Checking the data capture.

3.5.- Preparation of data.

3.6.- Registration and georeferencing:

- Indirect registration and georeferencing.
- Direct registration and georeferencing
- General aspects of the registry and direct georeferencing.

3.7.- 3D point clouds processing:

- Representation of point clouds.
- Improvement of the data.
- Direct 2D modeling from point clouds.
- Direct 3D modeling from point clouds.
- 3D modeling of complex surfaces.
- Indirect 2D modeling from point clouds.
- Mapping with texture.

4.- Quality control during the scanning process.

4.1.- Computer programs and equipment for quality monitoring in the scanning process. Applications. Elements for control.

4.2.- Criteria to be followed in the quality control of the scanned model, conditions in the control process, lighting and observation angle.

4.3.- Control of the digitized element, scannability conditions of the 3D prototype.

4.4.- Guidelines to follow in the inspection of scanned elements: dimensional and geometric verification, textures, etc ...

5.- Maintenance operations.

5.1.- Maintenance of first level of the tools, elements and equipment of 3D scanning.

5.2.- Lubricants: oils, fats.

5.3.- Cleaning sequence in 3D scanning equipment.

6.- Safety and health in 3D scanning processes. General risks and their prevention.

6.1.- Work and health: professional risks. Risk factor's.

6.2.- Damages derived from work. Accidents and occupational diseases. Other pathologies derived from work.

6.3.- Basic regulatory framework in the area of prevention of occupational hazards.

6.4.- Elementary risk assessments: simple identification and assessment techniques.
6.5.- Security techniques: prevention and protection measures.
6.6.- Risks linked to security conditions. Risks linked to the work environment. Risks linked to the organization of work in 3D scanning companies.
6.7.- Elements defined in the self-protection plan: fire protection equipment, emergency exits and others.
6.8.- Emergency situations and first aid in 3D scanning processes.
6.9.- Protocols for action and evacuation procedures in emergency situations.
6.10.- Basic techniques for action against accidents at work. First aid. Resources and necessary means.

7.- Analysis, evaluation and control of environmental risks in 3D scanning processes.

7.1.- Standards and work procedures in the field of environmental protection.
7.2.- Risks related to environmental conditions. Risk factor's.
7.3.- Management of waste produced in the 3D scanning process. Treatment of discharges.
7.4.- Legal requirements in environmental matters required in 3D scanning machines and equipment.
7.5.- Development of environmental protection plans in 3D scanning companies.
7.6.- Analysis and evaluation of environmental risks linked to 3D scanning processes.
7.7.- Investigation techniques of environmental incidents, causes and consequences.
7.8.- Preventive and corrective measures. Individual Protection Equipment.
7.9.- Products used in 3D scanning processes: technical data sheets, instructions and labeling.
7.10.- Documentation and administrative procedures in environmental matters.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a classroom, classroom-workshop, practice workshop, laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer

1.- Mastery of knowledge and techniques related to the scanning processes of prototypes and/or 3D models of mechanical manufacturing products, which will be accredited by one of two ways:

- Level 3 academic education, Technical Engineering or other higher level related to the professional field.
- Professional experience of at least 3 years in the field of competences related to this training module.

2.- Accredited pedagogical competence according to what the competent administrations establish.

FORMATIVE MODULE 5: 3D modeling and inverse engineering (or reverse.)

Level 3
Code: MF0005_3
Associated to UC: Reconstruction of 3D models, from clinical images (DICOM) or photographs through reverse engineering software.
Lenght: hours

Capacities and evaluation criteria

C1: Receive the images by applying the established processes and methods, using the specific software.

CE1.1 interpret and apply the methods and rules established in the reception of image files (CT), (MRI) or those from any means of non-invasive imaging generated by the established procedures.
CE1.2 Verify that the content of the images (TC), (MRI) or those coming from any means of non-invasive image capture corresponds to the technical specifications given in the work order.
CE1.3 Copy the image files (TC), (MRI) or those from any means of non-invasive image taking by duplicating security, according to established procedures.
CE1.4 **In a practical case** of receiving a file of images generated by (TC), (MRI) or those from any means of non-invasive imaging, verify that:
- The generated files have: file name, check avoiding duplicate files, adequate file formats and others (resolution, mode and gray scale).
- The correct storage media for information: CDs, DVDs, hard drives, virtual spaces, servers, among others.

CE1.5 Identify the specific computer equipment and programs (DICOM, 3D SLICER, INVESALIUS, MANGO ... etc.) for the three-dimensional reconstruction and 3D modeling of the images.
CE1.6 Select the appropriate equipment and software from the received images.
CE1.7 Properly process the images (CT), (MRI) or those from any non-invasive image taking means applying the established techniques.
CE1.8 Correctly segregate images (CT), (MRI) or those from any non-invasive means of taking images, applying the established techniques.
CE1.9 Analyze statistically the textures of the images (TC), (MRI) or those coming from any means of non-invasive segmented image taking by applying the pre-established techniques.
CE1.10 **In a practical case** of processing information from different reception image files:
- Identify the computer format and characteristics to adapt it to the technical specifications, by using the appropriate software.
- Establish the appropriate file formats.
- Apply the methodology of generation of three-dimensional models through the established routines, applying the required quality procedures.
- Contrast the relationship between the obtained three-dimensional models and the starting images.
- Store the optimized digital files, using the available software that guarantees the inalterability of the content.

CE1.11 The quality control of the process is carried out according to the established working methods.
CE1.12 The results of the verification are arranged in the control sheets in this regard indicating the incidents detected for analysis.

C2: Reconstruct three-dimensional models based on images (TC), (MRI) or those from any means of non-invasive image taking, applying statistical descriptors of textures.

CE2.1 Interpret and apply the preprocessing of images (CT), (MRI) or those from any non-invasive image taking method applying the methodology and routines established to obtain three-dimensional models of hard tissues.
CE2.2 Interpret and apply the preprocessing of images (CT), (MRI) or those from any means of non-invasive imaging, applying the methodology and routines established to obtain three-dimensional models of soft tissues.
CE2.3 Analyze and compare the geometrical models obtained, with the starting images, using statistical descriptors of textures.
CE2.4 Save and export the resulting digital files to CAD, in pre-established formats (formats * .vtk, * .stl, *. Sat, *. Iges).
CE2.5 Discretize by applying the finite element method (FEM) to the files imported into CAD, obtaining the best possible approximate result, and applying the required quality procedures.
CE2.6 Save and protect the digital files contained in the reconstructed three-dimensional models, making a backup copy of the file according to established procedures.
CE2.7 **In a practical case** of processing information from different reception image files:
- Apply the methodology of generation of three-dimensional models by means of the established routines,

identifying and discriminating the soft tissues of the soft ones, and applying the required quality procedures.
- Contrast the relationship between the obtained three-dimensional models and the starting images.
- Store and export digital files to CAD according to the established formats, using the specific software and guaranteeing the inalterability of the content.
- Apply the finite element method (FEM) to the files imported into CAD by selecting the best possible approximate result and applying the required quality procedures.
- Back up the files according to established procedures.

CE2.8 Establish and control the quality of the process according to the determined work method.
CE2.9 Verify and collect in the control sheets the results and errors obtained, indicating the incidents for analysis and improvement proposal.

C3: Analyze occupational and environmental risk prevention plans and regulations applicable to 3D model reconstruction processes.

CE3.1 Describe the properties and uses of the personal protective equipment used to carry out the reconstruction processes of three-dimensional models.
CE3.2 Identify and describe the personal and / or collective protection measures used in three-dimensional reconstruction machines and equipment.
CE3.3 **In a practical case**, assess the safety of a three-dimensional reconstruction process, based on a prevention plan for occupational and environmental risks of companies in the sector:
- Identify and describe the most relevant aspects of the plan included in the documentation that contains it.
- Identify and describe the situations and risk factors for health and safety, relating it to the activity carried out.
- Apply and use personal and collective protection measures and equipment throughout the work process.

Capacities whose adquisition must be completed in a real working environment

C1 regarding CE1.4 y CE1.10; C2 regarding CE2.7; C3 regarding CE3.3.

Other Capacities

Assume responsibility for the work that is carried out and the fulfillment of objectives.
Demonstrate a certain degree of autonomy in the resolution of contingencies related to their activity.
Propose alternatives with the aim of improving results.
Demonstrate flexibility to understand changes
Adapt to new situations and / or contexts.
Learn new concepts or procedures and take advantage of training effectively using the knowledge acquired.

Contents

1.- Previous Knowledges.

1.1.- DICOM (Digital Image Communications in Medicine).
1.2.- Computed tomography (CT).
1.3.- Magnetic resonance imaging (MRI).
1.4.- Images by 3D ultrasound.
1.5.- Other non-invasive methods

2.- Construction of the 3D model from DICOM files.

2.1.- Introduction
2.2.- Two-dimensional or three-dimensional medical images in radiology: from DICOM files to the concept of image thickness.
2.3.- Inverse (or reverse) engineering and implementation of the stl file: the 3D model.
2.4.- Use of 3D replicas for the intervention program.

3.- Obtaining the 3D model through the software (3D SLICER, INVESALIUS, MANGO).

3.1.- Used software introduction.

3.2.- Data loading
3.3.- Volume representation and images manipulation.
3.4.- Creation of a map of labels.
3.5.- Construction of the model.
3.6.- Save model and export data.
3.7.- Advantages and disadvantages.

4.- Medical imaging for soft and hard tissues.

4.1.- Introduction.
4.2.- Computed tomography (TC):
- Parameters of a TC image.
- Standardization of TC with Hounsfield units.

4.3.- Magnetic resonance (MR).
4.4- Ultrasound 3D applications.

5.- Medical image processing techniques for obtaining three-dimensional models.

5.1.- Introduction.
5.2.- Three-dimensional reconstruction.
5.3.- Modelling.
5.4.- Preprocess:
- Histogram equalization; Negative of an image; Noise reduction; Enhanced edges.

5.5.- Segmentation:
- Manual Segmentation.
- Segmentation based on thresholds.
- Growing Regions.
- Segmentation of watersheds.
- Level Set Methods.

5.6.- Statistical analysis of medical image textures:
- Media.
- Moment of second order (standard deviation).
- Moment of third order (asymmetry).
- Moment of fourth order (Homogeneity).
- Average entropy

6.- Methodology for the generation of three-dimensional models of human tissues.

6.1.- Introduction.
6.2.- 3D reading and reconstruction routine.
6.3.- Preprocess routine:
- Escalation according to Hounsfield intensities.
- Noise filtering routines.
- Edge enhancement routines.

6.4.- Segmentation routines:
- Segmentation routines based on thresholds.
- Growing Regions.
- Watershed Segmentation.
- Algorithm Level Set.

6.5.- Resampling routines:
- Correction of unconnected areas; Smoothing of surfaces.

6.6.- Routines of export of geometric models and discretization with numerical methods.
6.7.- Routines of statistical analysis of geometric models obtained.

7.- Generation of three-dimensional models of hard tissues and soft tissues.

7.1.- Introduction.
7.2.- Practical assumptions of hard tissues:
- Craniofacial bone, (Skull, mandibular bone); Bone of the hip; Bone of the spine; other bones

7.3.- Practical cases of soft tissues:
- Organs, Cardiovascular Tissue, (Left and right ventricle, left and right atrium);
- Pathologies: Ischemic scar due to severe myocardial infarction.
- Ascending and descending aorta.
- Brain tissue, (white matter, gray matter).

8.- Analysis of geometric models using statistical descriptors of textures.

8.1.- Introduction.
8.2.- In a practical case of brain tissue:
- Validation of techniques using a phantom of the Brain Magnetic Resonance:
  - Growing Region Segmentation– BrainWeb.
  - Watershed Segmentation – BrainWeb.
  - Anisotropic diffusion filtering and Growing Region Segmentation– BrainWeb.
  - Anisotropic diffusion filtering and Watershed Segmentation– BrainWeb.

9.- Applicable regulations for the prevention of occupational risks and protection of the environment.

9.1.- Applicable regulations for the prevention of occupational hazards in reference to the three-dimensional reconstruction processes applying reverse or reverse engineering software.
9.2.- Applicable environmental protection regulations in reference to three-dimensional reconstruction processes applying reverse or reverse engineering software.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a classroom, classroom-workshop, practice workshop, laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer

1.- Mastery of knowledge and techniques related to the treatment of images (CT), (MRI) or those from any means of non-invasive imaging and software management of reconstruction of three-dimensional models by reverse or reverse engineering, which will be accredited by one of the following two methods:
- Level 3 academic education, Technical Engineering or other higher level related to the professional field.
- Professional experience of at least 3 years in the field of competences related to this training module.

2.- Accredited pedagogical competence according to what the competent administrations establish.

Professional Qualification: MANAGEMENT AND SUPERVISION OF 3D PRINTING SYSTEMS, IN PROFESSIONAL ENVIRONMENTS.

Associated Vocational Families: (Electricity-Electronics, Computing, Mechanical Manufacturing)
Level3
Code ESDEI3D_3
Draft 1
Situation Final

General competence
Perform the processes of Management and Supervision of 3D printing systems by applying the technologies and knowledge of specific materials in the 3D printing process, with quality, safety and respect for the environment criteria.

Units of competence
UC0006_3: Manage and supervise the assembly and maintenance of 3D printers, in industrial, personal and social environments.
UC0007_3: Use 3D printers, to obtain final products.
UC0008_3: Technologies and knowledge of materials for 3D printing.

Professional field

Professional context
Its activity is organised in functions or supervision of assemblies, maintenance and use of 3D printing equipment, and technical advice on the specific materials used in the 3D printing process.

Productive Sectors
This qualification is located in the subsector of industries and companies dedicated to 3D printing, as well as in the technical advice of the materials used in 3D printing, framed in the industrial, architectural, civil engineering, clinical, agri-food, artistic, educational, sports, domestic and other scientific-technological sectors.
Construction of machinery, mechanical equipment and industrial products in the different production sectors.

Main jobs and employments
3D printers technician.
3D printing technician.
Technician in specific materials for 3D printing.

Associated training (... h)

Formative modules
MF0006_3: Assembly and maintenance of 3D printing systems (... h)
MF0007_3: 3D printing (... h)
MF0008_3: 3D materials (... h)

UNIT OF COMPETENCE 6: Manage and supervise the assembly and maintenance of 3D Printers, in industrial, personal and social environments.

Level 3
Code UC0006_3

Professional achievement and implementation criteria

RP1: Arrange the working area, prepare equipment, tools, instruments and EPIs, to join the elements and structures of 3D printers, complying with the rules of prevention of occupational and environmental risks.

CR1.1 In the conditioning of the work area, the dimension of the 3D printer, the necessary auxiliary spaces, weights to be supported and the maneuvers to be performed have been taken into account.
CR1.2 The materials, machines, equipment, tools, work tools and accessories necessary for the development of the specified work are selected in compliance with the instructions and standards for prevention of occupational risks.
CR1.3 Machines or equipment are kept operational by applying user maintenance procedures.
CR1.4 The security of the equipment and personal means are prepared according to the requirements of the required safety standards.

RP2: Join elements and components of 3D printers according to the specifications, complying with the rules of prevention of occupational and environmental risks.

CR2.1 The assembly and positioning of the elements or constructions is done following the sequence of operations indicated in the technical documentation and within the admissible tolerances for later joining.
CR2.2 The assembly is carried out according to the specifications of the construction drawings and the connection points are made in the appropriate place and with the established procedure.
CR2.3 The handling of the means and auxiliary tools of assembly, is done without interference and complying with the rules of prevention of occupational risks.
CR2.4 The union of elements and materials is done by taking the necessary measures and complying with the specifications.
CR2.5 The use of safety equipment and means is done according to the requirements of the safety regulations.

RP3: Carry out the start-up and functional tests of the equipment and all its elements of the 3D printing systems, according to the technical documentation, instructions given and manufacturer's standards, applying the established procedures, in conditions of quality and safety, and complying with current regulations.

CR3.1 The assembly, anchoring and leveling of the machinery has been carried out following established procedures, using the tools and tools specified in each case, ensuring the absence of damage and the functionality of the equipment.
CR3.2 The connections to the networks of energy fluids and services are made with the kind and type of elements described, accessories, devices, materials required by the technical specifications, and are made:

- Complying with the applicable regulations.
- Using the type of electrical channeling, routing and fastening specified in the assembly documentation, avoiding mechanical stresses and complying with the technical specifications.
- With the conductors of section, insulation, stiffness and protection specified, without changing their characteristics during assembly.
- Using the required terminals and connectors, connected to the necessary pressure and identifying the conductors in accordance with the diagram.
- Supervising the food protections, complying at all times with the requirements of the applicable regulation regarding low voltage.
- The power values are correct for the electrical, hydraulic or pneumatic elements.

CR3.3 The start-up is made:

- Following the sequence of commissioning according to what is indicated in the project.
- Loading control programs and operating the 3D printing machine following the established procedures, with the guards and quality systems activated.
- Visualizing the information provided by the screens, if any, which is appropriate and corresponds to the actual state of the machine or equipment.
- The correct functioning of mobile systems and the absence of elements that interfere with it.
- Regulating the operating parameters within the established ranges of action, adjusting them if necessary and following the procedures indicated in the corresponding manuals.
- The safety systems of the equipment act correctly, according to the manufacturer's instructions and current regulations of application.

CR3.4 The functional verification of the system is carried out according to the technical documentation.
CR3.5 The work developed and the modifications introduced are included in the assembly report or work order.
CR3.6 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

RP4: Implement the program of preventive and predictive maintenance of 3D printing equipment, revising the operating conditions of the installation and its components, in the established deadlines and times, in conditions of quality and safety, and complying with current regulations.

CR4.1 The technical manuals of the equipment, installation and accessories are consulted, when necessary, in maintenance interventions.
CR4.2 The technical means, tools and measuring devices are adequate and are used according to the requirements of each intervention, and must be adjusted and with the corresponding calibration certificate in force when required by regulations.
CR4.3 Preventive and predictive maintenance operations are carried out following the maintenance plan.
CR4.4 Maintenance is carried out following established protocols and taking into account, among others:
- External cleaning and absence of deformations in equipment, installation and accessories.
- Connections and continuities of cables, connectors, power strips, among others, both power and communications.
- The functionality of the control equipment of the safety devices of the system, of the electrical, pneumatic and hydraulic elements and of the field elements.
-The adjustment and calibration of equipment and system elements.

CR4.5 The work order of the intervention carried out is completed in the corresponding format indicating the elements replaced, the modifications introduced and the actions carried out, among others, for their incorporation into the history of the installation, as well as the communication to the person in charge of the impediments observed in maintenance.
CR4.6 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

RP5: Diagnose and repair the dysfunctions or breakdowns found in the field of its competence, applying it to 3D printing systems, based on the symptoms detected, manufacturer information and history of breakdowns of the equipment, meeting the established deadlines, under quality conditions and security, and complying with current regulations.

CR5.1 The initial tests or observations allow to verify the symptoms of dysfunction or breakdown collected and are contrasted with the history of the equipment.
CR5.2 The possible dysfunction is checked according to instructions, performing the usual starting sequence and acting in a routine way to gather information about it.
CR5.3 The initial hypothesis and the plan of action developed allow to diagnose and precisely locate the damaged device as well as the cause that produces it, evaluating the possibilities of repair or its transfer to the person in charge, as well as establishing priorities according to the level of risk of repair and availability of use of the installation.
CR5.4 The diagnosis and location of the malfunction or breakdown is made using the technical documentation of the installation, when necessary, with the appropriate tools and measurement devices, applying the established procedure.
CR5.5 Replacement of the damaged element is carried out using the disassembly and assembly sequence recommended by the manufacturer, ensuring that the element, component or part of the equipment, installation or accessory replaced is identical or compatible with the damaged one and does not alter any mandatory regulation. Fulfillment.
CR5.6 The waste generated is collected according to the waste management plan.
CR5.7 The extensions and updates carried out verify that they do not alter the intended purpose, the conditions of the equipment nor the initial quality conditions set by the manufacturer.
CR5.8 The work developed is included in the repair report.
CR5.9 Operations are carried out according to quality criteria and in accordance with the plan for the prevention of occupational risks and environmental protection.

Professional context

Means of production

Measurement and verification instruments. Tools and supplies for assembly and installation. Fixing systems, manual tools for mechanical work (pliers, screwdrivers, among others). Manual tools for electric-electronic works (crimping pliers and fiber cutters, among others). Lifting and transport means. Review equipment. Machines for pneumatic and hydraulic works. Machines for mechanical works. Equipment for electrical, electronic, pneumatic and hydraulic tests, as measuring instruments (phase tester, network certifier, manometer, multimeter, oscilloscope, wiring tester, among others). IT tools Equipment for the

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prevention of occupational risks. Maintenance management software. Fault history. Team book. Warehouse book.

Products and results

3D printing systems mounted and diagnosed.
Maintenance in 3D printing systems.
3D printing systems start-up.

Used or generated information

Plans and assembly diagrams and work instructions, electrical, pneumatic, hydraulic, situation and connection diagrams. Lists of materials. Assembly sequences. Machine manuals. Installation manual, user maintenance and technical service. Quartering. Project documentation. Work orders. Failures reports. Technical protocols of action. Rules for equipment maintenance, standards for quality control, regulations for prevention of occupational and environmental risks and applicable regulations. Assembly report. Breakdowns historic report. Team book.

UNIT OF COMPETENCE 7: Use 3D printers to obtain final products.

Level 3
Code UC0007_3

Professional achievement and implementation criteria

RP1: Interpret and manage the digital information necessary to print the elements and/or 3D models.

CR1.1 The digital files containing the model to be printed in 3D are received, applying the rules established for the process.
CR1.2 The digital files that contain the model to be printed in 3D are protected by backing up the file according to established procedures.
CR1.3 The digital information is checked by checking that it corresponds with the technical specifications of the work order.
CR1.4 Digital files are opened using specific computer applications.
CR1.5 Corrected digital files are saved using specific computer applications.
CR1.6 The compatibility between computer programs is checked by pre-checking, verifying that the validated digital files are compatible with the control and management software of the printing device.
CR1.7 The operational status of equipment, tools, instruments and materials is maintained by the established plan.
CR1.8 The process, control and maintenance documents used are formalized according to the correct use of the specific terminology and lexicon.
CR1.9 Digital information is sent to 3D printing devices, using the appropriate computer applications.
CR1.10 The work activities in the printing equipment are organized with efficiency criteria from the production order.
CR1.11 The data corresponding to the calibration of the digital file is entered using the required software.
CR1.12 The correction parameters of the digital file are made on specific programs.
CR1.13 The status and performance of 3D printing equipment is pre-tested, according to the manufacturer's manual.

RP2: Prepare the equipment, adjust the parameters and make the printing of the elements and/or 3D models.

CR2.1 The materials to be used in 3D printing are checked by verifying their physicochemical structure and their characteristics in relation to the manufacturing order.
CR2.2 The surface finish and the color of the element to be printed is checked, assessing that they correspond to the specifications of the work.
CR2.3 The quantity and quality of the item to be printed are checked by verifying that it corresponds with that established in the production order.
CR2.4 The material to be used in the printing is transported from the warehouse, following the established protocols and safety standards.
CR2.5 The material to be used in printing is handled and treated according to the established working methods, which ensure its entry and passage through the machine.
CR2.6 The material feeding system is prepared by adjusting it to obtain an impression according to the established quality.
CR2.7 The adjustable elements of the device are prepared by adjusting them according to the needs of the material used and/or the design to be printed.
CR2.8 The contribution of the material in the manufacturing process of the element is controlled visually and / or by the printing management software, according to the established control plan.
CR2.9 The anomalies that arise during the start-up of the printing device, movements in the support, misalignments in the amount of raw material used, and others, are corrected until reaching the required printing parameters.
CR2.10 The first printed element is checked by checking: its dimensional and / or geometric tolerances, colors, physical-chemical properties, defects and others, according to the characteristics specified in the manufacturing order.
CR2.11 The process variables are modified, according to the valuation and the results of the first printed element.
CR2.12 The correction and adjustment is carried out by acting on the elements, parameters and/or control mechanisms, model design and chromatic correction of the machine, if applicable.
CR2.13 Adjustments are made in compliance with the applicable regulations for the prevention of occupational and environmental risks.
CR2.14 Quality control of the process is carried out according to the established work method, both in terms of the characteristics to be controlled and the way to perform it and its periodicity, and a sample of the printed element must be taken periodically applying the procedures of quality established.

CR2.15 The results of the verification are arranged in the control sheets in this regard, indicating the incidents for analysis.
CR2.16 The production parts are filled in to check the agreement between the specified productivity and the one obtained.
CR2.17 The security devices of the 3D printing machine are checked, checking their correct operation, following established procedures.
CR2.18 The maintenance plan of the printing equipment is carried out following the instructions of the manufacturer of the machine and the established procedures.
CR2.19 The elements of the 3D printing equipment comply with the cleaning levels established in the maintenance regulations.

RP3: Management of safety and environmental protection in 3D printing processes

CR3.1 The information and training provided is verified to be adapted to the needs established in the risk assessment and to the planning of the preventive activity.
CR3.2 The resources necessary to achieve the objectives of the prevention plan in the 3D printing section are identified and adapted to the real needs of the working and environmental conditions, participating in the determination and election of the same.
CR3.3 The own operations of the processes of 3D printing are supervised verifying that they respect the norms and procedures of work in matter of security and environmental protection established in the general plan of prevention.
CR3.4 The use of personal protective equipment (safety footwear, hearing protection helmets, protective gloves against mechanical, chemical and / or thermal aggressions, protective goggles, masks with the appropriate filters, safety belts and others), it is checked by checking that they are used according to the current regulations.
CR3.5 The corrective measures proposed for the prevention and elimination of identified risks are evaluated in collaboration with the prevention technician, to assess their feasibility and compatibility with production and the improvement of safety and environmental protection in the 3D printing processes.
CR3.6 The security devices of 3D printing equipment and machines, (apartabodies, fixed or mobile guards, sensitive control, interlocking devices, emergency stops, photocells or other devices), are periodically checked, verifying their correct functioning and adaptation to the applicable regulations, according to the current prevention and safety plan.
CR3.7 The signaling of the risk areas in the 3D printing section is checked by verifying its correct visibility and that the requirements established in the current regulations are met, notifying the prevention service of any anomaly.
CR3.8 Cleaning and maintenance operations in 3D printing processes (feeding systems, step and exit, printed forms, auxiliary elements, replacement operations of interchangeable elements, cleaning and lubrication of all elements), they are supervised verifying that the appropriate products are used and that the established work procedures are complied with.
CR3.9 The incidents or anomalies detected in issues related to environmental protection in 3D printing processes are resolved, in collaboration with the technician responsible for prevention, taking corrective measures that allow their solution immediately.
CR3.10 The proposals for improvement in preventive matters are applied in collaboration with the responsible superior for the improvement of safety and health.

Professional context

Means of production

Computer equipment, capture and digitization equipment. Image processing software. Software for 3D printing. 3D printers and digital process simulation systems. Drivers Servers of repositories and elements of communication. 3D printing machine, work desk with normalized light. Verification elements. Software for the evaluation of occupational risks in 3D printing processes. Personal protection equipment (EPIs). Collective protection equipment. Safety systems for machines and transport equipment. Portable safety detectors. Emergency devices for first aid or emergency response. Fixed and mobile emergency equipment. Fire ladders, extinguishers, hoses, emergency lighting, warning signs. Environmental detectors Security signage or labels for all types of risks. Selective waste containers.

Products and results

Received files, optimized for processing or reproduction of 3D models. Digital information treated. Control and maintenance documentation. Elements printed in 3D. First level maintenance. Occupational risk and environmental protection plan. Evaluation of occupational and environmental risks linked to 3D printing processes. Reports of incidents and accidents analyzed in printing processes. Proposed preventive measures to carry out in the processes. Tokens of each job with associated risks. Product safety sheets.

Action protocols applied in different emergency situations. Environmental management of the 3D printing section. Waste management in the printing process.

Used or generated information

Technical documentation of equipment. File management manuals. User manuals. Work order. Applicable regulations for the prevention of occupational and environmental risks. Manufacturing order Technical documentation of 3D printing equipment, applicable regulations for prevention of occupational and environmental risks. Standards and quality standards. Preventive maintenance plan. Control plan. Plan for the prevention of occupational risks and environmental protection. Self-protection plan. Documentation required in environmental matters. Manuals of the printing process. Plans or schemes of printing machines and equipment. CE mark standards. Manuals and standards of safety, health and environmental protection. Recommendations and instructions for the use of personal protective equipment. Risk sheet for each job. Printed forms and forms. Manuals for the use of consoles or computer terminals used in different printing systems. Technical safety sheets for materials, products and raw materials. Plans of the facilities. Product handling standards. Occupational risk prevention plan.

UNIT OF COMPETENCE 8: Technologies and knowledge of materials for 3D printing.

Level 3
Code UC0008_3

Professional achievements and implementation criteria

RP1: Identify the processes of obtaining metallic materials from the study of their properties.

CR1.1 The alloy of the metallic materials and their properties is differentiated by the alloying elements as well as by their constituents through an analysis of their composition.
CR1.2 Changes in constituents of metallic materials differ in phase diagrams, especially iron-carbon.
CR1.3 Metal semi-finished products are distinguished by their shapes and dimensions relating to the established standards.
CR1.4 Alloys are classified through the analysis of their properties for their industrial applications.
CR1.5 The constitution of metallic composite materials is related to defined properties.

RP2: Identify manufacturing processes or transformation of non-metallic materials (polymeric, ceramic, composite, among others) by studying their properties.

CR2.1 Non-metallic materials are distinguished by their shapes and dimensions relating to manufacturing processes or transformation.
CR2.2 The most important polymeric and composite materials are identified through their components and their properties through the study of their manufacturing or transformation processes.
CR2.3 The most important construction materials (concrete, among others) are identified through their components and their properties through the study of their manufacturing or transformation processes.
CR2.4 The most important glass and ceramic materials are identified through their components and their properties through the study of their manufacturing or transformation processes.
CR2.5 The constitution of the elaborated materials of biological origin (paper, wood and cork, skin, among others) is related to properties through the study of their manufacturing or transformation processes.

RP3: Differentiate the processes of subsequent elaboration of metallic materials according to their complexity and the influence of the process on their behavior.

CR3.1 Metallic semi-finished products are identified by their finishes and shapes, associating them with the 3D printing process they have been subjected to.
CR3.2 The manufacturing processes of metallic materials are related to the mechanical properties of the products obtained.
CR3.3 The applications of the final product and the materials used in the realization of a fusion of metallic materials are identified by the process used.
CR3.4 The heating treatments applied to metallic products are established according to the final physical properties of the material.
CR3.5 Surface treatments applied to metallic products are established based on the final physical properties of the material.

RP4: Differentiate the processes of subsequent elaboration of non-metallic materials (polymeric, ceramic, composite, among others) according to their complexity and the influence of the process on their behavior.

CR4.1 Non-metallic semi-finished products are identified by their finishes and shapes, associating them with the transformation processes or other treatments to which they have been subjected.
CR4.2 The processes of elaboration of construction materials are related to the mechanical properties of the products obtained.
CR4.3 The processes of elaboration of glass and ceramic materials are related to the mechanical properties of the products obtained.
CR4.4 The manufacturing processes of textile and leather materials are related to the mechanical properties of the products obtained.
CR4.5 The processes of transformation of wood materials are related to the mechanical properties of the products obtained.
CR4.6 The transformation processes of polymeric materials are related to the mechanical properties of the products obtained.

RP5: Identify anomalies, discontinuities, or expected inhomogeneities that occur in materials and products, and the processes that originate them.

CR5.1 The discontinuities found in the different materials are related to the alterations of their components and processing processes.
CR5.2 The processes of surface wear, structural fatigue and aging of materials are identified by the working conditions to which they have been subjected.
CR5.3 The discontinuities produced in a material during the fusion are related to those associated to each fusion process.
CR5.4 Corrosion deterioration processes in a material are related to the existing environmental and working conditions.
CR5.5 Discontinuities such as delaminations, voids, pores and inclusions are identified with the processes of elaboration of composite materials.
CR5.6 The anomalies found in materials of biological origin are related to alterations produced by natural physical means of their components or by microorganisms.

Professional context

Means of production

Catalog of materials and products: catalog of materials and metal products, catalog of materials and construction products, catalog of plastic products, catalog of products of derivatives of natural origin such as wood, paper, cork, textiles, leather, among others.
Diagrams and standards of materials and products: balance diagrams of alloys and norms of classification of materials and products. Equipment for the recognition of materials: metallographic microscope, binocular loupes, magnifiers, chemical reagents and auxiliary equipment for the preparation of metallographic samples, electrolytic buckets, metallographic polishers, cutting machines, equipment for visualization and treatment of images, among others. Environmental and thermal equipment: furnace for thermal treatment, thermometer, thermocouples, hygrometer, among others. General equipment: gauges, millimeter rules, graph paper, consumables, among others. Computers and computer programs for data processing. Personal protection equipment (EPIs).

Products and results

Design scales and metallographic graphs. Elaborate macrographs. Revise laboratory inventory. Report constitution of alloy elements. Protection systems used. Products manufactured in composite, microfusion, metallic materials, among others used. Reports and graphics of microfusioned unions. Waste management.

Used or generated information

Report of composition of materials. Manuals or atlases of defects or imperfections. Norms and catalogs of commercial products. Documentation of chemical products and reagents and equipment manuals. Product safety sheets and chemical reagents. Graphics, tables and reports related to the existence of defects of the parts in manufacturing processes. Photographs and videos of defects or imperfections.

FORMATIVE MODULE 6: Assembly and maintenance of 3D printing systems.

Level 3
Code: MF0006_3
Associated to UC: Manage and supervise the assembly and maintenance of 3D printers, in industrial, personal and social environments.

Lenght: **Hours**

Capacities and evaluation criteria

C1: Analyze the technical information required for the assembly of 3D printers, extracting the necessary information to perform it, complying with the required technical and security specifications.

CE1.1 Identify and interpret the symbology and technical characteristics that are related to the assembly process of 3D printing systems.
CE1.2 Identify the different views and sections of the elements and assemblies of 3D printing equipment constructions.
CE1.3 Describe the assembly process and the means, tools and tools to be used in it.
CE1.4 From a plan or assembly process of a representative 3D printing system, it must:
- Identify and interpret the technical specifications provided by the plan.
- Identify and interpret the cutting plans, characterizing the different elements that make up the set and its dimensions and dimensions.
- Evaluate the quality requirements and tolerances required for assembly.
- Define the relative position of the elements and sets and identify the functionality of the set.
- Identify and characterize operations and processes involved in the assembly by determining the means and equipment necessary to carry it out.
- Establish the order or sequences of the assembly to be made.
- Establish the aspects required by the occupational and environmental risk prevention plan.
- Establish a distribution plan in the plant: provision of auxiliary means, storage areas and, in general, how many needs must be met to prepare the assembly area.
- Establish access needs according to the assembly to be made.
- Evaluate the defined assembly process.
- Present the information necessary for assembly in an orderly and sequenced manner.

C2: Prepare the work area for the assembly of 3D printing systems (equipment, tools, auxiliary means and work protections), based on the technical information provided, applying the plan for the prevention of occupational and environmental risks.

CE2.1 Describe the machines, equipment, accessories and auxiliary services necessary to carry out the assembly work.
CE2.2 Identify and characterize the materials necessary for the assembly work.
CE2.3 Characterize the work areas according to the type of assembly to be made.
CE2.4 Describe the plan for the prevention of occupational and environmental risks.
CE2.5 **In a practical case** where there is a documentation that defines the assembly of a representative 3D printing system, the following should be done:
- Collect the necessary material to make the assembly.
- Select the necessary equipment, tools, tools and auxiliary services.
- Check that the equipment, tools and tools are in good condition and perform the maintenance of use.
- Select the location of the assembly according to its dimension, the auxiliary means, its position and orientation in the work area.
- Apply environmental prevention and protection measures throughout the process.

C3: Assemble and install 3D printing systems: Align, position and assemble elements and structures from the "assembly process", complying with the plan for prevention of occupational and environmental risks.

CE3.1 Describe the means and equipment of measurement and leveling that are used in the assemblies.
CE3.2 Describe the different auxiliary means of assembly and repair specifying its constitution and use.
CE3.3 Identify, interpret and use the control signals used in the handling of equipment and auxiliary means.

CE3.4 Relate the elements of the installation with the function they perform and their applications.
CE3.5 Identify the location of the elements of the installation according to the areas of application and using the appropriate symbology, from the execution process.
CE3.6 **In a practical case** where a process of assembly or repair of a representative 3D printing equipment is available, and once the work area is prepared to proceed with the assembly and installation of the whole or part of it, the following should be done:

- Apply communication and collaboration techniques to perform teamwork.
- Identify the referential elements of position and form of the set.
- Rethink the elements and sub-assemblies according to the assembly process.
- Select the necessary measurement and leveling elements.
- Select equipment, and auxiliary assembly tools.
- "Apply" and level the elements of the structure of the 3D printer, leaving them presented according to specifications.
-"Rigidize"the assembly appropriately, maintaining specified limits and tolerances.
- Verify that the measurements of the assembly coincide with those indicated in the drawing and the dimensions and tolerances are as specified.
- Select and install the necessary auxiliary means to carry out the assembly.
- Use the standard command signals, when handling equipment and auxiliary means.
- Handle the machines, tools and auxiliary means used in the assembly.
- Verify the parameters, alarms, securities, interlocks, movements, among others, of the installation by contrasting the values obtained with those specified in the technical documentation.
- Describe the operating logic of the installation according to the elements that make up each circuit, using the electrical diagrams and checking it through the functional analysis of the installation.
- Verify that the sensors, control equipment, actuators and auxiliary elements that make up the installation meet the requirements established in the documentation of the same.
- Determine the variation that occurs in the operation of the installation assuming changes in the parameters of the elements and checking functionally on the installation.
- Use the means of personal protection and the environment required by the plan for the prevention of occupational and environmental risks.
- Apply the rules of use of equipment and media.

C4: Perform operational tests and start-up operations of equipment and elements of a 3D printing system, based on the technical documentation.

CE4.1 Select the necessary documents for the start-up of the equipment and elements of the installation (start-up protocols, manufacturer's manual, among others) from the technical documentation.
CE4.2 Describe the phases to be followed in the start-up of different equipment and elements of the installation according to their technical complexity.
CE4.3 **In a practical case** of start-up of equipment and elements of a system of a 3D printer, based on the technical documentation:

- Check that the installation complies with what the technical documentation indicates.
- Carry out commissioning according to the technical manual.
- Prepare a report of the activities developed and results obtained.

C5: Analyze and apply predictive or preventive maintenance techniques in 3D printing systems, based on technical documentation and acting under personal safety rules and the materials used.

CE5.1 Identify the parts and elements that make up the facilities analyzing the operation, characteristics, maintenance needs and applicable regulations.
CE5.2 Relate the elements of the installation with the function they perform and their applications.
CE5.3 Describe the parts of the installation that can be maintained, as well as the types of maintenance of
CE5.4 Select and prepare the materials, equipment, tools and documentation necessary to perform the tasks
CE5.5 Describe the procedures of each of the predictive maintenance operations that must be performed on the equipment and elements of an installation based on the 3D printing equipment to be maintained and according to the maintenance plan.
CE5.6 **In a practical case** of preventive maintenance of a type 3D printing installation, and from the technical documentation:

- Identify the elements on which preventive maintenance operations should be carried out.
- Identify the waste management plan.
- Identify the risk factors, the associated risks and the measures to be adopted.
- Prepare the work area according to the requirements of the operation according to established procedures.
- Check the general condition of supports, fixings, protections, elements, insulation, among others.
- Carry out cleaning operations and check the absence of deformations in equipment, installations and accessories.
- Check the power supply of the equipment and the connections and continuities of cables, connectors, power strips, among others, of electrical and communication systems of the 3D printing installation.
- Check the performance of the safety elements and protections.

- Check the status of the infrastructure of the installation (electrical, pneumatic and hydraulic).
- Check the parameters of the system and the equipment and compare the measurements obtained with the technical documentation, checking its correct operation.
- Review and maintain the equipment and tools used in maintenance in the operating state.
- Replace the element or component indicated in the maintenance plan, making the necessary interventions for this replacement.
- Carry out the necessary tests and adjustments according to the specifications in the technical documentation.
- Complete the intervention report by collecting the operations carried out in the established format.

C6: Apply corrective maintenance techniques in 3D printing systems based on technical documentation.

CE6.1 Describe the common faults that occur in 3D printing systems, determining the cause of them and their effects on the system.
CE6.2 Describe the procedures of each of the corrective maintenance operations that must be performed on the equipment and components of the facilities in the most common faults.
CE6.3 Describe the tools and equipment used in corrective maintenance operations, indicating the manner
CE6.4 **In a practical case** of diagnosis and troubleshooting of a type 3D printing installation, and from the technical documentation:

- Interpret the symptoms of the fault by relating it to the elements of the system.
- Carry out hypotheses of the possible causes of the fault describing the relationship between the effects described and the causes of them.
- Carry out an intervention plan to detect the cause or causes of the breakdown.
- Identify the waste management plan.
- Indicate the tests, measurements and verifications that should be carried out, specifying the procedures, equipment and technical and safety means that must be used.
- Replace the element or component responsible for the fault, making the necessary interventions for this replacement.
- Carry out the necessary tests and adjustments according to the specifications of the installation documentation.
- Write a report of the activities carried out and the results obtained.

Capacities whose acquisition must be completed in a real working environment

C1 regarding CE1.4; C2 regarding CE2.5; C3 regarding CE3.6; C4 regarding CE4.3, C5 regarding CE5.6; C6 regarding CE6.4.

Other Capacities:

Adapt to the organization of the company by integrating into the system of technical-labor relations. Correctly execute the instructions you receive, taking responsibility for the work you do, communicating effectively with the right person at all times.
Show an attitude of respect towards the companions, procedures and rules of the company.
Assume responsibility for the work that is carried out and the fulfillment of the objectives.
Propose alternatives with the objective to improve results.
Recognize the productive process of the organization.
Participate and collaborate actively in the work team.
Getting used to the pace of work of the company.
Adapt to the organization, to its organizational and technological changes as well as to new situations or contexts.

Contents:

1.- Graphic interpretation for the assembly of constructions of structures and elements of 3D printing systems

1.1.- Interpretation of plans and diagrams in the installations of specific assemblies and sub-assemblies. Electric schemes. Pneumatic and hydraulic diagrams. Process diagrams (P & I). Sketch of distribution and implementation plans.

1.2.- Assembly manuals of equipment and elements.

1.3.- Quality regulations, waste management and safety and prevention of occupational risks.

1.4.- Symbology used in the technical documentation in assembly of structures and elements of 3D printing systems.

2.- Elements and equipment for leveling elements and subassemblies, tools and standard tools for the assembly of 3D printing systems.

2.1.- Leveling equipment; plumb equipment; Leveling and plumb processes.

2.2.- Positioning elements; tools; auxiliary assembly elements; lifting and transport machinery; cats, tensioners; tools for screwing, riveting, etc ...

2.3.- Analysis and study of the structures of 3D printers:

- Constructive characteristics of the knots.

3.- Pneumatic and hydraulic, electrical and electronic elements and equipment for the assembly of 3D printing systems.

3.1.- Pneumatic and hydraulic elements:

- Tires: production and treatment of air, distributors, valves, pressure switches, cylinders, pneumatic motors, vacuum, among others. Standardized symbology.
- Hydraulic: Hydraulic group, distributors, hydro valves, servo valves, pressure switches, cylinders, hydraulic motors, accumulators, among others. Standardized symbology.

3.2- Electrical and electronic elements:

- Power supply network, electrical cabinets, command and control desks, wiring, sensors, actuators, among others Technologies applied in automation: wired logic and programmed logic.
- Types of controls of a process: open loop or closed loop.
- Types of applicable industrial processes.
- Electrical switchgear: contactors, switches, relays, among others.
- Detectors and sensors. Field instrumentation: instruments for measuring flow pressure, level and temperature, among others.
- Control equipment: analog regulators and digital regulators. Actuators: starters, variators, regulation and control valves, motors, among others.
- Cables and driving systems: types and characteristics. Elements and electrical safety equipment. Standardized symbology.

4.- Assembly techniques:

4.1.- Assembly of elements of machines:

- Elements of transmission. Couplings Bearings Clutches and brakes. Belts, pulleys, chains, cogwheels, among others. Control cables. Mechanical and manual tools of the specialty. Equipment and tools.

4.2- Assembly of pneumatic and hydraulic circuits:

- Pneumatic elements. Structure of pneumatic circuits. Types of controls in pneumatic circuits. Sequential hydraulic and pneumatic circuits. Assembly of the different elements of the pneumatic circuit: tanks, valves, actuators, pipes, accumulators, among others.
- Hydraulic elements Structure of hydraulic circuits. Types of controls in hydraulic circuits. Hydraulic circuits. Assembly of the different elements of the circuit: tanks, valves, actuators, pipes, among others.

4.3.- Assembly of mechanical and electrical mechanisms:

- Assembly of: reducers, linear to circular motion transformers and vice versa, clutches, brakes, gear trains, pulleys, couplers of transmission shafts, bearings, bearings, cams, springs,

connecting elements, control cables, among others. Sliding surfaces: Guides, columns, bushes, trolleys. Sealing gaskets. Assembly of mechanical, electrical, hydraulic, pneumatic equipment or assemblies, among others. Installation of cable bundles. Connection of terminals and wire bundles.

4.4.- Attachements and union techniques:

- Techniques of manual and machine machining. Braking. Sealing. Joints between rigid / flexible pipes. Curved and flared tubes. Placement of electrical terminals. Normalization and specific identification of the elements of union. Bolts, nuts bolts and bolts. Washers and pins. Flanges and broaches. Fittings. Separators, electrical terminals. Special binding elements.

5.- Functional tests and start-up of 3D printing equipment:

5.1.- Measurement, adjustment and control devices.

5.2.- Verification of:

- Parameters.
- Alarms, securities and interlocks.
- Monitoring and visualization system.

5.3.- Protocols of:

- Tests, Adjustments and regulation.
- Start-up of equipment and field elements.
- Start-up of control and visualization equipment.

5.4.- Protection equipment.

5.5.- Assembly and commissioning reports.

6.- Types of maintenance of 3D printing equipment

6.1.- Predictive and preventive maintenance:

- Established procedures.

6.2.- Substitution of elements according to their average life:

- Mantenimiento correctivo.
- Scheduled repair:
  - Established procedures.

7.- Maintenance techniques of 3D printing equipment

7.1.- Types of breakdowns.

7.2.- Tools, equipment, measuring instruments and auxiliary technical means.

7.3.- Diagnostic techniques:

- Tests, measurements and procedures.

7.4.- Maintenance ranges.

7.5.- Protection equipment.

8.- Regulations for the prevention of occupational risks and environmental protection applied to the assembly of 3D printing equipment:

8.1.- Risks evaluation.

8.2.- Techniques and protection elements

8.3.- Environmental management:

- Waste treatment

8.4.- Legislative and regulatory aspects.

Context parameters of the training

Spaces and Facilities

The spaces and facilities will respond, in the form of a classroom, classroom-workshop, practice workshop, laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1.- Mastery of knowledge and techniques related to the assembly and maintenance of 3D printing systems and equipment, which will be accredited by one of the following forms:

- Academic formation of Technical Engineer, degree of equivalent degree or of other higher level related to this professional field.
- Professional experience of at least 3 years in the field of competences related to this training module.

2.- Pedagogical competence accredited in accordance with what the competent Administrations establish.

FORMATIVE MODULE 7: 3D Printing

Level 3
Code: MF0007_3
Associated to UC: Use 3D printers to obtain final products.
Lenght: hours

Capacities and evaluation criteria

C1: Determine and apply the methods of processing digital information, using software appropriate to the needs of the 3D printing process.

CE1.1 Interpret the methods and rules established in the reception of the original files used in 3D printing.
CE1.2 Verify that the content of the digital files corresponds to the technical specifications of the product.
CE1.3 **In a practical case** of receiving files for 3D printing, check:
- The files of 3D models: file names, avoid duplicate files, suitable file formats and others (resolution, mode and color).
- Information storage media: CDs, DVDs, diskettes, external hard drives, virtual spaces, servers, among others.

CE1.4 Identify computing equipments and programs required for the digital information of the design.
CE1.5 Interpret the operation and characteristics of computer equipment and software based on the interpretation of technical documentation and user manuals.
CE1.6 Determine the causes that motivate the deviations of the characteristics of the 3D design, in relation to the process followed, to take timely corrective measures that allow us to obtain the quality specified in a given work order.
CE1.7 **In a practical case** of processing information from different files:
- Identify the computer format and characteristics to adapt it to the technical specifications, by using the appropriate software.
- Establish the appropriate file formats.
- Optimize the parameters of the images in relation to the needs of 3D printing.
- Store the optimized digital files, using the available software that guarantees the inalterability of the content.

CE1.8 Recognize the most appropriate software of the content of the digital file for delivery to the 3D printing machine.
CE1.9 In a practical simulation of preparing files to be sent to print to the machine, from design files, we will:
- Select the appropriate software that allows the opening of validated digital files for the introduction of parameters and technical characteristics in the 3D printing system, (software for treatment of designs, software to determine printing parameters and others).

CE1.10 Relate the current 3D printing systems with different elements to be printed.
CE1.11 **In a practical case** of valuation of different 3D printing systems, from some given models:
- Set the calibration of the printing system for the given models.
- Relate the print quality of the 3D models in the different existing 3D printing systems.
- Contrast the relationship between the elements obtained and their designs.

C2: Recognize and analyze the main properties and characteristics of raw materials and auxiliary products, as well as the quality variables used in 3D printing.

CE2.1 Recognize and describe the main characteristics, physical-chemical properties and structure of the materials used in 3D printing.
CE2.2 Characterize the main defects and alterations of the different materials used in 3D printing.
CE2.3 Relate the properties of the materials with the behavior requirements in the different processes.
CE2.4 Identify the risks and level of danger involved in handling the different materials and products used in 3D printing.
CE2.5 Relate the durability and behavior of the different 3D printing products with the alterations they suffer, due to: humidity, temperature, property of the materials, oxidation, exposure to light and mechanical stress.
CE2.6 **In a practical case** of assessment of the quality of raw materials, from different measuring equipment (precision, densimeter, colorimeter, spectrophotometer and others):
- Check the characteristics of the printed elements.
- Assess the quality of raw materials and correctly express the results of the measures.
- Determine optimal storage conditions for raw materials.

C3: Perform the operations of commissioning and setting up of the main machines and 3D printing equipment, to make the printing with the required quality.

CE3.1 Describe the different 3D printing systems that are currently used.
CE3.2 Analyze the regulatory operations necessary to adjust the 3D printing process, according to the type of machine to be used.
CE3.3 Explain the different methods of checking and regulation in 3D printing machines.
CE3.4 **In a practical case** of adjustment of a 3D printing machine, from a work order properly characterized, regulate all configurable parameters.
CE3.5 In a case of maintenance of 3D printer, from the maintenance sheet of the machine:
- Identify the elements that must be maintained.
- Define the appropriate first level maintenance plan for the 3D printing machine.
- Carry out the maintenance operations methodically: greasing, cleaning dry grease, cleaning dust remains, following the manufacturer's instructions.
- Carry out methodical cleaning of the machine complying with the applicable regulations for the prevention of occupational and environmental risks.

CE3.6 Identify the appropriate way to arrange the materials in the machines, in order to obtain the optimal results and times.
CE3.7 Describe the defects of the 3D printing system.
CE3.8 **In a practical case** of adjustment of elements of 3D printing machines, from a type job to be printed:
- Relate the causes and effects of the readjustment of the parameters on the printed model.
- Acting manually or using computer equipment, the parameters adjusting them to the needs.

CE3.9 **In a practical case** of 3D printing, from the original design and prepress tests:
- Obtain the printed element with the required quality in relation to the original design.
- Compare the printed element with the prepress tests, readjusting the parameters of the same.
- Match the machines and raw materials used with the printing speed, according to the parameters of the printed element.

C4: Relate the measurement of the products obtained in 3D printing with the quality variables of the process, using the appropriate instruments.

CE4.1 Describe the method and frequency of obtaining samples for verification during the production of a series of 3D printed pieces.
CE4.2 Carry out the measurement on elements printed in 3D, using the appropriate instruments and expressing the result of the measurement in the units and in an appropriate way.
CE4.3 **In a practical case** of a process to measure the quality variables of 3D printed elements:
- Relate the different elements that intervene in a series of control with the deviation of the required quality parameters.
- Identify, describe and, where appropriate, represent the defects that must be controlled during production.
- Identify the control devices that must be used.

CE4.4 Identify the risks and level of danger involved in handling the different materials, products and equipment used in 3D printing.
CE4.5 Relate the products and materials used in 3D printing, with the environmental regulations, considering the substitutes of the products traditionally used that adapt to said regulations.
CE4.6 **In a practical case** of 3D printing characterized by the operations that must be carried out:
- Identify and describe the security mechanisms of printing machines: stop buttons, protections, housings, grids, as well as the means of protection and clothing that should be used.
- Describe the safety conditions in the preparation and maintenance operations of the machines.
- Establish the safety and precaution measures that must be adopted, according to the applicable regulations for the prevention of occupational and environmental risks and the specific instructions of the equipment applicable to the different operations.

C5: Analyze occupational and environmental risk prevention plans and the corresponding applicable regulations to correctly use means, equipment and materials in the realization of 3D printing.

CE5.1 Relate and describe the rules regarding the cleanliness and order of the work environment in 3D printing.
CE5.2 Describe the properties and uses of the most commonly used personal protective clothing and equipment for 3D printing.
CE5.3 Identify and describe standards for stopping and manipulating 3D printing systems and machines.
CE5.4 Relate the materials used in 3D printing with the environmental regulations, considering the substitutes of the products used.
CE5.5 **In a practical case** of security assessment in 3D printing, based on a number of prevention plans for occupational and environmental risks of companies in the sector:
- Identify and describe the most relevant aspects of each plan, included in the documentation that contains it.

- Identify and describe the factors and situations of risk to health and safety in the plans related to that activity.
- Relate and describe the appropriate preventive measures and methods of prevention established to avoid accidents.

Capacities whose acquisition must be completed in a real working environment

C1 regarding CE1.3, CE1.7, CE1.9 y CE1.11, C2 regarding CE2.6, C3 regarding CE3.4, CE3.5, CE3.8 y CE3.9, C4 regarding CE4.3, y CE4.6, C5 regarding CE5.5.

Other capacities:

Assume responsibility for the work that is carried out and the fulfillment of objectives.
Demonstrate a certain degree of autonomy in the resolution of contingencies related to their activity.
Propose alternatives with the aim of improving results.
Communicate effectively with the right people at all times, respecting established channels.
Adapt to the organization, to its organizational and technological changes as well as to new situations or contexts.
Learn new concepts or procedures and take advantage of training effectively using the knowledge acquired. Respect the procedures and internal rules of the company.
Interpret and execute work instructions.

Contents:

1.- Receiving 3D design files

1.1.- Methods. Rules. Protection.
1.2.- Design files, (graphic formats in computer support, resolution, and color).
1.3.- Graphic tools.
1.4.- Information supports.

2.- Processing of the Information

2.1.- Equipment: classes, types, characteristics and operation.
2.2.- Viewing of files
2.3.- Software for treatment of designs; Software for workflow management.
2.4.- Simulations, pre-check, and digital tests. Types.
2.5.- 3D printing processes, classification; functioning; transfer of the image.
2.6.- Adjustment of parameters in 3D printing equipment.

3.- 3D printing processes

3.1.- Printing procedures.
3.2.- Types of technologies.
3.3.- Operations. Control parameters.
3.4.- Printing machines, characteristics, structures and types.
3.5.- Applicable regulations for the prevention of occupational and environmental risks.
3.6.- Protection measures.

4.- Preparation and commissioning of equipment for 3D printing

4.1.- Charger device.
4.2.- Parts: mechanisms and regulation.
4.3.- Measuring devices.
4.4.- Problems of the regulation of the machine. Solutions
4.5.- Safety regulations for machines, installations and materials.

5.- Production of the 3D printed model

5.1.- Manual or electronic readjustment of the mechanical elements of the equipment.
5.2.- Review of the printed element. Readjustment of the equipment parameters.
5.3.- Team speed relationship between raw materials and printing speed.
5.4.- Defects in 3D printing. Cause/correction
5.5.- Check of the printed element in 3D, with prepress tests.
5.6.- Factors and risk situations, personal protection equipment.

6.- Quality control during the prototyping process

6.1.- Computer programs and equipment for monitoring the quality of the printed model. Applications. Equipment for the control of the 3D printed model. Elements for control.
6.2.- Criteria to be followed in the quality control of the 3D printed model, conditions in the control process, lighting and observation angle.
6.3.- Control of the finished printed element, conditions of printability of the 3D model.
6.4.- Guidelines to follow in the inspection of 3D printed elements: sampling, reliability and measurement.
6.5.- Quality standards of the model printed in 3D.

7.- Maintenance operations

7.1.- First level maintenance.
7.2.- Lubricants: oils, fats.
7.3.- Cleaning sequence in 3D printing equipment.

8.- Safety and health in 3D printing processes. General risks and their prevention.

8.1.- Work and health: professional risks. Risk factor's.
8.2.- Damages derived from work. Accidents and occupational diseases. Other pathologies derived from work.
8.3.- Basic regulatory framework for occupational risk prevention.
8.4.- Elementary risk assessments: simple identification and assessment techniques.
8.5.- Security techniques: prevention and protection measures.
8.6.- Risks linked to security conditions. Risks linked to the work environment. Risks linked to the organization of work in 3D printing companies.
8.7.- Elements defined in the self-protection plan: fire protection equipment, emergency exits and others.
8.8.- Emergency situations and first aid in 3D printing processes.
8.9.- Action protocols and evacuation procedures in emergency situations.
8.10.- Basic techniques of action against accidents at work. First aid. Resources and necessary means.

9.- Analysis, evaluation and control of environmental risks in 3D printing processes

9.1.- Labor standards and procedures in the field of environmental protection.
9.2.- Risks related to environmental conditions. Risk's factors.
9.3.- Management of waste produced in the 3D printing process. Treatment of discharges.
9.4.- Legal requirements in environmental matters needed in 3D printing machines and equipment.
9.5.- Development of environmental protection plans in 3D printing companies.
9.6.- Analysis and evaluation of environmental risks linked to 3D printing processes.
9.7.- Research techniques of environmental incidents, causes and consequences.
9.8.- Preventive and corrective measures. Individual Protection Equipment.

9.9.- Products used in 3D printing processes: technical data sheets, instructions and labeling.
9.10.- Documentation and administrative procedures in environmental matters.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a classroom, classroom-workshop, practice workshop, laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1. Domain of knowledge and techniques related to the interpretation and management of digital information necessary for 3D products printing, which will be accredited by one of two ways:
   - Level 3 academic training, technical engineering or other higher level linked to the professional field.
   - Professional experience of at least 3 years in the field of competences related to this training module.
2. Pedagogical competence accredited according to what the competent Administrations establish.

FORMATIVE MODULE 8: 3D Materials

Level 3

Code: MF0008_3

Associated to UC: Technologies and knowledge of 3D printing materials.

Lenght: hours

Capacities and evaluation criteria

C1: Recognize the manufacturing processes of metallic materials by studying their properties.

CE1.1 Relate the constituents of the alloys of metallic materials with the properties that it confers to the material.
CE1.2 Explain in a Fe-C diagram the points of change of the constituents and their relations with the properties of the material.
CE1.3 Establish a classification of metallic products based on commercial standards and catalogs, indicating their shape and dimensions.
CE1.4 Prepare a list of the alloys according to their industrial applications.
CE1.5 Select different composite materials according to their manufacturing process.
CE1.6 **In a practical case** of a sample of a metallic material, observe it under the metallographic microscope and classify the characteristics of the material.

C2: Recognize non-metallic materials or products (polymeric, ceramic, composite, among others) by studying their properties and relating them to manufacturing or transformation processes.

CE2.1 Classify different non-metallic materials by their shapes and dimensions relating them to their manufacturing or transformation processes.
CE2.2 Classify different polymeric and composite materials according to their components and properties.
CE2.3 Classify concretes according to their resistance by relating them to the proportion and characteristics of their constituent materials.
CE2.4 Classify different glass and ceramic materials according to their components and properties.
CE2.5 Distinguish different biological materials (paper, wood and cork, skin among others) and relate them to their properties.
CE2.6 **In a practical case** of a sample of a non-metallic material, prepare a sample, observe it and classify the characteristics of the material by their properties.

C3: Distinguish the processes of subsequent elaboration of metallic materials according to their complexity and the influence of the process on their behavior.

CE3.1 Link the mechanical properties to the materials with the 3D printing processes.
CE3.2 Identify the semi-finished metallic materials for their endings.
CE3.3 Distinguish the transformations that occur in the properties of a material through a thermal or thermochemical treatment.
CE3.4 Distinguish the transformations that occur in the surface property through a thermal or surface thermochemical treatment.
CE3.5 Identify the 3D printing process of a material according to its surface finish.
CE3.6 **In a practical case** of a sample of metallic material Printed in 3D, note the mechanical properties and compare it with the same material without printing.

C4: Distinguish the processes of subsequent elaboration of non-metallic materials (polymeric, ceramic, composite, among others) according to their complexity and the influence of the process on their behavior.

CE4.1 Distinguish semi-finished non-metallic products by their finishes and shapes, associating them with the transformation processes.
CE4.2 Prepare a list of the main construction materials and their mechanical properties, grouped by their production processes.

CE4.3 Distinguish the main glass and ceramic materials and their mechanical properties, according to their manufacturing processes.
CE4.4 Distinguish the main textile and leather materials and their mechanical properties, according to their manufacturing processes.
CE4.5 Distinguish the mechanical properties of wood materials, according to their transformation processes.
CE4.6 Distinguish the mechanical properties of polymeric materials, according to their transformation processes.

C5: Associate anomalies, discontinuities, or expected lack of uniformity that occur in materials and products with the processes that originate them.

CE5.1 Identify the discontinuities found in a material relating them to the alterations of its components and the alterations produced in its elaboration processes.
CE5.2 Relate the causes of surface wear, structural fatigue and aging of the materials according to the working conditions to which they have been subjected.
CE5.3 Prepare a list of discontinuities associated with the microfusion processes used.
CE5.4 Relate the environmental and work conditions with the corrosion deterioration processes of the materials and products.
CE5.5 Identify discontinuities such as delaminations, voids, pores and inclusions of composite materials produced in the manufacturing processes.
CE5.6 Identify the types of alterations produced by natural physical means of its components or by microorganisms in materials of biological origin.
CE5.7 **In a practical case** of vitreous materials identify the defects with the manual of defects and imperfections indicating the process in which they have occurred, such as the contamination of raw materials, the agitation in the refining, the melting temperature, among others.
CE5.8 **In a practical case** of a 3D printed piece of thermoplastic material, identify defects associating them with the processes that originated them, such as model design, extrusion temperature, resilience, among others.
CE5.9 **In a practical case** of a laminated piece of thermosetting material, identify defects associating them with the processes that originated them, such as delaminations, hollows, fiber-resin ratio, gelling time, among others.
CE5.10 **In a practical case** of a pavement made with bituminous mixtures identify defects associating them with the processes that have originated them, such as plastic deformations, disintegration, breakage by fatigue, among others.
CE5.11 **In a practical case** of a material obtained from skin, identify defects such as spots, discolorations, heterogeneities, among others.

Capacities whose adquisition must be completed in a real working environment

C5 regarding CE5.9, CE5.10, CE5.11, CE5.12 y CE5.13.

Other Capacities:
Assume responsibility for the work that is carried out and the fulfillment of objectives.
Demonstrate a certain degree of autonomy in the resolution of contingencies related to their activity.
Propose alternatives with the aim of improving results.
Demonstrate flexibility to understand changes
Adapt to new situations or contexts.
Learn new concepts or procedures and use the information obtained from the acquired knowledge efficiently.

Contents:

1.- Properties of metallic materials and their study through basic metallographic tests

1.1.- Classification. Metallic structural materials; advanced materials: composite materials and superalloys. Metals and alloys.
1.2.- The metallic state, basic principles of metallurgy, processes for obtaining metals.
1.3.- Physical and structural properties of metals. Technological properties Balance diagrams Properties of the alloys.
1.4.- Steel as Fe-C alloy: Classification and applications.
1.5.- Foundries: classification and applications.
1.6.- Light alloys: types, properties and applications.

1.7.- Other alloys.
1.8.- Metallographic constituents of low alloy steels and foundries.
1.9.- Testing tubes preparation. Features of basic destructive tests (metallographic, mechanical and other physical parameters).
1.10.- Types of reports of basic destructive tests.
1.11.- Environmental control of waste.

2.- Properties of non-metallic materials and products (polymeric, ceramic, composite) and their study by basic tests.

2.1.- Classification. Non-metallic structural materials: polymers and composites, construction materials, glass and ceramics, wood and cork, leather, among others.
2.2.- Polymers and compounds: types, compositions and their applications.
2.3.- Building materials: types, compositions and their applications.
2.4.- Materials from cement-concrete, prefabricated, materials made from baked clay, materials from natural stone, among others.
2.5.- Influence of the quality of the constituent materials and their proportions in the final products.
2.6.- Glass and ceramics: types, compositions and their applications.
2.7.- Wood and cork: types, compositions and their applications.
2.8.- Leather: types, compositions and their applications.
2.9.- Other types of materials.
2.10.- Preparation of test tubes. Characteristics of basic destructive tests. Types of reports of basic destructive tests.
2.11.- Environmental control of waste and its management.

3.- Processes of subsequent transformation of metallic materials and non-metallic materials (polymeric, ceramic and composite)

3.1.- General knowledge of metallic materials. Classification.
3.2.- Microfusion: processes, classification.
3.3.- Powder Metallurgy (Sintered).
3.4.- Coatings and surface treatments.
3.5.- Development of non-metallic materials.
3.7.- Composite materials.
3.6.- Heat treatments: hardening, tempering, annealing, isothermal treatments, cementation, sulfinization and nitriding.
3.7.- General notions of non-metallic materials (polymeric, ceramic and composite).
3.8.- Polymers and compounds: types, designs and their applications.
3.9.- Construction materials: setting and curing process.
3.10.- Glass and ceramics: Glass manufacturing processes due to their subsequent use.
3.11.- Wood and cork: Types of wood processing, cutting, among others.
3.12.- Leather: Types of processed.

4.- Recognition of anomalies, discontinuities or lack of homogeneity of materials, products and microfusion related to the processes that produce them.

4.1.- Typical discontinuities associated with metal fabrication processes: microfusion, powder metallurgy, thermal treatments, coatings, surface treatments, composite materials and other non-metallic materials.

4.2.- Operational defectology.

4.3.- Metal corrosion, main corrosion mechanisms: by pitting, by cavitation, intergranular, stress corrosion, fatigue corrosion.

4.4.- Fatigue of metals. Fatigue mechanisms, fatigue limit.

4.5.- Failure of metallic materials.

4.6.- Ductile break, fragile break.

4.7.- Metallography: sample preparation, chemical attack, reagents, polishing, microscope, metallographic and replicas.

4.8.- Notions of macro and micrography.

4.9.- Notions of metallography of non-ferrous materials.

4.10.- Typical discontinuities associated with non-metallic manufacturing processes.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a classroom, multipurpose classroom of a minimum of 2 m^2 per student, classroom-workshop, practice workshop, 45 m^2 test laboratory or singular space, to the training needs, in accordance with the Professional Context established in the associated Competition Unit, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1. Mastery of knowledge and techniques related to the recognition of the properties of materials and products associated with their manufacturing or transformation processes, which will be accredited by one of the following forms:
   - Academic education of Bachelor, Engineer, Architect, equivalent degree qualifications or other higher level related to this professional field.
   - Professional experience of at least 3 years in the field of competences related to this training module.
2. Pedagogical competence accredited in accordance with what the competent Administrations establish.

Professional Qualification: RESEARCH, DEVELOPMENT, INNOVATION AND DESIGN PROJECTS MANAGEMENT, 3D PRINTING AND SCANNING, IN PROFESSIONAL ENVIRONMENTS.

Associated Vocational Families: (Electricity-Electronics, computing, Mechanical manufacturing)
Leve 3
Code: ESDEI3D_4
Draft 1
Situation Final

General competence

Develop 3D components manufacturing projects, establishing their features, developing layouts, undertaking all needed tasks to its processing, follow up and update, planning control costs, materials, equipments and documents applied to the Project throughout all phases of the process, in compliance with the relevant Regulation, and the established specifications and procedures. Researching and innovating to ensure the intended quality, as well as the personal and environmental safety.

Unit of competence

UC0009_3: Research, develop, plan, Schedule, innovate, control timings, provide the production, supervise the start-up, as well as the maintenance of 3D scanning and printing systems. Considering the installation conditions and the manufacturer's recommendations, guaranteing precaution, safety, environmental and quality conditions.

Professional Field

Professional context

It develops its profesional activity in the engineering area or technical office, which provides the venture projects department dealing with the design and manufacture of 3D printing items. Researching and innovating to ensure the quality of those components; which roles are the management of the projects, the planning control, the costs or the related documents, as well as the development of other projects dealing with the assembly and maintenance of 3D scanning and printing equipments.

Productive Sector

This qualification is set in different productive sectors:

- Engineering companies engaged in 3D models design.
- 3D scanning and printing asembly of installations in insustrial and auxiliary processes linked to the production.
- Research and innovation, and companies specialized in the management of projects.

Main jobs and employments

- 3D scanning and printing designer.
- 3D model planner.
- Higher Technician in design and maintenance of 3D scanning and printing systems.
- 3D model designer.
- Researcher of 3D models mechanical topology.
- Technical office technician, planning, costs control and 3D documents control.

Associated training (... h)
Formative Modules

UNIT OF COMPETENCE 3: Develop, Plan, Programme, Control of times, Supply the production, Supervise the start up, as well as the maintenance of 3D scanning and printing system, considering the installation conditions and the manufacturer's recommendations, guaranteing precaution, safety, environmental and quality conditions.

Level 3
Code UC0009_3

Professional achievement and implementation criteria

RP1: Preliminary proposal of the 3D printing and/or scanning work, setting a Plan and achieving the initial basic calculations.

CR1.1 The startig point is analysed according to a model established in the processes (Process/Subprocess), finding out the needed information for its complete definition.
CR1.2 The efficiency data of the subprocesses (activities), are determined from databases or from estimates provided by the person in cahrge and/or superior.
CR1.3 The lenght calculations are done using the starting point data, the formula provided by the model itself or the one stated.
CR1.4 The calculations of the links among the parts of the plan are developed without errors or mistakes, complying with the logic of the process of design and/or the construction resised by the modelo or those stated.
CR1.5 The plan is generated through a specific computer application, incorporating the sections or subprocesses of the model and introducing the results of durations and relationships.
CR1.6 The resulting plan is presented together with the calculations justifying the responsible and / or superior, according to the established formats.
CR1.7 The Base Plan is generated by incorporating the modifications proposed and agreed by all the responsible agents involved in this phase, being filed with the established format and codification.

RP2: Prepare general assembly plans and an exploded list of elements and/or materials, based on the initial proposal, their specifications and established design criteria, to achieve the expected quality levels.

CR2.1 The description and characterization of the printing and/or 3D scanning systems, of their components, and the regulations that affect the facilities, are identified for their application in the drawing process.
CR2.2 The plans are made applying the appropriate drawing standards and, where appropriate, the internal rules of the company and the established instructions.
CR2.3 The layout is made taking into account the conditions of exploitation, assembly and maintenance of the facilities, the characteristics and use, buildings where it is located and other types of factors.
CR2.4 The location and disposition of the printing and/or scanning machines, as well as the control elements, are fixed following the principles of accessibility, for assembly, maintenance and repair.
CR2.5 The arrangement of supports, fixed points and/or their constructive forms is carried out guaranteeing stability, avoiding mechanical stresses and unwanted deformations in the 3D printing and/or scanning equipment.

RP3: Determine the characteristics of the equipment, elements, materials, elaborating diagrams for the processes of printing and/or 3D scanning based on the conditions and previous design criteria, and complying with the application regulations.

CR3.1 The conditions and characteristics of the systems comply with the related regulations. Contemplating the safety standards and environmental protection.
CR3.2 The calculations of the magnitudes are made using tables, computer programs and established procedures.
CR3.3 The characteristics of the 3D elements are determined according to the type of equipment and installation. and its features responding to the requirements of it.
CR3.4 The necessary information for the elaboration of the 3D elements is included in the plans, sketches and / or diagrams.
CR3.5 Make the specifications report collecting all the data necessary for the preparation of the project: the purpose, location, functional and technical characteristics, as well as the equipment and elements, among others to be taken into account in the manufacture of 3D elements.

RP4: Select the equipment, tools, materials and control systems for the production of 3D elements, based on the specifications report and complying with the application regulations.

CR4.1 Equipments, supplies, materials and systems of control are chosen according to the current regulations, to the approval standars of the sector internal of the company.

CR4.2 The models and characteristics of the machines, equipment, and tools fulfill the required function
CR4.3 The adjustment and control parameters correspond to the technical specifications and characteristics included in the specifications report.
CR4.4 The choice of materials is made by combining the guarantees of quality, compatibility, reliability, durability, supply and costs.
CR4.5 The 3D printing and/or scanning equipment is uniquely identified with all brand references, model, among others, as well as with the approval standards to which it responds.
CR4.6 The general list of elements of the installation and safety measures with all the technical references, approval standards, identification of manufacturers and unit prices, among others, is included in the corresponding report and allows the preparation of budgets and the basic safety study.

RP5: Develop measurement and/or control programs in the 3D elements production processes, using the appropriate techniques, from the technical documentation and with the required quality.

CR5.1 It uses the necessary technical documentation (project, technical specifications, technical manuals and product manuals) to program the measurement and / or verification controls.
CR5.2 The needs to program the control systems are determined by identifying the equipment, elements, operation and accuracy of these.
CR5.3 The tools and control tools are selected according to the equipment, elements and precision of these.
CR5.4 The control program is prepared in response to the needs of the project.
CR5.5 The functional tests of the control program are carried out following the established procedure and verifying the correct execution.

RP6: Prepare the execution plan to carry out the manufacturing process, based on the data collected in the project (sketches, plans, diagrams and selected materials, with the required quality).

CR6.1 The plans and diagrams of the elements and control systems are represented taking into account, among others:

- The symbology and standardized conventions of application and, where appropriate, the internal rules of the company.
- The identification of the different systems and their components.
- The scale and the representation system most suited to the contents.

CR6.2 The graphic layout of the representation of the elements, their groupings and the systems of reference and coding in the different planes, is elaborated taking into account, among others:

- The established relations among them.
- The sequential follow-up of the production process and the facilities.
- The specifications of the equipment and the constituent elements of the installation.

CR6.3 The location of the equipment, its dimensions, elements and technical specifications are represented in the general plans and comply with the regulations and application standards.
CR6.4 The detail plans include the assembly of the elements to the printers and / or 3D scanners taking into account, among others:

- The construction forms and the dimensions of supports and / or anchors, pipes, equipment and environmental conditions.
- The transport, the passage through the accesses and the manipulation with the available means and in the required conditions of security.
- The security elements necessary for production, as well as their specifications and requirements

CR6.5 The current regulations regarding the safety of people, equipment and facilities are met in the defined implementation, achieving the established quality levels.
CR6.6 The general list of equipment, elements of the installation and security means is updated in the case of variations.

RP7: Determine costs in the processes of printing and/or 3D scanning, defining the manufacturing units and the quantities of each of them, applying established unit prices, based on the technical documentation of the project, and with the required quality

CR7.1 The established manufacturing units are decomposed, to obtain their cost, applying established procedures taking into account, among others:

- The elements that compose them.
- The quantities of each of them.
- Measurements and tolerances dimensional and/or geometric established, with their units.
- The operations to be performed.
- The conditions of assembly.
- The labor involved.
- The estimated time for execution.
- The quality conditions required and others that may arise.
- The total cost of each manufacturing unit.

CR7.2 The manufacturing units comply with the technical specifications of the project and those of the specifications.
CR7.3 The total set of units to be manufactured is calculated considering the work to be done and includes all the materials and elements used.
CR7.4 The measurements obtained are specified in the corresponding document with the required precision and are collected with the precise and standardized unit of measurement.
CR7.5 The information obtained is reflected in the corresponding document and allows the preparation of the budget.

RP8: Define the technical conditions of testing and implementation, providing proposals for innovative improvements or research in the field of competence, in technical documentation of the project of printing systems, 3D scanning, measuring and / or control elements, taking into account Count the required quality.

CR8.1 The technical specifications for the supply of materials, products and equipment, is prepared taking into account the characteristics, standards, regulations and approvals of manufacturing, quality and safety conditions.
CR8.2 The required reception tests are defined to ensure the established quality level.
CR8.3 The conditions of storage and handling of materials and / or equipment are extracted from the manufacturer's information.
CR8.4 The reception conditions and the test protocol of the facilities are clearly specified in the corresponding documentation.
CR8.5 The moments and results obtained are specified in the corresponding documentation.
CR8.6 The necessary technical documentation (project and technical specifications) is collected to prepare the work plan.

RP9: Prepare the manual of service and maintenance of the printing and / or 3D scanning systems, of the measuring and/or control elements, taking into account the technical documentation of the project, and the required quality.

CR9.1 The service instruction manual is prepared specifying the conditions of use, operation, safety and manual operations of operation.
CR9.2 The actions that must be followed in case of breakdown or emergency are specified in the service instruction manual.
CR9.3 The maintenance manual is prepared taking into account, among others:
- Inspection points for maintenance.
- The parameters to control.
- The operations to be performed.
- The means employed.
- The periodicity of the actions.

RP10: Prepare the basic study of safety, health and environmental protection for the execution of the project with the required quality.

CR10.1 The risk factors associated with the operations (transport of materials, assembly of elements and equipment, among others) are identified with precision.
CR10.2 Risks associated with risk factors are identified and preventive measures are indicated as well as the protections to be used, both individual, collective and environmental.
CR10.3 The basic study of safety, health and environmental protection is prepared taking into account the instructions for handling equipment and materials supplied by the manufacturer, as well as the experience obtained in productive processes of similar characteristics.

Professional Context

Means of production

Specific computer equipment and applications for computer-aided 3D design, CAD and measurement and control system programming for 3D element production processes.
Printers Scanner. Reproducing drawings. Drawing instruments. Calculator. Applications and specific environments for measurements and budgets. Office automation applications. software calculation and simulation. Tables and graphics.

Products and results

Initial proposal of the work. Proposal of the Plans. Design proposals for design. Innovative and / or research proposals applied to the designs of the models. Projects for the manufacture of 3D models. List of equipment and materials to be used. Process diagrams Detail plans. Plans of the facilities. Lists of materials. Control guidelines. Reports of feasibility studies of the manufacture of the product. Programs of measurement, verification and control of production. Manufacturing units. Costs of production, budgets. Technical specifications for testing and testing facilities. Tokens and records. Instruction manual for service and maintenance of equipment, tools and control elements. Basic study of safety, health and environmental protection.

Used or generated information

Project specifications. Reports. Diagrams of operation of machines and processes of printing and / or 3D scanning. Plans and schemes of equipment and systems. Regulations and regulations in force. Manufacturers catalogs List of instruments. Technical specifications. Design manual Technical documentation of standardized elements. Commercial catalogs and specific materials. AMFE of the product and design. Homologation requirements. Safety rules and protection of people, equipment and environmental. UNE, EN, IEC standards. Rules of symbology and representation of facilities (ISA, ASA, ISO, among others).

FORMATIVE MODEL 9: Research and Project Management of 3D printing and scanning systems.

Level 3
Code: MF0009_3
Associated to UC: Investigate, develop, plan, program, innovate, control times, provision production, supervise the start-up, as well as the maintenance of systems scanning and 3D printing, taking into account the installation conditions, and the manufacturer's recommendations, ensuring the conditions of prevention and safety, environmental and quality
Lenght: Hours

Capacities and evaluation criteria

C1: Analyze planning processes, valuing their usefulness, comparing the different methods used, and performing calculations without using specific computer applications.

CE1.1 Explain the difference between the notion of a project as a technical document and as a planned and directed action, specifying the relationship between both concepts.
CE1.2 Explain why planning in projects is useful and necessary, formulating a definition of the concept of planning adjusted to the development of projects.
CE1.3 Explain the elements common to all planning methods, defining the following concepts: process model, subprocesses, phases, subphases, activities and relationships.
CE1.4 Classify and compare the different types of planning methods, diagrams, critical path methods, differentiating their objectives, scope and calculation procedures.
CE1.5 Explain the different types of relationships between activities, inferring what the critical path consists of.
CE1.6 In a practical assumption of a basic 3D printing process, perform the calculations and make their equivalent representation in a basic diagram, solving all the parameters without using specific computer applications.
CE1.7 Explain the needs for monitoring, updating and reviewing the planning, describing the changes that the project undergoes during its development.
CE1.8 Describe the usual defects in the application of the planning of a project, associating its causes and effects.
CE1.9 Describe the factors of research and technological and organizational innovation in the work of project planning, assessing its impact.

C2: Analyze the processes associated with the development of projects, defining the phases that compose them and determining the necessary activities to include in their base program.

CE2.1 Relate the phases involved for the achievement of a project (initial definition, design, contracting, execution), determining the purpose of each phase, the result achieved (base program, design program, contracting program and execution program) respectively) and the temporal relationships that bind them.
CE2.2 Explain the level of detail that is reached in the previous definition of an action, and its corresponding base program, identifying the intervening and/or consulted agents during its elaboration and the roles that they perform.
CE2.3 In a practical case of a given project, determine the activities necessary to generate the base program, which includes all the phases that make up that same project.
CE2.4 Identify the stages (plan, study, preliminary project, project) that may be involved in the development of a project to manufacture 3D elements and the documents that comprise it, specifying the degree of definition reached by the design in each of these stages.
CE2.5 Describe the process of procurement or contracting, ordering the stages involved.
CE2.6 Describe the usual deviations in the temporal development of 3D element manufacturing projects, associating the measures to reduce them.

C3: Analyze the graphic technical information of the 3D models, prepare plans in the established support and obtain all the data that characterize them.

CE3.1 Relate the symbols of the elements with the function they perform.
CE3.2 Identify and represent with the applicable standard symbology: machines and equipment, automation and

control systems, materials, etc...

CE3.3 Select the most suitable supports and formats for the realization of the plans.

CE3.4 Choose the most appropriate graphic representation system.

CE3.5 Select the scale to be used, determine the elevations, floors, sections and details that are necessary for the best definition of the drawing.

CE3.6 Represent, according to the regulations, the elevations, floors, sections and details that are part of the graphic information contained in the plans.

CE3.7 Dimension the drawings according to their functionality and the assembly process.

C4: Identify the components of the 3D equipment, drawing up diagrams, analyzing their operation, and describing the operating parameters of the same and the facilities.

CE4.1 Given the 3D production equipment and characterized by its drawings and technical documentation:

- Interpret these plans of these equipment and the intended use to which they will be allocated.
- Identify its parts and elements, relating them to the symbols that appear on the plans.
- Identify the parts of said equipment and relate the dimensions that appear in the planes with reality.
- Describe the general operation of the equipment.
- Establish the operating relationships between the different systems and elements of said equipment.
- Describe the structure of the system and the elements that comprise it:
- Control elements.
  - Working parts.
  - Wiring and driving systems.

CE4.2 Classify the different control systems according to their technology and application.

CE4.3 Describe the elements of control, the elements of work and wiring, indicating their function, technical characteristics and relationship between them.

CE4.4 Describe the technical characteristics of the 3D equipment used and each of the parts of which the system is composed.

CE4.5 From the technical documentation of 3D equipment characterized by its drawings and technical memory:

- Check the main characteristics of the differentparts of those equipments.
- Check whether the regulations are applied.
- Prepare hypotheses about the effects that would produce on the operation of such equipment, the modification of the characteristics of the same or the malfunction of one or more parties.

C5: Develop measurement and/or control programs in the production processes of 3D elements, based on the specifications or conditions given and applying the regulations.

CE5.1 Based on specifications or given indications of a measurement and/or control system for 3D element production processes:

- Identify for its application the regulations that affect the layout.
- Draw and complete the general schemes, the situation of the elements of the same and the verification schemes.
- Complete and calculate the basic parameters so that they meet the conditions indicated in the specifications.

CE5.2 Finish and perform the calculation of the mechanical and dimensional magnitudes.

CE5.3 Select the equipment and elements of the installation from specific catalogs, responding to the characterization of the same.

CE5.4 Prepare a list of equipment, elements and dimensioned materials, using the nomenclature of the sector and indicating quantities and location of the verification elements.

C6: Design and develop measurement systems and/or control of production processes of 3D elements.

CE6.1 Compile the necessary technical documentation (project, technical specifications, technical manuals and product manuals) for use in the programming of the measurement and / or control system.

CE6.2 Determine the needs to program the measurement and/or control systems, identifying the necessary equipment, elements and tools.

CE6.3 Select the development tools and equipment according to the equipment and elements of the system.

CE6.4 In a practical case of elaboration of a measurement and/or control system using the documentation, tools and necessary equipments:

- Elaborate the measurement and/or control scheme.
- Prepare the execution diagram.
- Verify the functionality of the established procedure.

C7: Draw up plans and diagrams of the entire process of manufacturing 3D elements, using computer applications and starting from the sketches, diagrams and technical documentation collected in the project or in the general list of equipment and elements of the facilities.

CE7.1 Draw the plans and diagrams of the 3D models taking into account sketches, diagrams and technical documentation collected in the project or in general equipment and elements of the facilities.
CE7.2 Draw the plans and diagrams of the 3D models in the corresponding format and with the standardized graphic specifications of the sector.
CE7.3 Draw the plans using the most appropriate symbology and representation system and complying with current regulations.
CE7.4 Graphically dispose the elements in the plans in a way that allows knowing the relationships established between them, and the presence of other facilities involved in the process.
CE7.5 Draw the plans and detail schemes, taking into account their specific construction, dimensions and connections.

C8: Determine the manufacturing units and the cost in the processes of printing and/or 3D scanning, from the project documentation and taking into account standard scales, or unit prices extracted from catalogs.

CE8.1 Identify the manufacturing units indicating the elements or characteristics that compose them, the quantities of each of them, the operations to be carried out in each one of them, assembly conditions, manpower involved and the time necessary for the execution.
CE8.2 Elaborate the costs of the manufacturing units taking into account the standard scales used in the sector or the unit prices extracted from catalogs.
CE8.3 Prepare the total cost of the process taking into account the total number of manufacturing units.
CE8.4 In a practical case of calculation of costs of a 3D model manufacturing project, using the necessary documentation and tools:

- Identify the measurements with their units.
- Identify the manufacturing units, and the quantities of each of them.
- Identify the materials and resources used.
- Calculate the estimated time for execution.
- Calculate the cost of the facilities.
- Prepare the budget in the established format or software.

C9: Determine the technical conditions of testing and commissioning by providing proposals for innovative improvements or research, applied to 3D printing and scanning systems, and/or measurement and/or control elements, taking into account the technical documentation and quality required

CE9.1 Identifies the technical specifications required to select the supply of materials, products and equipment, taking into account the characteristics, standards, regulations and homologations of manufacturing, quality and safety conditions.
CE9.2 Perform the reception tests required to ensure the level of quality established.
CE9.3 Apply the conditions of storage and handling of the materials and / or equipment, extracting the information from the technical documentation provided by the manufacturer.
CE9.4 Apply the reception conditions and verification protocols of the facilities according to the specifications of the corresponding documentation.
CE9.5 Collect all data and specific results in the corresponding documentation.
CE9.6 Consult the necessary technical documentation (project and technical specifications) compiled in the preparation of the work plan.

C10: Write the manual of service instructions, and maintenance of the printing and/or 3D scanning systems, of the measuring and/or control elements, taking into account the technical documentation of the project, and the required quality.

CE10.1 Organize and collect the information for the preparation of the manual of service and maintenance instructions.
CE10.2 Prepare the user's instruction manual for the user specifying the basic operating and safety conditions.
CE10.3 Prepare the start-up protocol following the instructions of the equipment manufacturers and taking into account safety regulations.
CE10.4 Prepare the maintenance manual specifying the inspection points, parameters to be monitored, periodicity of the actions and the general rules in case of breakdown or emergency.
CE10.5 Prepare instructions for environmental management.

C11: Write basic safety, health and environmental protection studies for the execution of the printing and/or 3D scanning project with the required quality.

CE11.1 Identify the risk factors associated with the operations to be performed.
CE11.2 Identify the risks associated with each of the risk factors, indicating the preventive measures and the protections to be used both individually, collectively and environmentally.
CE11.3 Prepare the basic safety, health and environmental protection study taking into account the risk factors, associated risks, protection measures, handling conditions given by the manufacturer and other safety studies of similar characteristic

Capacities whose acquisition must be completed in a real working environment

C2 (C2.3), C4 (C4.1), C6 (C6.4), and C8 (C8.4)

Other Capacities:

Assume responsibility for the work that is carried out and the fulfillment of the objectives.

Show creativity in the development of the work you make.

Propose alternatives in order to improve the results.

Finish the work according to criteria of suitability, speed, economy and efficiency.

Demonstrate a certain degree of autonomy in the resolution of contingencies related to their activity.

Learn new concepts or procedures and take advantage of training effectively using the knowledge acquired.

Contents:

1.- Planning/programming of 3D production projects.

1.1.- Meanings of the term project.
1.2.- Function of the planning / programming**.**
1.3.- Usual deviations in the project deadline**s.**
1.4.- Defects of application of planning / programming.
1.5.- Factors of technological and organizational innovation:
- Recently implemented organizational systems, recently implemented procedures and techniques, applications and recently implemented computer equipment.

2.- Methods of representation and calculation in planning.

2.1.- Concepts: tasks, hammocks, milestones, activities, path and critical path, process model, subprocesses, phases and subphases, structure of project breakdown.
2.2.- Temporal relationships between activities (start-start, start-end, end-end, end-start), total and free float.
2.3.- Gantt chart: representation, calculation, advantages and disadvantages.
2.4.- Critical way methods(CPM):
- Types, precedence network, arrows method or PERT; representation; calculation; advantages and disadvantages.
2.5.- Reference calendars.

3.- Development of 3D production projects.

3.1.- Initial phase: objectives, intervening agents; relationship with the design, contracting and execution phases; base program.
3.2.- Design phase: objectives, intervening agents; Previous, simultaneous and subsequent steps to the design phase. Stages in the elaboration of projects: building (preliminary study, preliminary project, basic project, execution project) degree of definition; delivery strategy of the design lots; relationship with the contracting and execution phases; design program; usual deviations in terms

(causes and effects).

3.3.- Contracting phase: objectives, intervening agents; supply systems for products and services under construction; strategy and lots of contracting; stages of the sourcing and contracting process; relationship with the design and execution phases; Hiring program; usual deviations in terms (causes and effects).

3.4.- Execution phase: objectives, intervening agents; relationship with the design and execution phases; Execution program.

3.5.- Deactivation phase.

4.- Basis of graphic representation.

4.1.- Representation systems. Dimension. Tolerances.

4.2.- Technical drawing of manufacturing processes:

- Elevations, floors and sections of 3D elements.
- Interpretation of the technical documentation of projects of 3D elements (plans, memory, specifications and budgets).

4.3.- Rules of graphic representation of standardized elements:

- Normalization of profiles, tubes, plates, strapping. Fixed and demountable unions.
- Superficial signs. Surfaces Rugosity. Machining signs
- Treatments of materials.
- Written indications.
- Symbology of facilities and schemes

4.4.- Overall plans:

- Schematics of facilities, equipment and flow diagrams.
- Electrical and regulation schemes.
- Pneumatic and hydraulic diagrams.
- Symbology, standardization and representation conventions.

4.5- Geometry and 3D adjustments:

- Geometric and dimensional regulations; Adjustments and tolerances.

4.6.- Dimensional accuracy in 3D printing:

- Resolution of the 3D printer. (Layer thickness) (ppp).
- Printing tolerance.

4.7.- STL reparation.

- Introduction to Mesh Repair.
- Neffabb basic.
- MeshMixer.

4.8.- 3D design models advices.

5.- 3D Model Design Software.

5.1.- CAD: Current Design Software.

- Openscad. Design of parts, through programming.
- Parameterizable designs. Source files.*.scad
- Freecad.
- Tinkercad.
- Google Sketchup.
- Autodesk applications:
  - 123D Design, 123D Make, y ThingMaker (TinkerPlay).
- Others: IntelliCAD, LibreCAD, DraftSight, Blender, 3Dtin, etc

5.2.- Other 3D design applications.

5.3.- 3D graphic file standards:

- *.SCAD, *.STL : Standard Triangle Language and *.AMF: Additive Manufacturing Format.

5.4.- Printer Firmware.

- Marlin:

- Load the firmware in Arduino. - Firmware files: (File configuration.h, and other files). - Marlin Firmware Configuration. - Calibration of the Printer. - Calibrated thermistors: (PID Control, Proportional, Integral Derivative). - Sprinter. Etc...

6.- 3D parts scanning.

6.1.- Introduction to photometric software.

6.2.- Applications for PC:

- Cyclop scanner of bq.
- Microsoft Kinect.
- Scan XYZprinting.
- Structure Sensor.
- Cubify Sense. Etc...

6.3.- Mobile applications.

- 123 Catch from AutodesK.

6.4.- Three-dimensional reconstruction of medical images.

- Creation of STL models, from tomography DICOM images:
- InVesalius; 3D Slicer; Osirix (Pixmeo); MITK (German Cancer research centre).

7.- Introduction of CNC equipment. Numerical Control Machines.

7.1.- Introduction to CNC (Numerical Control by Computer).

7.2.- History. Numerical Control (CN).

7.3.- Components and Architecture

7.4.- Classification.

7.5.- Operating principle:

- Coordinate system.

7.6.- Applications:

- Machine tools. Lathes Milling machines Boring, Automatic welding of SMD components, Etc.
- Metal modeling. Joinery, Carpentry. Sculpture. Ceramic, etc...

7.7.- CAD / CAM Systems (Design and Computer-Assisted Manufacturing).

7.8.- CNC programming:

- Programming in the Numerical Control.
- Manual programming, automatic programming.
- Foundations and methodology to prepare a program.
- Standardization of programming codes. DIN 66024 and 66025.
- CNC programming languages:
- Characters used in CNC programming; Codes G and M. Examples; * .STL and * .Gcode files. Examples.

8.- 3D printers:

8.1.- Types of printers.

- SLA: 3D printers by Stereolithography.
- SLS: 3D printers of selective laser sintering.

- 3D printers by injection.
- FDM: Printing by deposition of molten material:
    - 3D Cartesian printers; 3D Polar Printers; Delta 3D printers; 3D Printers by Robotic Arm.

8.2.- 3D Printing Technologies: (Addition printing).

8.3.- Evolution and type of 3D printers.

8.4.- 3D Printer Applications: Fields of Application:

8.5.- Process and Stages of 3D printing. Obtaining the STL:

- 3D design.
- 3D design programmed. SCAD.
- 3D scanning.
- From STL to G-Code. Laminators.
- G-Code 3D printing.

8.6.- 3D printers parts:

- Mechanics: structures (Methacrylate, Aluminum, Steel, XXL); smooth and threaded rods; Bearings; Bearings; Screws; Pulleys Gears; Transmission belts; Printed pieces; Parts Repositories.
- Electrónica: Arduino, SAV MK1, Sanguinololu, u Otras Placas; RAMPS. (Conectores. Shields. Pantallas LCD). Motores: (Motores paso a paso, Servomotores y Drivers o Controladores "Pololus"). Resistencias (Resistencias Calefactoras, Termistores); Finales de carrera; Hotends; Cama Caliente; Ventiladores.

9.- 3D Printing materials:

9.1.- Thermoplastic materials; Polymers; Metals; Alloys; Powder; Edible Materials; Finishes; Additives; Other materials.

10.- Verification and Quality of 3D products:

10.1.- Considerations to take into account:

- Cost of the Printer; Cost of printing materials. Price per Kg .; Print speed; Cost of the printed prototype; Color printing
- Post-printing work. (Removal of support material, Hardening of material with waxes and thermoplastic polymers, in ABS, use of acetone, Sanding, polishing by abrasion, varnish, etc ...).
- Other Physical-Chemical Characteristics: Hardness, Flexibility, Resistance, Opacity, Transparency, Rigidity, High Temperature, Colors. etc...
- Dimensional accuracy: (Resolution of the 3D printer. (Layer thickness), (ppp); Printing tolerance).

11.- Manuals of service instructions, and maintenance of printing systems and/or 3D scanning.

11.1.- Technical specifications of printing systems and/or 3D scanning.

11.2.- Conditions for commissioning the facilities: test protocol:

- Application regulations.
- Manufacturers documentation.

11.3.- Inspection points for maintenance and parameters to control.

11.4.- Preparation of data sheets and records.

11.5.- Preparation of safety and environmental recommendations.

11.6.- Preparation of service and maintenance manuals.

12.- Security in the elaboration and execution of projects of printing and/or 3D scanning. Regulations of safety and hygiene and environmental protection.

12.1.- Projects, type of security. Security plans in the execution of printing and/or 3D scanning projects.

12.2.- Identification of risk factors and associated risks.

12.3.- Preparation of basic safety and environmental protection studies.

12.4.- Collective and individual protection equipment.

Context parameters of the training

Spaces and facilities

The spaces and facilities will respond, in the form of a multipurpose classroom of a minimum of 2 m^2 per student, and a classroom of 80 m^2 or singular space, to the training needs, according to the Professional Context established in the Unit of Associated Competition, taking into account the applicable regulations of the productive sector, risk prevention, occupational health, universal accessibility and environmental protection.

Professional profile of the trainer:

1.- Mastery of knowledge and techniques related to the design of printed products in 3D, which will be accredited by one of the following two ways:

- Level 3 academic training, Technical Engineering, higher design studies, or other higher education, related to the professional field.
- Professional experience of at least 3 years in the field of competences related to this training module.

2.- Pedagogical competence accredited in accordance with what the competent Administrations establish.