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# RECENT ADVANCES OF THE LONG-TERM AVAILABLE DCC SCHEMA VERSION 3

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***Abstract*** – The aim of this publication is to provide an overview of the recent advances of the XML schema for digital calibration certificates. The motivation and benefits of digital calibration certificates is explained and the basic requirements to which the DCC complies are stated in Section 1. A representative selection of changes is presented and explained in Section 2; and finally, conclusions are drawn, and an outlook on further work is given in Section 3.

***Keywords*: DCC, XML schema, data types, data elements**

## 1. INTRODUCTION AND MOTIVATION

Digitization is more important than ever. Experience shows us that digitization helps us to optimize the work processes and to reduce wasting our limited resources. In recent years, many steps towards the digitization in the area of metrology were made. One major step was laying the foundations for the development of a standard for digitization of the calibration certificates: Digital Calibration Certificate (DCC). Consequent use of DCCs in calibration, quality management, and production processes will provide machine readable and interpretable data, thus resulting in media break-free reusability of the calibration data. This makes the introduction of the DCC potentially valuable and important for the industry. This is even more beneficial as the industry still uses the 4-eyes-principle to transfer calibration data from paper into digital form. That means a huge amount of work and is ultimately prone to human error. Using DCCs will allow these resources to be shifted to other areas. Moreover, the DCC will mean more reliable processes and eventually a complete digitization of the value chain in many different industries.

The prototype of the digital calibration certificate (DCC) was first described in the PTB Mitteilungen [1] in 2017. The fundamental architecture of the DCC has been published in [1]. DCC is based on an XSD-Schema which helps with the generation of calibration data in XML format. DCC uses SI units with the format that is defined in the D-SI (Digital-SI) [2]. DCC also complies with the internationally accepted documents, such as the SI-Brochure of the BIPM [3], International Vocabulary of Metrology VIM [4], Uncertainty of measurement GUM [5] and the list of basic physical constants (CODATA) [6].

## 2. RELATED WORK

With the version 3.0.0, the DCC-Schema was finally published as a publicly available open-source project in the summer of 2021. There were many changes compared to the previous version 2.4.0. Before the publication of the schema version 3.0.0, we have generated sample DCCs in collaboration with our partners, such as Boehringer Ingelheim and Perschmann Calibration. This collaboration has helped us tremendously to better understand the needs of the industry and the calibration laboratories. There were some very important additions for the industry, some corrections, and optimizations. In addition, LGPL [7] has been chosen as the licence of the DCC-Schema. The choice of this licence type has been discussed and agreed with the industry partners.

### *2.1. Additions, corrections, and optimizations*

Some new elements have been added to the DCC-Schema, others were corrected, and some features have been optimised. An overview of selected changes is given in Table 1. It goes far beyond the purpose of this paper to offer a comprehensive documentation of all changes of the schema. However, the online repository of the DCC schema allows to follow the changes [8]. Moreover, a comprehensive list of changes along with an explanation of the background can also be found on the DCC Wiki [9].

Whereas the upgrade from DCC schema version 2.4.0 to version 3.0.0 brought with it some breaking changes that required a version change, the development of the schema version 3.0.0 towards the most recent version 3.1.2 were rather incremental. Nevertheless, they improved the usability of the schema significantly and therefore will be described here.

### *2.2. Spotlights on changes*

Some changes can best be explained using context and examples for use. This will be done in the following for five of the selected changes listed in Table 1.

Table 1: Selected changes of the DCC schema version 3.0 and 3.1. Rows shaded in grey contain changes described in this paper.

| No | Parent element or type | Change (addition a, correction c, optimisation o) | Purpose | Schema version |
|---|---|---|---|---|
| 1 | 'statementMetadataType' cf. Fig. 1 | a: added element 'conformity' | To indicate whether the calibration object or a specific measurement is conformant with a defined requirement. | 3.0.0 |
| 2 | 'statementMetadataType cf. Fig. 1 | a: added element 'respAuthority' | To define a contact person, i.e., the responsible authority. | 3.0.0 |
| 3 | 'statementMetadataType cf. Fig. 1 | a: added element 'data' | To define a numerical value under the element 'statement', for example the nominal value of the object, which is a numerical, but not a measured value. | 3.0.0 |
| 4 | 'coreData' | a: added element 'performanceLocation' | To specify the location of the calibration. | 3.0.0 |
| 5 | 'performanceLocation' cf. Fig. 2 | a: added element 'positionCoordinates' | To add the exact coordinates to a location. | 3.0.0 |
| 6 | n.a. | a: expansion for use of attribute 'idRef' | Already used with 2.4.0, now expanded to many more elements. | 3.0.0 |
| 7 | n.a. | a: introduced attribute 'refType' | First introduced in v 3.0.0 to provide possibility to reference to certain types. | 3.0.0 |
| 8 | 'influenceCondition' | c: element 'state' changed to 'status' | To indicate if any adjustments or repairs occurred and to avoid confusion with element 'state' under 'location'. | 3.0.0 |
| 9 | n.a. | o: banned the use of CDATA sections within DCCs | To prevent potential misuse otherwise possible by putting code or other prohibited characters in CDATA sections interpreted by parsers as text [10]. | 3.0.0 |
| 10 | 'list' and 'quantity' | o: use of element 'measuringEquipments' allowed under both parent elements | To provide information about the measuring equipment either under the element 'list' for the whole list of measurements or under the element 'quantity' for a specific measurement value only. | 3.0.0 |
| 11 | 'formulaType' | o: formula format extension to mathML | To enable to write formulas either in Latex or in mathML format. | 3.0.0 |
| 12 | 'quantity' | a: added element 'realListXMLList' with all associated child elements defined by D-SI schema | To enable blank space separated lists of data that represent data in a far more compact way. | 3.1.2 |
| 13 | | c: 'measuringEquipmentListType' | To enable the description of measuring devices that are represented as a unit and thereby consist of several components. | 3.1.2 |
| 14 | 'measuringEquipmentQuantities' | a: introduced the new type measuringEquipmentQuantityListType | To enable giving a list of values which describes the measurement equipment associated to 'measuringEquipmentListType'. | 3.1.2 |
| 15 | 'statementMetadataType' cf. Fig. 3 | a. added 'nonSIDefinition' and 'nonSIUnit' elements | To enable definition and use of non-SI units with the DCC in a correct and unambiguous way. | 3.1.2 |
| 16 | 'conditionType' | a. added element 'certificate' | To refer to another certificate for the value of an influence condition. | 3.1.2 |
| 17 | n.a. | a. further expansion for use of attributes 'id', 'refId' and 'refType' | The use of attributes is a success story. The development of good practice examples has shown that attributes should be used in many more places. | 3.1.2 |
| 18 | n.a. | o. allowed the use of multiple attributes | To enable using multiple attributes, e.g., for refId or refType. | 3.1.2 |
| 19 | 'quantityType' | a. introduction of 'relativeUncertainty' | To enable implementing relative uncertainty statements required by many norms and standards. | 3.1.2 |

Fig. 1 shows the child elements of the 'statement' element. Here, the change no 1 is illustrated with the additional element 'conformity'. Although a calibration certificate is not a certificate of conformity (CoC), it is necessary for some industries to have a conformity statement in a calibration certificate.

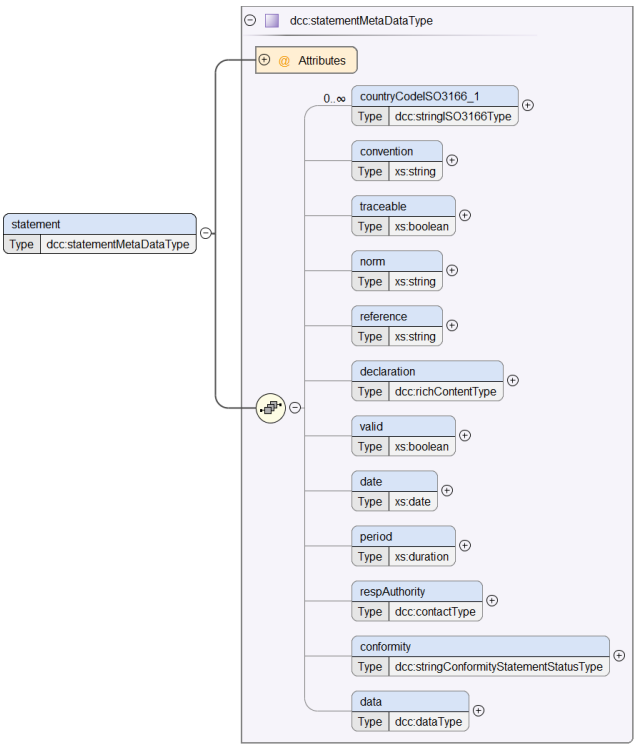


Fig. 1: The element dcc:statement in version 3.0.0

The conformity statement, which is optional, has a restriction. Users must choose either one of the given choices. The following listing shows the choices:

```
<xs:simpleType name="stringConformityStatementStatusType">
    <xs:restriction base="xs:string">
        <xs:enumeration value="pass"/>
        <xs:enumeration value="fail"/>
        <xs:enumeration value="conditionalPass"/>
        <xs:enumeration value="conditionalFail"/>
        <xs:enumeration value="noPass"/>
        <xs:enumeration value="noFail"/>
    </xs:restriction>
</xs:simpleType>
```

Change no 4, which is an addition, concerns the element ‘coreData’, to which an element for the location of the calibration (with the name ‘performanceLocation’) is added. One of the following values can be chosen as the location of the calibration:

```
<xs:simpleType name="stringPerformanceLocationType">
    <xs:restriction base="xs:string">
        <xs:enumeration value="laboratory"/>
        <xs:enumeration value="customer"/>
        <xs:enumeration value="laboratoryBranch"/>
        <xs:enumeration value="customerBranch"/>
        <xs:enumeration value="other"/>
    </xs:restriction>
</xs:simpleType>
```

Fig. 2 shows the structure of the ‘positionCoordinates’ element and is associated to change no 5. This addition enables the user to add customised coordinates to a location. This is done by adding the element ‘positionCoordinates’ to the element ‘location’. This could be of specific interest for non-laboratory calibration locations or even mobile labs such as cars or vessels.

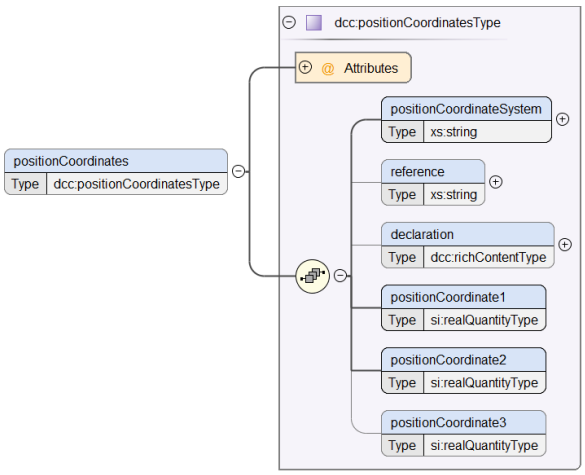


Fig. 2: The element dcc:positionCoordinates

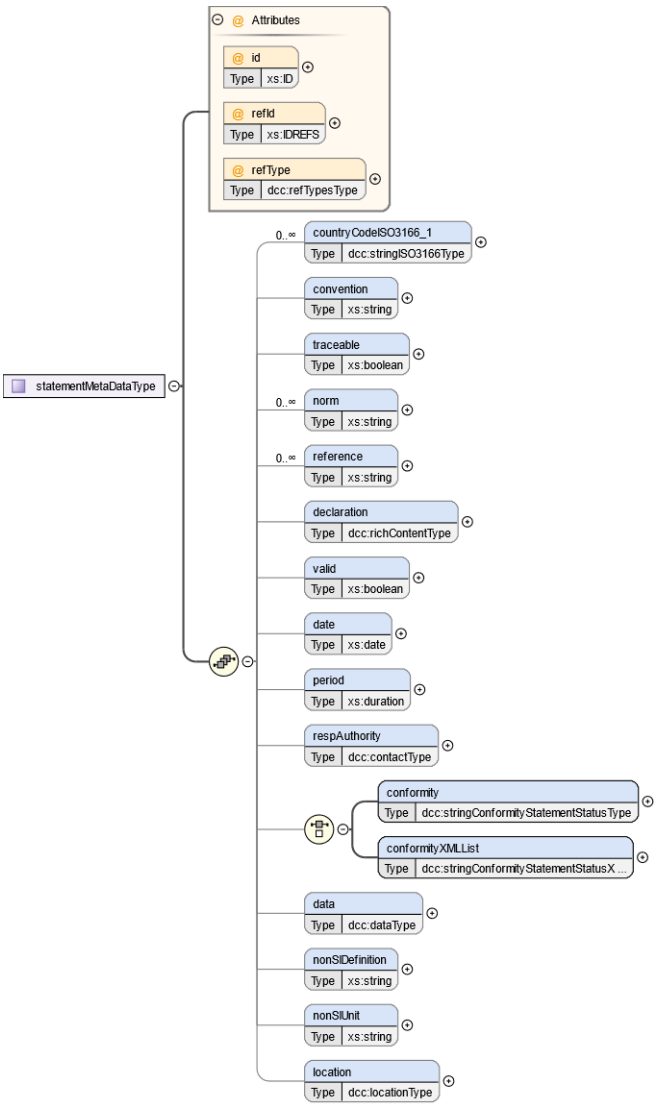


Fig. 3: The element dcc:statementMetaDataType since version 3.1.2

Fig. 3 shows the new structure of the ‘statement’ element as it is implemented since version 3.1.2. It demonstrates both the possible use of the recently introduced functionality of XMLList as in change no 12, e.g. within the ‘conformityXMLList’ element, as well as the elements

allowing use of non-SI units in DCCs (see change no 15). Both changes have a significant effect on the usage and will be therefore explained in more detail.

The introduction of XML lists is associated with an upgrade of the D-SI schema to version 2.1.0. The structure of the 'realListType' is shown in Fig 4. It enables the use of blank space separated data such as measurements. Such lists allow a very efficient use of data, as it is possible to state elements that remain the same for all measurements in one row only once, e.g. the unit or even the uncertainty. This has the potential for enormous data savings.

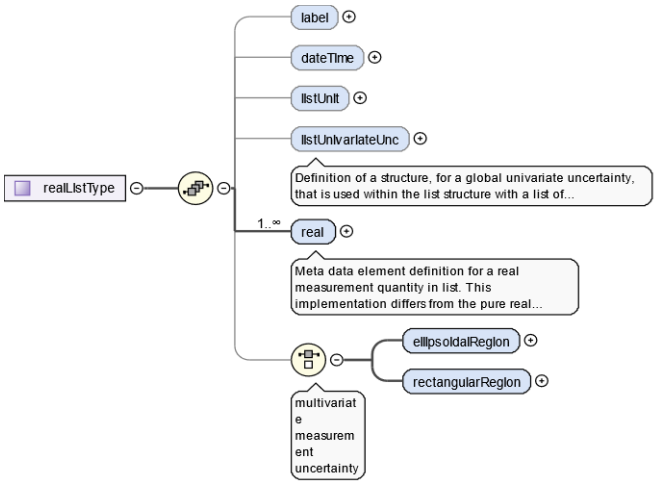


Fig. 4: The element realListType

All SI units are known to the DCC and can therefore be used immediately. However, since version 3.1.2 it is also possible to use non-SI units, as this is sometimes required by customers or certain communities. Before a non-SI unit can properly be used in the DCC, the definition of this non-SI unit must be referenced, the name of the unit and the used characters must be named unambiguously. This is useful because in some cases there are several identically named units for the same quantity. The FAQ section of the DCC wiki gives a guidance how this can be done by the user [9].

## 3. CONCLUSIONS

This paper gave a short overview of the most important changes of the DCC schema introduced in the versions 3.0.0 up to 3.1.2. Much more information can be found on the project homepage https://www.ptb.de/dcc, where also the recent development of the DCC is described. It also comprises a constantly growing wiki of the current DCC schema and provides in-depth description and explanation of how to use it, including a tutorial and FAQ section.

The development of the schema is still ongoing, and especially thanks to the development of additional good practice examples [11] will be constantly improved and shaped according to users' needs.

In March 2022, the second International DCC Conference was held as a fully digital event with more than 700 participants from 84 countries, representing all continents. The discussions initiated at the event helped to a great extent to improve the schema once more. They are still ongoing in various interest groups and on an international level. For example, the German Calibration Service DKD as the major forum for industrial calibration service providers is currently deeply involved in the discussion of the area specific implementations of the DCC. Coordinated by the EURAMET TC-IM project 1448, similar discussions are taking place in various EURAMET TCs which serve as multiplicators for NMIs and their industrial partners and customers across Europe and beyond.

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