ViDiT

Newsletter

June 2026

ViDiT (Trustworthy virtual experiments and digital twins) was 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 running from 1 May 2023 to 30 April 2026. The project had 22 participants consisting of eight National Metrology Institutes, two research centres close to industry, six universities and six companies. The project was coordinated by Physikalisch-Technische Bundesanstalt (PTB). This is the last newsletter published by the project.

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 developed these methods and procedures, which will 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 were written, and the applicability of the methods was demonstrated in twelve case studies covering a variety of industrial metrology applications.

Project Meeting and Stakeholder Workshop at PTB in Berlin

On April 22nd and 23rd, 2026, the ViDiT M36 meeting and stakeholder workshop took place at PTB in Berlin, Germany.

PTB is the National Metrology Institute of Germany with scientific and technical service tasks. PTB measures with the highest accuracy and reliability – metrology as the core competence. PTB stands for progress and reliability in metrology for the benefit of society, trade and industry, and science. PTB is located in Braunschweig and Berlin. A total of approximately 2100 members of staff work at PTB, 1700 of them in Braunschweig. PTB's tasks are the determination of fundamental and natural constants, the realization, maintenance and dissemination of the legal units of the SI, and safety technology – supplemented by services such as the German Calibration Service and metrology for the area regulated by law, for industry, and for technology transfer. As the basis for its tasks, PTB conducts fundamental research and development in the field of metrology in close cooperation with universities, other research institutions, and industry.

Figure 1: Project participants and stakeholders at PTB in Berlin.

During the M36 meeting, results of the project were presented, and remaining tasks were discussed internally. During the stakeholder workshop, the results were presented to a wider audience. The agenda had three thematic sessions focusing on flow measurement, advanced manufacturing, and digital twins in metrology, complemented by expert presentations, technical discussions, a poster session, networking opportunities, and a concluding general discussion. One notable feature of the stakeholder workshop was that, in addition to the results of the ViDiT project, other related projects were also presented. Further information on these projects can be found at the end of the newsletter.

Deliverables

The ViDiT project has produced three good practice guides and altogether eight deliverables. Some of them have been presented in previous newsletters but one good practice guide and three reports have been published lately. Their content is summarised briefly below.

All deliverables are available on the project website as well as on the Zenodo ViDiT community.

Good Practice Guide on the Validation of the Virtual Experiments and Digital Twins

The purpose of this good practice guide is on the validation of the virtual experiments and digital twins, which are topics in the ViDiT project, including detailed guidance on how to apply validation procedures (i.e. statistical procedures for the assessment of differences between calibrated standards and corresponding data from their virtual counterpart) to the virtual experiments and digital twins. The applications are technically very different, showing how multiple approaches for different concepts of virtual experiments and digital twins are put to work in different use cases that serve as examples.

Report on How to Account for Errors in the Surrogate Models of Virtual Experiments and Digital Twins

In this report, the different surrogate models that have been developed in the ViDiT project are discussed in detail. These surrogate models are efficient approximations of the virtual experiment/digital twin. They are deployed in cases, where using the full virtual experiment/digital twin would be too computationally demanding. The report covers how the surrogate models have been constructed, how they have been improved and refined, how the different error and uncertainty sources are treated and how the models can be validated.

Report on the Practical Applicability of the Developed Uncertainty Evaluation and Validation Methods to Five Selected Industrial Case Studies Including Virtual Experiments

The ViDiT project developed methods to ensure the reliability, traceability, and uncertainty evaluation of virtual experiments and digital twins for metrology, combining GUM-compliant approaches with Bayesian inference and Monte Carlo simulation, and providing validation procedures suitable for industrial deployment. This report translates these advances into representative industrial scenarios through collaboration with stakeholders. The report documents the practical applicability of the developed methods to five industrial case studies including virtual experiments.

Report on the Practical Applicability of the Developed Uncertainty Evaluation and Validation Methods to Seven Selected Industrial Case Studies Including Digital Twins

This report documents the practical applicability of the developed methods across seven digital twin-based case studies spanning optical/form measurement, nanoindentation, robotic 3D measurement, and electrical measurement, explicitly incorporating industrial requirements and feedback. It synthesizes objectives, models, validation strategies, quantitative results, and integration potential, complementing earlier good practice guides and reports by demonstrating fitness for purpose in realistic conditions.

Highlights

Multi-Fidelity Surrogate Modelling in Virtual Flow Metering

PTB has developed a surrogate model for predicting two-dimensional velocity fields in disturbed pipe flows, designed for use in virtual flow metering applications. The model uses Gaussian process regression in a multi-fidelity framework that combines abundant computational fluid dynamics (CFD) simulations with sparse laser Doppler velocimetry (LDV) measurements to produce fast and accurate flow field predictions. A key feature is the built-in uncertainty quantification, achieved through conformal calibration to ensure reliable 95% confidence intervals. The model was validated against high-fidelity LDV measurements across a range of flow conditions and pipe configurations, demonstrating strong predictive accuracy and successful correction of systematic CFD-LDV biases.

Key Highlights:

- **Multi-fidelity fusion:** CFD simulations (196 samples) and sparse LDV measurements (28 samples) are combined using Gaussian process regression, significantly reducing the need for costly experiments.
- **Strong prediction accuracy:** Per-sample root mean square error of 1.55% (calibration) and 1.92% (validation), with near-zero mean bias confirming no systematic over- or underprediction.
- **Reliable uncertainty quantification:** Conformal calibration achieves well-calibrated 95% confidence intervals, making the model suitable for metrological applications.
- **Computational efficiency:** Velocity field decomposition based on fast Fourier transform reduces data dimensionality by 72.5%, enabling fast predictions across the full parameter space.

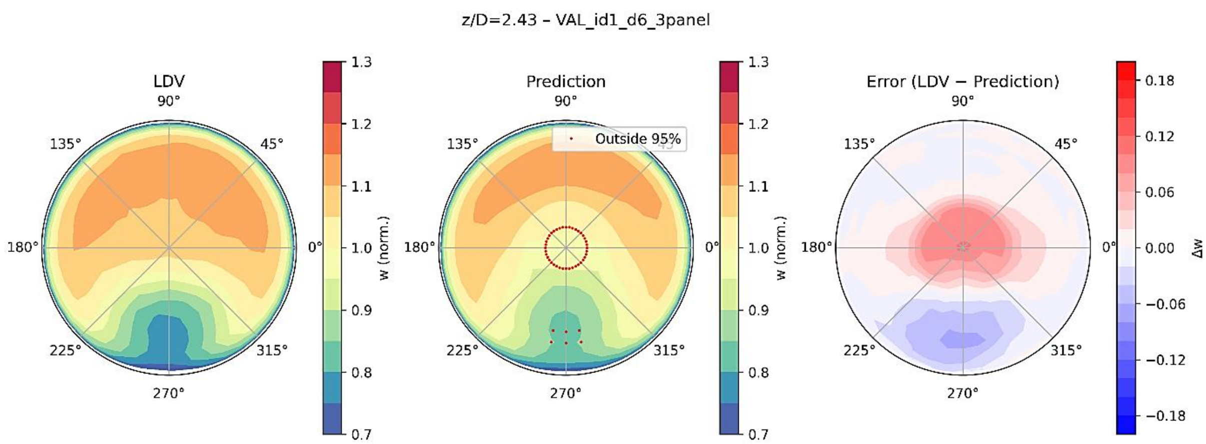

Figure 2: Validation example showing (left to right) LDV reference measurement, surrogate model prediction (with outliers of the conformally calibrated 95 % confidence bounds marked in red) and prediction error (difference between LDV data and prediction).

Development of a Digital Twin for the Improved Operation of Power Lines

A digital twin has been developed, using as starting point a virtual experiment that was already developed and in use for the study of the grounding connections of high voltage alternating current (HVAC) cable systems, see Figure 3. This digital twin enables dynamic analysis and interaction with HVAC insulated cable systems for improved operation of the power lines. It also allows performing maintenance and corrective actions in a more efficient way.

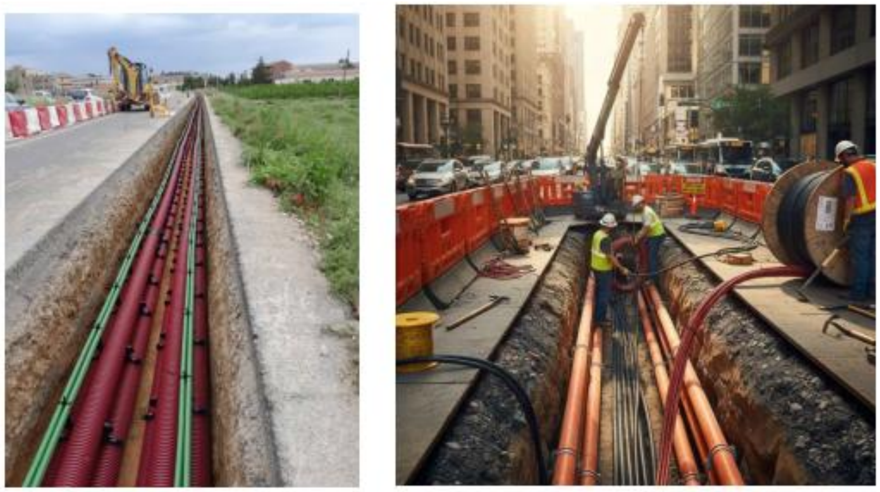

Figure 3. Insulated cable systems under supervision.

This research focused mainly on improving the calculation of the sheath induced currents by considering dynamic aspects, such as the heating of the cable over time due to the current circulating by it. It also focused on the physical-to-virtual (P2V) and virtual-to-physical (V2P) connections, see Figure 4. If the digital twin provides accurate results, then the necessary measures can be taken to correct or minimize the effect of any real problem that might arise. For example, the load flow could be rerouted through other lines, to avoid aggravating an existing problem in the power line under supervision.

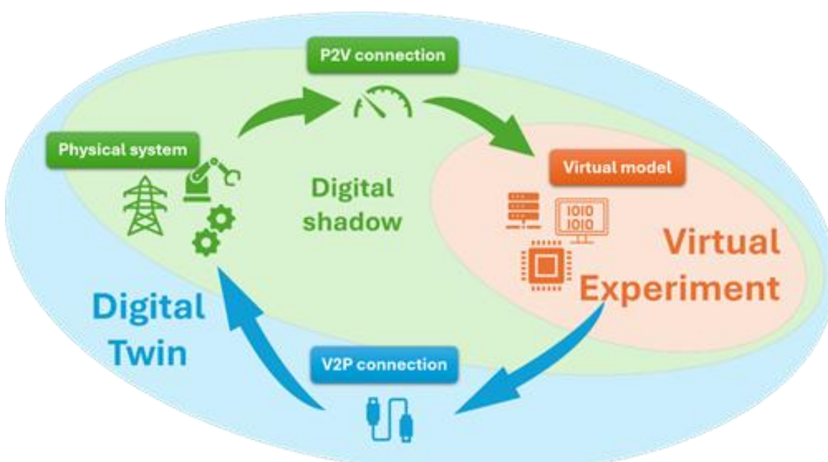

Figure 4: Digital twin concept (physical ↔ virtual interaction).

To perform all this with the required effectiveness, the digital twin is based on the calculation of the sheath currents under varying operating conditions. To do so, special attention has been given to the effect of the temperature, the cables geometry and the cables' capacity in the calculated sheath currents.

A key aspect of this research is the evaluation of the uncertainty sources, both individually and collectively, understanding their impact on the model outputs and improving the confidence in digital twin-based decision making. The results of the software are now accompanied by the estimation of an uncertainty interval, increasing the reliability of the digital twin for its use in an industrial environment. An example of the results given by the digital twin is shown in Figure 5.

The functioning of the digital twin has been validated against three real HVAC cable systems of 45 kV, 220 kV and 400 kV, with solid bonding and cross bonding sheath configurations. This confirms that the digital twin is ready to support condition monitoring and operational assessment of insulated power cable systems. Overall, the developed digital twin provides practical value for electrical companies by enabling optimized design, maintenance, and lifecycle management decisions for power cables' infrastructure.

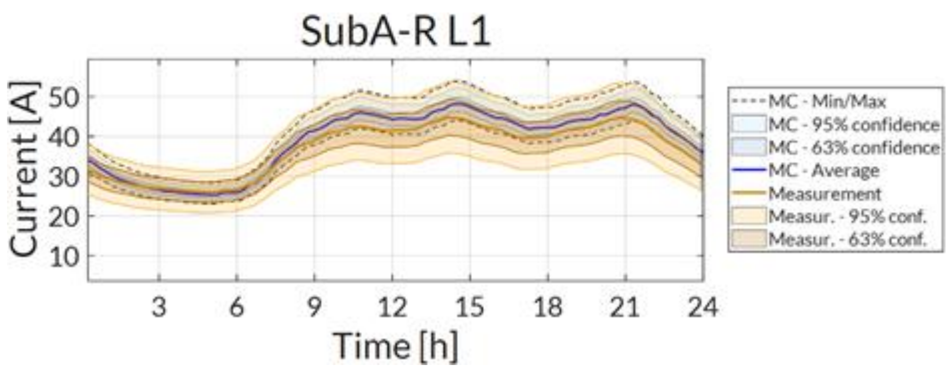

Figure 5: Results provided by the digital twin compared with real on-site measurements.

Publications and Presentations

Results of the project have been delivered in 29 presentations at national and international conferences (e.g. WTP congress, IMEKO 2024, ICHVE 2024, 3DMC, etc.), 14 presentations at workshops (e.g. MSMM 2023, VirtMet2025, etc.), and three presentations at symposia (e.g. Dassault Systemes industry seminar "The Digital Twin for Sustainable Manufacturing Industry"). Up to date, 15 peer-reviewed papers has been published and three more has been submitted for publication. The topics of the papers include the development of uncertainty evaluation methods, validation procedures, and surrogate models for VEs and DTs, often using the case studies of the project as examples. In addition, a webinar with the title "Metrological Digital Twin for Nanoindentation: Traceable automated procedure for out-of-control measurements identification" was held in April 2026.

A list of publications of the ViDiT project can be found at the project website.

Results, Impact, and Outlook

The project has been successful, and all partners and stakeholders deserve many thanks for their effort and interest. The ViDiT project advanced the development of trustworthy virtual experiments and digital twins for metrology by establishing methods to validate simulation-based measurements and quantify their uncertainties. Through a series of industrially relevant case studies, the project demonstrated how virtual experiments and digital twins can complement or enhance traditional measurement systems while maintaining confidence in measurement results. It delivered practical tools, validation procedures, datasets, and guidance to support the adoption of these technologies across industry and research. The project also strengthened collaboration between metrology institutes, academia, and industrial partners, helping to harmonize best practices for digital measurement.

The funding from the European Partnership on Metrology made this project possible, and similar topics regarding digitalization in metrology are studied further in ongoing projects as

- Traceable machine vision systems for digital industrial applications – DiVision
- Application of digital-metrological twins for emerging measurement technology in advanced manufacturing – ADAM
- Traceability for industrial 3D digitalisation by advanced scanning systems – ScanClouDT
- Automated, adaptive and uncertainty-aware smart measurements using machine learning – A3SmartML
- Metrology for reliable power grid data analytics – GridData

Although measurement instruments in these projects are of different type, they all contribute to a better understanding and knowledge of new metrology and its digitalisation.

Some facts:

<table>
<tr><td colspan="2">Project start date and duration:</td><td>May 2023, 36 months</td></tr>
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1. PTB, Germany
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Participants:

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EUROPEAN PARTNERSHIP

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METROLOGY PARTNERSHIP

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