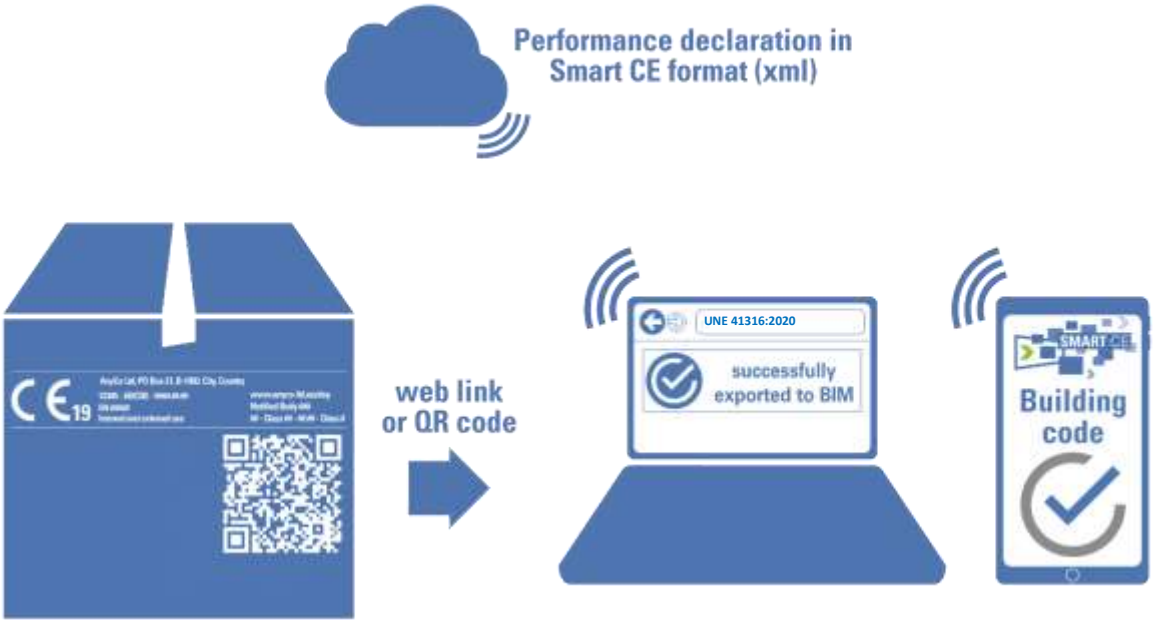

Reliable communication of product performance information in the BIM value chain: Smart CE marking

The declaration of performance (DoP) is the most important tool to characterize a construction product and a requirement before place a product in the Single Market.

The manufacturer assumes, at the time of issuing the signed declaration, responsibility for its contents. Therefore, this document is a guarantee for all actors in the value chain, such as other manufacturers, quality control in the construction works or the built asset owner.

The standard UNE 41316:2020 provides a digital format for the information contained in the DoP: the *Smart CE marking*. The purpose is to generate an XML structure for each family of construction products or, more specifically, for each harmonized standard.

The final objective is to facilitate the exchange of construction product performance information throughout the value chain, reducing costs and increasing the reliability of the data incorporated into BIM models, to ensure a better management of the life cycle of built assets.

Aitor Aragón Basabe. *Spanish Association for Standardization (UNE). Madrid, Spain*

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1 CONTEXT

1.1 Introduction

This article begins with an explanation that may seem *far away from* BIM, but vital for a proper understanding of the potential of a *simple* format such as the *Smart CE* proposed in UNE 41316 [10]. It is necessary to explain concepts such as *Declaration of Performance* (DoP), who assumes responsibility for the information, with what methodologies the characteristics are defined and how this information is provided -currently- in the value chain of the construction industry.

1.2 CE marking and declaration of performance

In order to guarantee the free circulation of construction materials in the Single Market, the Construction Products Directive (CPD) [1] was published in 1989 and transposed into Spanish law by Royal Decree 1630/1992.

This Directive established six requirements to be met by **construction works**, in particular:

1. Mechanical resistance and stability
2. Safety in case of fire
3. Hygiene, health and the environment
4. Safety in use
5. Protection against noise
6. Energy economy and heat retention

In line with the New Approach Directives - for example, Directives 2014/32/EU on measuring instruments or 2009/48/EC on the safety of toys - the application of the CPD was based on harmonised standards but, unlike other Directives, its scope was different from the scope of the harmonised standard. In the case of toys, for example, both the Directive and each standard apply to the toys themselves. In the case of construction products, on the other hand, the Directive applied to construction works (buildings, roads, dams, etc.) and the harmonised standards to their constituents: construction products. This important difference makes the CPD a *very special* directive, since it does not indicate that the product is *suitable for use* or complies in a strict sense (i.e., suitable and safe in any case), but rather **obliges to communicate a *measured* performance according to harmonised methods,** leaving the client or public administration the task of evaluating the suitability of each specific product for the work in question.

This evaluation, depending on the intended use, is based on the declared performance, which is tested according to common methodologies, for each product family, throughout Europe. The way to declare these performances is defined in the harmonized standards (see section 1.5below) issued by the European standardization bodies.

Manufacturers were required to assess conformity with the requirements of the CPD and the relevant harmonised standard. Once the necessary operations had been carried out, they could affix the CE mark to their product, to the packaging or to the associated technical documentation.

In 2011 the European Regulation on Construction Products (CPR) was published [2]. Although it introduced some changes, it did not alter fundamental elements such as the use of harmonised standards.

The CPR requires, as a previous step to fix the CE marking, that the manufacturer issues a declaration of performance (DoP[1]), with the following conditions:

- **The manufacturer assumes responsibility** for the conformity of the construction product with the declared performance.
- Member States must give a **presumption of conformity to** the content of the declaration of performance, unless they have **evidence** that it is not correct or reliable.

The scope of digitalization of UNE 41316 is the information contained in this declaration of performance. Therefore, it would have been more *correct* to have called this concept SmartDoP, but it was decided to link it to the *better known* CE marking.

It is important to highlight the guarantee that, for the user - prescriber, builder or owner -, the information contained in the DoP represents, since the manufacturer is, without any doubt, legally responsible for it. This responsibility for the data is not so clearly defined in other formats used in BIM. In addition, in many cases, performance is tested in

[1] Declaration of Performance

accredited test laboratories and factory production control is audited by certification bodies.

Another relevant change introduced by the CPR is a new requirement for construction works: the sustainable use of natural resources. The communication of performance related to the environment and circularity, through environmental product declarations, is covered in section 4.3.

1.3 An obsolete format?

Despite being published in 2011 and therefore being relatively recent, the CPR does not adequately cover digitization. As an example, although in its article 7 it indicates that the manufacturer can provide the DoP by electronic means, it obliges him to send it printed (in paper) if the client requests it.

In 2014, the Commission established the requirements for publishing the DoP on a website [3], but without providing a common digital format. The usual practice is to send the declaration in *pdf*, a type of file that makes it very complicated to extract structured information because, although -theoretically- it could be *scraped, in* practice it is not feasible because each manufacturer uses its own structure.

As a result, BIM models are not usually fed with reliable and high-quality information, provided directly by the manufacturer; they only *save* the DoP *pdf* file with the reception control register or in the building log book.

The Commission is aware of these limitations. In document C(2013) 7086 final, as part of the processing of the Delegated Regulation [3] that establishes the conditions for publishing the DoPs on websites, the importance of applying new technologies to increase the speed of communication in the supply chain and reduce paper consumption, pointing to XML formats, was highlighted:

*The information is to be displayed preferably using semantic web technologies making sure that that it is displayed in a human readable format, like HTML, and a machine readable format, like **XML**. The schema for the machine readable format should preferably use **standard** or widely used data schemas, so that the information is interoperable with most architectural tools.*

1.4 Revision of the Regulations

The CPR is currently under review. One of the key aspects should be the digitalization of information, to improve, among other aspects, the resource efficiency.

The significant cost reduction for manufacturers (and the rest of the actors involved in the value chain) obtained by the application of an *electronic* DoP is one of the direct benefits reflected in the study [5] that the Commission carried out in 2018 for the review of the CPR. The European Parliament stated, in the clause on *Embracing IT-based methods* contained in its report [6] on the review of the CPR, published in September 2020, the following:

*The volume of product information that has to be communicated to users in accordance with the CPR will in all likelihood increase, especially in the light of sustainability and environmental requirements. Therefore, it is to be expected that the product information can no longer be fully reflected in the CE marking on the product. (...) In this way, the Rapporteur views concepts and methods such as Blockchain and **Smart DOP** as indispensable developments that should be incorporated into a revised CPR.*

The volume of data derived from the incorporation of environmental data into the DoP is dealt in 4.3.

1.5 Harmonized standards

The harmonized European standards (hEN) provide a common technical language for all actors in the construction sector. These standards are fundamental, as they are the basis for establishing legal requirements (such as the Technical Building Code or the Structural Concrete Instruction EHE-08 in Spain) and in the procurement specifications of public or private clients.

Harmonized standards establish how each specific performance should be measured or evaluated, using supporting standards that generally define testing methods.

These documents are developed in the European standardization committees of CEN/CENELEC, in which Spanish experts participate through the Spanish Association for Standardization (UNE).

Harmonized European standards become a mandatory reference for the products covered once they are cited in the Official Journal of the EU, which also set the deadlines established by the Commission for its implementation. It is possible to access the list of applicable standards for each harmonization legislation through the NANDO information system [8].

Once published, the standards are adopted through each national standardization body, in Spain, UNE.

2 SMART CE MARKING

2.1 The challenge

Manufacturers are under increasing pressure from their customers to deliver digital formats with product information but, in practice, the usefulness of the delivered files is arguable.

The investment made to be able to issue the declaration of performance (tests, factory production control and, sometimes, the intervention of third parties such as external laboratories or certification bodies), is not fully exploited, due to the absence of a digital format suitable for direct use in BIM.

Currently, some manufacturers have libraries in which they make available BIM representing their catalogue, in proprietary or open formats. These catalogues have simplified the task for designers and builders, facilitating the transfer of product information to BIM. However, for many products or purposes, these objects are too *complex* or might have other drawbacks:

- **Compatibility**: files (generated by different tools or even versions of the same software) sometimes present compatibility problems.
- **File size**: the file size is sometimes quite big, often exceeding the Mb for a single *simple* product. BIM models manage hundreds or thousands of products, so the *weight* can reduce their efficiency.
- ***Far from* the *common language* of European manufacturers**: the harmonised standards define the language by which manufacturers communicate the performance of their products. In some cases, there is no *bijection* between DoP performance and the coding used on the object.
- **Responsibility:** in the chain *manufacturer provides data → BIM object is created → portal has the data available → designer downloads the file and incorporates it into the model…* who is responsible, if the information in the BIM model is not correct?
- **Cost:** The resources required to generate BIM objects is relatively high, either because of the need for software and technicians with training or due to the need for external resources.

For many construction products, 3D is not relevant, either because they do not have a defined geometry (p.e. additives), or because it is not relevant as an *individual product* for the performance in the built asset (p.e. ribbed bars or aggregates, which contribute to the performance as part of the concrete), or because it can be easily communicated using parameters (p.e. dimensions in mm, for the geometry of the thermal insulation).

Current BIM objects are useful, especially for composite construction solutions, but it seemed necessary to consider more efficient alternatives for products and materials.

2.2 The industry solution

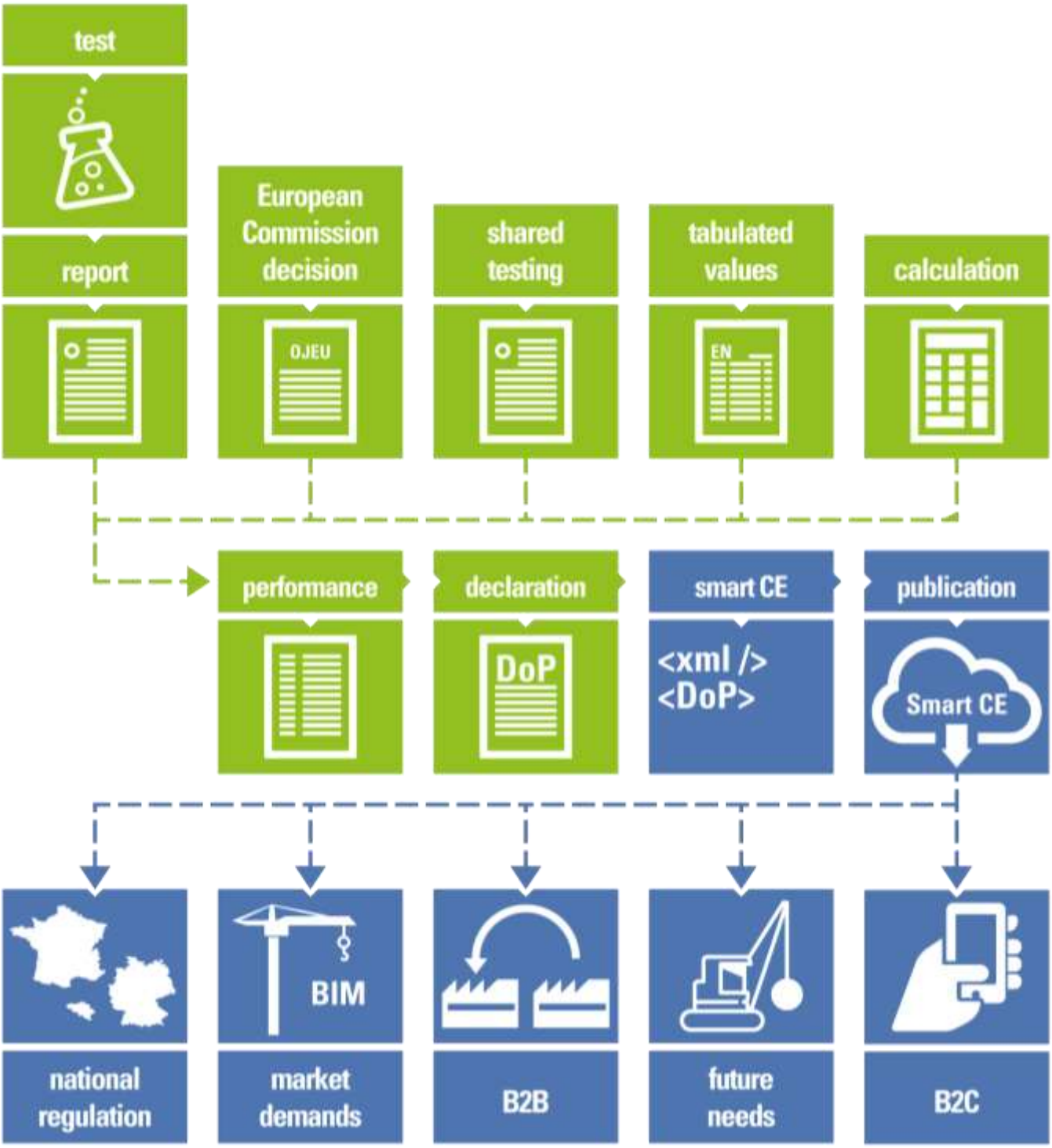
The construction product manufacturing industry was aware of the challenge and in May 2015, the association *Construction Products Europe* published the document *Towards smart CE marking* [15], which introduced for the first time the concept *of Smart CE*, illustrated in the figure below.

The goal was to make the exchange format as easy to generate and read as possible, complying with the requirements to make the DoP available on a web page [3]. It was also necessary to be able to transfer the information to IFC (EN ISO 16739-1 [12]).

There were several suitable options for the format, such as JSON, a *simple* language easy to analyse syntactically (*parse),* which generates very light files. However, XML was chosen, as it is a widely used format (therefore, easier to implement in companies), which also generates light files, and designed to store and transmit structured data. In

addition, XML is cited by the European Commission as a proposed solution for the DoP in digital format (see [3]).

Harmonized standards contain a wide range of types of information, so it is necessary to define a structure for each standard. However, it was considered necessary to have a European document to



The Smart CE concept
Source: *Construction Products Europe*

define a homogeneous structure to facilitate interoperability. To this end, a project in the European Committee for Standardisation, CEN was proposed (see 2.3).

BIM is much more than 3D. UNE 41316 seeks to communicate **data,** in which **geometry** is *just one more*. The geometry can be presented as dimensions or as the URL of the drawings (in DXF or other format), included as additional information (see 4). Using a reference to other files to provide this information will create more *manageable* objects, incorporating the information into the model depending on the required level of detail.

2.3 Standardisation

In December 2017, the kick-off meeting of CEN/WS *Smart CE marking* took place. Experts from several countries, representing manufacturers, BIM practitioners, software developers or certification bodies, agreed to publish in July 2018 the CWA 17316 [11].

Since its publication, several European associations have initiated the development of schemes for their harmonized standard. However, the implementation of the Smart CE concept is still limited. One of the reasons for the low implementation is the large number of harmonized standards to be *transformed* into Smart CE and the absence of a *critical mass to* motivate BIM software developers to import this format. On the other hand, the Smart CE concept was limited to DoP information, but there are other data of great interest to users of construction products that were not included.

To promote the implementation of the Smart CE concept, the Spanish Association for Standardization (UNE) began, in March 2020, the draft UNE 41316 [10], which was published in September of the same year.

This standard establishes a *common ground* to define a format for each harmonized technical specification in construction product standardization committees, at National or European level. Having a reference in Spanish facilitates the participation of the national industry in the development of the formats at European level and, in addition, the drafting at National level of formats that, once approved in Spain, can be presented to CEN.

CWA dealt with DoP information (see 3), but the UNE standard also includes criteria and guidelines for incorporating additional information (see 4).

Therefore, UNE 41316 is not a *simple* adaptation of the CWA 17316. It contains additional (non-contradictory) clarifications for the XML structure and defines how to communicate additional information. This approach is also intended to be used for the XML structure of products not covered by harmonized standards.

The support at European level is *a must* for an adequate deployment of this concept. Several industry associations are preparing their formats, although the transition from CWA to European standard is not foreseen in the short term.

At international level, EN ISO 23387 develops a common concept for data templates. The European Committee CEN/TC 442 is preparing projects such as prEN 17473 for the definition of data templates to communicate the information of the harmonized standards according to the European harmonization legislation, such as the CPR.

For the construction industry, it is important to follow the developments on BIM standards. In Spain, this task is carried out by CTN 41/SC 13 [16].

3 DIGITAL DECLARATION OF PERFORMANCE

3.1 General structure

Both CWA 17316 and UNE 41316 define the XML structure that, in general, will be UTF-8 encoded and have an XSD schema, whose path is provided in the *XML Schema Instance*.

The DoP data is nested within the ***DeclarationOfPerformance*** element, whose label includes the language in which the declaration is presented (generally English). The translation into different languages can be done, automatically, using the official texts from the Commission and the translations of the standards made by the national standardization bodies.

The following elements define the reference standard, the intended use, the unique product identification code, the DoP number, the information about the manufacturer or the system of

evaluation and verification of constancy of performance (AVCP). Usually, it will be easy for manufacturers to fulfil these data.

The most complex part is the structure of the declared performance, explained in section 3.2.

Finally, other necessary elements are included such as appropriate and specific technical documentation, or the manufacturer's declaration of responsibility with its signature (see 3.3).

3.2 Performance

DeclaredPerformance is a complex element in which the defined in each Standardization Mandate (***EssentialCharacteristic***) are nested. These essential characteristics have a level 1 ***Property*** nested.

Each level 1 ***Property*** has, at least, three nested elements:

- ***Name***: designation of the ***Property***.
- At least one level 2 ***Property.*** Normally only one will exist, but in the case of properties that depend on each other, there can be more, as explained below.
- One last ***Property*** containing the AVCP system.

Sometimes, there may be properties that depend on each other and which, in *current* DoPs, are usually presented as a table. This is the case, for example, of the thickness of an insulation and the associated thermal resistance, which are presented as *pairs of* elements.

All level 2 ***Property*** have the following structure:

- ***Name***: designation, which can be expressed as a physical quantity (e.g. *lenght,* to express lengths and thicknesses), as a classification (*class*) or expressing a *pass/fail* result.
- ***ReferenceDocument***: testing standard or equivalent.
- ***Declaration***: contains the declared values through a complex element that has the elements ***Name***, ***Value***, ***Unit*** and ***Relation*** nested.

The AVCP system, which indicates the tasks assigned to the notified bodies, is a particular case of level 2 ***Property***, in which the ***Name*** is *AVCP*.

Although the explanation of the structure may be *cumbersome*, it is *intuitive* when shown in tabular format, as in table B.1 of UNE 41316. The standard contains guidelines and examples to facilitate the creation of XML structures. Before proposing an XML scheme for digital DoP in the standardization committees, it is important to analyze both the corresponding harmonized standard and Annex B of UNE 41316.

3.3 Signature

The DoP must be signed, as an attestation of the **responsibility** assumed by the manufacturer regarding the declared performance.

The information covered by CWA 17316 is to be included as text and, in the ***DoPLink*** element, the link to the signed declaration of performance in *pdf*. In this case, the Smart CE file cannot be used *independently* (meaning, without the signed *pdf*), since it does not contains the signature of the manufacturer.

UNE 41316 standard has not resolved the issue of the signature, although it points to some potential solutions (see 4).

4 ADDITIONAL INFORMATION

4.1 Concept and how to include it

Any information not included in Annex ZA of the relevant harmonized standard is considered additional information.

Additional information may include test results, product color, link to CAD drawings, environmental information or relevant product certificates.

This additional information shall, in any case, be reported separately from the DoP. Thus, the element ***AdditionalInformation*** has been created, nested in ***Declarations***.

Without standardization of tags and structures, it will not be possible to use this additional information in BIM. Therefore, it is important to base them on technical standards.

This additional information is covered in the Spanish standard, but not in European CWA. This topic is one of the main improvements in the Spanish standard, since it will allow manufacturers to communicate data of great interest to their customers. The following sections contain some examples.

4.2 Non-harmonized performance

The performance characteristics not included in the harmonised standard have a similar structure to the performance contained in the DoP, with some necessary changes such as replacing ***AVCP***, which refers to the Assessment and Verification of Constancy of Performance system, with ***AoC***, which refers to the Assessment of Conformity.

UNE 41316, table C.1, should be used for the preparation of the XML structure.

If a performance characteristic affects several products covered by different committees, consensus should be reached to designate and structure the information in a homogeneous way.

4.3 Environmental Data

BIM is a fundamental tool for evaluating and improving sustainability in construction. The Spanish Strategy of Circular Economy [9], states:

*The use of the **BIM** methodology (Building Information Modeling) should be promoted and implemented in the **analysis of the life cycle of the buildings** and, thus, be able to reliably calculate their sustainability, including their rehabilitation, thus contributing to the improvement regarding climate change impacts and the sustainability of construction works, including the infrastructures.*

The core, again, is the **data**. Today, there are thousands of environmental product declarations (EDP) in Europe, verified in according to EN 15804 standard. These documents have the advantage of using a common methodology and structure for the life cycle of products, buildings and civil engineering works, developed by CEN/TC 350.

At international level, the future standard ISO 22057 [14] is under development. It defines the information exchange format from EPD to BIM, based on the *Smart CE concept*.

Until this international standard is published, UNE 41316 proposes a minimum information to be communicated, stating that once ISO 22057 is available, the structure defined in it should be included as additional information.

4.4 Signature and file integrity

Clause C.6 of UNE 41316 deals with the possibility of verifying the integrity of the file using a cryptographic hash, such as SHA-256.

As a first step, this verification can be made calculating the hash of the ***DeclarationOfPerformance*** element and comparing the result with the hash reported in the file. Obviously, if it has been modified intentionally, the hash may also have been altered, so this check is not enough. The verification should also be made using a hash that cannot be altered by the *value chain actors* who may have an interest in modifying the file. Among others, the following options can be used:

- ***Trusted timestamping*** of the DoP in a blockchain network.
- Verification of the hash using a **reliable server**.

The cryptographic hash function must be placed outside *the* elements ***DeclarationOfPerformance*** and ***AdditionalInformation***, to avoid problems.

The standard also explains the signature *XMLDSig* or *XML-DSIG* defined by the W3C consortium. For the time being, it is not considered a valid option, as it would modify the structure defined in the CWA 17316, which is not compatible with the approach made in the Spanish standard. However, it could be applied if the CWA is revised at a European level.

Although not covered in UNE 41316, a similar scheme can be used to include a **third-party validation** of the file, checking the hash against the server of a *trusted body*, such as the Public Administration or a notified body. This validation is different from the integrity check of the file, as it can be used to indicate that the values reported have been verified using the actual reports of the test results or that the product is covered by an official recognition or approval from the public administration.

The cornerstone of this signature system is the recognition by the Public Administration and in case of litigation. As there is no *approved* European system for a digital CE marking, the inclusion of a link to the signed declaration of performance (for example, in *pdf*) is a good solution. The study [7] on possible legal obstacles to the use of digital DoP contains an analysis by country, which should be considered before assessing the possibility of delivering the XML without a link to the signed DoP by means of, for example, an advanced or qualified electronic signature system (using a trusted service provider).

5 BIM INFORMATION MANAGEMENT

5.1 Data, NOT Big Data

Managing information is **not** about *accumulating* data. To take advantage of the potential of BIM, it is necessary to be efficient in the information that is incorporated into the model.

The XML based on UNE 41316 has a size of *around a k*B that, for the DoP of **each product**, contains exclusively the information identified as relevant by Member States (through the Mandate from the Commission) or the industry (in the product standardization committee).

The additional information defined in UNE 41316 can make other necessary information accessible, depending on the level of detail. As an example, links to CAD drawings or maintenance instructions can be included.

This approach can optimize the information incorporated into the BIM model.

5.2 BIM objects for the model

BIM objects developed in specific software are still very useful for the development of BIM models.

Generally, it is not necessary to have the specific product and manufacturer information in the project phase, but a specification of the required performance.

Architects can still use libraries of construction solutions based on BIM objects but, in addition, the software should generate a file with the specifications for use in procurement specifications, or to select products from an information portal in accordance with the UNE 41316.

With this approach, the BIM model can be fed with the necessary data at each stage: specifications in the project phase, particular product for the bidding conditions and, in the construction phase, it can be linked to the product actually received (see 5.3and installed (see 5.4).

5.3 Quality control and on-site reception

The specifications can be automatically checked against the DoP according to the UNE 41316 format. With the DoP, the manufacturer is **solely responsible** for the performance declared, which is an important guarantee for other actors.

For example, the on-site reception control can scan (with a mobile device) the QR code on the packaging and automatically download the *XML-UNE-41316*, checking the data against the purchase specification and the regulations in force, and finally saving the result (compliant or non-compliant, together with the cause of non-conformity, if relevant) with the date, time and operator identification. This concept is applicable both to construction on-site control and to the reception of raw materials from a manufacturer who processes other construction products (for example, concrete).

5.4 Building log book and facility management

The performance declarations can be stored in a digital, indexable, building log book. Knowing the performance of the actual installed products has obvious advantages for the management during the service stage of the built asset, which is not necessary to explain here.

6 BIM, throughout the value chain

BIM reduces costs. This motto, almost a *mantra*, is a reality in projects and construction works, but not for many manufacturers. It is necessary that information *flows* from manufacturers to designers, builders, asset owner or public administration. To ensure it, the exchange shall optimize the relationship ***added value*** *provided* vs. ***resources*** *needed to implement it*.

The proposal defined in the UNE 41316 is considered easy to apply and to conceive of a simpler and

effective, directly available to the majority of organizations. Which manufacturer (currently considering the digitalization of the information of its products) does not have employed at least one person capable of editing a plain text file, using the *Notepad*? If this employee has *basic* knowledge about VBA or Python, it will be easy to export to XML from the *Excel* tables in which the manufacturer might already have stored the characteristics of its product. More *advanced* organizations can incorporate *XML-UNE-41316* into the output formats of their corporate tools and, in addition, *cost-effective* applications will emerge, to streamline this task for the industry. This simplicity makes the cost of generating the product catalog clearly lower than *current* BIM objects.

From the perspective of BIM software, if this concept is used in the majority of DoPs throughout Europe, which developer will not include such a *simple format* as input for their software?

This concept can be extended to other products installed in buildings or civil engineering works which do not have CE marking or, if they have it, do not meet the definition of a construction product under the CPR. With this approach, more structured information can be incorporated into the BIM model.

The *XML-UNE-41316* (digital DoP) concept is an opportunity for BIM deployment and to ensure that BIM also reduce costs *before the construction stage*, starting at the factory.

A cornerstone to success is to reach, in a reasonably short time, a *critical mass of* users throughout the construction value chain. It is also essential to have standardized formats and, thus, the XML structure should be defined in National or European technical standards, via the European Committee for Standardization (CEN) and, for Spain, the Spanish Association for Standardization (UNE).

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