

A PDF/A-3 solution for digital calibration certificates at METAS

The digitalisation of metrology poses a challenge to all members of the community. METAS proposes an approach for digital calibration certificates (DCCs) based on a PDF/A-3 solution that could be a stepping-stone towards the digitalisation of metrological services.

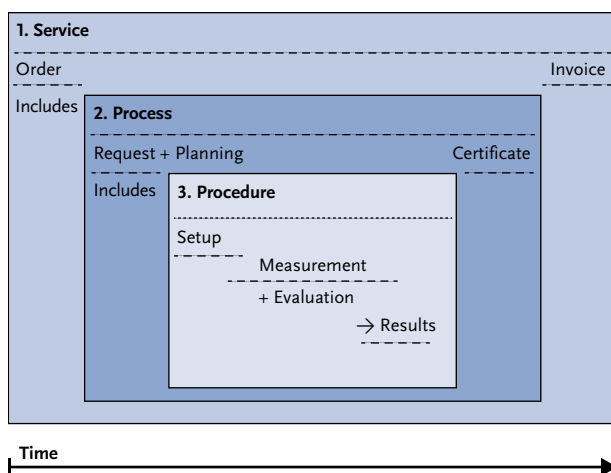
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The transformation to digital metrology services starts with the digital calibration certificate (DCC). This natural digitalisation of the current paperless calibration certificate will address the new requirements and needs of NMIs, calibration laboratories and industry in general.

The METAS DCC approach converges on the common requirements agreed at European level, aimed to cover new needs from calibration laboratories and customers, while following ISO/IEC 17025:2017 [1]. At METAS we are proposing a solution for DCCs based on a PDF/A-3 [2]; a specific file format used for long-term archiving of digital documents, in which any additional information (i.e., data and metadata) can be embedded before the file is digitally signed. With this bottom-up approach, METAS will provide an easy-to-understand transitional solution that can be tested and expanded, while focusing on the customers' current and future needs.

Introduction to digital metrological service

Digitalisation, according to Gartner's glossary, is «the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business» [3]. This implies that digitalisation does not only mean to streamline existing services, but ultimately it implies the creation of new markets by means of digital technologies.



1: Visual representation of current metrological services [4].

This article focuses on the digitalisation of metrological services. Here it is important to distinguish between digitalisation and digitisation. Digitisation means the conversion from an analog to a digital form. Therefore, the digitisation is often a first step towards digitalisation. However, the digitalisation of a metrological service does not only include the update of the service by means of digitisation and the integration of existing competences.

To digitalise a metrological service implies to find new additional value in METAS services by extending features in ways that were not possible beforehand. Figure 1 presents how current metrological services in METAS can be deconstructed. Within the described schema, the certificate is the perfect place to start our digitalisation efforts [4].

Digital calibration certificates and common requirements

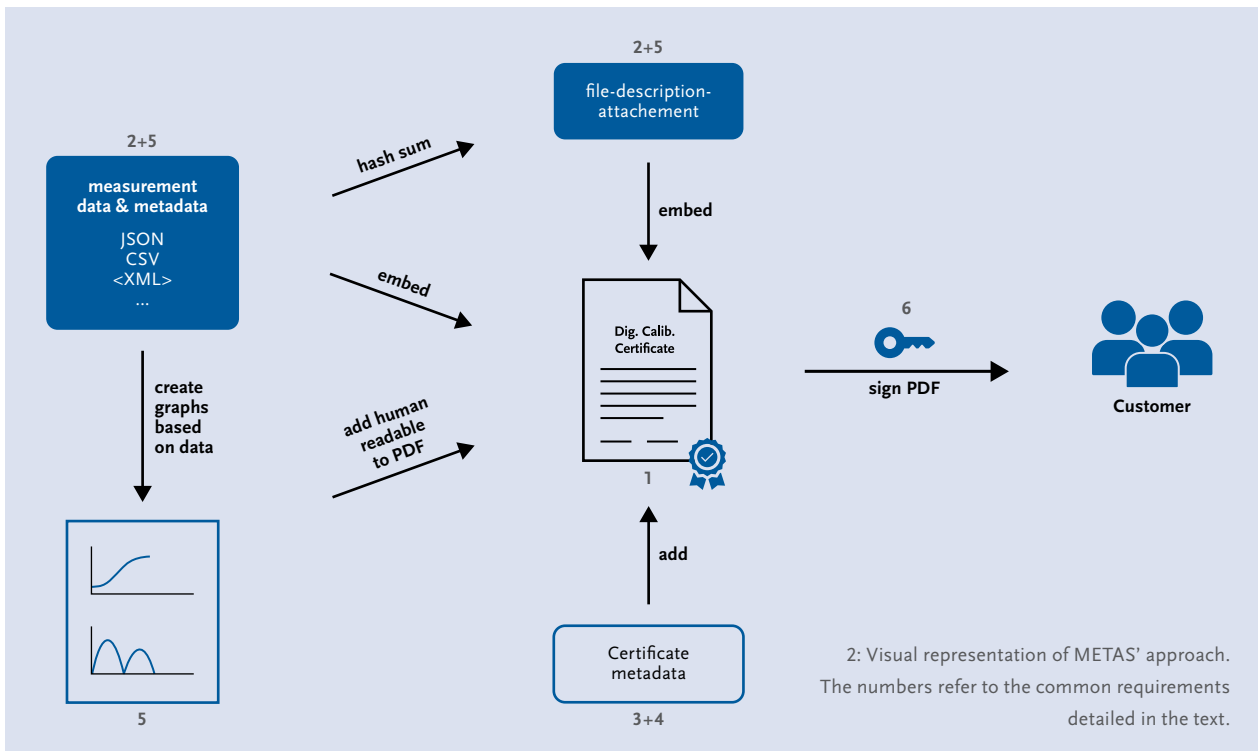
Our proposal for a digital calibration certificate (DCC) at METAS poses a natural evolution of the existing calibration certificate. At METAS we believe that the development of a DCC must start in a shared agreement, i.e., in common requirements and needs from NMIs, calibration laboratories and industry. Therefore, our approach focuses on converging the agreed common requirements for DCCs with clearly defined needs from laboratories and customers, while following ISO/IEC 17025:2017 [1].

In order to find consensus at European level, current work of EURAMET TC IM project 1448 «Development of digital calibration certificates» [5] focuses on the definition of common requirements for DCCs, regarding both their content and their potential interfaces.

Common requirements for digital calibration certificates

During the TC IM 1448 project meeting organized at METAS in January 2020, the following common requirements for DCCs were agreed on:

- Requirement 1: a DCC must be useful for long-term archiving (i.e., it shall be as useful as current paper and/or paperless PDF certificates).
- Requirement 2: a DCC must be machine-readable (i.e., it shall allow machine-to-machine [M2M] communication).
- Requirement 3: a DCC must be traceable directly or indirectly to the national standards (i.e., it shall provide the same results information from a current calibration certificate).
- Requirement 4: a DCC must constitute proof of metrological traceability (i.e., it shall provide the same metrological information from a current calibration certificate).



- Requirement 5: a DCC may include additional information (data and metadata) (i.e., it may include results data points, numerical calibration curves or any other additional calibration evaluation information required by the customer).
- Requirement 6: a DCC must use cryptographic signatures as security procedures to guarantee a. integrity, b. authenticity (and, if needed, c. confidentiality) of the calibration certificate.

Figure 2 presents how METAS' approach follows the agreed common requirements for a DCC. While the metrological aspects (R3 and R4) are covered by the composition of certificate following ISO/IEC 17025:2017 [1], the PDF/A-3 format allows METAS' solution to covers R1, R2 and R5. Finally, IT security aspects (R6) are covered by the digital signature function of the resulting PDF/A-3 file.

Customer- and laboratory-oriented transitions

Our approach takes into consideration the transition period from current calibration certificates to digital calibration certificates (DCCs) and the impact for both customers and laboratories.

Hence, following the common requirement for DCCs from the previous section, at METAS we aim to meet the current and future needs of our customers, as well as the needs learned from our laboratories and other calibration laboratories. The DCC examples presented at IMEKO Conference 2021 [6] have their limitations and only represent demonstrators of the METAS approach towards a fully integrated PDF/A-3 DCC solution as part of the digitalization of metrological services. The following section focuses only on the VNA example. For the rest of examples, refer to [7].

Digital calibration certificates for VNA

In the radio frequency and microwave domain, VNA Tools is one of the standard software tools in the evaluation, visualisation and assessment of uncertainty of Vector Network Analyser (VNA) measurements.

A VNA measures the frequency response of a single component or a network consisting of many components. These components can be both passive and active. It measures amplitude and phase of reflection and transmission of a high frequency signal that is sent into the component or the network. The measurands are referred to as scattering parameters (or S-parameters).

For a calibration service, VNA Tools is used to perform S-parameter measurements with a VNA and assess associated uncertainties. The data is collected in a VNA Tools file format, specifically designed to store S-parameter estimates and uncertainties.

In the next step, a LaTeX template (available on METAS GitHub [8]) to automatically generate the digitalized certificate with the attached VNA Tools files. This is a great example of METAS PDF/A-3 solution for DCCs, since our customer can load the generated digital calibration certificate directly into VNA Tools and access the additional information (calibration data) from within the tool. From there, the results data can be visualised in various ways, transformed, further processed and/or even exported into different file formats.

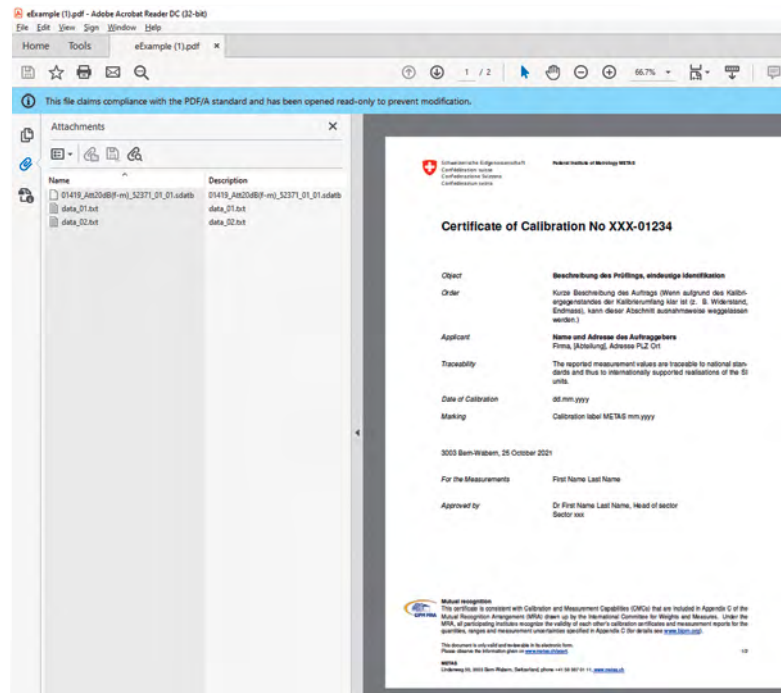
This mechanism is available to any customer, because VNA Tools is a free software [9].

Conclusion and further reading suggestions

The transformation towards digital metrological services starts with DCCs. In this article, we described the DCC approach at METAS. This solution creates PDF/A-3 documents, flexible enough to cover the current and future needs from both customers and laboratories. The presented solution entails one type of solution for DCCs, following both ISO/IEC 17025:2017 and the agreed common requirements. Further work is necessary towards harmonised DCCs, such as the integration of the System of Units into the digital framework [10] [11], and its adoption by BIPM key comparison database API [12]. Additional harmonisation discussions, regarding the data formatting and the representation of measurement data and metadata are required towards greater DCCs (e.g., with machine-readable and machine-executable content [13]). Potential future implementations of DCCs might follow similar objectives as ZUGFeRD/Factor-X [14] a hybrid electronic invoice format embedding a standardised XML invoice file inside a PDF/A-3 invoice document for automated billing processes.

References

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- [3] Information Technology – Gartner Glossary: Digitalization [https://www.gartner.com/en/information-technology/glossary/digitalization]
- [4] Brief overview of the future of metrology [https://doi.org/10.1016/j.measen.2021.100306]
- [5] EURAMET TC IM project 1448 «Development of digital calibration certificates» [https://www.euramet.org/technical-committees/tc-projects/details/project/development-of-digital-calibration-certificates/]
- [6] IMEKO Conference 2021: The proceedings of IMEKO 2021 [https://www.sciencedirect.com/journal/measurement-sensors/special-issue/10CTR9ZPK1R]
- [7] PDF/A-3 solution for digital calibration certificates [https://doi.org/10.1016/j.measen.2021.100282]



3: Screen capture of DCC from VNA: The PDF/A/3 solution includes additional information (data and metadata) relevant to the customer [7].

- [8] METAS GitHub: eCertificate LaTeX template [https://github.com/metasp-ch/metasp-ecertificate]
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Eine PDF/A-3-Lösung für digitale Kalibrierzertifikate

Die Transformation zu digitalen metrologischen Dienstleistungen beginnt mit einem digitalen Kalibrierzertifikat (DCC). Ein DCC stellt eine Weiterentwicklung des bestehenden Kalibrierzertifikats dar und sollte Anforderungen und Bedürfnisse von NMIs, Kalibrierlaboratorien und Industrie berücksichtigen. Daher konvergiert unser Ansatz auf Mindestanforderungen für DCCs mit klar definierten Anforderungen von Laboratorien und Kunden, in Anlehnung an ISO/IEC 17025:2017. Unser Vorschlag für ein digitales Kalibrierzertifikat basiert auf einer PDF/A-3-Lösung. PDF/A-3 ist ein Dateiformat, das zur Langzeitarchivierung digitaler Dokumente dient und in dem sich beliebige Dateitypen einbetten lassen. Ein Beispiel aus dem Bereich Hochfrequenz verdeutlicht diesen Bottom-up-Ansatz:

Die Messunsicherheiten von Vektornetzwerkanalysatoren (VNA) zu kennen, ist entscheidend, um Aussagen über die Konformität von Geräten und Komponenten zu machen. Bei Kalibrierungsdienstleistungen ist VNA Tools eine Standard-Software für die Auswertung, Visualisierung und Bewertung der Unsicherheit von VNA-Messungen. Um das digitalisierte Zertifikat mit den angehängten VNA-Tools-Dateien automatisch zu generieren, wird eine LaTeX-Vorlage erstellt.

Unser Kunde kann das generierte digitale Kalibrierzertifikat direkt in VNA Tools laden und auf die Kalibrierungsdaten innerhalb des Tools zugreifen. Von dort aus können die Daten auf verschiedene Weise visualisiert, transformiert, weiterverarbeitet oder in verschiedene Formate exportiert werden. Dieser Mechanismus steht jedem Kunden zur Verfügung, denn VNA Tools ist eine kostenlose Software. Dies ist ein erstes Beispiel für die PDF/A-3-Lösung für DCC des METAS. In der Metrologie braucht es zusätzliche Standardisierungsdiskussionen über die Formatierung und Darstellung von Messdaten und Metadaten, um mehr maschinenverwertbare DCCs auszustellen.

Une solution PDF/A-3 pour les certificats d'étalonnage numériques

La transition vers des prestations de métrologie numériques commence avec un certificat d'étalonnage numérique (DCC). Le DCC est un prolongement du certificat d'étalonnage existant et devrait tenir compte des exigences et besoins des instituts nationaux de métrologie, des laboratoires d'étalonnage et de l'industrie. Notre approche converge donc vers des exigences minimales pour des DCC avec des exigences clairement définies par des laboratoires et clients, sur le modèle de la norme ISO/IEC 17025:2017. Notre proposition pour le certificat d'étalonnage numérique repose sur une solution PDF/A-3. PDF/A-3 est un format de fichier qui sert à l'archivage à long terme de documents numériques et dans lequel tout type de fichier peut être intégré. Un exemple tiré du domaine de la haute fréquence illustre cette approche «bottom-up»:

Connaître les incertitudes de mesure d'analyseurs de réseau vectoriel (VNA) est un facteur décisif pour pouvoir se prononcer sur la conformité d'appareils et de composants. En ce qui concerne les prestations d'étalonnage, VNA Tools est un logiciel standard pour l'interprétation, la visualisation et l'évaluation de l'incertitude des mesures réalisées par un VNA. Pour générer automatiquement le certificat numérique avec les fichiers VNA Tools joints, un modèle LaTeX est créé.

Notre client peut charger le certificat d'étalonnage numérique généré directement dans VNA Tools et accéder aux données d'étalonnage figurant dans l'outil. De là, les données peuvent être visualisées, modifiées et traitées de diverses manières et être exportées dans divers formats. Ce dispositif est à disposition de chaque client, car VNA Tools est un logiciel gratuit. Il s'agit d'un premier exemple de l'application de la solution PDF/A-3 pour le DCC de METAS. Des discussions supplémentaires sur la standardisation du formatage et de la représentation des données de mesure et métadonnées doivent être menées dans le domaine de la métrologie, afin d'établir davantage de DCC pouvant être traités automatiquement.

Una soluzione PDF/A-3 per i certificati di taratura digitali

La trasformazione verso le prestazioni metrologiche digitali inizia con un certificato di taratura digitale (DCC). Il DCC costituisce uno sviluppo del certificato di taratura esistente e deve tener conto dei requisiti e delle esigenze di istituti nazionali di metrologia, laboratori di taratura e industria. Il nostro approccio converge con i requisiti minimi per DCC grazie a una definizione chiara delle esigenze di laboratori e clienti in conformità con ISO/IEC 17025:2017. La nostra proposta per un certificato di taratura digitale si basa su una soluzione PDF/A-3, ovvero un formato di file concepito per l'archiviazione digitale a lungo termine di documenti e nel quale può essere integrato qualsiasi tipo di file. Un esempio dal mondo delle alte frequenze illustra questo approccio bottom-up:

Conoscere l'incertezza di misura degli analizzatori di reti vettoriali (VNA) è decisivo per potersi pronunciare sulla conformità di dispositivi e componenti. Per il servizio di taratura, VNA Tools è un software standard per la valutazione, la visualizzazione e la classificazione dell'incertezza di misurazioni effettuate tramite VNA. Al fine di generare automaticamente un certificato digitale con i file di VNA Tools allegati, viene creato un modello LaTeX.

Il nostro cliente è in grado di caricare in VNA Tools il certificato di taratura digitale generato e accedere ai dati di calibrazione direttamente dal software. Da qui, i dati possono essere visualizzati, trasformati o elaborati in diversi modi oppure esportati in diversi formati. Questo dispositivo è a disposizione di qualsiasi cliente, perché VNA Tools è gratuito. Questo è che un primo esempio per la soluzione PDF/A-3 per DCC del METAS. Nel mondo della metrologia sono richieste ulteriori discussioni sulla standardizzazione riguardo alla formattazione e alla rappresentazione dei dati delle misurazioni e dei metadati, al fine di mettere a disposizione ulteriori DCC elaborabili elettronicamente.