An integrated framework of reference for the qualification of personnel in coordinate metrology

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In the Digital Manufacturing context, Coordinate Measuring Systems (CMSs) are an important resource both for advanced product/process engineering and for quality control.

Measurement results are used to take decisions, and inappropriate measurement process can lead to wrong decisions, productivity losses, low-quality products and loss of reputation. When using CMSs, reliability of results depends strongly on the competence of users.

Qualification of personnel in Coordinate Metrology is therefore a subject that is highly relevant to many sectors of industry.

Features of current training and qualifications on CMSs:

- Mostly specific to Coordinate Measuring Machines;
- Other CMSs treated separately (e.g. CT) or ignored (e.g. laser trackers);
- Limited modularity in qualifications related to the use of different types of CMSs;
- Separate schemes for the qualification of personnel using specific equipment;
- Dependency from a the specific training proposal;
- Difficult qualification recognition and transfer among Europe;
- No use to the European Credit system for Vocational Education and Training (ECVET).

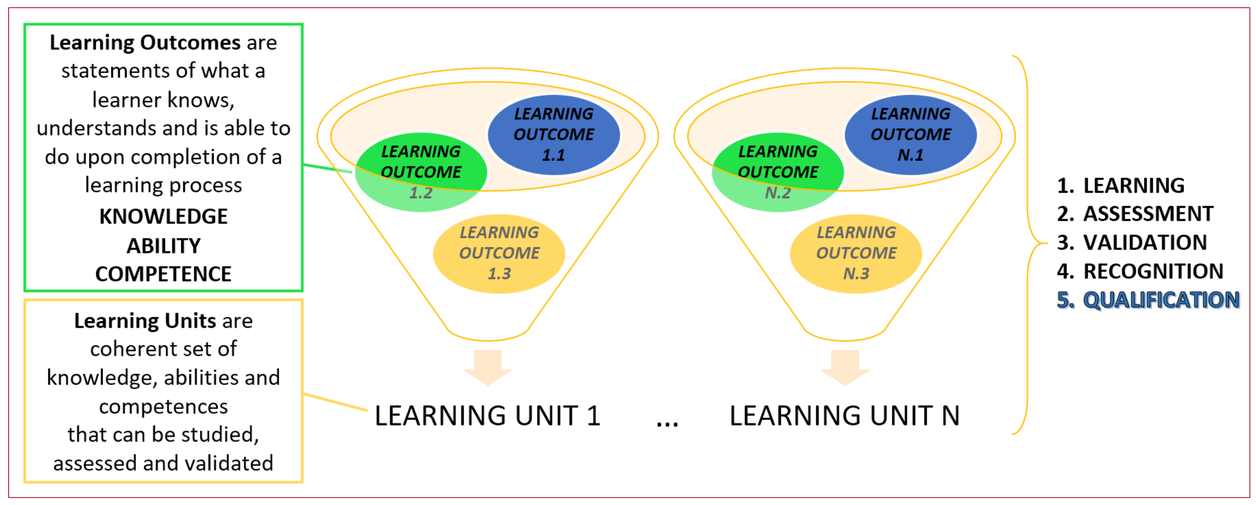
AN INDEPENDENT FRAMEWORK OF REFERENCE

The proposed framework of reference for the qualification of personnel in Coordinate Metrology is consistent with the **ECVET** and it is based on the identification of 200+ **Learning Outcomes (LOs)** grouped in **Learning Units (LUs)**.

Main expected benefits:

- To make training proposals **consistent** in terms of LOs against a common reference;
- To increase the **employability** and use of **qualifications** related to Coordinate Metrology;
- To allow easier identification of training needs in **SMEs** and large industrial organisations.

The framework is **independent from the training proposals** and allows the definition of competencies for specific **qualifications.**



INTEGRATED MODULAR STRUCTURE

The **integration** of **F**undamental aspects common to all the CMSs and technology **S**pecific content in a modular structure allows the definition of qualifications considering the combination of transversal/cross LOs and device specific ones.

10 STEPS

To provide a consistent structure across qualifications, the LOs have been grouped in 10 sections inspired by the workflow linking the need (**measurement aim**) to the outcome (**measurement result**). The example shows a summary of a qualification in **Computed Tomography**, with an indication of the **F**undamentals and technology **S**pecific LOs.
The same approach allows a consistent definition on qualifications for other CMSs.

1. Identification of measurement requirements

- To identify the measurement requirements by the technical drawing, CAD model and other sources.
- To recall the GPS system elements with focus on the tolerances to be verified, including datums and datum systems, modifiers and filters indicators for form tolerances.

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2. Inspection planning

- To design an inspection plan based on the measurement requirements and on the measurement aim (e.g. product conformity, product R&D or reverse engineering).
- To recall and apply the decision rules for conformity and extrapolate the target (max permissible) measurement uncertainty.

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3. Equipment selection

- To recall the working principle, the main components and the applications of a CT system.
- To understand if the CT system meets the measurement requirements taking into account multiple factors, such as accuracy, part dimensions, shape complexity, material sensitivity
- To interpret the basic metrological performance indicators for CT and state typical reference artefacts.

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4. Workpiece preparation

- To recall the importance of preparing the workpiece and of considering temperature effects.
- To understand how to clamp and locate the workpiece in the CT kin. system to optimize the scan.

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5. Measuring system preparation

- To recall procedures for set-up and initialise the CT, ensuring proper conditions.
- To understand the importance of CMS verification.
- To recall procedures for the CT system verification together with the related reference artefacts.

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6. Measurement process execution

- To understand how to optimize the CT scan parameters to perform the acquisition procedure.
- To recall and perform CT data preparation activities (i.e. volume reconstruction and surface determination)

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7. Evaluation process

- To recall CT data processing operations (e.g. filtering, partition, extraction, association, quantification).
- To evaluate the validity of the obtained results.

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8. Measurement uncertainty

- To interpret CT measuring result being aware of measurement uncertainty.
- To recall and limit the error sources (i.e. environment, evaluation, workpiece, device, operator).

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9. Documentation

- To report the CT measurement including results, information about the measuring process and CT configuration.
- To recall different types of documentation concerning the measurement aim.

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10. Infrastructure and environment

- To recall the safety protocols and good practices for the CT measuring environment.
- To safeguard reference standards to assure their integrity and stability.
- To assure CT performance by periodic maintenance and verification.

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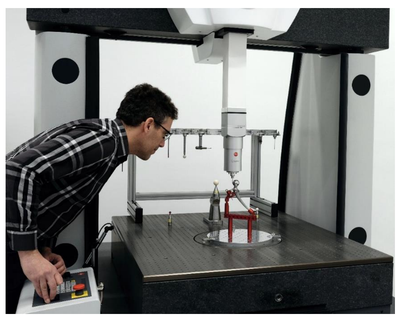
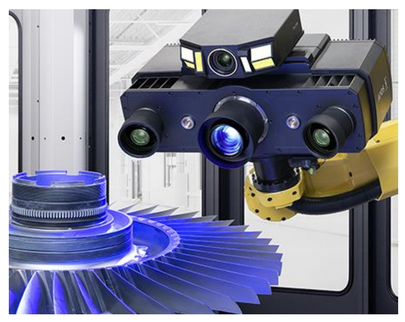


Coordinate Measuring Machine

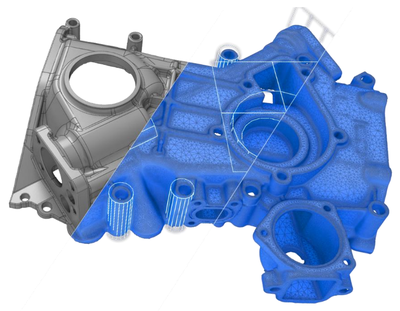
Articulated Arm CMM

Laser Tracker

Industrial Computed Tomography



Fringe Projection System



Reverse Engineering

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