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Informacijsko modeliranje gradenj - Digitalni dvojčki v grajenem okolju - Primeri uporabe

Building information modelling - Digital twins applied to the built environment - Use cases

Building information modelling - Digitale Zwillinge in der bebauten Umwelt - Anwendungsfälle

Modélisation des informations de la construction - Jumeaux numériques appliqués à l'environnement bâti - Cas d'usage

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English Version

Building information modelling - Digital twins applied to the built environment - Use cases

Modélisation des informations de la construction - Jumeaux numériques appliqués à l'environnement bâti - Cas d'usage

Building information modelling - Digitale Zwillinge in der bebauten Umwelt - Anwendungsfälle

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European foreword

This document (CEN/TR 18077:2024) has been prepared by Technical Committee CEN/TC 442 “Building Information Modelling (BIM)”, the secretariat of which is held by SN.

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Introduction

Complementary to a building information model, which contains as built and historical data, a digital twin (DT) can be used to assess the current state of the asset and to potentially forecast the future state.

Given the wide range of buildings and infrastructure in the built environment, both in application and in scale, there is currently insufficient information available to make informed decisions about good practice in the development of digital twins. There is a need for clear use cases to inform any such provisions. This document will collect and collate use cases from throughout Europe to show how digital twins are currently being applied, and then to analyse these use cases to identify common characteristics and methods. This analysis could then be used to support future projects of CEN/TC 442/WG 9 “Digital Twins in built environment”.

1 Scope

This document collates case studies of digital twins applied to the built environment, including infrastructures, in Europe. These case studies have been obtained from CEN experts and related EU research projects.

This document identifies common characteristics to support further standardization work.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp/

3.1
case study
instance of a use case or, more generally, a record of specific set of actions

Note 1 to entry: A case study could record research relating to an instantiated use case.

Note 2 to entry: Most of the cases presented in this document are case studies.

EXAMPLE A case study could be “Free University of Berlin’s application of AI to improve space utilization”.

3.2
use case
document set of actions performed by one or more actors and by the system itself

EXAMPLE A case could be “predictive maintenance”, with the actions including monitoring performance, and repair/replacement activity prior to failure.

4 Abbreviations

ADT	Assets Digital Twin
AECO	Architectural, Engineering, Construction & Operations
AI	Artificial Intelligence
AODB	Airport Operational Database
API	Application programming interface
AR	Augmented Reality
BACnet	Protocol, Building Automation and Control Networks.
BAS	Building Automation System

BDT	Building Digital Twin
BDT Manager	Building Digital Twin Manager
BEM	Building Energy Model
BIM	Building Information Modelling
CAFM	Computer-aided facility management
DT	Digital Twin
GIS	Geographical Information System
HTM	Human Thermal Model
HVAC	Heating Ventilation Air Conditioning
ICDD	Information Containers for linked Document Delivery
ICT	Information Communications Technology
IFC	Industry Foundation Classes
IoT	Internet of Things
KNX	Standard. Stands for "Konnex"
KPI	Key Performance Indicator
LD	Linked Data
LoD	Level of Detail
MEP	Mechanical, Electrical and Plumbing engineering
Modbus	A request-response protocol implemented using a master-slave relationship
MPC	Model Predictive Controller
NDT	Non Destructive Testing
OBIX	Open Building Information Exchange
PBS	Product Breakdown Structure
PDF	Portable Document Format
PV	Photovoltaic
R&D	Research and Development
RDF	Resource Description Framework
REST API	Protocol (Application programming interface for REST)
RISA	Commercial brand
SOAP	Simple Object Access Protocol
SPARQL	RDF query language

TOS	Terminal Operation Systems
UAV	Unmanned Aerial Vehicles
URI	Unique Resource Identifier
VR	Virtual Reality
WebGL	Web Graphics Library

5 Objective

The main objective of this document is to collect a wide range of case studies of Digital Twin (DT) implementations across the built environment, to generate a set of examples ranging across different life cycle phases and different constructive assets.

In addition, the collected case studies include their purpose or purposes. The aggregation of these main or secondary purposes allows to infer new potential use cases of the application of DT in the built environment.

6 Methodology

6.1 Introduction

The use cases were collected using a simple generic template approved by the expert's group. The template was defined in order to gather general information on a use case, its main use, a description, what improvements could be found beyond the state of the art and replication potential (see Annex A).

After that, the completed templates were circulated amongst the group responsible for receiving and reviewing the case studies. The decision to accept a case study was determined by the degree and clarity of information provided.

To enable future compilation of use cases, some iteration with the authors was carried out to facilitate comprehension and benchmarking among the case studies received. Before the agreed deadline, a total number of 37 cases were gathered and 34 were selected (see Annex B for the selected use cases). To ease their aggregation, they were included in a dynamic table. That table included the main uses of the DT as well as other key considerations provided by the experts, such as the types of assets, the phase of their life cycle or the tools used beyond the current state of the art.

This table was also shared between the experts showing the key information collected, as well as their evolution, in case of iteration of each case study. The result, therefore, allows for a more homogeneous comparison and a panoramic view of the contents, hence enabling the conclusions given in Clause 6.

6.2 Table of compiled case studies

As a summary of the dynamic table, Table 1 presents all the case studies collected and accepted. Each line is a case study that was presented.

The first column of the table ("#") is a sequential number that would be the reference number used in other tables. The second column ("Name") gives the name or a short description of the case study. The third column ("General info") contains a short description. In the fourth column ("Main use") is the declared main use of the case study. Column five ("Asset type") contains an asset type for grouping the case studies. Finally, the last column ("Phase") indicates the life cycle phase.

Table 1 — Summary table, case studies presented

#	Name	General info	Main use	Asset type	Phase
1	D2EPC THESS	Building Residential	Energy Performance	Building Residential	Operation
2	D2EPC NICOSIA	Building School	Energy Performance	Building Tertiary	Operation
3	PLANON DT	Smart Climatized Asset/Space Management	Energy Performance, Control, Events, Space Management	Building Tertiary	Operation
4	SAMBA	Building Office, Coworking	Operation	Building Tertiary	Operation
5	H2 ELECTRO	DT for Technical Marketing	Marketing	Others (Machinery)	Production (Offsite Construction)
6	BRIDGE WEBGL	Bridge INFRA	Maintenance, marketing	Civil Infrastructure (Linear)	Operation
8	CRANE	Building Crane	Planning Construction Operations	Others (Machinery)	Operation
9	KUBIK	Building	Test Lab	Building Industrial	Design
10	BRIDGE ZUBIOTE	Bridge INFRA	test bridge	Civil Infrastructure (Linear)	Design
13	BIM2TWIN	Digital Twin of Construction Execution	Construction Management	Building Tertiary	Execution (Onsite Construction)
14	ENERGY_TWIN	Building Office	Commissioning, Operation	Building Tertiary	Commissioning
15	BRIDGE BASt	Bridge Rail/Road Infra	Operation, Maintenance	Civil Infrastructure (Linear)	Operation
16	ROAD TU	Road Infra	Operation	Civil Infrastructure (Linear)	Operation
17	BRIDGE ROAD INFRA	Bridge Road Infra	Operation, Maintenance	Civil Infrastructure (Linear)	Operation
18	BUILDING OFFICE	Building Office	Construction	Building Tertiary	Construction
19	BRIDGE RAIL INFRA	Bridge Rail Infra	Operation, Maintenance	Civil Infrastructure (Linear)	Operation
20	SNCF	Rail Infra	Knowledge optimization	Civil Infrastructure (Linear)	Operation

#	Name	General info	Main use	Asset type	Phase
21	ZADAR	Airport Infra	Maintenance	Civil Infrastructure (Punctual)	Operation
22	AVILES PORT	Port Infra	Operation, logistics	Civil Infrastructure (Punctual)	Operation
23	SETEC-StMALO	Port Infra	Heritage	Civil Infrastructure (Punctual)	Reconstruction/preservation
24	LEGENDRE	Building, provisions for openings	Construction Management	Building Tertiary	Execution (Onsite Construction)
25	ETSICCP	Building School	Operation	Building Tertiary	Operation
26	IRRIGATION	Smart Irrigation Management	Operation	Utility network	Operation
27	LLOBREGAT	BUILDING (Council)	Operation	Building Tertiary	Operation
28	HIDROPOWER	Powerplant Rabenstein (AUSTRIA)	Maintenance, optimization, simulation and VR	Energy Infrastructure	Operation
29	NUCLEAR_DECOMM	(Confidential)	Optimization, Simulation, Training	Building Industrial	Dismantling
30	ST_ETIENNE	Building School	Optimization, simulation, operation	Building Tertiary	Operation
31	ECOLE CENTRALE	Building School	Building information model, CMMS and BMS DATA.	Building Tertiary	Operation
32	LILLE	Building Public	Facilities ticketing system interface	Building Tertiary	Operation
33	TNO SPHERE	Building Residential	Energy management	Building Residential	Operation
34	VTT SPHERE	Abloy factory	Energy optimization	Building Tertiary	Operation
35	EGIS	Gironde Estuary, Grand Port Maritime de Bordeaux	Operation and maintenance	Civil Infrastructure (Punctual)	Operation
36	ANDRA	Nuclear waste recycling plant	Waste management	Building industrial	Operation
37	VSB-TUO	Building office	Operation	Building Tertiary	Operation

7 Conclusions

All of the case studies have been grouped according to their similar characteristics to help extract the potential use cases.

The results show a wide range of use cases (see Table 2). A total of 14 use cases have been identified based on the grouping according to purpose. As can be seen in Annex A, the case studies received present not only a dedicated main use but some secondary uses in some cases. From this can be extracted that a digital twin could add more value through different use cases and their associated benefits.

Regarding the typology of the use cases, the majority of use cases concentrates on improving the operation (see Table 2) through optimization of the decision making.

Table 2 — Group of use cases from case studies presented

	USE CASE	MAIN USE	SECONDARY USE
I	Design Optimization		16, 36
II	Construction Optimization	8, 13, 18, 24	36
III	Commissioning Optimization	14	
IV	Operation Optimization (Energy Performance)	1, 2, 4, 14, 30, 33, 34	3, 4, 27, 31, 37
V	Operation Optimization (Space and Administrative Management)	3, 22, 25, 27, 32	4, 20, 30, 31, 37
VI	Operation Optimization (Logistics)	35	20, 22
VII	Operation Optimization (Waste Management)	36	
VIII	Maintenance Optimization	15, 16, 17, 19, 20, 21, 23, 28, 31	6, 22, 25, 27, 36
IX	Dismantling Optimization	29	16
X	Safety		4, 29
XI	Training		4, 28, 29
XII	Marketing	5,6	
XIII	Test Lab	9, 10, 19, 37	
XIV	Others	26	34, 35

As shown above, the optimization pursued in the collected examples can target the constructive operations (planning and design, construction, commissioning, energy performance, maintenance or dismantling) as well as the dedicated operative of the asset (space management in buildings, logistics in transport infrastructures or heritage administration). A special case of dedicated operative of the asset is research infrastructures. In this case, four case studies have been grouped as “Test Lab” use cases, with the DT being a way to enhance products and services developed in real laboratories. Additional purposes have also been grouped into three main use cases focusing on safety, training and marketing. As in all use cases, specific examples of them can be found in Annex A.

Finally, there is a small heterogeneous group of main and secondary uses which include a main purpose, irrigation operative (26), and several secondary uses such as occupants (employees) wellbeing (34) or climate change resilience estimation (35).

Based on the description received so far, many of the case studies show a big potential for replication, with the possibility of being converted into a commodity or a massive product.

Beyond use cases, early adoption can also be inferred from the information received using another aggregation based on the typology of the assets. Tertiary buildings and infrastructure (see subclause 6.2, Table 1, column “Asset type”) are the rule from the case studies received. There are 11 cases of tertiary buildings, 5 linear infrastructure and 4 cases of punctual (or spatial) civil infrastructure, in a total of 30.

It is important to note that case studies #5 and #6 (H2ELECTRO and BRIDGE WEBGL) are not representing a real physical asset.

The analysis of the use cases will allow the development of a standardized framework and definitions for digital twins.

The digital twin approach is designed to provide a better understanding of the asset throughout its life cycle. It will facilitate a sustainable future by better management of energy, resources and other requirements in the context of the EU Green Deal.

Annex A
(informative)

Case study template

Introduction

To develop a TR covering the application of Digital Twins (DT) in Europe, CEN/TC 442/WG 9 is gathering case studies and use cases.

The TR will cover DT of buildings and infrastructures (civil engineering works). Information on other technologies, such as smart cities or GIS, can be included in the DT, but as part of the data of the construction asset (i.e. the TR will not cover a DT of a smart city, only building or relevant infrastructure within a neighbourhood or city).

CEN and/or CENELEC experts, EU funded research projects and other stakeholders are invited to send their use cases or case studies to the Secretariat, Aitor Aragón, before 2023-04-27. Feedback regarding the template itself (new fields to be included, etc.) is also welcome.

Use case: NAME OF THE USE CASE

General information

Typology: (for example, residential, road infrastructure, etc.)

Location:

Asset owner:

Building Digital Twin (BDT) manager:

Main use of the DT

Max. 50 words.

Description of the DT

Max. 50 words. Figures can be included.

Main improvements beyond the state of the art

Max. 200 words. KPIs should be included, if possible.

Replication potential

Max. 200 words. KPIs should be included, if possible.

Relevant links

More information provided in websites, scientific papers, etc.

Contact information

Name, email and telephone of a contact person on behalf of the DT owner and/or the BDT manager. This information will not be included in the final TR, but will be used to ask for further information, if needed.