FRAUNHOFER-SOCIETY

# CERTIFICATION HANDBOOK AND EXAMINATION REGULATION

## Personnel Certification
## Digital Twins

## Revision 6

Valid from 1st January 2024

Fraunhofer Personnel Certification Authority
Schloss Birlinghoven
53757 Sankt Augustin

# CERTIFICATION HANDBOOK AND EXAMINATION REGULATION

## Personnel Certification
## Digital Twins

**Fraunhofer Personnel Certification Authority**

Fraunhofer-Institut für Angewandte Informationstechnik FIT
Schloss Birlinghoven
53757 Sankt Augustin

# Content

# 1
# Foreword

The certification services of the Fraunhofer Personnel Certification Authority in the field »Digital Twins« are open for all interested persons. The Certification Authority guarantees the equal treatment of all applicants.

Below the process of the personnel certification in the field »Digital Twins« will be described according to EN ISO 17024 »General requirements for bodies operating certification of persons« and a uniform certification system will be provided.

The certification handbook serves simultaneously as examination regulation for certification examinations in the field »Digital Twins«.

# 2
# SCOPE OF APPLICATION

The scope of the present certification handbook includes personnel certifications in the field »Digital Twins« by the Fraunhofer Personnel Certification Authority.

The personnel certifications in the field »Digital Twins« refer to the following certification profiles:

- Certified Digital Twin Business Consultant
- Certified Digital Twin Solution Architect
- Certified Digital Twin Technical Developer

Each certification profile is independent from the other ones. The requirements of the different certification profiles are listed in the annex of this document and are part of the respective personnel certification.

The different certification profiles are developed as independent profiles, but complement each other. They differ and complement each other as follows:

The certificate »Certified Digital Twin Business Consultant« covers the basic understanding of Digital Twins, their application potential and business impacts. The certificate is aimed at corporate decision-makers and consultants. It qualifies for well-founded business strategy development and high-level conception for Digital Twin implementation.

The certificate »Certified Digital Twin Solution Architect« aims at managers responsible for the operational implementation of Digital Twin strategies. Knowledge and abilities in the areas of processes, methods, technology and organization are acquired in order to create the necessary environment for the development and operation of Digital Twins.

The "Certified Digital Twin Technical Developer" is entrusted with the actual implementation of Digital Twins. The certificate is awarded for the learning of competences and abilities in dealing with IT systems, standards and protocols in the field of Digital Twin development and operation.

Further certification profiles are planned for the years to come. The prospective certification profiles will as well be developed for the basic level as for "Advanced Level" and "Expert Level".

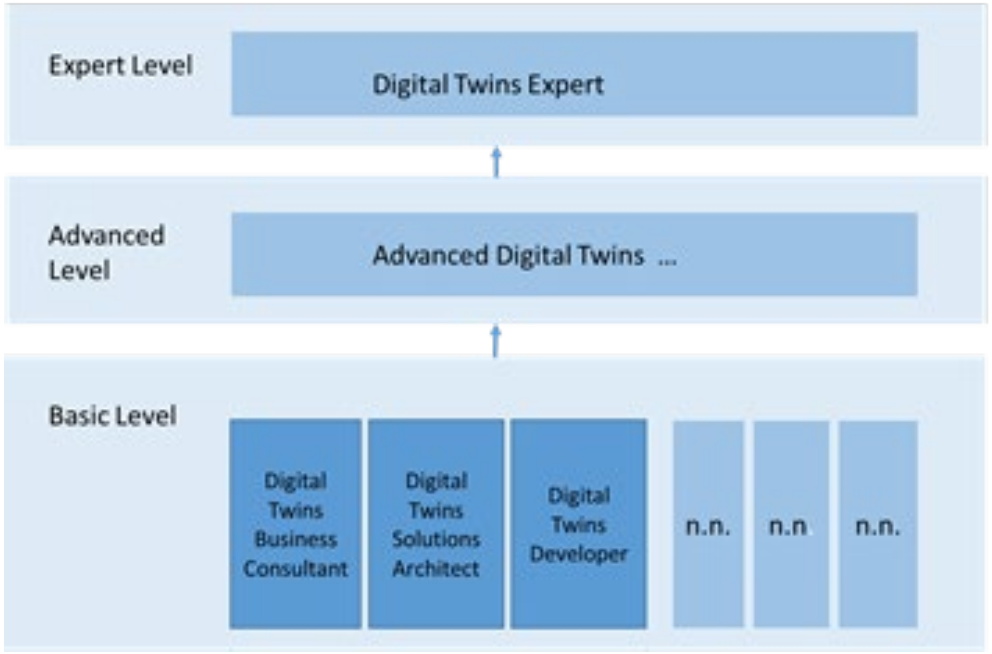


*Figure 1: Relationships between personal certifications in the field of Digital Twins*

Figure 1 shows how the present and perspective certification profiles fit in a certification system that includes a basic, advanced and expert level.

The requirements of the specific certification profiles are listed in the annexes to this document and are part of the respective certification of persons.

# 3
# GENERAL TERMS

- **Fraunhofer Personnel Certification Authority**
  Authority in the Fraunhofer Society that organises certificates of the conformity of normative specifications and the actual personnel qualification.

- **Examiner (E)**
  Experts who are acting on behalf of the Fraunhofer Certification Authority in order to examine persons. They are independent in terms of their examination tasks. It is guaranteed that the examiners know the complete course content.

- **Examination Observer (EO)**
  Persons, who are acting on behalf of the Fraunhofer Certification Authority in order to support the examiners during the exams. They are responsible to the examiners.

- **Expert Committee (EC)**
  Committee of experts that is appointed by the Fraunhofer Personnel Certification Authority. The tasks of the committee are the following: verification and validation of examination content, creation of examination questions, responsible authority for professional requests and consulting of the Fraunhofer Personnel Certification Authority in terms of the professional quality of the examiners. Full particulars in terms of the tasks and competences can be found in the »internal rules of procedure of the expert committee«. An expert committee will be formed for each certification profile.

- **Term »know«**
  The term »know« can be found in the first and second level of the six level scale of the Bloom's Taxonomy of Educational Objectives (Taxonomy of educational objectives, 1974, 5. Auflage. Beltz Verlag, Weinheim 1976). It includes the ability to replicate terms on call by using keywords. The required skills for this are knowledge, recognition and imitation.
  The goal of »know« in the examination of the »Digital Twins« certification includes different contents for each certification profile. These will be described in the annex.

- **Term »apply«**
  The term »apply« is used to describe the third and fourth level of the Bloom's Taxonomy of Educational Objectives. The learner should be able to convert and order the content. The distinctive skills for this are understanding, reaction and practice.
  The goal of »apply« in the examination of the »Digital Twins« certification includes different contents for each certification profile. These will be described in the annex.

- **Term »evaluate«**
  The term »evaluate« is used to describe the fifth and sixth level of the Bloom's Taxonomy of Educational Objectives which are called »transfer« and »problem-solving competence«. It is characterized by the transfer of basic principles to new and similar tasks. Distinct abilities are the application, evaluation, coordination, and problem-solving, and automation.
  The goal of »evaluate« in the examination of the »Digital Twins« certification includes different contents for each certification profile. These will be described in the annex.

# 4 SPECIFICATIONS FOR THE CERTIFICATION PROCEDURE

In the following section the specifications for the certification procedure will be described.

## 4.1 Goal

The certification serves to examine qualification characteristics according to defined qualification profiles and to attest the quality of those through a certificate of competence.

## 4.2 Application

Applicants may be certified after successfully completing the examination fulfilling the requirements stated in § 1.
Applicants who wish to take or retake the examination shall apply to the Fraunhofer Personnel Certification Board in writing. The application has to include the following information of the applicant

- Name, date of birth, private address.
- Workplace with address (if any)
- Occupation
- Relevant certification profile
- Statement, whether the application concerns an initial certification, a retake or a recertification.

Eligible for certification are all persons that have successfully passed an examination of the Fraunhofer Personnel Certification Authority in the field of Digital Twins and that meet the defined admission requirements according to the annex of this certification handbook.

The examination dates will be determined by the Fraunhofer Personnel Certification Authority.

## 4.3 Examination procedure

The examination consists of two parts which are described in the paragraphs below:

1. Theoretical Part
2. Practical Part

### 4.3.1 Compilation and allocation of the examination documents and assignment of the examiners

The Fraunhofer Personnel Certification Authority compiles the examination questions for the written certification examination based on a catalogue of questions which is confirmed by the expert committee. The allocation of the examination questions has to be protected from unauthorized access.

The Head of the Fraunhofer Personnel Certification Authority authorizes the examiners for the examination.

### 4.3.2 Execution of the written examinations

The theoretical and practical part of the examination are written exams which can either take place in presence or as an online proctored exam.

Examinations in presence will take place at a location which meets the criteria of and has been approved by the Fraunhofer Personnel Certification Authority.The questions and tasks have to be answered in handwriting.

Online-proctored examinations take place at a place chosen by the participants, considering the specifications provided by the Fraunhofer Personnel Certification Authority. The online-proctored examinations are held with the help of a suitable Software to prevent attempts at cheating. The participants are provided information about all requirements in time. Online-proctored examinations are to be answered by input with a keyboard.

It will be ensured that there is enough time available to answer the examination questions. For this, the examination committee will evaluate how much time is required to answer the questions in the conception phase.

Auxiliary means are not allowed.

For participants who cannot partake in the examination due to unpredictable impairments, individual exemptions are foreseen.

## 4.4 Examination questions and tasks

The catalogue of examination questions is different for each certification profile. The same is valid for the amount of questions asked per subject areas.

The questions are clearly assigned to the different certification profiles and subject areas. Questions may only be asked to participants with the corresponding qualification profile.

## 4.5 Evaluation of the examination

The participants have to achieve a minimum degree of performance of 67 % in the examination, in the theoretical as well as the practical part. If this is not the case, no certificate will be issued.

If participants fail to pass the examination may be repeated up to maximal two times.

For each question and task the examiners will be provided with sample solutions which will be used as guideline for the evaluation of the question at hand. Additionally, the expert committee fixes the achievable scores for each question or task.

## 4.6 Certification

Upon successful completion of the examination a certificate will be handed to the candidate by the Fraunhofer Personnel Certification Authority.

# 5
# RIGHTS AND OBLIGATIONS

The rights and obligations of the Certificate Holder are described below.

## 5.1 Preliminary information

Upon written request (e.g. from potential clients of a Certificate Holder), the Fraunhofer Personnel Certification Authority may provide information on whether this person is legally holding the certificate by stating the certificate number. The name, date of birth and place of birth of the Certificate Holder are stored for identification purposes. With the registration, participants declare by their signature their intention to accept these regulations in the event of the certificate being issued. The Fraunhofer Personnel Certification Authority is bound by the provisions of the German Federal Data Protection Act.

## 5.2 Rights

Within the scope of his/her occupation in "NAME OF CERTIFICATE", the Certificate Holder is entitled to

- refer to his/her certification on letterheads, on the internet in connection with their person and other printed documents in connection with their person in the following way: certified "NAME OF THE CERTIFICATE", approved by the Fraunhofer Personnel Certification Authority" or certified "NAME OF THE CERTIFICATE". By using Alternative 1, he/she shall check that the designation of "approved by the Fraunhofer Personnel Certification Authority" does not appear bigger than the name of the certified person.
- use the certificate as a whole referring to the certification
- view the document "Certification Handbook" of the respective certification profile, which explains the certification system of the Fraunhofer Personnel Certification Authority at Fraunhofer FIT.

  Further details: cf. section 5.3 below.

## 5.3 Obligations

The following principles must be complied with by the Certificate Holder while performing the tasks in the area of the respective certification profile:

### 5.3.1 Diligence

The certificate holder shall exercise his/her occupation in accordance with the "State of the Art".

The actions of the certificate-holder are characterized by the principle of always achieving an error-free and high-quality work result.

The Certificate Holder is obliged to not use the certification in an improper manner and to not make any statements that must be considered misleading or unauthorized by the Fraunhofer Personnel Certification Authority.

### 5.3.2 Independence

The Certificate Holder shall act without regard to official relations within the company and/or its employees or their desired results (personal independence).

### 5.3.3 Personal performance

The certificate holder shall perform all required services with regards to preparation, execution and evaluation of projects in the field of the respective certification profile in person. He/she shall not use the deed of the certification falsely or in any misleading way.

### 5.3.4 Permitted use of certificates

The following regulations shall also apply for the use of certificates:

- The certificate shall be granted to the Certificate Holder. The actual certificate/document shall remain the property of the Fraunhofer Personnel Certification Authority.
- Only valid certificates shall be used.
- The certificate shall not be abused inappropriately.
- The actual certificate may only be used in its unmodified and complete form.
- The certificate shall be returned to the Fraunhofer Personnel Certification Authority
    - after expiration of the certificate,
    - after the Certificate Holder has been informed by the Fraunhofer Personnel Certification Authority about the withdrawal.
- In case of suspension, withdrawal or lapse of the certification, the Certificate Holder shall immediately cease the use of the certificate. References of the Certificate Holder to the certification and/or the Fraunhofer Personnel Certification Authority shall be removed immediately. In this event letterhead or other printed material shall be destroyed immediately or in case of suspension shall not be used during suspension.
- The use of the certificate or references to it are only permitted within the scope of the certificate.
- The certificate may only be used in connection with the person who is mentioned as certified in the certificate.
- The use of the certificate and references to it are only permitted if the observer explicitly recognizes who has been examined and certified.
- By using the certification or making references to it he/she shall not give the impression that the certified person is an employee of Fraunhofer-Gesellschaft or that he/she acts on behalf of Fraunhofer-Gesellschaft.
- The Certificate Holder is responsible for the correct use of the Certificate. Possible doubts shall be the responsibility of the Certificate Holder.

### 5.3.5 The Use of Fraunhofer-Logo

The certificate of the Fraunhofer Personnel Certification Authority contains the Fraunhofer-Logo. The Logo shall exclusively be used as a part of the certificate in that way that the certificate as a whole may be copied or made available in the internet as proof of the issuing Fraunhofer Personnel Certification Authority for e.g. clients or employers. Any further use beyond this of the Fraunhofer-Logo or the use of the name Fraunhofer as trade mark is expressly prohibited. In case of violation the Fraunhofer-Gesellschaft is entitled to apply for injunctive relief or damage claims.

### 5.3.6 Duty to give Notice

The Certificate Holder shall notify the Fraunhofer Personnel Certification Authority without delay of:

- any changes of name (e.g. in case of marriage),
- any change of place of residence,
- the loss of the certificate.

In addition, the Certificate Holder must inform the Fraunhofer Personnel Certification Authority immediately of any matters that may affect their ability to continue to fulfil the certification requirements (e.g. newly occuring physical limitations).

### 5.3.7 Duty to Disclose

Upon request of the Fraunhofer Personnel Certification Authority at Fraunhofer FIT, the Certificate Holder shall disclose and furnish all necessary particulars and documents regarding the monitoring of activities and compliance with the aforementioned duties within a set deadline and without compensation.

He/she may refuse to provide self-incriminating information or such information that may incriminate his/her relatives.

## 5.4 Violation to Duties as Certificate Holder

Depending on the gravity of the violation of a duty stated in this document the certification may be suspended or revoked, which is communicated to the Certificate Holder in written form. For the duration of the suspension or after the certification has been revoked, the Certificate Holder is no longer entitled to refer to his/her certification and the Fraunhofer Personnel Certification Authority.

# Annex A: »CERTIFIED DIGITAL TWIN BUSINESS CONSULTANT«

## A 1 Reference to other norms and documents

- EN ISO 17024

## A 2 Profile of qualification

### A 2.1 Determination

The qualification profile of a »Certified Digital Twin Business Consultant« results from the characteristics and description of his or her field of work.

The responsibility of a "Certified Digital Twin Business Consultant" is the strategic development and anchoring of the concept of Digital Twins within companies' value creation. The core task is to create the necessary organizational and technical framework conditions and to accelerate the change process. He performs this task either in a managerial position of a company or as an external strategy consultant.

A » Certified Digital Twin Business Consultant« :

- is competent to efficiently and future-proof manage Digital Twin projects
- is informed about the value creation potential of Digital Twins
- understands the implications and interdependencies of Digital Twins with business models, product development, services etc.
- systematically uses methods to envision Digital Twin based business opportunities
- has the overview to estimate technical and financial feasibility
- represents a link between different levels and business units of a company.

### A 2.2 Entrance requirements

#### A 2.2.1 Previous education

A certified »Digital Twin Business Consultant« must have:

Successfully graduated at a state-recognized university or institution

**or**

- an occupation of at least three years in the field of introducing new concepts and technologies in companies e.g. as a business developer, consultant or product developer
- an occupation of at least three years in the field of the qualification profiles described in section A2.1

**Note:**
In special cases the applicant has the possibility to prove missing entrance requirements within one year after taking the examination.

After examination of the submitted documents, the Fraunhofer Personnel Certification Authority will decide on the requirements. If entry requirements are not fulfilled, the Fraunhofer Personnel Certification Authority will directly communicate the decision to the applicant.

In principle, the Fraunhofer Personnel Certification Authority may in well-founded and justifiable exceptions accept varying evidence. These evidence, documents and decisions of the Fraunhofer Personnel Certification Authority have to be documented.

### A 2.2.2 Additional education, entitlement and practical experience

A »Certified Digital Twin Business Consultant« does not have to prove any additional education, entitlement or practical experiences.

### A 2.2.3 Personal requirements

None.

## A 2.3 Required competences (learning goals)

Basis for the examination to become »Certified Digital Twins Business Consultant« are the following competences (learning goals):

| Topic | Competences (Learning Goals) | know | apply | evaluate |
|---|---|---|---|---|
| **Foundations of Digital Twins** | | | | |
| | Definition and delimitation of the terms Digital Twin, Digital Shadow, Digital Master | | X | |
| | Naming and describing different types of Digital Twins (Production, Product, Service Twins) | X | | |
| | Identification of potential Digital Twin within a product structure (individual twin vs. summarizing twins for configurations, series etc.) | | X | |
| | Explaining the use of summarizing twins in a scenario | | X | |
| **Potentials, benefits and challenges of Digital Twins** | | | | |
| | Naming areas in which digital twins can add value. | X | | |
| | Explaining Digital Twin use cases (predictive maintenance, feedback to design, continuous start of production etc.) | X | | |
| | Identifying risks and countermeasure strategies for Digital Twins in a given scenario | | X | |
| **Application of Digital Twins in Industry - today and tomorrow** | | | | |
| | Knowing industrial application scenarios for production, product and service, performance twins including business model implications | X | | |
| | Naming and explaining potential future developments of Digital Twins (networked twins, block chain integration etc.) | X | | |
| | Explaining the use of interconnected digital twins | | X | |
| **The lifecycle perspective on Digital Twins** | | | | |
| | Delimitation of product and Digital Twin lifecycles, naming their typical phase | X | | |
| | Naming typical challenges in the phases of a Digital Twin lifecycle | X | | |

| Topic | Competences (Learning Goals) | know | apply | evaluate |
|---|---|---|---|---|
| | Explaining why product and Digital Twin lifecycles need to be considered integrated | X | | |
| | Defining Product Lifecycle Management | X | | |
| **Establishing Digital Twins: project approach** | | | | |
| | Knowing the typical phases of a Digital Twin project, its elements and characteristics | X | | |
| | Explaining the basics of change management | X | | |
| | Describing the different roles within a Digital Twin project team | | X | |
| | Explaining how to handle challenges in digital twin projects | | X | |
| **Competencies and capabilities for the management and development of Digital Twins** | | | | |
| | Explaining the stages of the Industrie 4.0 development path and placement of Digital Twins within those stages | X | | |
| | Outlineing and exemplifying the acatech Industrie 4.0 maturity index | | X | |
| | Knowing and explaining the fields of action: resources, organizational structure, information systems, culture | X | | |
| **Dimensions and design patterns for Digital Twins** | | | | |
| | Knowing the 8D model and explaining its dimensions | X | | |
| | Appling the 8D model to a given scenario | | X | |
| **Technologies for Digital Twins** | | | | |
| | Outlining the underlying technological architecture of Digital Twins and naming its components | x | | |

# ANNEX B: »CERTIFIED DIGITAL TWIN SOLUTION ARCHITECT«

## B 1 Reference to other norms and documents

- EN ISO 17024

## B 2 Profile of qualification

### B 2.1 Determination

The qualification profile of a »Certified Digital Twin Solutions Architect« results from the characteristics and description of his or her field of work.

As managing domain expert or line manager with personnel responsibility a certified "Digital Twin Solutions Architect" is accountable for the architectural design of Digital Twin solution. They conceptualize and explore solution alternatives for digital assets at the architectural level in the discourse with top management and subject matter experts. They accompany and guide the implementation of Digital Twin projects and are responsible for their embedding in the overall product or overall corporate context.

A certified » Digital Twin Solution Architect «:

- is competent to efficiently and future-proof manage Digital Twins projects
- is informed about the value creation potential of Digital Twins
- is accountable for the creation, integration or operation of product and systems
- systematically uses methods to describe and analyses Digital Twin use cases concerning its architectural and technical implication
- has the overview to estimate technical and financial feasibility
- can name and quantify project preconditions needed concerning competencies, man power, technologies and finances
- represents a link between different levels and business units of a company.

### B 2.2 Entrance requirements

#### B 2.2.1 Previous education

A certified » Certified Digital Twin Solution Architect « must have:

Successfully graduated at a state-recognized university or institution

**or**

- an occupation of at least three years in the field of technical design for products or systems e.g. as IT or process solutions architect,
- an occupation of at least three years in the field of the qualification profiles described in section B2.1

**Note:**
In special cases the applicant has the possibility to prove missing entrance requirements within one year after taking the examination.

After examination of the submitted documents, the Fraunhofer Personnel Certification Authority will decide on the requirements. If entry requirements are not fulfilled, the Fraunhofer Personnel Certification Authority will directly communicate the decision to the applicant.

In principle, the Fraunhofer Personnel Certification Authority may in well-founded and justifiable exceptions accept varying evidence. These evidence, documents and decisions of the Fraunhofer Personnel Certification Authority have to be documented.

### B 2.2.2 Additional education, entitlement and practical experience

A »Certified Digital Twin Solution Architect« does not have to prove any additional education, entitlement or practical experiences.

### B 2.2.3 Personal requirements

None.

### B 2.3 Required competences (learning goals)

The basis for the examination of a »Certified Digital Twin Solution Architect « are the following competences (learning goals):

| Topic | Competences (learning goals) | know | apply | evaluate |
|---|---|---|---|---|
| **Foundations of Digital Twins** | | | | |
| | Definition and delimitation of the terms Digital Twin, Digital Shadow, Digital Master | | X | |
| | Naming and describing different types of Digital Twins (Production, Product, Service and Performance Twins) | X | | |
| | Identification of potential Digital Twins within a product structure (individual twin vs. summarizing twins for configurations, series etc.) | | X | |
| **Potentials, benefits and challenges of Digital Twins** | | | | |
| | Naming areas in which digital twins can add value. | X | | |
| | Explaining Digital Twin use cases (predictive maintenance, feedback to design, continuous start of production etc.) | X | | |
| | Identifying risks and countermeasure strategies for Digital Twins in a given scenario | | X | |
| **Application of Digital Twins in industry - today and tomorrow** | | | | |
| | Knowing industrial application scenarios for production, product and service, performance twins including business model implications | X | | |
| | Naming and explaining potential future developments of Digital Twins (networked twins, block chain integration etc.) | X | | |
| **The lifecycle perspective on Digital Twins** | | | | |
| | Delimitation of product and Digital Twin lifecycles, naming their typical phase | X | | |
| | Naming typical challenges in the phases of a Digital Twin lifecycle | X | | |
| | Explaining why product and Digital Twin lifecycles need to be considered integrated | X | | |

| Topic | Competences (learning goals) | know | apply | evaluate |
|---|---|---|---|---|
| | Defining Product Lifecycle Management | X | | |
| **Dimensions and design patterns for Digital Twins** | | | | |
| | Knowing the 8D model and explaining its dimensions | X | | |
| | Appling the 8D model to a given scenario | | X | |
| **Technologies for Digital Twins** | | | | |
| | Outlining the underlying technological architecture of Digital Twins and naming its components | X | | |
| **Establishing Digital Twins: project approach** | | | | |
| | Knowing the typical phases of a Digital Twin project, its elements and characteristics | X | | |
| | Explaining the basics of change management | X | | |
| | Describing the different roles within a Digital Twin project team | | X | |
| **Definition of Digital Twin use cases** | | | | |
| | Learning the method for recording use cases / user stories | | X | |
| | Applying a use case diagram in a given scenario | | X | |
| **Analysis of Digital Twin use cases** | | | | |
| | Comparison of target / actual state and derivation of demand for action | | X | |
| **Shaping conditions for Digital Twin development and operation** | | | | |
| | Understanding the EOS (Engineering Operating System) concept and its application purpose for Digital Twin projects | X | | |
| | Understanding the dependencies between 8D model and EOS (Engineering Operating System) | | X | |
| | Knowing the "Data-Flow Architecture" | X | | |

# ANNEX C: »CERTIFIED DIGITAL TWIN TECHNICAL DEVELOPER«

## C 1 Reference to other norms and documents

- EN ISO 17024

## C 2 Profile of qualification

### C 2.1 Determination

The qualification profile of a »Certified Digital Twin Technical Developer« results from the characteristics and description of his or her field of work.

Digital Twin Technical Developer are product development engineers specialized in IT or vice versa. Compared to classical, partly isolated, software development projects, Digital Twin implementations projects have extensive technical interdependencies with other disciplines (e.g. engineering, production, service), domains (e.g. control engineering, product data management) and competences (human-machine interaction, digital factory, data science ) and so on. In this context Digital Twin Technical Developer design, implement and innovate holistic solutions.

A certified »Certified Digital Twin Technical Developer«

- is informed about the underlying technologies and IT standards of Industrie 4.0 e.g. Cloud and Edge Computing, Internet of Things, OPC etc.
- is informed about the IT -architectures and -systems use in product development, production and service as well as integration approaches
- is accountable for the creation, integration or operation of those systems and its interface
- knows possible applications of industrial data science and simulations as well as the underlying technologies
- is informed about safety and security requirements for Digital Twin IT solutions

### C 2.2 Entrance requirements

#### C 2.2.1 Previous education

A »Certified Technical Developer« must have:

Successfully graduated at a state-recognized university or institution

**or**

- an occupation of at least three years in the field of technical design for products or systems e.g. as software developer or simulation engineer.
- an occupation of at least three years in the field of the qualification profiles described in section C2.1

**Note:**
In special cases the applicant has the possibility to prove missing entrance requirements within one year after taking the examination.

After examination of the submitted documents, the Fraunhofer Personnel Certification Authority will decide on the requirements. If entry requirements are not fulfilled, the Fraunhofer Personnel Certification Authority will directly communicate the decision to the applicant.

In principle, the Fraunhofer Personnel Certification Authority may in well-founded and justifiable exceptions accept varying evidence. These evidence, documents and decisions of the Fraunhofer Personnel Certification Authority have to be documented.

### C 2.2.2 Additional education, entitlement and practical experience

A »Certified Digital Twin Technical Developer« does not have to prove any additional education, entitlement or practical experiences.

### C 2.2.3 Personal requirements

None.

## C 2.3 Required competences (learning goals)

The basis for the examination of a »Certified Digital Twin Technical Developer« are the following competences (learning goals):

| Topic | Competences (Learning Goals) | know | apply | evaluate |
|---|---|---|---|---|
| **Foundations of Digital Twins** | | | | |
| | Definition and delimitation of the terms Digital Twin, Digital Shadow, Digital Master | | X | |
| | Naming and describing different types of Digital Twins (Production, Product, Service and Performance Twins) | X | | |
| | Identification of potential Digital Twins within a product structure (individual twin vs. summarizing twins for configurations, series etc.) | | X | |
| **The lifecycle perspective on Digital Twins** | | | | |
| | Delimitation of product and Digital Twin lifecycles, naming their typical phase | X | | |
| | Naming typical challenges in the phases of a Digital Twin lifecycle | X | | |
| | Explaining why lifecycles of products and it digital twins need to be considered in an integrated manner | | X | |
| | Defining Product Lifecycle Management | X | | |
| **Technologies for Digital Twins** | | | | |
| | Outlining the underlying technological architecture of Digital Twins and naming its components | X | | |
| **Engineering IT and APIs for Digital Twin-Design** | | | | |
| | Naming and knowing the purpose of engineering IT-systems e.g. CAx, PDM/PLM, ERP, MES. Depicting and explaining the interplay with Digital Twins. | | X | |
| | Knowing Digital Twin relevant interfaces and interchange formats of engineering IT-Systems e.g. OSLC, JT, REST, COLLADA etc. | | X | |
| | Know how to choose the right connectivity protocol. | X | | |
| | Decide whether to use TCP or UDP in a given scenario | | X | |

| Topic | Competences (Learning Goals) | know | apply | evaluate |
|---|---|---|---|---|
| **Standards and safety** | | | | |
| | Having an overview on relevant standards for Digital Twin / cyber physical system development and operation | X | | |
| | Understanding and explaining the implications of Digital Twins and functional safety / safety of machinery (IEC 61511 / IEC 62061 / ISO 13849) | X | | |
| **Cloud and databases** | | | | |
| | Knowing different cloud types (e.g. fog, edge, private, public) and explain pros / cons in a given situation | X | | |
| | Delimitation of different database (SQL, NoSQL, Timeline, In-Memory), weighing of advantages and disadvantages in a certain situation | | X | |
| **Data analytics** | | | | |
| | Explain the Lambda architecture | X | | |
| | Deciding which type of machine learning is suitable in different scenarios. | | X | |
| | Understanding the concept of sensor fusion | | X | |
| **Simulation and automation** | | | | |
| | Knowing the purpose of digital simulations, naming different simulation types and their relevance for Digital Twin realisations | X | | |
| | Understanding and explaining the path from automation to autonomy and the role of Digital Twins within | X | | |
| | Knowing the term "Simulation" | X | | |
| **Digital Factory** | | | | |
| | Understanding the particularities of Digital Twins for digital factories and the interplay with PLCs | X | | |
| | Knowing the definition of "Digital Factory" | X | | |