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.