



Newsletter

April 2024

ViDiT (Trustworthy virtual experiments and digital twins) is a European research project within the European Partnership on Metrology programme co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States. The project has 21 participants consisting of eight National Metrology Institutes, two research centres close to industry, five universities and six companies. The project is coordinated by Physikalisch-Technische Bundesanstalt (PTB).

Why ViDiT?

Virtual experiments and digital twins are key enabling technologies to achieve and realise European strategic policies devoted to sustainability and digitalisation within the complex framework of Industry 4.0 and the European Green Deal. Virtual experiments and digital twins are both simulation models that accurately replicate physical systems and characteristics in a virtual environment. Digital twins further include dynamic updates of the virtual model according to the observed state of its real counterpart. Hence, they consist of two parts, a Physical to Virtual connection that models the considered system and a Virtual to Physical connection that implements prevention and control strategies to achieve the target accuracy in the physical system.

The use of virtual experiments and digital twins in metrological applications requires uncertainty evaluation methods, as well as reliable validation procedures, to make them fit for purpose, e.g. as substitutes or extensions, to certified measurement devices. This project will develop these methods and procedures to ensure the reliability and trustworthiness of virtual experiments and digital twins in metrology. In addition, this will enable the traceability of modern measurement systems and it will boost and strengthen the European lead in this field. To facilitate the uptake of the developed methods by National Metrology Institutes and industrial stakeholders, three good practice guides will be written, and the applicability of the methods will be demonstrated in twelve case studies covering a variety of industrial metrology applications.

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Our objectives

The overall objective of this project is to develop methods and tools that will ensure the reliability and trustworthiness of virtual experiments and digital twins in metrology in order to support digital transformation within Industry 4.0 and the European Green Deal.

The specific objectives of the project are:

1. To develop methods for evaluating the uncertainty associated with real measurements for three different applications by using the results from corresponding virtual experiments in line with the current state-of-the-art for uncertainty evaluation.
2. To develop methods for uncertainty quantification for digital twins representing complex measurement processes and mechanisms for four different applications, in each case including the effect of dynamic influences on the digital model such as thermal drift or vibrations.
3. To develop approaches for the validation of virtual experiments and digital twins for all applications of objectives 1 and 2, using statistical procedures for the assessment of differences between calibrated standards and corresponding data from their virtual counterpart.
4. To demonstrate the practical applicability of the developed methods, using twelve different case studies covering all the metrological applications of objectives 1 and 2.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations and end users.

Highlights/Progress

On 17th & 18th of January 2024, the ViDiT project had a progress meeting at IDEKO/TEKNIKER in Elgoibar/Eibar (Figures 1-3).



Figure 1: The ViDiT progress meeting at IDEKO on the first day. On the second day, the meeting was held at TEKNIKER.

The first day was in **IDEKO** base on Elgoibar. This company is a **research center** founded in 1986. Its main focus is on the application of **advanced technologies** to improve competitiveness and efficiency in the manufacturing industry. IDEKO collaborates with companies, universities, and other research centers to develop innovative technological solutions that **address the challenges of industrial production**.

The second day of the meeting was in **Tekniker** at Eibar. Tekniker is a **technological center** specializing in **Advanced Manufacturing**. Its mission is to contribute to growth and well-being through **R+D+i**, supporting the overall society's sustainable competitiveness. Founded in **1995** their focus specializes in **Advanced Manufacturing technologies, Surface Engineering, Product Engineering, and ICTs**, transferring this knowledge to companies.

The consortium discussed the work done during the first 9 months of the project and planned for its continuation, especially for the next 9 months. There were 18 persons attending the meeting on-site and 17 persons attending the meeting online. **TEKNIKER** and **IDEKO** are very grateful to all members of the consortium for their participation and contributions. Their involvement is essential to the success of the meeting.

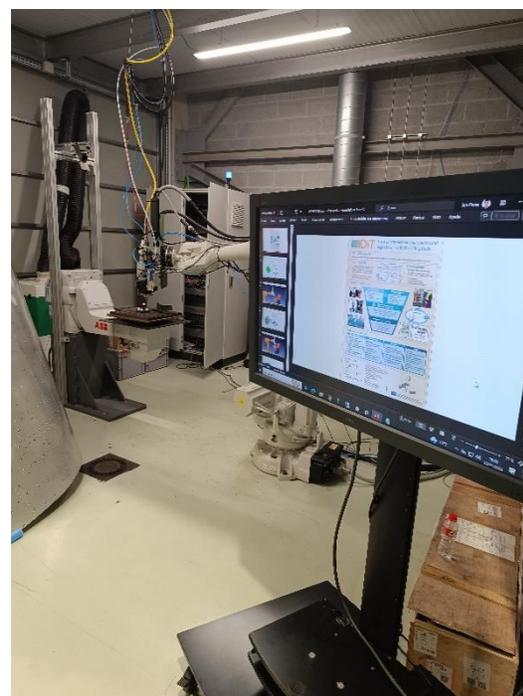


Figure 2: Tekniker visit with presentation of project DEMO.

The next project meeting will take place at ENS and LNE in Paris on 13th & 14th November 2024. It will be combined with a stakeholder workshop.

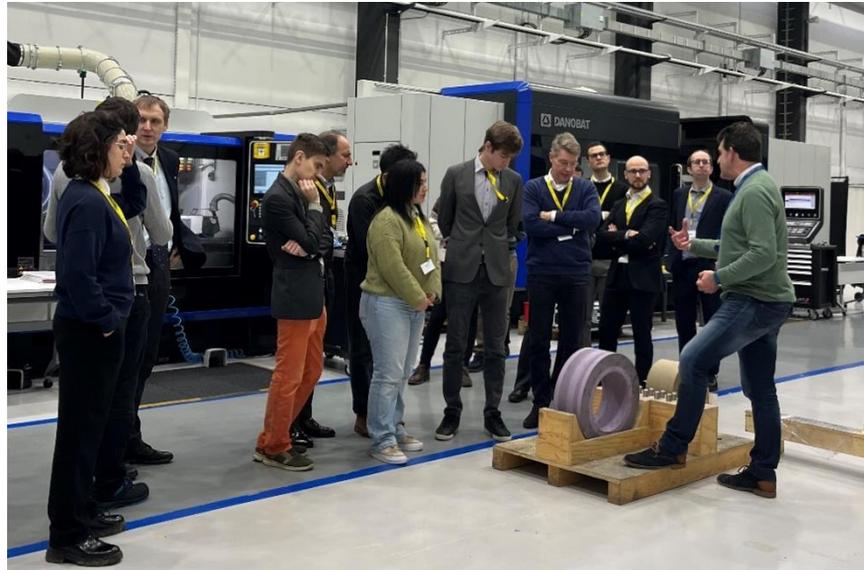


Figure 3: Lab tour at IDEKO.

Results from the ViDiT project have been presented at several conferences, including

- On September 11th, Giacomo Maculotti (Politecnico di Torino, Italy) was invited to join the special session on Measurement Uncertainty at the 23rd annual conference of [ENBIS](#). In his talk “Towards traceable and trustworthy Digital Twins for quality control” he provided insights on the ViDiT project.
- At the [3DMC](#), Brahim Ahmed (TEKNIKER, Spain) presented the development of the digital twin for the robotic 3D scanning system, emphasizing how to provide metrological traceability as an insight from the ViDiT project. This initiative is aimed at ensuring the creation of a trustworthy digital twin.
- In November 2023, Politecnico di Torino hosted an [industry seminar](#) organized by Dassault Systemes. In this seminar, Giacomo Maculotti gave a talk about “The Digital Twin for sustainable manufacturing Industry”.
- On November 30th, Sonja Schmelter (PTB, Germany) was invited to give a talk at the [14th M4DT Day](#) on “How to ensure trust in virtual experiments and digital twins in metrological applications?”
- On September 28th, Marcel van Dijk (VSL) gave an online presentation at the [AMCTM](#) conference about “Bayesian inversion applied to a virtual coordinate measurement machine”. This talk highlighted the work that was done to develop trustworthy uncertainty evaluation methods for a virtual coordinate measurement machine and virtual experiments in general.

At the [3DMC](#), Tekniker and IDEKO have also prepared a demo illustrating the robotic cell of the 3D digitization system (Figure 4). It highlighted the developed methods of self-calibration and self-referencing, which are crucial for the effective calibration of the system.

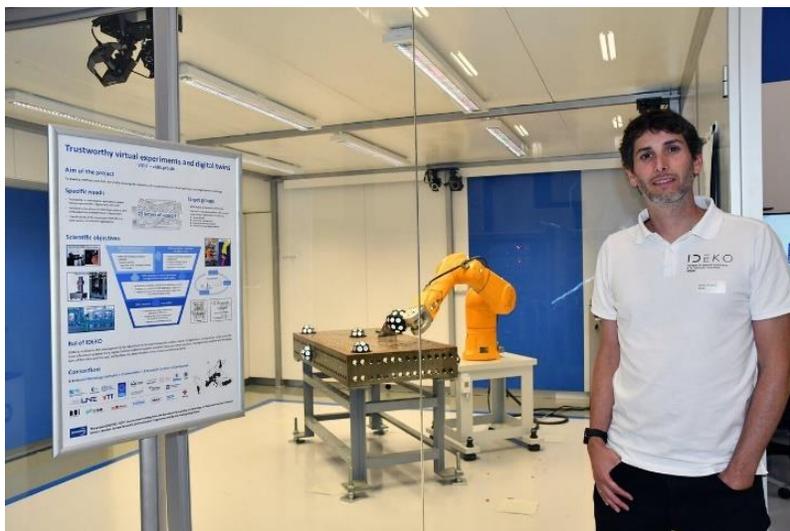


Figure 4. Demo at the 3DMC presented by Tekniker and IDEKO.

At UPM and FFII work has been done to develop the first steps for the physical-2-virtual implementation of the DT for the application: HV electrical measurement in insulated cable sheaths, considering:

- two cable systems with and without cross-bonding and
- the HV range 66 kV-220 kV with 5 A-500 A.

For the performance check, contacts were performed with the Spanish Transmission System Operator (TSO) Red Eléctrica (REE) for real data acquisition and analysis. For the DT implementation and the identification of the parameters relevant to the uncertainty, several research articles have been considered. The important parameters are dielectric degradation level (tan delta), type of insulation material, mechanical stress in the cables, variation of the capacity with the cable mechanical stress, heat conditions in the cable system, heat transfer coefficient, thermal conductivity and variation of the resistance with temperature. Software code is being implemented for the consideration of the dynamic dependence of the cable parameters and electrical quantities. Figure 5 shows the layout of an insulated cable system with a cross-bonding configuration, generated with the DT software being implemented. The induced currents in the cable sheaths are monitored.

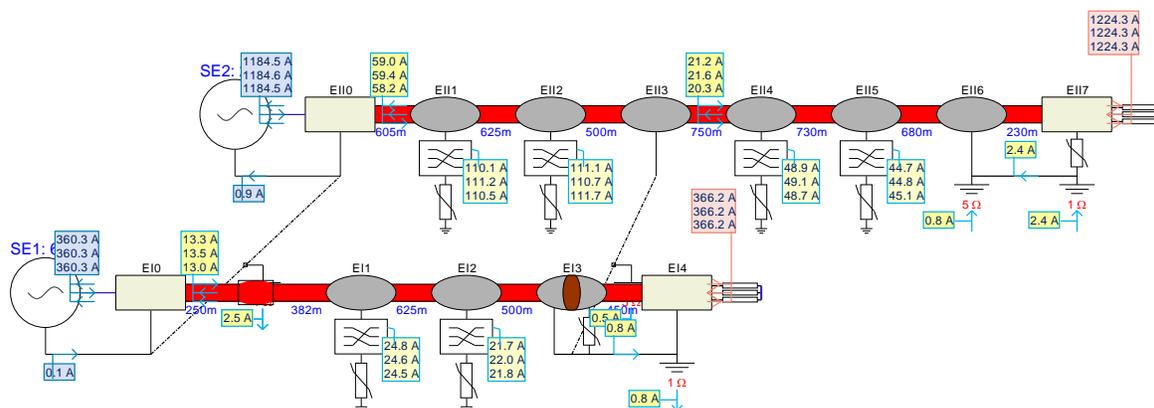


Figure 5. Induced sheath currents monitoring with the DT in an insulated cable system with a cross-bonding configuration.

The research unit of Politecnico di Torino has developed a non-parametric simulation approach to estimate the measurement uncertainty of nanoindentation. The approach has been demonstrated to be sensitive to different measurement conditions and highlight external influence factors negatively affecting the measurement dispersion and accuracy, e.g. high environmental noise and poor surface integrity of the measurand. These results will represent a first step towards the creation of a traceable and trustworthy digital twin for nanoindentation, and yield to the publication:

Giacomo Maculotti, Gianfranco Genta, Maurizio Galetto. [An uncertainty-based quality evaluation tool for nanoindentation systems.](#) *Measurement*, 225: 113974, 2024.

Impact on relevant standards

The consortium will promote the project's results and outcomes within the standardization community, as well as providing input into the standardization process. The project participants are involved in the JCGM WG1, which is in charge of the Guide to the expression of uncertainty in measurement (GUM) and its supplements. These documents serve as the de facto standard for evaluating uncertainty in metrology and are utilized globally at all stages of the measurement chain, from National Metrology Institutes to industry. Furthermore, the project's findings will be shared with working groups at DIN, ISO, and CEN. The relevant standards in preparation/revision will be identified for ISO, and work on these standards will be suggested to the appropriate working groups or committees. The participants will also present the project's outcomes to the International Academy for Production Engineering (CIRP), EURAMET, IMEKO and other networks, where they are active. All these activities will ensure the uptake of the project's results by the metrological community.

Longer-term economic, social, and environmental impacts

The outcomes of this project will include the provision of methods for the GUM-compliant uncertainty evaluation of virtual experiments and digital twins, as well as procedures for their validation. Furthermore, the newly developed approaches will be applied to a variety of industrially relevant test cases. These methods, procedures and case studies will enable the industry and users of virtual experiments and digital twins to e.g., optimise meter design or to improve the efficiency of welding processes. This will provide the basis for gaining traceability in several metrological applications, where virtual experiments or digital twins are employed (e.g., asphere and freeform metrology, nanoscale mechanical characterisation, the quality control of welded parts). This will lead to a reduction in the production time as well as to parts being manufactured with better surface quality. Industrial stakeholders will be involved in defining case studies to ensure the transferability of the developed methods and procedures for uncertainty evaluation and validation in industrial setups. The good practice guides that will be written in this project will be disseminated to industrial stakeholders to further support the uptake of the developed methods in these and other fields of application. Additionally, representatives of industry (both manufacturers and users) will be invited to a workshop on uncertainty evaluation for virtual experiments and digital twins, which will be organised and held by the project participants.

The outcomes of this project will provide a common understanding among European National Metrology Institutes on how to make virtual experiments and digital twins fit for use in metrological applications. The methods for assessing the uncertainty will be summarised and published in good practice guides so that they can be easily adapted by the metrological and scientific communities. Research papers will also be published in high impact peer reviewed journals, and as part of the knowledge transfer, a workshop on uncertainty evaluation for virtual experiments and digital twins, will be organised and held, to which representatives of academia and National Metrology Institutes will be invited. Results will be disseminated to the European Metrology Networks AdvanceManu and MATHMET as well as to the International Academy for Production Engineering (CIRP), which will make them accessible to a wider audience including stakeholders from all these networks. The collaboration of European National Metrology Institutes in this project will increase their visibility and authority in drafting common regulations and guidelines.

Stakeholder Committee

In the last months, the Stakeholder Committee of the ViDiT project has grown, now consisting of 18 members from different industrial sectors. The Stakeholder Committee provides the consortium with information to help them steer the project and they receive the project's results firsthand. The aim of the Stakeholder Committee is to clarify the needs of the various interested parties, to feed these into the project and to ensure that the project remains focused on practical, applicable, and essential research.

Upcoming events

There is a stakeholder workshop of the ViDiT project planned for 14th November 2024 at LNE in Paris, France (and online). Further information on this will be provided within the next months.

Some facts:

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| Project start date and duration: | | May 2023, 36 months |
| Coordinator: Sonja Schmelter, PTB | | Tel: +49 30 3481 7766 |
| Project website: https://www.vidit.ptb.de/home | | E-mail: vidit@ptb.de |
| Internal Funded Partners: | External Funded Partners: | Unfunded Partners: |
| <ol style="list-style-type: none"> 1. PTB, Germany 2. FFII, Spain 3. GUM, Poland 4. LNE, France 5. VSL, Netherlands 6. VTT, Finland | <ol style="list-style-type: none"> 1. ENS Paris-Saclay, France 2. IDEKO, Spain 3. INTI, Argentina 4. PK, Poland 5. POLITO, Italy 6. TEKNIKER, Spain 7. UNIPD, Italy 8. UPM, Spain | <ol style="list-style-type: none"> 1. DUI, Netherlands 2. FLEXIM, Germany 3. GEOMNIA, France 4. KROHNE, Germany 5. Mahr, Germany 6. SICK, Germany 7. TUBITAK, Türkiye |

Participants:



Funding:

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