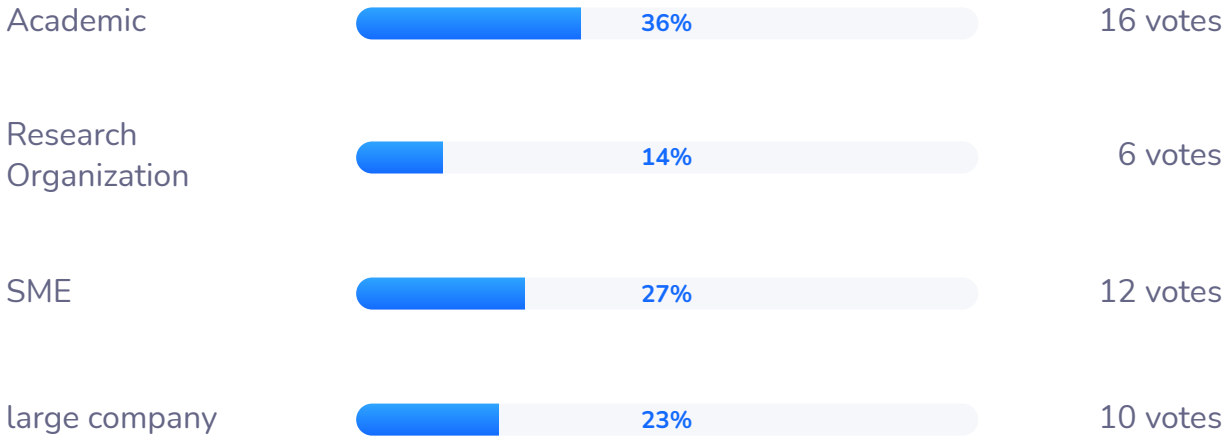
MATISSE G.A. Rome - 26/03/2025 - WP2 - Interactive Session

Number of participants: 55

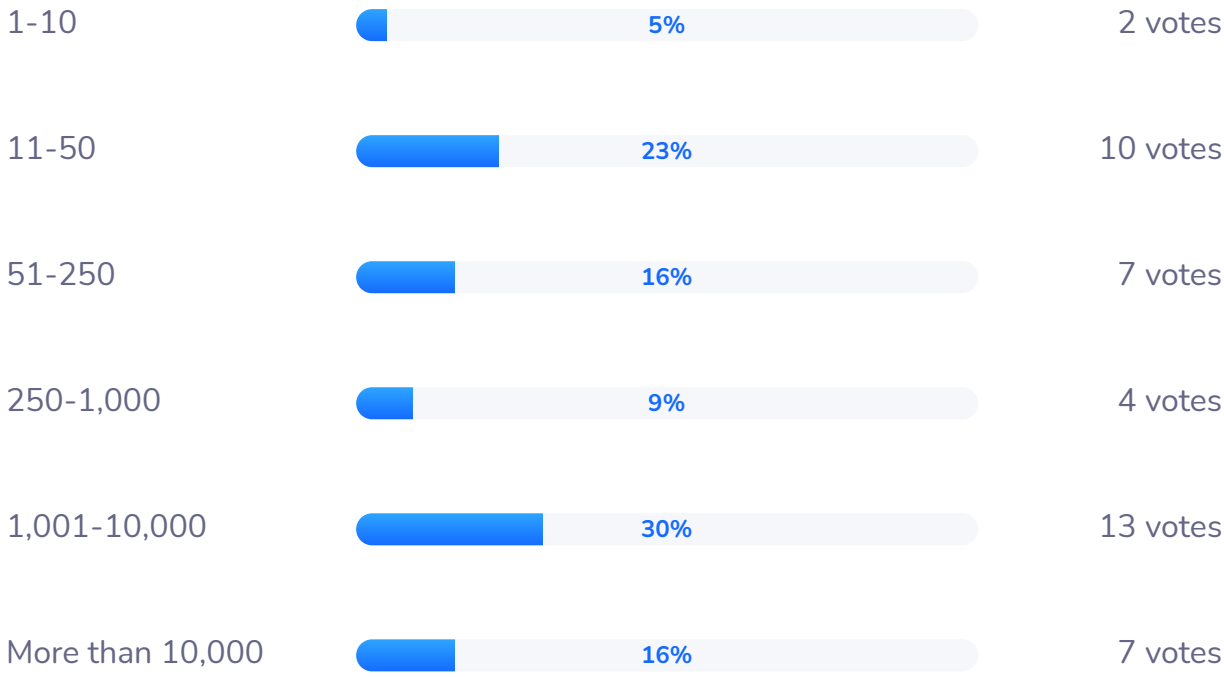
1. General information: Type of organization:

44 respondents



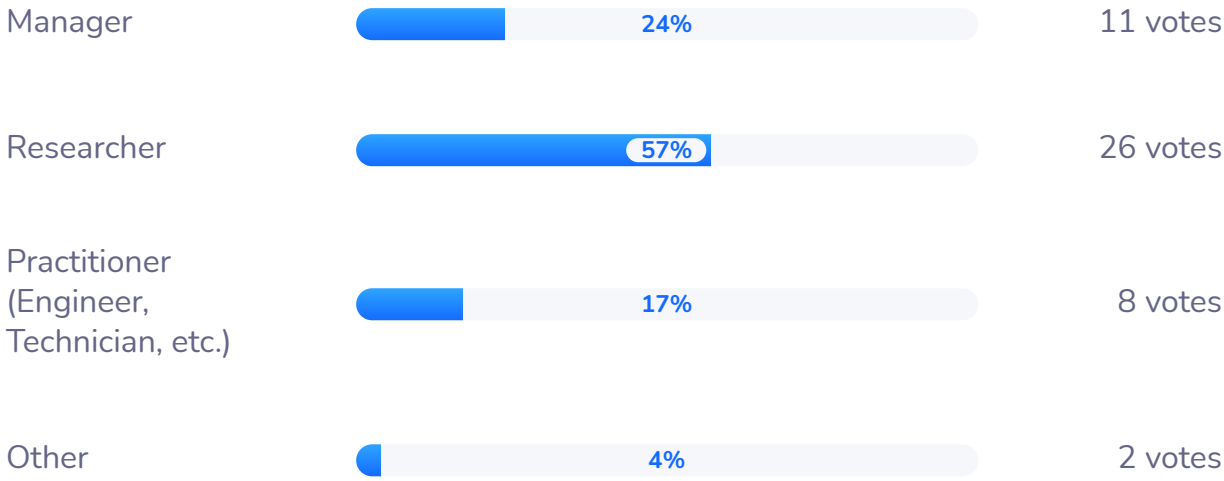
2. General information: Size

43 respondents



3. General Information: what is your role in the organisation? (if Other, please it as a comment)

46 respondents



Manager - Comments 6

- Digital and Smart Manufacturing
- It's a matter of fact :)
- project manager
- CTO
- Senior Manager Funded Projects
- CTO

Researcher - Comments 10

PhD (Servant)

MBD on real-time critical-systems research

Professor in Computer Science

Postdoc

student

PhD student

PhD candidate

Prof

Associate Professor

Post-doctoral Researcher

Practitioner (Engineer, Technician, etc.) - Comments 4

Full stack

Consultant, Trainer

Engineer

Software Development Engineer

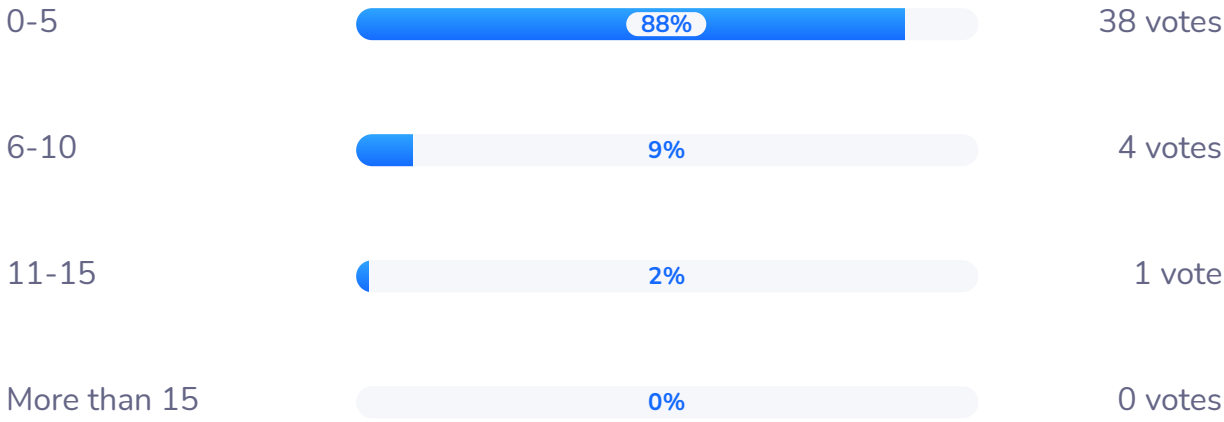
Other - Comments 2

Innovation Project Manager

PhD Student

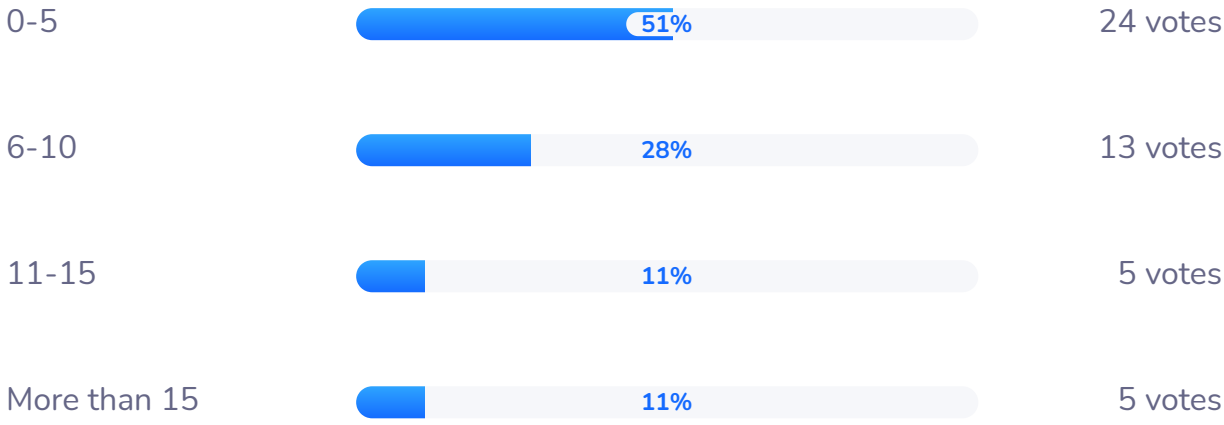
4. General information: Years of experience in Digital Twin Engineering: total number of years

43 respondents



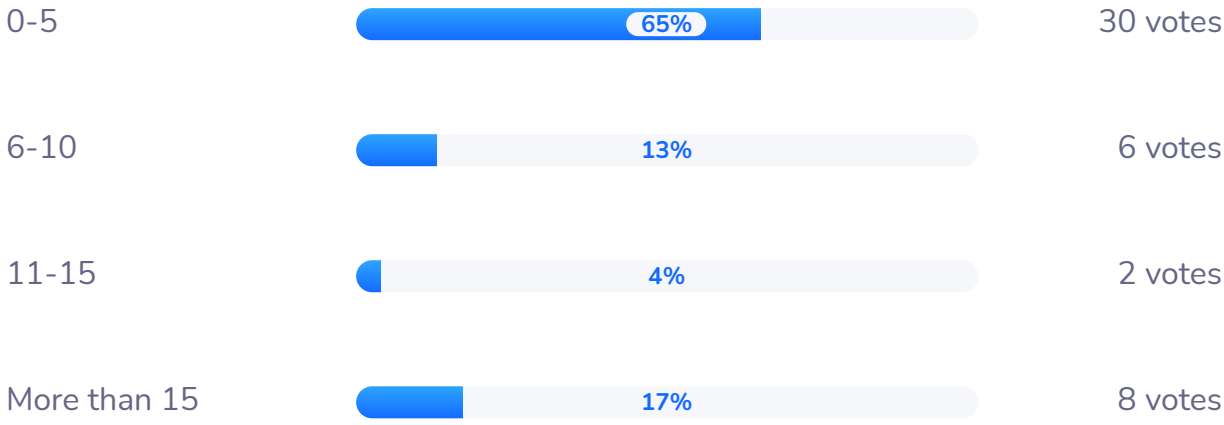
5. General information: Years of experience in modeling and simulation: total number of years

47 respondents



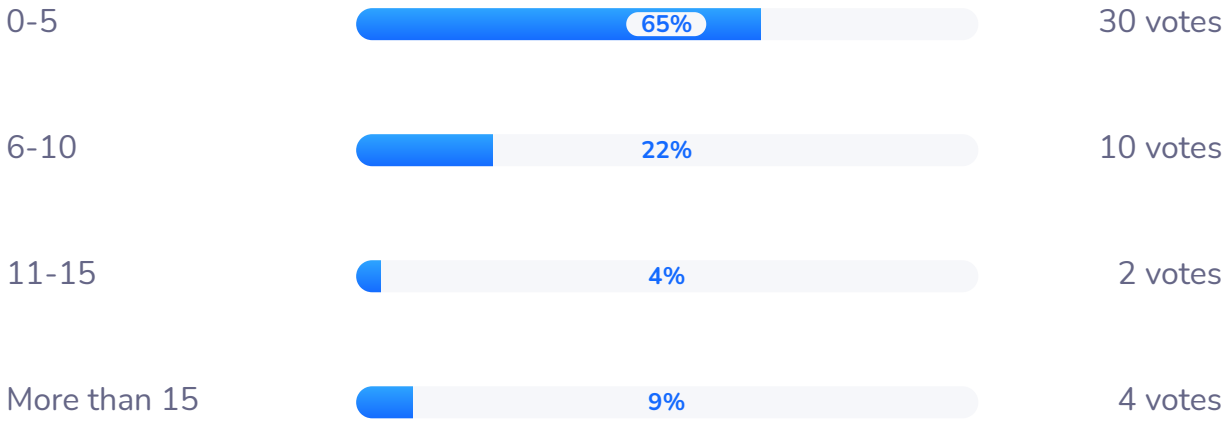
6. General information: Years of experience in MBE: total number of years

46 respondents



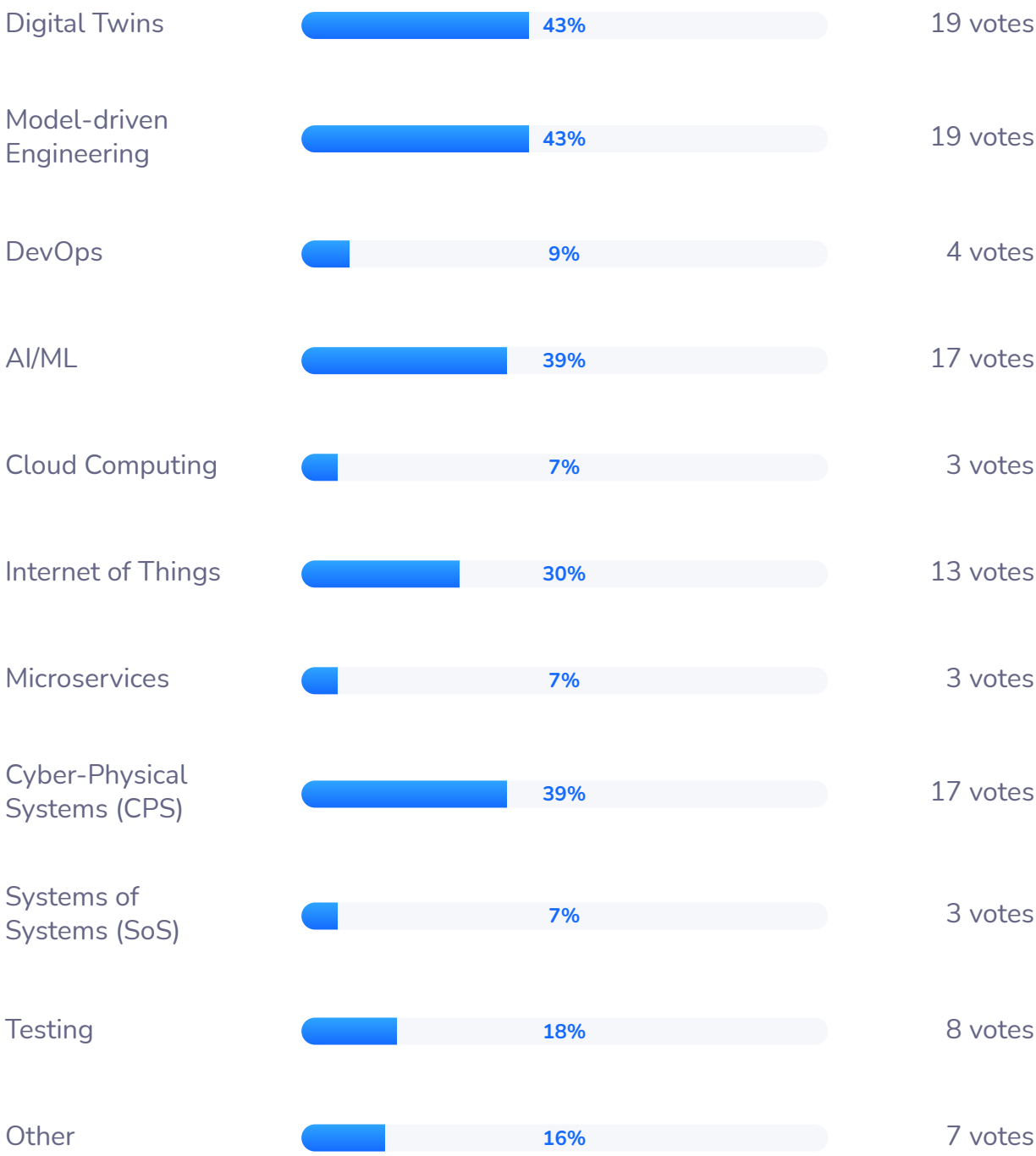
7. General information: Years of experience in Artificial Intelligence: total number of years

46 respondents



8. General information: Which is your research/business area? (Select all relevant options. If other, add it/them as a comment)

44 respondents



Digital Twins - Comments 1

Software Architecture, Standardization

Model-driven Engineering - Comments 3

Testing Frameworks

MDE (specifically MDA) approaches for DTs, with case study in mobility domain

Model-driven Engineering to enhance Digital Twins

DevOps - Comments 0

No comments for this answer

AI/ML - Comments 2

inference at the edge, high-performance computing to execute AI workloads

symbolic (logic-based) AI

Cloud Computing - Comments 0

No comments for this answer

Internet of Things - Comments 2

We build systems that incorporate IoT with cloud based systems for statistics and control

EDA frameworks for real-time systems

Microservices - Comments 0

No comments for this answer

Cyber-Physical Systems (CPS) - Comments 2

Robotics, Automotive, Healthcare

EDA frameworks to design CPSs

Systems of Systems (SoS) - Comments 1

Management systems

Testing - Comments 0

No comments for this answer

Other - Comments 5

Software architecture

Hardware software ci-design embedded systems

Renewable energy communities and Energy efficiency

Robotics

Robotics

9. General Information: Are you directly involved in MATISSE?

35 correct answers
out of 42 respondents

Yes	83%	35 votes
No	17%	7 votes

10. DTE: What immediately comes to your mind when thinking about Digital Twin Engineering (DTE)?

41 respondents

Building Digital Twins

Foundation model use

Ai

safety-critical systems avionic and automotive based

architecting digital twins, integration of multiple digital twins for different part of a physical system, AI integration in a dt system

Vision, imagination

artificial intelligence

models

Connecting the ”real” world with a cloud based representation

create a virtual representation of a system

Automation, smart factories

Simulation, verification, validation

Automatic modeling

Engineering Seperate Parts of a System using DTs

Interoperability

I've never seen a "full-fledged" DT

Building digital copies of real world systems while maintaning traceability

Interoperability

Modelling of complex systems

Validation and verification

Complexity

Simulation

Supporting the system operation with expertise from system engineering and design.

Methodology

Simulation

complexity

Verification

Data processing, simulation, analysis.

Modelling and simulation

configurability

Future

Data exchange

Model Driven Engineering

AI-based DTs for optimization

Simulation

MBSE

Artificial intelligence

the future

Complexity

how to build DT

automated simulations

11. DTE: Can you briefly elaborate on how your work relates to Digital Twin Engineering, Model-Based Engineering and/or Artificial Intelligence?

40 respondents

Data based model to elaborate DTE with LLM or Foundation Model dédicacées to industrial ap

Simulation, optimization, modelling automated systems

optimizing a cyber-physical system

Automation

Field-based testing for Robotics

Methods to enhance interoperability of MBE, MT

Analyzing physical objects using AI

Use case is related to these

The Development process of the Software, provides multiple use cases in our work where we can put MBE and AI together to make DTs.

Experience in CPS and model engineering to provide solutions for the REC use case

AI for anomaly detection, DT for implementing statistics and contro.

Large data

Multi-objective optimization of (federated) systems

MDE and AI for DT engineering

Robotics, smart factories

demonstrate the benefits of this technology and how it can be transferred to smes

SysML, simulations, FMI. MBE tools

robotics

Requirment Eng, SysML

Simulation-based Verification and Validation for critical-systems

I work on model Generation, model validation and digital ttansformation, and DSt engineering considering all the above mensioned topics

Simulation & Optimization

for DTE, monitor and characterize the status of the system in real-time to be able to take runtime decisions in a safe way. Applied in avionic.

Building MBE Tool

I'm a researcher in symbolic AI. So far not much experience with DTE/MBE.

We are de developing ai agents for software testing lifecycle

MDE/MDA applied for architecting Mobility DTs

Enhance modeling tasks using Ai techniques

leave the boring task

They manage models

Our work directly relates to Digital Twin Engineering by developing interactive and data-driven digital representations of forestry machines and manufacturing processes. These twins integrate real-time sensor data with simulation models to enable predictive maintenance and live monitoring. We apply Model-Based Engineering principles by structuring system data and behavior into reusable models that support machine visualization, fault detection, and maintenance planning. These models form the foundation for simulation, validation, and integration with XR-based training environments. In terms of Artificial Intelligence, we develop AI algorithms for anomaly detection and predictive maintenance. These models analyze operational data to forecast failures, optimize maintenance schedules, and improve system reliability — turning data into actionable insights across the lifecycle of the forestry machines.

Automation

Validation of robotic applications

We are developing a software for operational diagnostics of complex systems based on IoT data and digital twins.

Validation of robotics applications

Provide use case from energy business

Selling Modeling Tool and Services

V&V using (symbolic) AI techniques

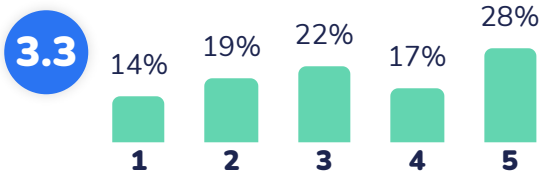
Design and developing DT using MDE

MBE

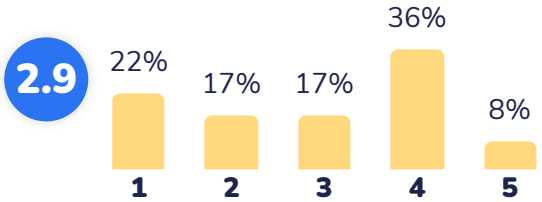
12. DTE: In which of the following engineering activities have you applied or experienced the use of the Digital Twin concept in your professional experience? (Select all relevant options.)

36 respondents

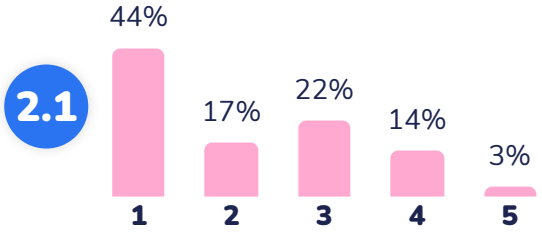
1 Modeling



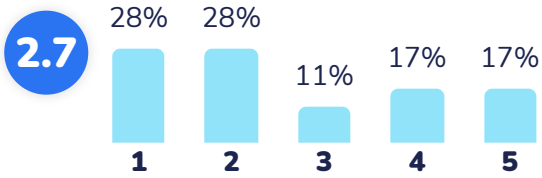
2 Simulation



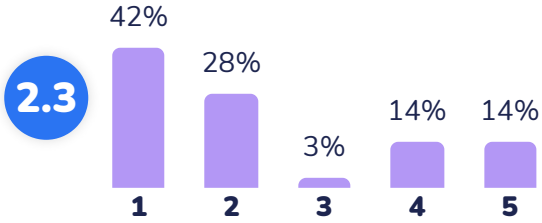
3 Data Integration



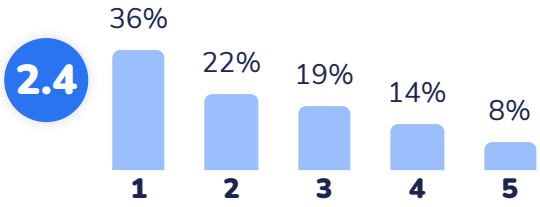
4 Real-Time Monitoring



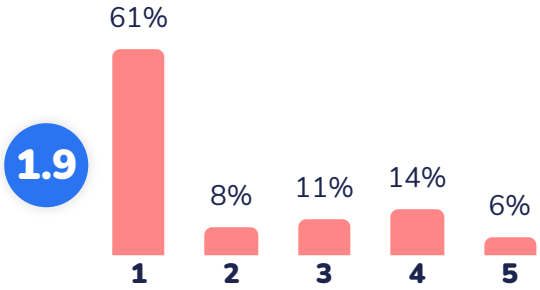
5 Predictive Analytics



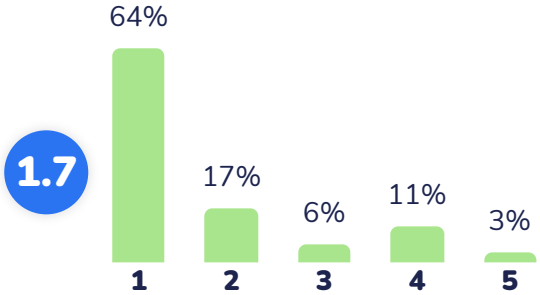
6 Optimization



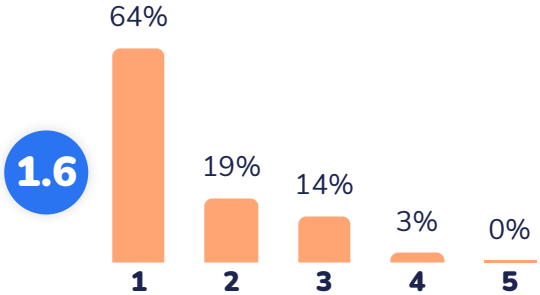
7 DT Interoperability



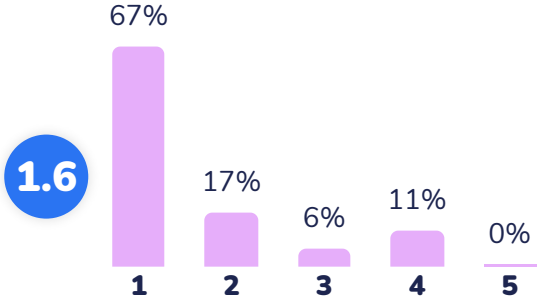
8 DT Scalability



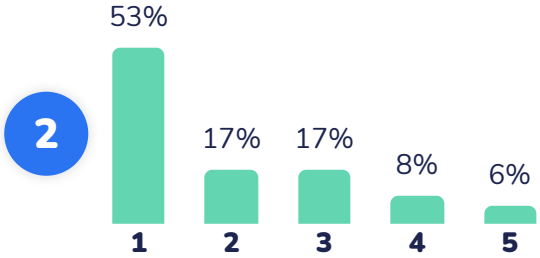
9 DT Security and Privacy



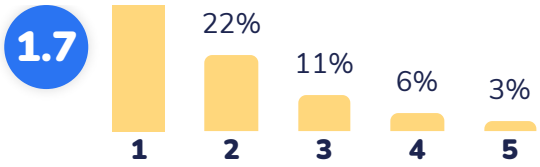
10 Lifecycle Management



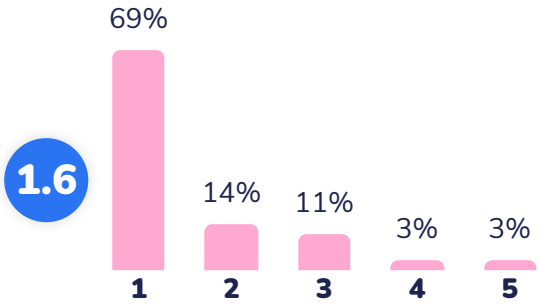
11 User Interaction



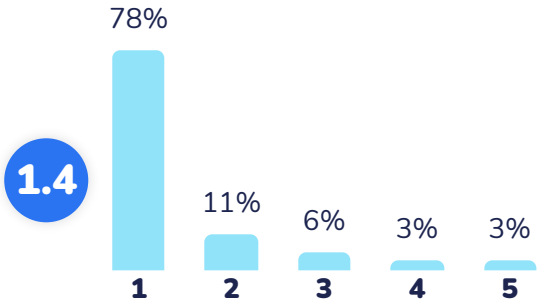
12 Federation



13 Traceability



14 Other



13. DTE: What are the main challenges in engineering digital twins?

45 respondents

traceability

model based engineering application

Fault tolerance and correctness

multiple tools, complexity in integration, complexity in instantiation

collect low-level behavior with the model

Standardisation and automation

constant alignment to the physical system

Federation, Traceability, Unclear understanding of the concept itself, Too many tools to Convert to DTs, Lack of Automation

automation

federation

Complexity

Latency

standardisation that covers various fields

missing standards

True model based engineering approach

trustworthiness

interoperability

It's many different technologies, modelling etc. for all the various aspects of digital twins. Interoperability will be a major challenge.

Lack of easy to use frameworks

modeling and validation

bidirectionality

Automatizing DT

DT integration and Traceability, real-time monitoring, Requirement fullfillment and accuracy w.r.t. Real world

multidisciplinarity standardization

Automation

Maintaining the models, ROI, accuracy

alignment system/DT

modelling the system correctly and real time data flow

automation

Update wrt Real System évolution, synchronisation with real system

real time traceability. minimizing the Delta(DT, AS).

One of the main challenges in engineering digital twins is achieving real-time data integration — ensuring that sensor data from physical systems is reliably and efficiently synchronized with the digital twin. In manufacturing and forestry environments, this involves handling noisy or incomplete data from harsh operational conditions. Another key challenge is developing interoperable and scalable models that can evolve over time and integrate with different systems and platforms. This requires standardized data structures and interfaces that can support collaboration between AI models, simulation tools, and visualization layers. A third challenge is ensuring usability and human interaction. The digital twin must deliver actionable insights to operators, technicians, and engineers in a way that is intuitive and effective — especially when XR or immersive interfaces are involved. Finally, validating the accuracy of digital twins over time remains a critical challenge, particularly when used for predictive maintenance or decision-making in dynamic environments like forestry machinery.

Holistic integration of all aspects

Creating an accurate and fast computational model

interoperability, composition/federation, feedback generation, closely dependent of physical system specification

Complexity, interoperability, federation

Model validation

Keeping it updated with the real system configuration

digital shadow

1000 different tools

Verification of digital twins

Synchronisation

early fault detection

No concrete applicable definition

Standarization

14. DTE: How would you better define Traceability in DT Engineering ?

25 respondents

Traceability must ensure seamless tracking of data, models and their changes across DT lifecycle, enabling accuracy and consistency.

Can be hard to trace

Being able to locate how and where a given data item was produced.

Connections and logs between the systems/parts of the systems

Ability to keep track of changes / refinements / adaptation of model, possibly for certification purposes

Health monitoring of DT

Communication

Tracing from Requirements to all other digital engineering artefacts

every entity that builds the DT can be traced

I don't know

Understanding data communication and coupling between different small DTs in order to create a bigger version of it.

Relationship between DTs

Accountability, auditability

Trace artefacts and information?

Relationship between the requirements and DT solutions

Ability to figure out the originality of the model component used for DT

Ability to trace the sw development artifacts used for DT engineering and/or operation. Tracing models, more than data. Data may be more suited to be reused

Traceability in Digital Twin Engineering refers to the ability to systematically track and link information across the entire lifecycle of a system — connecting physical assets, digital models, data sources, simulations, and decision-making processes. It ensures that every element within the digital twin — whether it's a sensor reading, a simulation output, a maintenance action, or an AI prediction — can be traced back to its origin, rationale, and impact. In practice, this means maintaining clear relationships between: - System requirements and functional models. - Sensor data and the corresponding physical component. - AI predictions and the training data used. - XR training modules and the real-world procedures they simulate. Effective traceability enables debugging, validation, compliance, and continuous improvement of the digital twin by making the flow of data, logic, and decisions transparent and auditable.

The capability to trace artifacts and find problem at runtime

follow and record everything regarding to DT during whole life cycle

I don't know

It should be domain specific, driven by abstraction

MBSE manage connections

Minimize the fidelity throughout the DT lifecycle

Fault localisation

15. DTE: How would you better define Federation in DT Engineering ?

29 respondents

Capability to reuse or combine several DT or DT components/services

Distributed system

broadcast information/collaboration, generalization, build new instances with previous knowledge

composition of twins intended as (i) replicating the composite structure of a real system (e.g. city); and/or (ii) realization of communication channel between different replicas of diverse physical systems not connected in the reality

Ability of different DTs to operate together. Here the question is how the federated DT affect the AS(s)

Ability to "connect" DTs, possibly developed by different vendors. This may require the development of ontologies, APIs, etc.

Engineering

DTs communicating with each other

Collaboration

Fedaration is the Unified Framework of DTs

Interoperability, manage interfaces

Federation in Digital Twin Engineering refers to the ability to interconnect and coordinate multiple independent digital twins — each representing different systems, subsystems, or organizations—into a larger, collaborative ecosystem. Instead of building one monolithic twin, federation enables distributed, modular digital twins to

interoperate while maintaining their autonomy. A federated approach allows: - Scalable integration of diverse data sources and system models (e.g., machines, processes, environments). - Cross-organizational collaboration, where each stakeholder manages their own DT but contributes to a shared operational picture. - Loose coupling between twins, making the overall system more flexible, maintainable, and adaptable to changes. In the Finland Use Case, for example, federation would allow ThingLink's XR training environments, Process Genius's factory visualizations, and UEF's AI maintenance models to operate together seamlessly — while each remains independently developed and managed.

System of systems of DTs

Federation enables the integration and interoperability of multiple DTs, ensuring data exchange and synchronization.

Cooperation between DTs

Multiple DTs interconnected each others to realize complex functionalities. Distributed DTs representing a complex SoS

combine seperate and similar purpose DTs

Summarize relevant informations

Integration and communication of digital twins

Group of DTs that work for the same mission.

Collaboration

a DT can communicate (i.e share data, call, control) with other DTs

Individual, interoperable DTs for systems in SoS

Integration of DTs

Uniting different DTs

Integration of different DTs

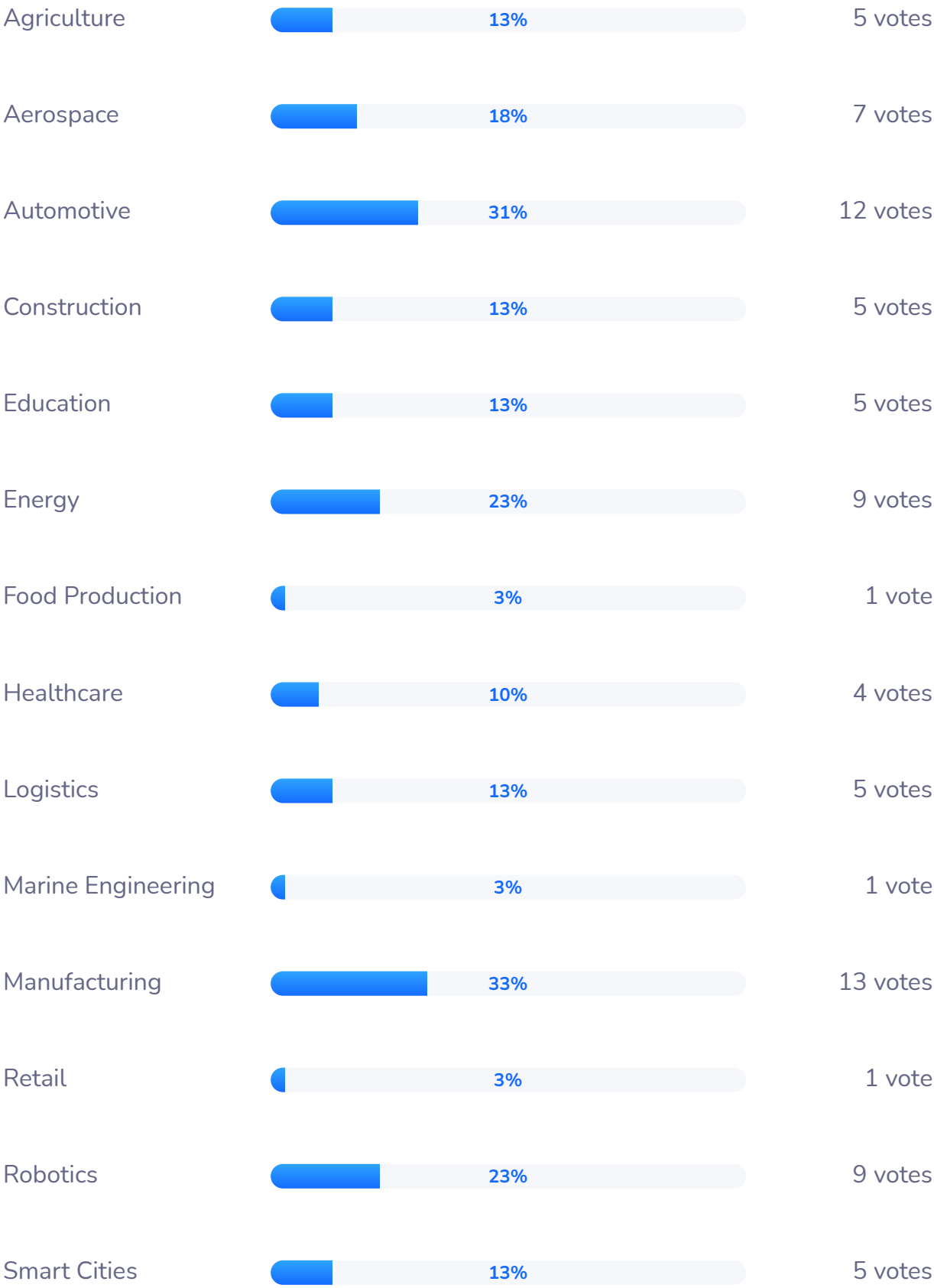
Digital twin information sharing

A group of DT system that can interoperate and coexist

Collaboration of DTs

16. DTE & Application Domains: In which application domains have you already used DTs? (Select all relevant options)

39 respondents



Telecommunications	3%	1 vote
Domain-agnostic	13%	5 votes
Other	10%	4 votes
None	13%	5 votes

Agriculture - Comments 1

Grain storage systems

Aerospace - Comments 1

Simulations

Automotive - Comments 1

Train

Construction - Comments 2

Infrastructure

Real estate more generally

Education - Comments 0

No comments for this answer

Energy - Comments 1

Aggregation of batteries

Food Production - Comments 0

No comments for this answer

Healthcare - Comments 1

Human skin

Logistics - Comments 0

No comments for this answer

Marine Engineering - Comments 0

No comments for this answer

Manufacturing - Comments 1

Mining

Retail - Comments 0

No comments for this answer

Robotics - Comments 0

No comments for this answer

Smart Cities - Comments 2

Transport

Urban Transportation (private and public traffic with ride sharing services)

Telecommunications - Comments 0

No comments for this answer

Domain-agnostic - Comments 0

No comments for this answer

Other - Comments 3

Critica scenarios (e.g., fireman scenario)

transportation

Railway

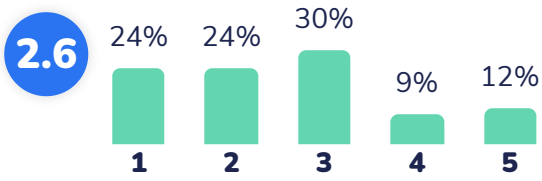
None - Comments 0

No comments for this answer

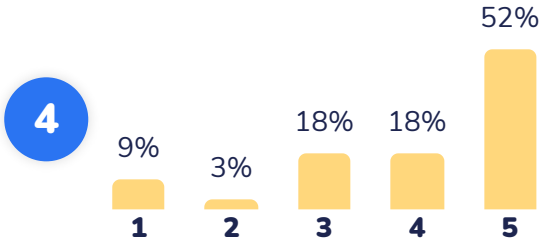
17. DTE & Application Domains: In which application domains do you think DTs are the most relevant?

33 respondents

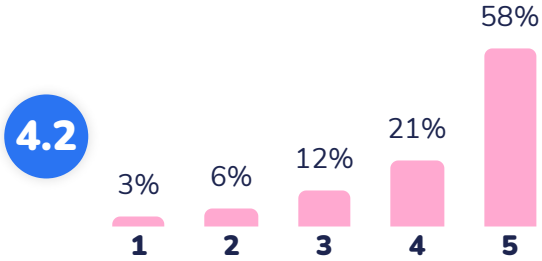
1 Agriculture



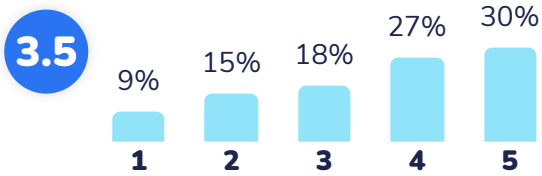
2 Aerospace



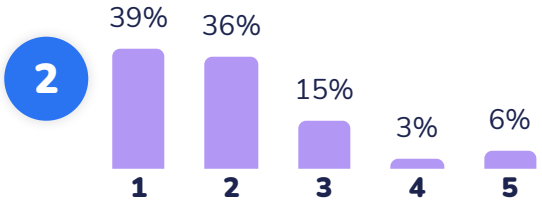
3 Automotive

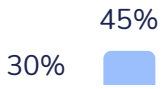


4 Construction

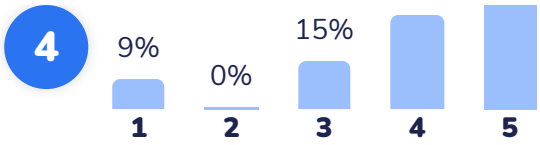


5 Education

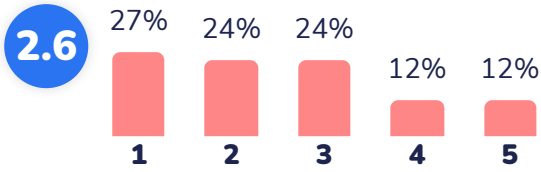




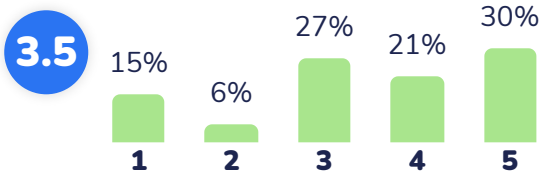
6 Energy



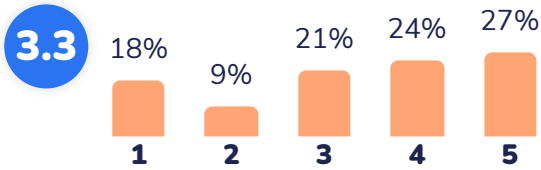
7 Food Production



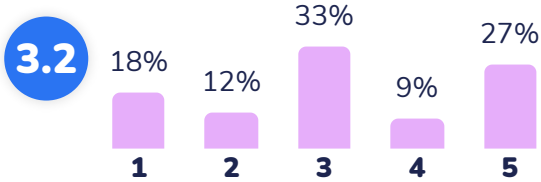
8 Healthcare



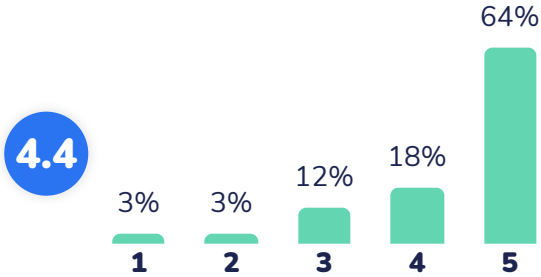
9 Logistics



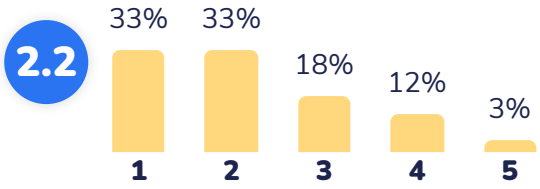
10 Marine Engineering



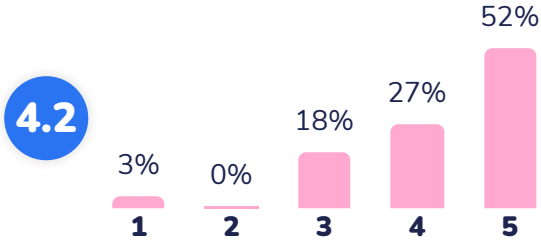
11 Manufacturing



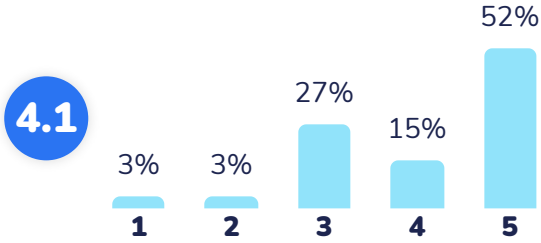
12 Retail



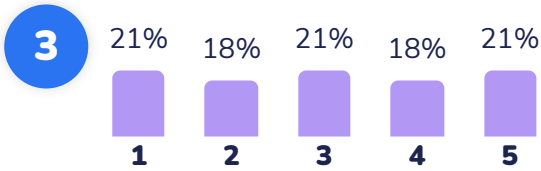
13 Robotics



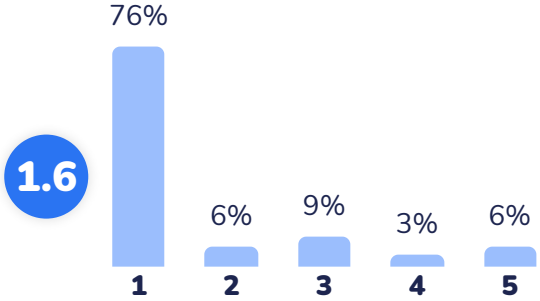
14 Smart Cities



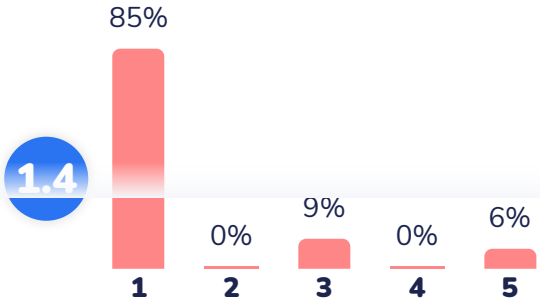
15 Telecommunications



16 Other



17 I do not know



18. DTE & Best Practices and Standards: In your experience with DT Engineering, have you adopted or encountered any standardized methodologies or best practices? If so, please specify.

34 respondents

No

SysML, FMI, DDS, HLA

HLA and FMI for co-simulation

Nope

Web of Things, SysML v2

Are there any yet?

Key Standards and Best Practices We've Engaged With: - Asset Administration Shell (AAS) – We have explored AAS from the Industry 4.0 framework to describe and manage digital representations of physical assets. It supports modularity and interoperability, which are essential for federated digital twin architectures. - OPC UA (Open Platform Communications Unified Architecture) – Widely used in industrial environments, OPC UA helps us ensure standardized, secure, and real-time data exchange between physical machines and digital twins. - Model-Based Systems Engineering (MBSE) – We follow MBSE practices using model-driven approaches to define system behavior, requirements, and structure. This supports traceability and consistency across the twin's lifecycle. - ISO 23247 (Digital Twin Framework for Manufacturing) – We are aligning our practices with this emerging ISO standard, which offers a reference architecture and terminology for digital twins in manufacturing domains. - Usability and Human-Centered Design – Particularly relevant for XR interfaces, we follow best practices from ISO 9241 (ergonomics of human-system interaction) to ensure intuitive and safe user experiences. - AI Transparency and Explainability – For AI-based predictive maintenance, we adopt guidelines aligned with the EU AI Act and ETHICS guidelines for trustworthy AI, ensuring transparency, fairness, and auditability.

BIM/ IFC, IDTA, RealEstateCore/ BRICK Schema/ ASHRAE

SysML

model-driven, low-code, ISO 23247, ISO 42010 for architecting, modeling with UML/sysml

BIM

SysML Statemachine, Simulation

AAS

MODELS

No

No

Using conventions to create models

FMI

No

Nope

No

Not yet

Arinc 429 aviation standard

no

Haven't seen any standard practice.

No

SysML

Not yet

OMG and DTC standards

no

Not many

No

no

Iso23247

19. DTE & Tools: In your experience with DT Engineering, have you adopted or encountered any particular solution tool or framework for DTE? If so, please specify if 1) it is your internal solution/tool/framework, or it is a third-party solution/tool/framework, and 2) if it is specific to your application domain or can be used broadly.

35 respondents

- simcenter (siemens)
- FMU/FMI
- eclipse ditto
- no
- Intellj for java
- Eclipse
- Eclipse EMF
- No
- Modelio
- Unity, Aws, Azure
- FMI, into CPS

- Eclipse Ditto, FIWARE: mostly for data management, sharing, interoperability - Eclipse SUMO for traffic modeling simulation - Visual Paradigm for UML modeling - customized tool for automated model transformation

Yes, I have, it is our internal solution and it is specific to our application domain.

INTO-CPS toolchain, Modelio, co-simulations

Enterprise Architect

Unity/Gazebo maybe?

AWS Twinmaker

Azure Digital Twins

Enterprise Architect

Eclipse

No

1. Process Genius – Genius Core® (Internal Tool) Type: Internal platform Scope: Primarily domain-specific (industrial operations and factory environments), but modular enough for broader applications. Use: Used to build visual, real-time Digital Twin environments of manufacturing systems. It supports sensor data integration, system behavior modeling, and operational visualization. 2. ThingLink – Interactive XR & Training Platform (Internal Tool) Type: Internal platform Scope: Initially developed for education and training but increasingly used across domains including manufacturing, logistics, and healthcare. Use: Used to create immersive, web-based XR environments for operator training and virtual instructions, integrated with real-world machine data. 3. 3D Talo – 3D Modeling and Visualization Tools (Internal & CAD-Based) Type: Internal and third-party tools (e.g., Autodesk, Unity) Scope: Broadly applicable across industries for creating interactive digital content. Use: Used for producing high-fidelity 3D models and visual simulations of machines and production lines to support DT interfaces. 4. UEF – AI/ML Toolchain for Predictive Maintenance (Internal Research Framework) Type: Internal research toolset (Python-based, TensorFlow, PyTorch) Scope: Broad applicability across sectors. Use: Used to design

and evaluate AI models for fault detection, anomaly prediction, and system performance optimization. Can be integrated into any DT environment via APIs. 5. OPC UA Integration (Third-Party Standard Protocol) Type: Third-party standard Scope: Widely used across manufacturing and industrial automation. Use: Ensures standardized and secure communication between physical assets and digital twin platforms.

No

Unity

Azure digital twins

No

no

Railway tools simulation

Iso23247, interoperability levels taxonomy

Internal solution and tools, application domain independent

Enterprise Architect

no

No

Fmpy, enterprise architect

no

20. DTE & AI: In your digital twin engineering work, have you integrated or encountered approaches that utilize artificial intelligence or large language models (LLMs)? If so, please describe your experience.

30 respondents

optimization (for domain, not for engineering of the DT)

Predictive maintenance and anomaly detection

LLM has potential to help enhancing interoperability and model transformation

no

Sensor data analysis

Yes symbolic AI tools for planning / verification ((probabilistic) model checkers etc). Some experiments with chatbots for code generation

Anomaly detection

production planning based on constraint optimization

LLM for model management support

Not really

LLM in model recommendation and Synthetic data Generation for DTs when there are privacy/security issues. AI/ML models for hardware/software partitioning and embedded system design and implementation

Reinforced learning

No

No

LLM to support general modeling tasks

LLMs in DT Context While not yet fully integrated in our DT pipelines, we have begun experimenting with LLMs (e.g., GPT-based models) for: Conversational AI & Guidance: ThingLink is exploring LLMs to power interactive, context-aware help systems and virtual maintenance assistants embedded in XR training environments. Natural Language Querying: We are assessing the use of LLMs to enable users to query Digital Twin systems using plain language, e.g., "Show me all machines with predicted downtime in the next 24 hours." Document Analysis: LLMs are being tested to process technical manuals, failure logs, and user feedback to improve model training and maintenance documentation.

No

anomaly detection

LLM to help V&V process

AI Integration in DT Engineering We use AI primarily for: Predictive Maintenance: UEF has developed machine learning models (e.g., anomaly detection, failure prediction) based on sensor data from forestry machines to detect early signs of wear or malfunction. Smart Monitoring: AI models are trained on historical and real-time telemetry data to assess system health and provide dynamic risk assessments. Visual Data Interpretation: AI supports visual analysis and feature extraction from image/video data collected from machines and XR environments. These AI components are directly integrated into Digital Twin platforms developed by Process Genius and 3D Talo to create responsive, self-learning systems that evolve with real-world usage.

LLMs for automated generation

predictive maintenance

No

No

No

No

reinforcement learning

No

no

No

21. DTE & Research: Could you recommend any valuable references (e.g., research papers, white papers, websites, etc.) on Digital Twin Engineering that have significantly influenced your understanding or practice?

27 respondents

COMBEMALE

Towards Development Platforms for Digital Twins: A Model-Driven Low-Code Approach

"Integrating FMI and ML/AI models on the open-source digital twin framework OpenTwins"

Process Prediction with Digital Twins

Matisse

Architecting Digital Twins

Hans Vangheluwe

Related works by A. Wortmann and J. Michael

D2.1 :-)

No

Survey on Digital Twins: from concepts to applications

Lukas Merkle

ChatTwin: Toward Automated Digital Twin Generation for Data Center via Large Language Models

No

no

Nope

No

No

Standards & Frameworks: ISO 23247 – Digital Twin Framework for Manufacturing – An emerging international standard providing a structured approach to DT engineering. ISO Website Industry 4.0 Asset Administration Shell (AAS) – A practical framework for standardized digital representation of assets. Platform Industrie 4.0 – AAS Info Hub Digital Twin Consortium – Technical Resources – Offers best practices, architecture frameworks, and white papers. https://www.digitaltwinconsortium.org

no

DTaS by INTO-CPS association

No

Foundational Research Papers & Articles: Grieves, M. (2014). Digital Twin: Manufacturing Excellence through Virtual Factory Replication – Often cited as the origin of the Digital Twin concept. Introduces the idea of the physical-digital-connection loop. [White Paper, Florida Institute of Technology] Tao, F., et al. (2018). Digital Twin in Industry: State-of-the-Art IEEE Transactions on Industrial Informatics – A comprehensive survey on DT definitions, enabling technologies, and application areas. DOI: 10.1109/TII.2018.2873186 Boschert, S., & Rosen, R. (2016). Digital Twin—The Simulation Aspect – Focuses on how simulation is integrated into DT systems. In: Mechatronic Futures (Springer)

Ask chatgbt

No

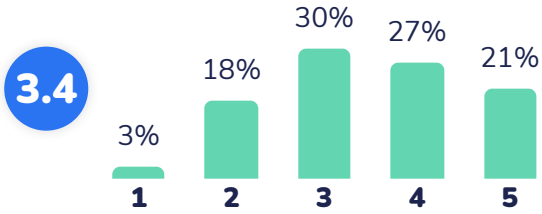
Social posts

no

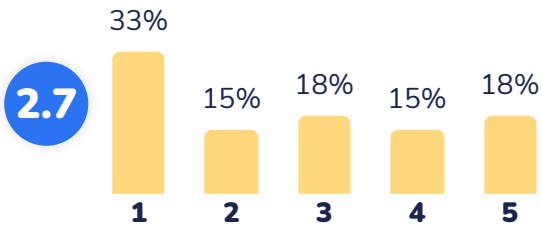
22. MBE: Please rate your level of expertise in the following MBE concepts for Digital Twin Engineering: Not Familiar (1): I have very limited or no theoretical knowledge and have never applied this concept in practice. Beginner (2): I am aware of this concept at a basic level, mainly through literature or training, but I have minimal practical experience. Intermediate (3): I understand the core principles of this concept and have applied it in a few projects, though my practical experience is still developing. Advanced (4): I possess significant theoretical knowledge and practical experience. I have applied this concept in several projects and understand its nuances. Expert (5): I have extensive theoretical knowledge and comprehensive practical experience. I can apply this concept confidently in complex scenarios and potentially mentor others.

34 respondents

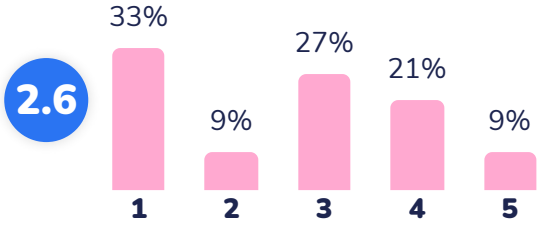
1 Model



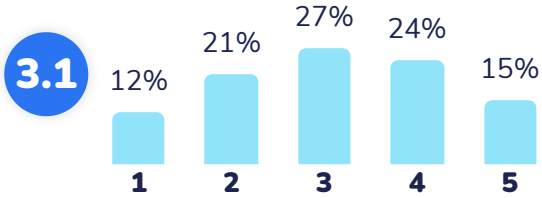
2 Abstract Syntax or Metamodel



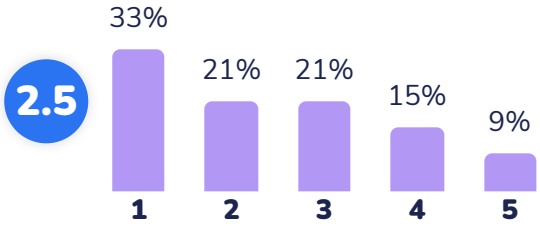
3 Concrete Syntax or Notation



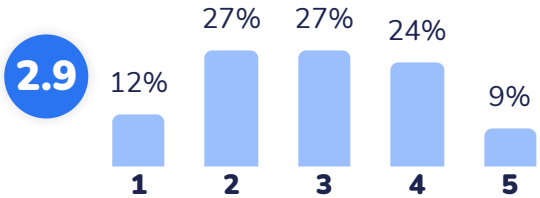
4 Modeling Language



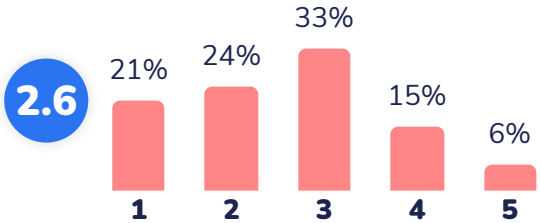
5 Model Semantics



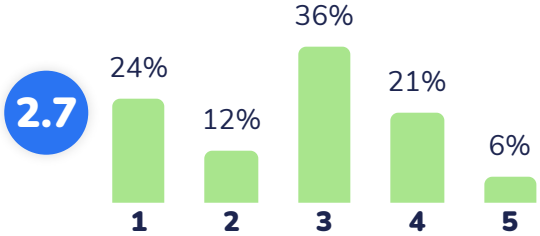
6 Model Simulation



7 Executable Model

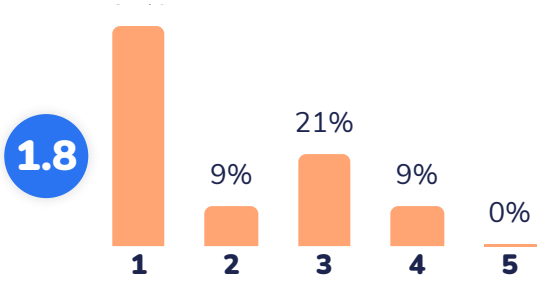


8 Model Transformation



61%

9 Megamodel

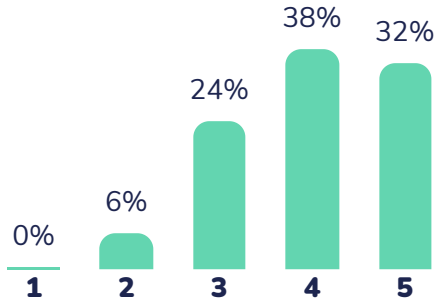


23. DTE and MBE: How much would you agree with the following statements? (1 to 5)

34 respondents

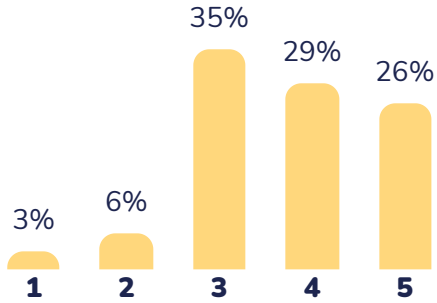
1. Model-based engineering (MBE) provides a robust framework for DT engineering

4



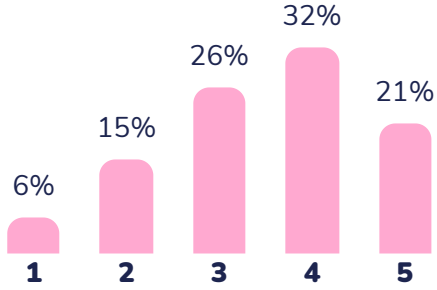
2. Traceability is a critical and achievable aspect of DT engineering.

3.7



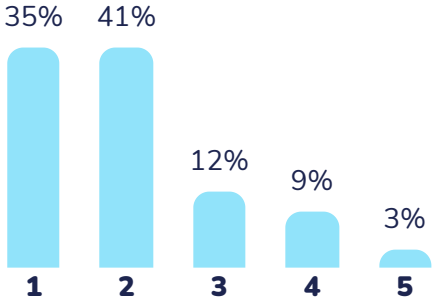
3. Traceability in DT engineering is hindered by a lack of standardized methods and tools.

3.5



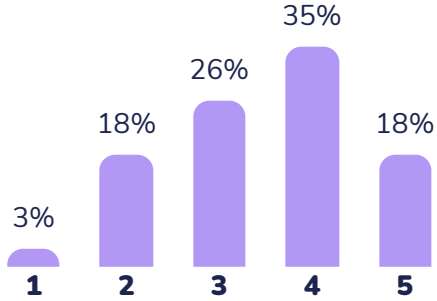
4. Federation strategies are well-supported by existing tools in DT engineering.

2



5. Federation in DT engineering is hindered by a lack of standardized methods and tools.

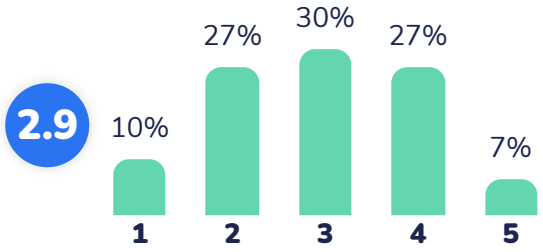
3.5



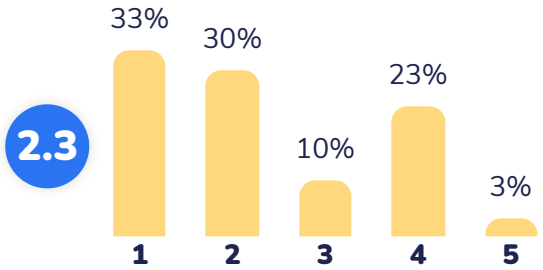
24. DTE and MBE: How much would you agree with the following statements? (6 to 10)

30 respondents

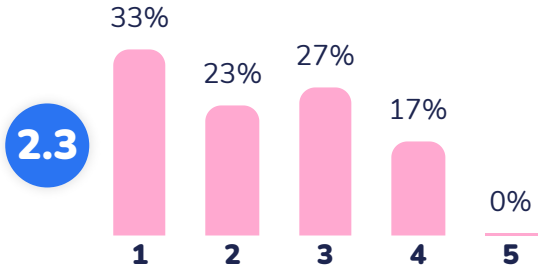
1. The tools I use for DT engineering effectively incorporate MBE principles.



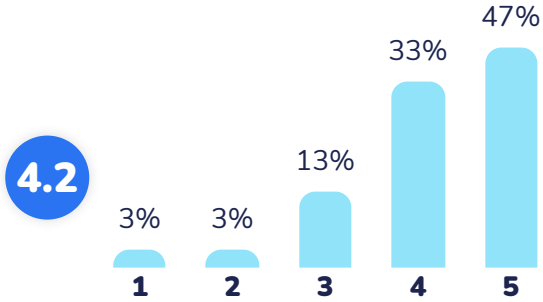
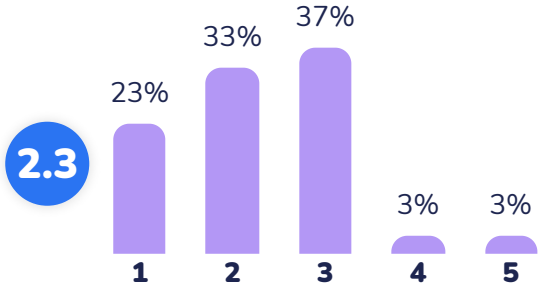
2. The tools I use for DT engineering effectively support traceability.



3. The tools I use for DT engineering effectively support federation among two or more DTs.



4. Collaboration between academia and industry is crucial for advancing MBE in DT engineering.



5. Current literature provides sufficient guidance on integrating traceability into MBE for DT Engineering.