



BSI Standards Publication

Internet of things (IoT) — Digital twin — Use cases

National foreword

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TECHNICAL REPORT



Internet of things (IoT) - Digital twin – Use cases

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Abbreviated terms	9
5 Applications.....	9
5.1 Application domains.....	9
5.2 Life cycle stage coverage.....	10
6 Use cases	10
6.1 Overview.....	10
6.2 Properties	10
6.3 Basic statistics.....	11
6.3.1 Use cases by application domain.....	11
6.3.2 Use cases by status of life cycle	13
7 Use case summaries	14
Annex A (informative) Use case template.....	16
A.1 General.....	16
A.2 Description of use case.....	16
A.2.1 Name of use case.....	16
A.2.2 Digital twin application area or context of use	16
A.2.3 Version management.....	17
A.2.4 Basic information to use case	17
A.2.5 Scope of use case (bullet points).....	18
A.2.6 Objectives of use case (bullet points)	18
A.2.7 Narrative of use case.....	18
A.2.8 Entities which need to be modelled as digital entities in use case	19
A.2.9 Actors: people, organizations or systems.....	19
A.2.10 Life cycle of digital twin system in use case	20
A.2.11 Key performance indicators (KPIs) of use case.....	21
A.2.12 Digital infrastructures.....	21
A.2.13 Referenced standards and standardization committees (optional).....	22
A.2.14 Referenced papers or patent (optional).....	22
A.2.15 Relation with other known use cases, for example common requirements (optional).....	22
A.2.16 General remarks (optional)	22
A.2.17 Challenges and issues (optional)	22
A.2.18 Data security, privacy and trustworthiness (optional)	23
A.2.19 User requirements and interactions with other actors (optional).....	23
A.3 Drawings or diagrams depicting the use case	23
A.3.1 Drawing of use case	23
A.3.2 Data flow diagram of use case (optional)	23
A.3.3 Sequence diagram(s) of use case (optional)	23
A.3.4 Deployment diagram(s) of use case (optional)	24
A.3.5 Others (optional).....	24
Annex B (informative) Collected use cases	25

B.1	Smart building – Smart building operation based on digital twins	25
B.1.1	Description of use case	25
B.1.2	Drawings or diagrams depicting the use case	37
B.2	Industrial smart park – Digital twin based industrial smart park design and construction	39
B.2.1	Description of use case	39
B.2.2	Drawings or diagrams depicting the use case	46
B.3	Smart city – Digital twin based smart city management system	49
B.3.1	Description of use case	49
B.3.2	Drawings or diagrams depicting the use case	59
B.4	Smart energy – Construction and application of digital twins for a large oil and gas processing facility	61
B.4.1	Description of use case	61
B.4.2	Drawings or diagrams depicting the use case	73
B.5	Smart building – Monitoring of water	74
B.5.1	Description of use case	74
B.5.2	Drawings or diagrams depicting the use case	82
B.6	Smart Power Grid – Smart grid operation based on a digital twin	82
B.6.1	Description of use case	82
B.6.2	Drawings or diagrams depicting the use case	90
B.7	Smart construction life cycle – Construction-phase digital twin model	91
B.7.1	Description of use case	91
B.7.2	Drawings or diagrams depicting the use case	104
B.8	Smart building – Residential explicit demand response – Consumer behavioural digital twin for energy demand prediction	106
B.8.1	Description of use case	106
B.8.2	Drawings or diagrams depicting the use case	119
B.9	Smart city - Greater Hobart Digital Twin	120
B.9.1	Description of use case	120
B.9.2	Drawings or diagrams depicting the use case	129
B.10	Smart city - NSW Spatial Digital Twin	130
B.10.1	Description of use case	130
B.10.2	Drawings or diagrams depicting the use case	138
B.11	Transport - Sydney Trains Engineering and Maintenance Digital Twin	138
B.11.1	Description of use case	138
B.11.2	Drawings or diagrams depicting the use case	145
B.12	Transport - TfNSW Infrastructure Delivery Digital Twin	148
B.12.1	Description of use case	148
B.12.2	Drawings or diagrams depicting the use case	155
B.13	Smart energy – From grid planning to grid operation and maintenance, based on grid digital twin(s)	157
B.13.1	Description of use case	157
B.13.2	Drawings or diagrams depicting the use case	164
B.14	Smart energy – Electrical field level subsystem digital twin, as the basis for its specification, commissioning, operation and maintenance	165
B.14.1	Description of use case	165
B.14.2	Drawings or diagrams depicting the use case	174
Bibliography		177

Figure 1 – Distribution of use cases collected in Annex B by application domains.....12

Figure 2 – Statistics on adopted key technologies from use cases in JTC 1/AG 11 report.....	13
Figure B.1 – Geometric analysis of safety prevention.....	94
Figure B.2 – Identification of close proximity events between heavy machinery.....	95
Figure B.3 – Safety training scenario	95
Figure B.4 – Segmented construction components after voxel space point matching.....	96
Figure B.5 – Sample defect predictions.....	96
Figure B.6 – On-site defect visualization, defect confirmation, and addition of remedial work.....	97
Figure B.7 – Use case diagram: before construction starts.....	104
Figure B.8 – Use case diagram: during construction	105
Table 1 – List of use cases in JTC 1/AG 11 report	12
Table 2 – List of use cases by status of life cycle.....	14
Table 3 – List of use cases	14
Table A.1 – Description of some qualitative indicators	21

INTERNET OF THINGS (IoT) – DIGITAL TWIN – USE CASES

FOREWORD

- 1) ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.
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ISO/IEC TR 30172 has been prepared by subcommittee 41: Internet of Things and Digital Twin, of ISO/IEC joint technical committee 1: Information technology. It is Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
JTC1-SC41/335/DTR	JTC1-SC41/363/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document provides use cases of digital twin applications in various domains using the template modified from IEC 62559-2 use case template and ISO/IEC TR 22417 use case template. Use case templates used in ISO/IEC JTC 1/AG 8, ISO/IEC JTC 1/AG 11 and ISO/IEC JTC 1/SC 41/AG 25 are also considered for the template in this document.

The use case template includes two parts: Description of use case; Drawings or diagrams depicting the use case. To collect use cases, the first step is to identify application domains of digital twin (DTw) systems and to provide a use case template. Contributors were requested to submit use cases using the provided template.

For improving the quality of the use case description, a guidance is provided to contributors. The guidance includes DTw concepts and reference models for preparing use cases.

By investigating use cases, it is possible to find the new technical requirements from the market, accelerating the transformation of science and technology achievements.

The use case template helps to group and categorize the use cases according to the identified application domains. Readers of this document can find use cases that relate to the desired application domain and can find original submissions of use cases in Annex A, which includes all submissions of use cases.

INTERNET OF THINGS (IoT) – DIGITAL TWIN – USE CASES

1 Scope

This document provides a collection of representative use cases of digital twin applications in a variety of domains, for example, smart manufacturing and smart cities.

This document is applicable to all types of organization (for example, commercial enterprises, government agencies, and not-for-profit organizations).

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 digital twin DTw

digital representation of a target *entity* (3.2) with data connections that enable convergence between the physical and digital states at an appropriate rate of synchronization

Note 1 to entry: Digital twin has some or all of the capabilities of connection, integration, analysis, simulation, visualization, optimization, collaboration, etc.

Note 2 to entry: Digital twin can provide an integrated view throughout the life cycle of the target entity.

[SOURCE: ISO/IEC 30173:–, 3.1.1]

3.2 entity

<digital twin> thing (physical or non-physical) having a distinct existence

EXAMPLE Person, object, event, idea, process, etc.

[SOURCE: ISO/IEC 20924:2021, 3.1.18, modified – The domain "<digital twin>" and the example have been added.]

3.3 physical entity

entity in the physical world that can be the subject of sensing and/or actuating

[SOURCE: ISO/IEC 20924:2021, 3.1.27]

3.4

digital entity

computational element comprising data elements and procedural elements

[SOURCE: ISO/IEC 30173:–, 3.1.5]

3.5

life cycle

evolution of a system, product, service, project or other human-made entity from conception through retirement

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.21]

3.6

conformity

process of analysis to determine whether a digital twin meets the specified requirements and to form a judgement as to whether the digital entity is fit for its corresponding physical entity

3.7

reliability

ability of an item to perform a required function under given conditions for a given time interval

[SOURCE: IEC 62657-1:2017, 3.1.12, modified – Note 1 to entry and note 2 to entry have been deleted.]

3.8

verification

confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.12, modified – The notes to entry have been deleted.]

3.9

validation

confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.13, modified – The notes to entry have been deleted.]

3.10

robustness

degree to which a system or component can function correctly in the presence of invalid inputs or stressful environmental conditions

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.3555]

3.11

fidelity

ability to accurately describe the relevant aspects of the physical counterpart within a well-defined set of conditions by its digital model

3.12

traceability

ability to trace the history, application or location of an object

[SOURCE: ISO 9000:2015, 3.6.13, modified – Note 1 to entry and note 2 to entry have been deleted.]

3.13

synchronization

<digital twin>action of making the states of target and digital entity synchronized, using network for real time system

[SOURCE: ISO/IEC 30173:–, 3.1.20]

3.14

reconfigurability

ability of an artefact to be changed through configuration changes rather than having to modify its underlying structure or its code or both

3.15

interoperability

ability of two or more different systems to exchange information and to use the information that has been exchanged

[SOURCE: ISO/TS 27790:2009, 3.39, modified – In the definition, "systems or components" has been replaced by "different systems".]

4 Abbreviated terms

2D	two dimensional
3D	three dimensional
AI	artificial intelligence
APP	application
BIM	building information modelling
DTw	digital twin
ERP	enterprise resource planning
GIS	geographic information system
HVAC	heating, ventilation, and air conditioning
IED	intelligent electronic device
KPI	key performance indicator
LGA	land grid array
MES	manufacturing execution system
MQTT	message queuing telemetry transport
PC	personal computer
PLC	programmable logic controller
R&D	research and development
SCADA	supervisory control and data acquisition

5 Applications

5.1 Application domains

DTw application domains can be classified into industry-based categories, and specific use cases can serve as examples for each category. The application domains listed below are the targeted areas for collecting use cases related to DTw; however, there may be other areas that are not included in this list.

- building or construction

- urban
- energy
- healthcare
- manufacturing
- home appliance
- mining
- telecommunications
- aerospace
- marine
- environmental monitoring
- transport

5.2 Life cycle stage coverage

The following life cycle stages, based on ISO/IEC 30173:–¹, are considered as target phases to collect use cases:

- inception
- design and development
- verification and validation
- deployment
- operation and monitoring
- re-evaluation
- retirement.

6 Use cases

6.1 Overview

Twelve use cases, based on the use case template described in Annex A, have been collected in Annex B. Some use cases include trademarks such as company names, product names, or service names. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.

The template provided in Annex A includes two parts: description of use case, and drawings or diagrams depicting the use case.

- Description of use case includes the following elements: name of use case, application area, version management, basic information to use case, scope of use case, objectives of use case, entities that need to be modelled as digital entities in use case, actors, life cycle of the digital twin system in use case, key performance indicators (KPIs) of use case, digital infrastructures.
- Drawings or diagrams depicting the use case includes the following elements: drawing of use case, data flow diagram of use case, sequence diagram(s) of use case, deployment diagram(s) of use case.

6.2 Properties

Description of the use case includes the following.

- Name of the use case to be provided by the contributor of the use code.

¹ Under preparation. Stage at the time of publication: ISO/IEC FDIS 30173:2023.

- Digital twin application area or context of use.
- Version management: the status of the version of the use case.
- Basic information to use case: descriptions of basic information of the use case that includes:
 - 1) conditions (limitations) of use;
 - 2) maturity of the use case, for example, in business operation, realized in demonstration project, realized in R&D, in preparation, visionary;
 - 3) generic, regional or national relation;
 - 4) vertical application area, for example, automotive industry, petrochemical industry, and aviation industry;
 - 5) keywords for classification, for example, system integration, performance evaluation, information exchange, IT security, and AI application.
- Scope of use case: the scope that defines the aspects covered by the limits use case or indicates the purview and limitations of the use case.
- Objectives of use case: the intention of the use case, in other words, what is to be accomplished and who will be benefited by the use case and how.
- Narrative of use case.
- Entities that need to be modelled as digital entities in the use case.
- Actors: people, organizations or systems.
- Life cycle of the digital twin system in use case: refers to 5.3 life cycle stage(s) or phase(s) coverage.
- Key performance indicators (KPIs) of use case.
- Digital infrastructures: description of digital infrastructures employed in the use cases.
- Referred standards and standardization committees.
- Referred papers or patent.
- Relation with other known use cases, for example, common requirements.
- Challenges and issues: descriptions of challenges and issues in the use case.
- Data security, privacy, and trustworthiness: issues relating to description of data, privacy, and trustworthiness in the use case.
- User requirements and interactions with other actors.

See Clause A.2 for details.

6.3 Basic statistics

6.3.1 Use cases by application domain

6.3.1.1 Use cases in Annex B

Distribution of use cases in Annex B by application domain is shown in Figure 1.

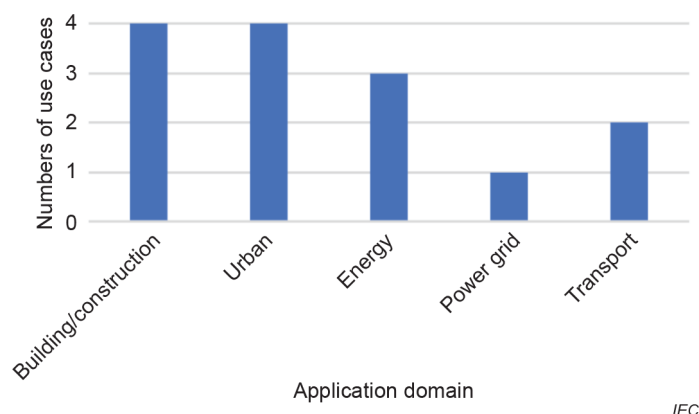


Figure 1 – Distribution of use cases collected in Annex B by application domains

6.3.1.2 Use cases in report of AG 11

Twenty-eight use cases have been collected from JTC 1/AG 11 report on DTw. The use case names and application fields are shown in Table 1. Statistics on distribution of use cases in JTC 1/AG 11 report by application domain are shown in Figure 2.

Table 1 – List of use cases in JTC 1/AG 11 report

Use case name	Application domain
Optimization of production execution	Manufacturing
Dicastal Morocco factory	Manufacturing
Product intelligent manufacturing production line	Manufacturing
Product Intelligent Assembly Process Simulation and Optimization	Manufacturing
Electro-hydraulic servo valve assembly process	Manufacturing
On Digital Twin in Additive Manufacturing	Manufacturing
Digital Twin for massive smart manufacturing	Manufacturing
Visual monitoring system for small and medium-sized machining automatic production line	Manufacturing
Visual monitoring system for assembly process	Manufacturing
The generative design and additive manufacturing of mass customized footwear lattices	Manufacturing
Research and Application of Digital Twin Technology in Joint Ship Hull Workshop	Manufacturing
Integrated Digital System for Smart Ship Pipeline Factory	Manufacturing
Luxury cruise sheet section turning device	Manufacturing
Dynamic scheduling of manufacturing tasks between multiple robots	Manufacturing
On-machine measurement for tool-life optimization	Manufacturing
Advanced Metrology	Manufacturing
Integrated Digital System for Smart Ship Pipeline Factory	Manufacturing
Digital Twin Technology Applied to the Automated Driving Test and Evaluation System	Manufacturing
Digital twin system of tobacco industry chain	Manufacturing
Research on the construction and application of digital twin in intelligent oil and gas pipeline network	Energy
Smart Cities with Digital Twin Technology	Urban
Digital Twin City Smart Control Cloud-Platform	Urban
Elderly Healthcare Services Using Digital Twin	Healthcare

Use case name	Application domain
Prototype Twinning	Prototyping
Digital Intelligence Huaguoyuan	Community
Digital Twin of Supply Chain for Automotive Industry	Supply Chain
Use of AI systems digital twins for conformity assessment	General Scenario
Digital Twin Solution for Thermal Fluid Systems based on Flownex	General Scenario

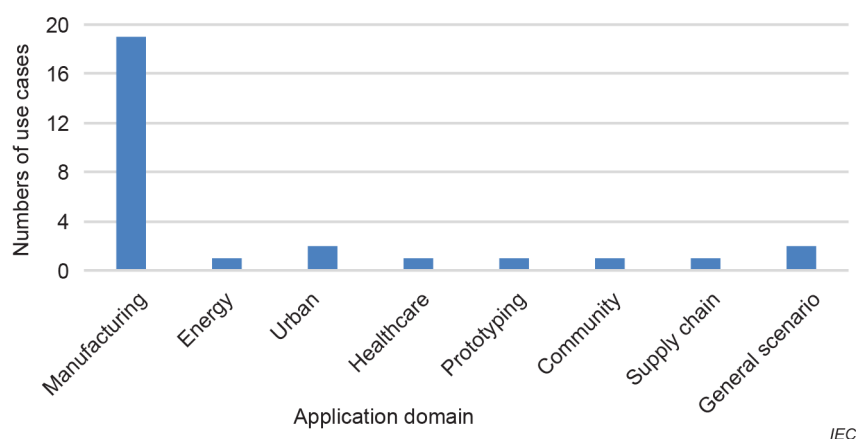


Figure 2 – Statistics on adopted key technologies from use cases in JTC 1/AG 11 report

6.3.1.3 Use cases in IEC SRD 62913-2-3 and IEC SRD 62913-2-4

A list of described use cases in IEC SRD 62913-2-3 and IEC SRD 62913-2-4 can be also considered:

- IEC SRD 62913-2-3-S050 "Process data related to the smart home behaviour to aggregate (forecasting, real-time), assess the value of, and certify flexibilities"
- IEC SRD 62913-2-3-S053 "Process data related to the Smart Building behaviour to aggregate (forecasting, real-time), assess the value of, and certify flexibilities"
- IEC SRD 62913-2-3-S069 "Elaborate a charge or discharge schedule"
- IEC SRD 62913-2-3-S079 "Forecast electricity price"
- IEC SRD 62913-2-3-S080 "Forecast power demand"
- IEC SRD 62913-2-3-S091 "Perform renewable energy forecasts"
- IEC SRD 62913-2-4-S007 "Forecast FCR capacity of an EV aggregate"

6.3.2 Use cases by status of life cycle

Distribution of each of the Annex B use case by status of life cycle is shown in Table 2.

Table 2 – List of use cases by status of life cycle

Status of life cycle	Numbers of use cases
Inception phase	4
Design and development phase	6
Installation phase	4
Deployment phase	11
Operation and monitoring phase	4
Re-evaluate phase	3
Retirement phase	2

7 Use case summaries

Table 3 shows summary information for each of the use cases, including use case name, application domain, and status.

Table 3 – List of use cases

Corresponding clause number	Use case name	Application domain	Status of life cycle
B.1	Smart building operation based on digital twins	Building or construction	Deployment phase
B.2	Digital twin based industrial smart park design and construction	Urban	Deployment phase
B.3	Digital twin based smart city management system	Urban	Re-evaluate phase
B.4	Construction and application of digital twins for a large oil and gas processing facility	Energy	Deployment phase
B.5	Monitoring of Water	Building or construction	Deployment phase; Installation phase
B.6	Smart grid operation based on digital twin	Power grid	Deployment phase; Operation and monitoring phase
B.7	Construction-phase digital twin model	Building or construction	Design and development phase
B.8	Consumer behavioural digital twin for energy demand prediction	Building or construction	Design and development phase; Deployment phase; Installation phase
B.9	Greater Hobart Digital Twin	Urban	Design and development phase
B.10	NSW Spatial Digital Twin	Urban	Deployment phase
B.11	Sydney Trains Engineering and Maintenance Digital Twin	Transport	Inception phase
B.12	TfNSW Infrastructure Delivery Digital Twin	Transport	Inception phase; Design and development phase

Corresponding clause number	Use case name	Application domain	Status of life cycle
B.13	From grid planning to grid operation and maintenance, based on grid digital twin(s)	Energy	Inception phase; Design and development phase; Verification and validation phase; Deployment phase; Operation and monitoring phase; Re-evaluate phase; Retirement phase
B.14	Electrical field level subsystem digital twin, as the basis for its specification, commissioning, operation and maintenance	Energy	Inception phase; Design and development phase; Verification and validation phase; Deployment phase; Operation and monitoring phase; Re-evaluate phase; Retirement phase

Annex A (informative)

Use case template

A.1 General

This Annex A is the template used for collecting use cases. The terms used in that template were defined in 5.1.

The template is based on:

- IEC 62559-2
- ISO/IEC TR 22417
- template developed by JTC 1/AG 8
- template developed by JTC 1/SC 41/AG 25
- template developed by JTC 1/AG 11

A.2 Description of use case

A.2.1 Name of use case

ID	Name of use case For example, xx (Application area)-xx(Application scenario)-xx(National Body)

A.2.2 Digital twin application area or context of use

Application area or context of use For example, manufacturing, agriculture, digital marketing, education, energy, finance technology, healthcare, home or service robotics, ICT, logistics, and city management.

A.2.3 Version management

Changes or version	Date	Name Author(s) or committee	Approval status (optional)
For example, V1.0	For example: xx(year)-xx(month)-xx(day)		For example: draft, for comments, for ballot

A.2.4 Basic information to use case

Source(s) or literature (optional)	Link (optional)	Conditions (limitations) of use (optional)
Maturity of use case		
☐ in business operation ☐ realized in demonstration project ☐ realized in R&D ☐ in preparation ☐ visionary		
Generic, regional or national relation		
Vertical application area		
For example, Automotive industry, petrochemical industry, and aviation industry.		
Well-known or related commercial or existing use cases (optional)		

Keywords for classification

For example, system integration, performance evaluation, information exchange, IT security, and AI application.

A.2.5 Scope of use case (bullet points)

Scope of use case

Include but not limited to following items:

- Describe xxxx in xxx scenario;
- Describe xxx among xxx systems;
- Describe digital twin system architecture in xxx scenario;
- Describe requirements about xxx in xxx area or scenario

A.2.6 Objectives of use case (bullet points)

Objectives of use case

- Objective 1: to obtain, realize, minimize or satisfy xxx
- Objective 2: xxx
- ...

A.2.7 Narrative of use case

Narrative of use case

Short description – max. 3 sentences

Complete description

A.2.8 Entities which need to be modelled as digital entities in use case

Entity name For example, robot, sensor, building, person, and car.	Data	Model type	Requirements or constraints on the models

NOTE

- (1) Data: can include asset data, operational data, context data, metadata, operational history, maintenance history, and knowledge.
- (2) Model type: can include physical model, chemical model, statistical model, AI model, engineering model, and metamodel.
- (3) The types of requirements or constraints on the models: can involve performance requirements of the models, input and output requirements of the models, and important constraints. Constraints: can include legal contracts, legal regulations, and others (including regional regulations).

A.2.9 Actors: people, organizations or systems

Actor name For example, Actor _n : xxx	Actor type	Actor description	Actor interactions (Transactions between Actors) (optional)
	☐ system actor ☐ business actor: role: _____		
	☐ system actor ☐ business actor: role: _____		
	☐ system actor ☐ business actor: role: _____		
	☐ system actor ☐ business actor: role: _____		
	☐ system actor ☐ business actor: role: _____		

	☐ system actor ☐ business actor: role: _____		
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NOTE 1 According to IEC 62559-2:

(1) Actor refers to people, organizations or systems that communicates and interacts, such as, consumer, customer energy management system, distribution management system, distribution system operator, meter operator, and system operator.

NOTE 2 These actors can include people, software applications, systems, databases, and even the power system itself.

The entities in A.2.8 refer to the objects that will be modelled as digital models in the digital space. The actors in A.2.9 refer to the people, organizations or systems that will trigger or have influences on the digital twin system. The business actor refers to the people, organizations that can apply, trigger or have influences on the digital twin systems.

(2) Actor type is divided into system actors and business actors.

- System actors are covering functions or devices. For example, in the energy system area, system actors are defined in the interface reference model (IEC 61968-1).
- A business actor specifies in fact a "role"; roles can be taken by diverse entities.

Typical examples for actors or roles in the energy system:

- "Meter operator" is a role that can be taken either by a specific company or by a distribution system operator (DSO) company;
- "Aggregator" is a role that could be taken by many entities like a DSO company, an energy service company (ESCO) or an energy supplier.

(3) Examples of actors given in IEC 62559-2:2015, Table A.1 are as follows:

Consumer refers to end user of electricity, gas, water or heat.

NOTE 3 As the consumer can also generate energy using a distributed energy resource, the consumer is sometimes called the "prosumer".

Customer energy management system refers to energy management system for energy customers to optimize the utilization of energy according to supply contracts or other economic targets. Customer energy management system is responsible for gathering flexibilities within the customer premises and providing them to an aggregator, and therefore does not directly participate in flexibility markets.

A.2.10 Life cycle of digital twin system in use case

Life cycle of digital twin system in use case
☐ inception phase ☐ design and development phase ☐ verification and validation phase ☐ deployment phase ☐ operation and monitoring phase ☐ re-evaluate phase ☐ retirement phase

A.2.11 Key performance indicators (KPIs) of use case

Name	Description	Reference to mentioned use case objectives
		For Objective x, xxxx.

NOTE Some qualitative indicators, such as synchronization, reliability, verification, robustness, traceability, reconfigurability and some quantitative indicators can be taken into consideration. The description of some qualitative indicators is given in Table A.1 and defined in Clause 3.

Table A.1 – Description of some qualitative indicators

Name	Description
conformity	process of analysis to determine whether a digital twin meets the specified requirements and to form a judgement as to whether the digital entity is fit for its corresponding physical entity
synchronization	action of making the states of target and digital entity synchronized, using network for real time system NOTE Synchronization is the measurement of or process by which the correspondence between a DTw and its target is measured or achieved.
reliability	ability of an item to perform a required function under given conditions for a given time interval
verification	confirmation, through the provision of objective evidence, that specified requirements have been fulfilled
validation	confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled
robustness	degree to which a system or component can function correctly in the presence of invalid inputs or stressful environmental conditions
fidelity	ability to accurately describe the relevant aspects of the physical counterpart within a well-defined set of conditions by its digital model
traceability	ability to trace the history, application or location of an object
reconfigurability	ability of an artefact to be changed through configuration changes rather than having to modify its underlying structure or its code or both

A.2.12 Digital infrastructures

Name	Description	Impact on use case

NOTE Digital infrastructures of a digital twin refer to the infrastructure that will exchange the information with the digital twin system in the use case, such as Computing devices, Sensors, Artificial intelligence, Situation- or Context-Awareness, Localization and Tracking, Actuators, Controls, Energy Consumption, Time Synchronization, Management Functions or Risk management, Unique Identification, Database, Networking, IT Security, Data Privacy, and Simulations.

A.2.13 Referenced standards and standardization committees (optional)

Relevant standardization committees	Standards relevant to the use case	Status of standard

A.2.14 Referenced papers or patent (optional)

References	Type	Impact on use case	Links

A.2.15 Relation with other known use cases, for example common requirements (optional)

Known use case	Source	Relationship

A.2.16 General remarks (optional)

General remarks

A.2.17 Challenges and issues (optional)

Challenges and issues

A.2.18 Data security, privacy and trustworthiness (optional)

Data security requirements and implications for applications and systems
Privacy requirements and implications for applications and systems
Trustworthiness requirements and implications for applications and systems

A.2.19 User requirements and interactions with other actors (optional)

User requirements and interactions

A.3 Drawings or diagrams depicting the use case

A.3.1 Drawing of use case

Drawing or diagram of use case – for example, graphic depiction of use scenarios, or "use case diagram"

A.3.2 Data flow diagram of use case (optional)

Data flow diagram of use case

NOTE Entities in A.3.2 can be aligned with entities listed in A.2.8.

A.3.3 Sequence diagram(s) of use case (optional)

Sequence diagram(s) of use case

NOTE In addition to a high-level sequence diagram, it can be helpful to split out critical interactions to provide additional details on actors involved at such stages (for example providing information on handling of fault conditions).

A.3.4 Deployment diagram(s) of use case (optional)

Deployment diagram(s) of use case

A.3.5 Others (optional)

If possible, provide a graphical image or a video of the demonstration model (optional)

Annex B (informative)

Collected use cases

B.1 Smart building – Smart building operation based on digital twins

B.1.1 Description of use case

B.1.1.1 Name of use case

ID	Name of use case
001	Smart building – Smart building operation based on digital twins – CN

B.1.1.2 Digital twin application area or context of use

Application area or context of use
• Smart building NOTE Donghe Center Building H in China has the total construction area of about 86 000 m², with 23 stories above ground and a height of 101,5 m. Its digital twin building system could reflect the whole life cycle process of the corresponding physical building, by applying physical architecture model and a variety of sensors to simulate the process and complete the mapping in the virtual space. The digital twin building system has four characteristics: accurate mapping, virtual–real interaction, software definition, and intelligent intervention.

B.1.1.3 Version management

Changes or version	Date	Name Author(s) or committee	Approval status (optional)
V 1.0	2021-07-11	Jiangf	draft
V 2.0	2021-09-15	Jiangf	draft

B.1.1.4 Basic information to use case

Source(s) or literature (optional)	Link (optional)	Conditions (limitations) of use (optional)
/	/	/
Maturity of use case		
☒ in business operation, ☐ realized in demonstration project ☐ realized in R&D ☐ in preparation ☐ visionary		
Generic, regional or national relation		
CHINA		
Vertical application area		
Intelligent building		
Well-known or related commercial or existing use cases (optional)		
Keywords for classification		
system integration; information exchange		

B.1.1.5 Scope of use case

Scope of use case
- Describe operation management and maintenance of the building based on digital twins and related systems; - Describe the intelligent building management system architecture in this scenario

B.1.1.6 Objectives of use case

Objectives of use case
- Objective 1: to realize intelligent property management and intelligent energy management of the building; - Objective 2: to achieve energy conservation, environmental protection and lower the operational cost; - Objective 3: to reduce the cost of management personnel, reduce building energy consumption cost, and optimize the qualification management strategy.

B.1.1.7 Narrative of use case

Narrative of use case
Short description
This use case establishes the mapping among physical entities and their corresponding virtual models based on data collection and integration, including key device parameters and logical strategy of operation and management. The use case establishes the precipitation algorithm based on experience and knowledge. At the same time, the use case achieves analysis of operation optimization strategies through real-time condition monitoring of devices and facilities as well as data acquisition, storage, analysis, visualization and use.
Complete description
The intelligent building management system in the use case includes the subsystems related to building automation, energy management, intelligent lighting, fire control, security and environmental monitoring. At the same time, the system integrates the various subsystems together organically to complete both the mapping among the physical environment and digital virtual reality space and the bilateral control. The system provides the building the ability of self-diagnosis, self-analysis, and some degree of self-decision. The system manages more than 30 000 dynamic data (such as data from environmental monitoring, intelligent lighting, energy management, equipment management, photovoltaic power generation, light-current system, HVAC system, water supply and drainage system, industrial control systems) and additional static data (static data such as 3D model, drawings, and technical documents.). The system covers the whole life cycle of the building, including the design, construction, and operations of the building. It achieves 3D virtual monitoring, equipment maintenance, energy management, property management, and further achieves the purpose of safety, stability, green, and intelligence. The system also includes energy saving and optimization control logistics and strategies to save energy and improve management effect in building public areas without any switch panel. Presently, the lighting energy saving rate reaches 70 %, and air conditioning energy saving rate reaches 17 % by statistics of more than a year of operation data. For special conditions (such as maintenance and reception), only simple configuration operation can realize the control of all the devices quickly to avoid manually changing the building equipment operation state and mode. System description: The whole system through BIM forward design, operation and maintenance model into a large number of designer languages, and the construction of a perfect coding system to achieve the model and drawings, equipment systems, systems between the virtual mapping and configuration association. The architecture of self-perception, self-decision, self-diagnosis and self-execution in the digital twin system is fully dependent on the developed digital graphics platform and industrial Internet platform. It realizes multi-source data fusion through the integration of end, edge and cloud equipment. In addition, lighting, air conditioning, fresh air, fan are all intelligently controlled in the public area of the building without any switch panel. Building operation and maintenance only need a property engineer.



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- (1) Digital entity establishment: Because information of the entire life cycle of a project in three dimensions is collected, users can directly view any drawings, any equipment and piping of fast positioning, and any component of the query, including design attributes (such as size, the working set, system and specifications), procurement information (such as brand, manufacturer, date of production) as well as the running data, alarm and maintenance logs. It greatly improves the operational efficiency.



IEC

- (2) Object model building: According to business requirements, the object models, the realization of attribute definition, feature identification, function definition, and event definition are established based on the virtual models. In addition, the abstract mapping between the virtual model and the real device is completed. At present, the system supports the object model construction of common air conditioning, lighting, water pump and other general equipment, and establishes the object model and review process. It can support user customization to edit, add, or modify the object model. Finally, the system is released through a variety of communication protocols to complete docking with the real side of the data and system correlation.

IEC

(3) Establishment of strategy optimization model: Similarly, the use case puts a large number of energy saving and optimized control logic strategies into the system, so that the building does not need a switch panel, and the energy saving and management effect is remarkable. Based on operation data statistics of more than a year, the lighting energy saving rate has reached 70 %, the air conditioning energy saving rate has reached 17 %. In terms of special conditions (such as maintenance, reception), only a simple configuration operation is needed to realize the control of all the devices quickly while manually changing the building equipment operation state and mode. The labour cost of building operation and maintenance was greatly reduced.



✓ 多联机空调分户计量模块

1、数据采集点，opc点位编码规则为：驱动设备编号 室内机编号 点位编号

2、建立空调室外机，空调室内机和电表 编号对应关系表

3、室内机能耗占比关键算法：

$$Q = \frac{(2 - \alpha)^2 + \alpha}{(2 - \alpha)^2 + \alpha} \cdot \Delta T$$

其中，
 α ——回风温度
 α ——设定温度
 k ——经验系数，设定为 9
 ϕ ——设定参数，设定为 0.0001
 γ ——室内机额定功率占比
 ΔT ——运行时间，设定为 1min

4、室内机分户计量算法：

$$E_i = \frac{Q_i}{\sum Q_i} \cdot E_{\text{总}}$$

其中，
 E_i ——第i台室内机在分户内的分户能耗
 $E_{\text{总}}$ ——第i台室内机在分户内的总能耗
 Q_i ——第i台室内机在所属系统的能耗分户占比
 $\sum Q_i$ ——每套中央空调系统内所有室内机的能耗分户占比之和

5、形成报表：

依据分钟能耗的数据，按照小时，日，月形成日报，月报和年报

6、分户计量：

依据日报数据，获取室内机每个小时的能耗，并按照如下公式计算租户每个小时的空调使用能耗：

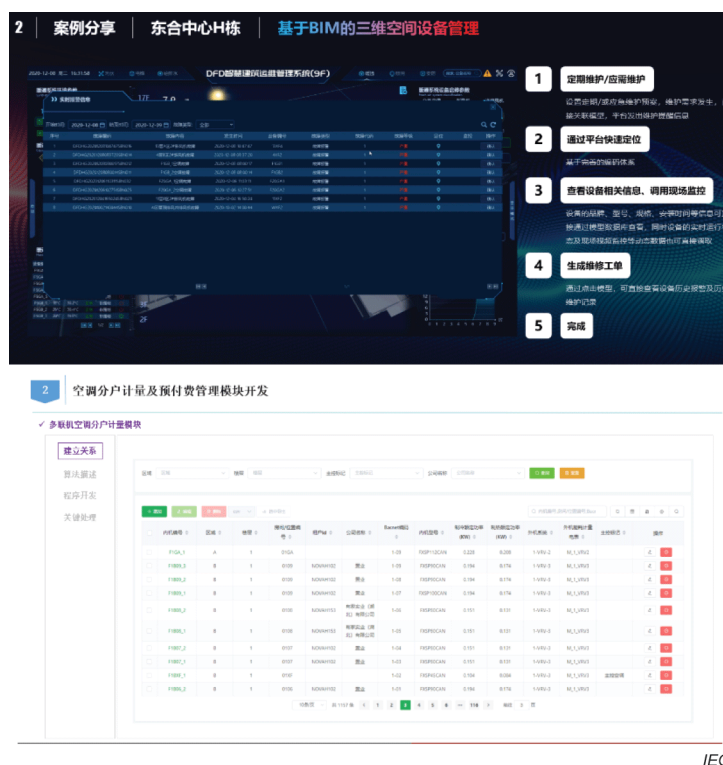
$$E_{\text{租户}} = \sum_{i=1}^n Q_i$$

$E_{\text{租户}}$ ——xx公司空调使用能耗
 $\sum Q_i$ ——xx公司所属室内机能耗之和

楼栋名称	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
东合中心H栋10F1001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
东合中心H栋10F1010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IEC

- (4) Business system application: The system is completely in the three-dimensional process of equipment management. In terms of the biggest difference with traditional operations, the use case doesn't apply the concept of various systems and implements a unified platform containing a lot of equipment diagnosis logics (including regular maintenance or emergency fault maintenance). Through the platform, the use case can directly locate the point of failure and retrieve the design parameters, drawings, historical maintenance records, and on-site video surveillance of the equipment to assist maintenance decisions. Finally, it can generate maintenance work orders. The whole process is fast, accurate and effective.



B.1.1.8 Entities that need to be modelled as digital entities in use case

Entity name	Data	Model type	Requirements or constraints on the models
Building	Geometric information, parameter information, material information, procurement information	physical model	Performance requirements: consistency, accuracy and fineness
Electromechanical equipment	Geometry information, parameter information, material information, procurement information, maintenance information, energy consumption information, sensor data, operation information	physical model	Performance requirements: consistency, accuracy and fineness
Environment	Temperature, humidity, illumination, CO ₂ concentration, human flow	physical model	Performance requirements: consistency, accuracy and fineness

Entity name	Data	Model type	Requirements or constraints on the models
Predictive analysis rules and algorithms	Equipment operation data, operation time data, tenant management data	artificial intelligence model	Performance requirements: accuracy rate, recall rate; Input and output requirements: interface
Fault diagnosis rules and algorithms	Equipment operation data, alarm failure data, sensor data, scheme execution data	artificial intelligence model	Performance requirements: accuracy rate, recall rate; Input and output requirements: interfaces
Process or rule	Business management process data, user role data, rights management data	knowledge model	Performance requirements: accuracy rate, recall rate; Input and output requirements: interfaces
Energy consumption optimization rules and algorithms	Equipment energy consumption data, time data, historical data	artificial intelligence model	Performance requirements: accuracy rate, recall rate; Input and output requirements: interfaces
Operation and maintenance knowledge	Maintenance orders, drawings, technical documents	knowledge model	Performance requirements: accuracy rate, recall rate; Input and output requirements: interfaces

B.1.1.9 Actors: people, organizations or systems

Actor name	Actor type	Actor description	Actor interactions (Transactions between Actors) (optional)
System manager	☐ system actor ☒ business actor: role: user	System users, who view the running status of the building, data statistics, control and manage the system.	
System operation and maintenance personnel	☐ system actor ☒ business actor: role: user	System operation and maintenance personnel, who are responsible for rights management, system configuration, upgrade and optimization.	
Decision user	☐ system actor ☒ business actor: role: user	System decision level users, who are responsible for data report view, data analysis and statistical use, construction management decisions.	
Project manager	☐ system actor ☒ business actor: role: service provider	Project manager, who is responsible for system requirements, and development, operation and maintenance management of the system.	
Developer	☐ system actor ☒ business actor: role: service provider	System coding developers, who are responsible for data development, background development, front-end development, 3D component development.	
Modellers	☐ system actor ☒ business actor: role: service provider	Modellers can be divided into system modeller, 3D modeller, parametric modeller, knowledge modeller, artificial intelligence modeller, rule modeller.	
Field implementer	☐ system actor ☒ business actor: role: service provider	System field implementation personnel, who are responsible for installation, deployment, debugging and testing of the system.	

Actor name	Actor type	Actor description	Actor interactions (Transactions between Actors) (optional)
Database engineer	☐ system actor ☒ business actor: role: service provider	Data collection personnel, who are responsible for report input, database strategy, data model establishment.	
Designer	☐ system actor ☒ business actor: role: service provider	Designer, who is responsible for architectural design, system design, model design, business process design.	
Civil construction staff	☐ system actor ☒ business actor: role: service provider	Civil construction staff, who is responsible for construction and maintenance of civil and structural works	
Equipment procurement staff	☐ system actor ☒ business actor: role: service provider	Equipment procurement staff, who are responsible for the purchase and installation of important equipment and facilities	
Mechanical and electrical installation staff	☐ system actor ☒ business actor: role: service provider	Mechanical and electrical installation staff, who are responsible for electromechanical equipment, cable wiring, network weak current, sensor deployment and installation	

B.1.1.10 Life cycle of use case

Life cycle of use case
☐ inception phase ☐ design and development phase ☐ verification and validation phase ☒ deployment phase ☐ operation and monitoring phase ☐ re-evaluate phase ☐ retirement phase

B.1.1.11 Key performance indicators (KPIs) of use case

Name	Description	Reference to mentioned use case objectives
Consistency	Agreement or logical coherence among the digital entities and the corresponding physical entities, in other words, the specified requirements.	For Objective 3, optimize the qualification management strategy through high-accuracy behaviours of digital entities.
Energy saving	Lighting energy saving rate	70 %
	Air conditioning energy saving rate	17 %
Cost	Reduction of property management personnel	30 %
	Reduction of equipment losses and maintenance costs	20 %

B.1.1.12 Digital infrastructures

Name	Description	Impact on use case
Sensors	All kinds of complete equipment PLC or DDC sensors, energy meters, IoT terminals, files and other communication terminals	Such devices access the edge layer of the platform through various IO links (such as LAN, WIFI, RTU, ZigBee, HTTP, TCP or IP, and MQTT.) or directly connect with the private cloud service providers.
Data storage devices	The real-time collected data are stored. According to the characteristics of large data volume and high frequency of architectural group data, a database cluster is built to satisfy the persistence of a large number of highly concurrent real-time data.	For the storage design of massive historical data of architectural complex, the data are partitioned and stored in pieces through the design of database partition and sub-database to meet the requirements of the upper application for data re-application.

B.1.1.13 Challenges and issues

Issue	Impact of issue on use case	Reference
Real-time data problems	Data from different sources have different time cycle, which can result in the analysis errors and accuracy reduction.	

B.1.1.14 Referenced standards and standardization committees (optional)

Relevant standardization committees	Standards relevant to the use case	Status of standard

B.1.1.15 Referenced papers or patent (optional)

References	Type	Impact on use case	Links

B.1.1.16 Relation with other known use cases, for example common requirements (optional)

Known use case	Source	Relationship

B.1.1.17 General remarks (optional)

General remarks

B.1.1.18 Data security, privacy and trustworthiness (optional)

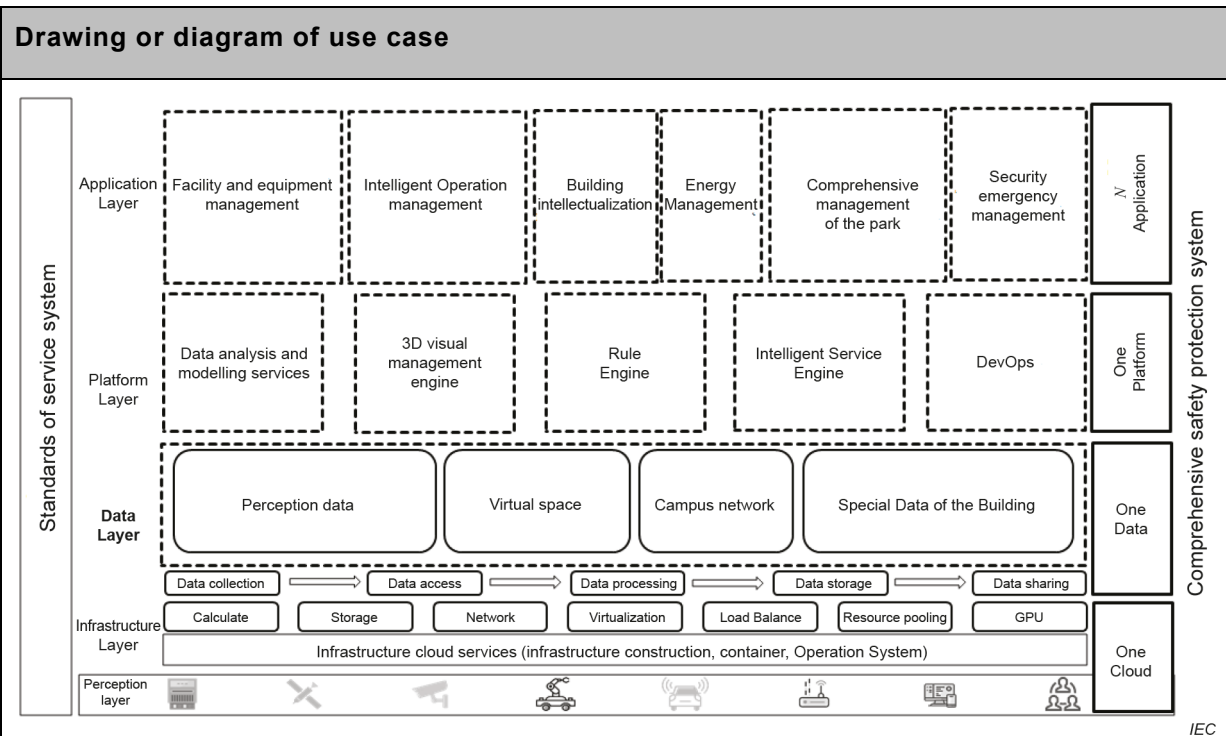
Data security requirements and implications for applications, systems
The use case deploys the VPN (Virtual Private Network) system. It can access certification management system, mobile security management system and firewall system to provide the functions of remote access and data encryption transmission for remote operation and maintenance users.
Privacy requirements and implications for applications, systems
Trustworthiness requirements and implications for applications, systems

B.1.1.19 User requirements and interactions with other actors (optional)

User requirements and interactions

B.1.2 Drawings or diagrams depicting the use case

B.1.2.1 Drawing of use case



The use case adopts the design of micro service architecture based on internet data collection technologies, big data management and analysis technologies, the whole process of encoding technology, BIM technologies, and 3D visualization technologies to build wisdom park or building integrated control platform. The platform realizes the resource flexibility management, modular application development, rapid response to business demands and ubiquitous connection of edge layers.

The architecture includes perception layer, infrastructure layer, data layer, platform layer and application layer. The details are shown as follows:

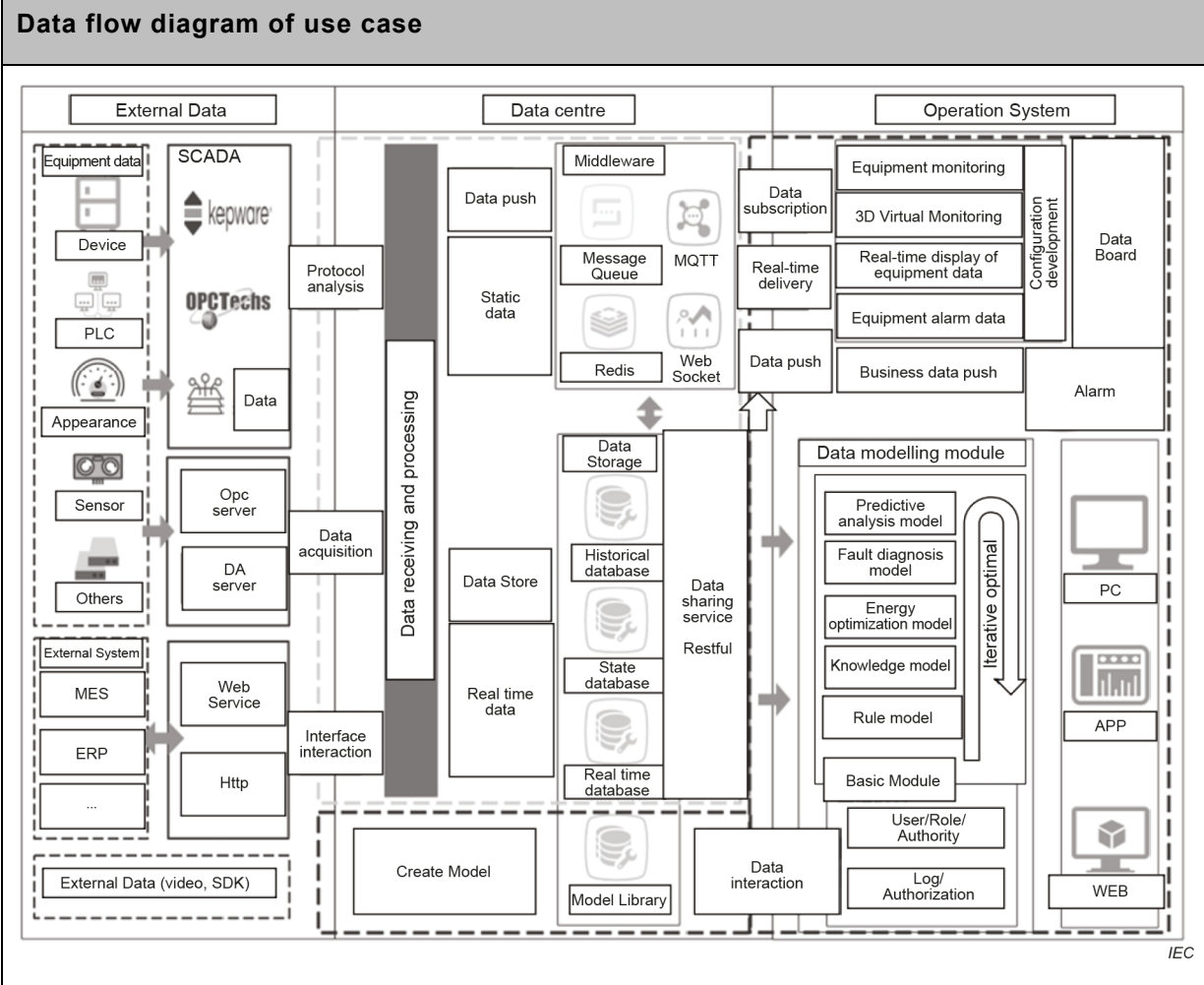
Perception layer includes building automation, weak-current control subsystem and other subsystems. Infrastructure layer includes industrial cloud.

Data layer is used for data storage, processing and sharing.

Platform layer is mainly to complete data collection, storage, processing, analysis, data interaction, intelligent computing, diagnosis and decision.

Application layer is mainly to complete the interaction with users, such as operation module, intelligent energy management module, wisdom property management module, intelligent building, personnel management, and vehicle intelligent security management. The client can access and display each system of the platform through a PC browser or a mobile device application or large-screen display.

B.1.2.2 Data flow diagram of use case (optional)



B.1.2.3 Sequence diagram(s) of use case (optional)

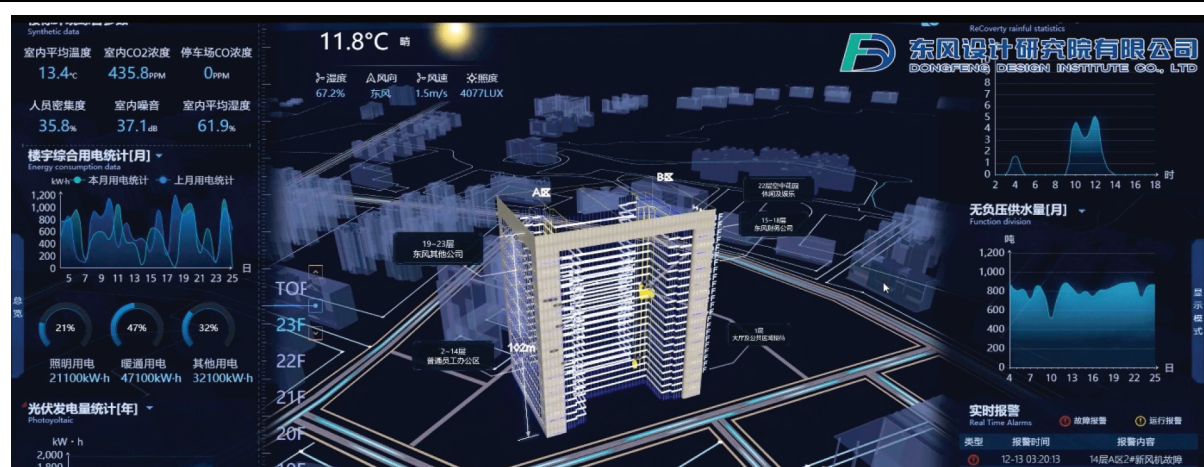
Sequence diagram(s) of use case

B.1.2.4 Deployment diagram(s) of use case (optional)

Deployment diagram(s) of use case

B.1.2.5 Others (optional)

If possible, provide a graphical image or a video of the demonstration model (optional)



IEC

B.2 Industrial smart park – Digital twin based industrial smart park design and construction

B.2.1 Description of use case

B.2.1.1 Name of use case

ID	Name of use case
002	Smart park – Digital twin based industrial smart park design and construction - CN

B.2.1.2 Digital twin application area or context of use

Application area or context of use
City management

B.2.1.3 Version management

Changes or version	Date	Name Author(s) or committee	Approval status (optional)
V1.0	2021-10-21	Tencent Cloud	draft

B.2.1.4 Basic information to use case

Source(s) or literature (optional)	Link (optional)	Conditions (limitations) of use (optional)
Maturity of use case		
☒ in business operation ☐ realized in demonstration project ☐ realized in R&D ☐ in preparation ☐ visionary		
Generic, regional or national relation		
CHINA		
Vertical application area		
industrial smart park		
Well-known or related commercial or existing use cases (optional)		
Keywords for classification		
AI, cloud computing, IoT, IT security		

B.2.1.5 Scope of use case

Scope of use case
Include but not limited to following items: • Address the spatial design, landscape planning, transportation planning, municipal planning and other schemes for industrial smart park by utilization of digital twin; • Describe the real-time construction progress status of the industrial smart park; • Give system architecture for this industrial smart park scenario.

B.2.1.6 Objectives of use case

Objectives of use case
• Objective 1: to realize effective and precise spatial design, landscape planning, transportation planning, municipal planning and other schemes of the industrial smart park; • Objective 2: to achieve precise visualization of the construction progress status of the industrial smart park with auxiliary capability of overall decision-making. • Objective 3: to reduce the economic and time cost of data acquisition, and to lower the safety risks of the technical personnel.

B.2.1.7 Narrative of use case

Narrative of use case
Short description
This use case explores the digital pre-construction, pre-judgment, and visualization for the planning and construction of the industrial smart park via two digital twin platforms. On one side, the planning and design platform achieves spatial design, landscape planning, transportation planning, municipal planning and others for the industrial smart park based on the high-precision rendering effect as well as various operabilities. On the other hand, the construction visualization platform shows the real-time construction progress status of the industrial smart park by integrating the industry-leading lightweight data technology, 3D as well as GIS (Geographic Information System) visualization technology, simple and easy-to-use functional operation.
Complete description
• Planning and design of the industrial smart park The planning and design platform is based on the high-quality and high-precision rendering effect, as well as operation of UE4 (Unreal Engine version 4) engine. It closely focuses on the overall planning and design business of the Shenzhen Bay super headquarter base, such as area overview, spatial design, landscape planning, traffic planning and municipal planning. It uses a high-quality three-dimensional visualization technology to realize the precise display of the concept and highlights of the industrial smart park planning via a variety of human–computer interaction methods and interaction effects. Further, through JS-SDK (a cloud game development kit), the planning and design platform adopts the cloud rendering technology. It can browse and display on the web, which breaks the limitations of the traditional C or S architecture and greatly alleviates the requirements of hardware configuration on the client. • Real-time construction progress visualization of the industrial smart park The construction of the visualization platform applies the three-dimensional measurement function, so that important information such as site area, volume and length can be collected without technicians on the site. Furthermore, it can ensure personnel safety and improve the work efficiency.

In addition, it displays the three-dimensional inclined model in time series, which is used to show the project progress and understand the construction progress and construction effect in different time periods. It is helpful for the engineering department to intuitively control the overall progress of the project, as well as to arrange the construction plan and process interleaving for each milestone in a reasonable manner. More importantly, it reduces the economic and time cost of data acquisition of the three-dimensional model and restores the real appearance of the industrial smart park more intuitively and effectively than the BIM model.



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- Interconnections of the two platforms

The planning and design platform can integrate the Client or Server and Browser or Server architecture with the construction visualization platform, which can be browsed on the web. Moreover, through RESTFUL protocol, the user information of the two platforms is integrated into the same database to uniformly manage the user permissions. Only one authentication is required to realize the mutual switching between the two platforms.



IEC

B.2.1.8 Entities which need to be modelled as digital entities in use case

Entity name	Data	Model type	Requirements or constraints on the models
Building	geometric, parameter, material, procurement	physical model	consistency, accuracy and fineness
Park	planned plot information, earthwork survey, area measurement	AI model	consistency, accuracy and fineness
Environment	sky, atmosphere, clouds and other natural environment and light	AI model	consistency, accuracy and fineness
Landscape	arrangement of flowers and plants, pavement of the ground, placement of public facilities such as seats	AI model	consistency, accuracy and fineness
Moving car	geometric, material, velocity	AI model	consistency, accuracy and fineness
Pedestrian	parameter, velocity	AI model	consistency, accuracy and fineness
Engineering process control	process	Knowledge model	accuracy rate, interface
Fault diagnosis	scheme execution, alarm failure	Knowledge model	accuracy rate, recall rate

B.2.1.9 Actors: people, organizations or systems

Actor name	Actor type	Actor description	Actor interactions
Project manager	☐ system actor ☒ business actor: role: user	Project manager, who is responsible for system requirements, development, operation and maintenance management	
Decision maker	☐ system actor ☒ business actor: role: user	System decision level user, who is responsible for data report view, data analysis and statistical use, construction management decisions	

Actor name	Actor type	Actor description	Actor interactions
Designer	☐ system actor ☒ business actor: role: service provider	Designer, who is responsible for architectural design, system design, model design, business process design.	
Modeller	☐ system actor ☒ business actor: role: service provider	Modellers can be divided into system modeller, 3D modeller, parametric modeller, knowledge modeller, artificial intelligence modeller, rule modeller	
Developer	☐ system actor ☒ business actor: role: service provider	Developer, who is responsible for system coding developers, data development, background development, front-end development, 3D component development	
Industrial smart park construction staff	☐ system actor ☒ business actor: role: service provider	Industrial smart park construction staff, who are responsible for construction and maintenance of the industrial smart park	

B.2.1.10 Life cycle of digital twin system in use case

Life cycle of digital twin system in use case
☐ inception phase ☐ design and development phase ☐ verification and validation phase ☒ deployment phase ☐ operation and monitoring phase ☐ re-evaluate phase ☐ retirement phase

B.2.1.11 Key performance indicators (KPIs) of use case

Name	Description	Reference to mentioned use case objectives
Security	Provide security access, data encryption, secure storage and other policies for platform services	
Synchronization	Display the equipment position and status in the building model. When something happens, users can immediately click the camera to view the real-time picture.	
Reliability	Focus on the on-site real scene model and information collection, comprehensively show the progress status of the project, pay attention to the decision-making, overall planning and visual assistance ability, and realize the visual business function of regional project information.	

B.2.1.12 Digital infrastructures

Name	Description	Impact on use case

B.2.1.13 Referenced standards and standardization committees (optional)

Relevant standardization committees	Standards relevant to the use case	Status of standard

B.2.1.14 Referenced papers or patent (optional)

References	Type	Impact on use case	Links

B.2.1.15 Relation with other known use cases, for example common requirements (optional)

Known use case	Source	Relationship

B.2.1.16 General remarks (optional)

General remarks

B.2.1.17 Challenges and issues (optional)

Challenges and issues

B.2.1.18 Data security, privacy and trustworthiness (optional)

Data security requirements and implications for applications, systems
Privacy requirements and implications for applications, systems
Trustworthiness requirements and implications for applications, systems

B.2.1.19 User requirements and interactions with other actors (optional)

User requirements and interactions

B.2.2 Drawings or diagrams depicting the use case

B.2.2.1 Drawing of use case

Drawing or diagram of use case

B.2.2.2 Data flow diagram of use case (optional)

Data flow diagram of use case

B.2.2.3 Sequence diagram(s) of use case (optional)

Sequence diagram(s) of use case

B.2.2.4 Deployment diagram(s) of use case (optional)

Deployment diagram(s) of use case

If possible, provide a graphical image or a video of the demonstration model (optional)

