Data-driven intelligence by digital twins – The Verification and Validation Task Group

Detlev Richter, Michael Pfeifer, Marcel Wagner, Jens Lachenmaier

DTC Meeting Heilbronn, Jan, 28th, 25

Outlook for Verification, Validaition and uncertainty Quantification WG

We plan **half day face to face workshop** in Reston on Q1/DTC Quarterly Meeting on March 17th 2025

Agenda of Verification and Validatiom

Ferdinand-
Steinbeis
-Institut

- **DTC Trustworthiness WG & Verifcation and Validation WG**

  Short intro about trustworthiness **Detlev**
- Starting Point: Risk Analysis – important point Jens
- TÜV SÜD – Digital Risk and Compliance Management Michael
- Intel – Semantic Data Verification and Validation Marcel
- Break
- DNV - Digital Trust by DNV Ove

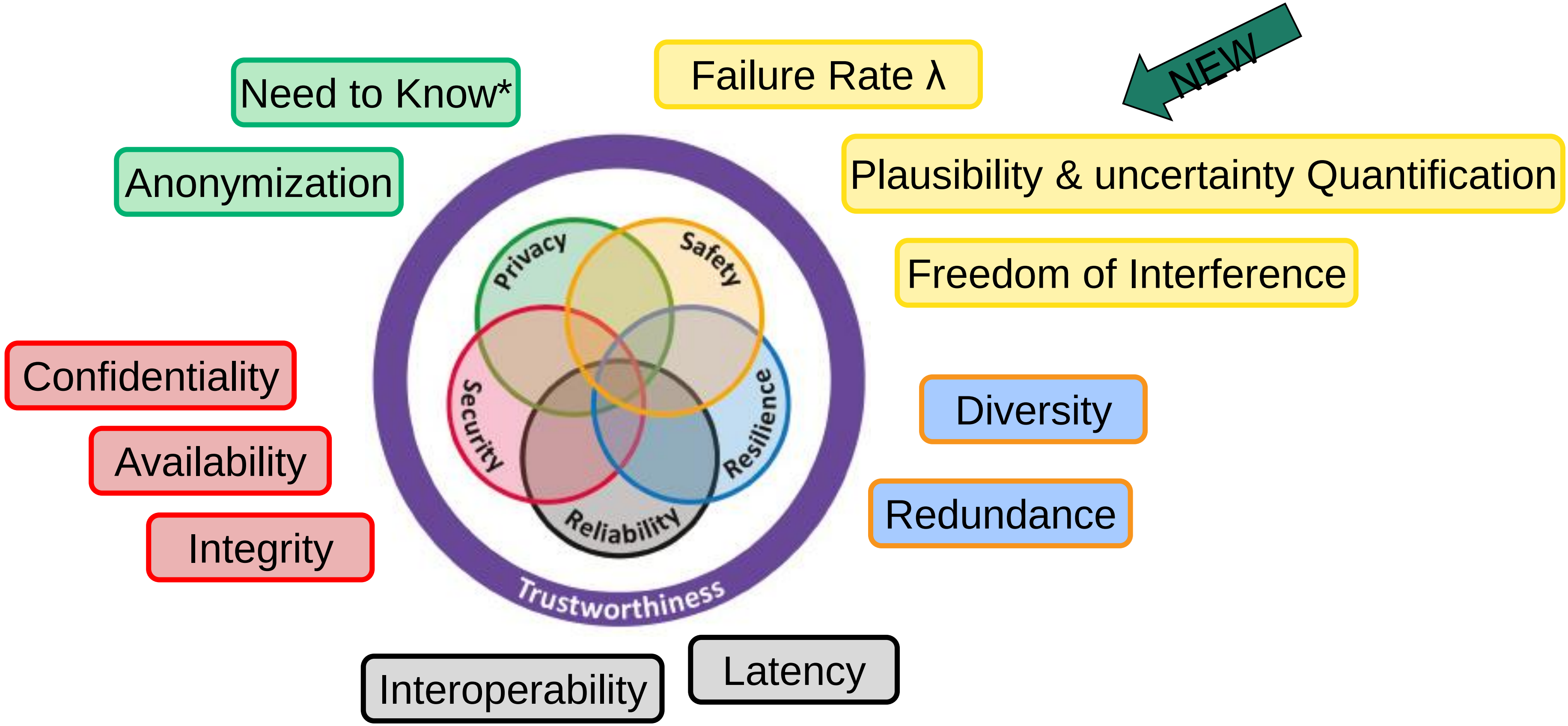
Digital Engineering Security & Trustworthiness Verification & Validation

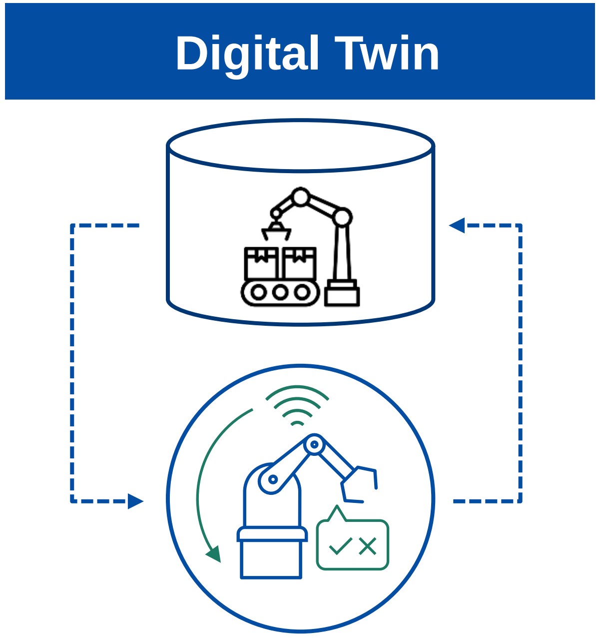
30th January 2025

Dr. Detlev Richter   *Robert A. Martin*

Trustworthiness WG → Terminology & Definition

Digital Twin offers capabilities to ensure trustworthiness





* incl. IP protection

Source: IIC Industrial Internet Consortium

Trustworthiness WG → *"Trust has to be designed in"*

1. Management of Trustworthiness

Each characteristic can be associated with policies and regulations, with objectives, and with agreements.

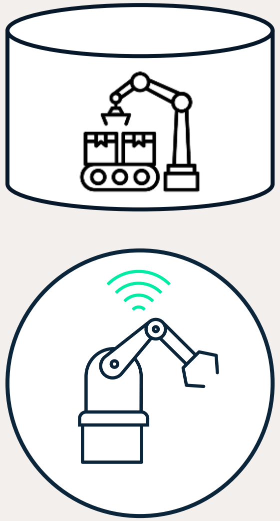
These policies, objectives, agreements are in turn subject to measures, audits, and assurance procedures that involve metrics, key performance indicators and targets.

Source: WG presentation by Ekaterina Rudina summarizing the impact of ISO 30149

Trustworthiness and Assurance Cases

An operational Digital Twin is a continuously monitoring function

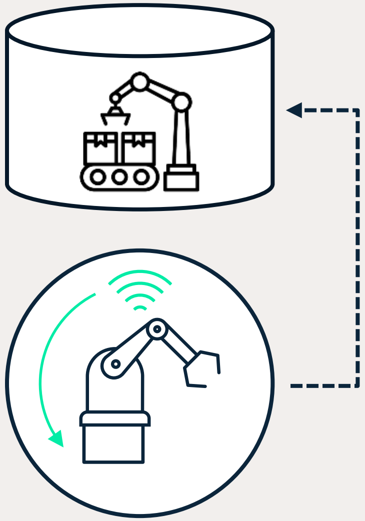
Digital Model



Asset + Model

Virtual Commissioning – system planning

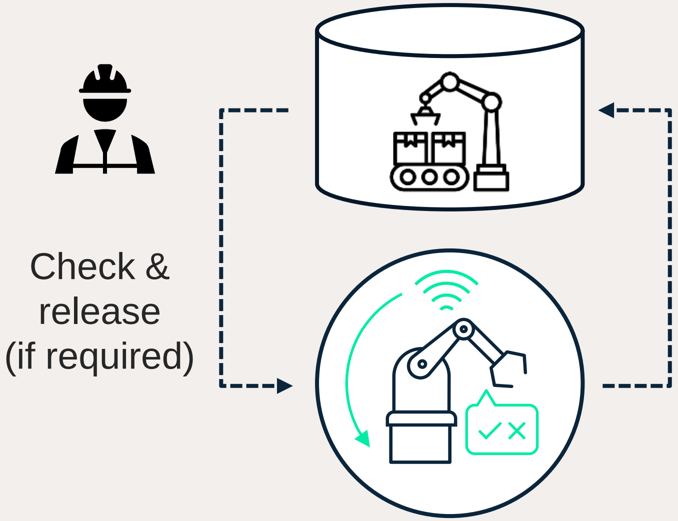
Digital Shadow



Asset + Model +
Run-time Data
backward looking, trend calculation

Monitoring of systems in operation

Digital Twin



Asset + Model +
Run-time Data + Feedback loop
active forward looking & shaping

Predictive risk management in operation

2. Managing Trustworthiness

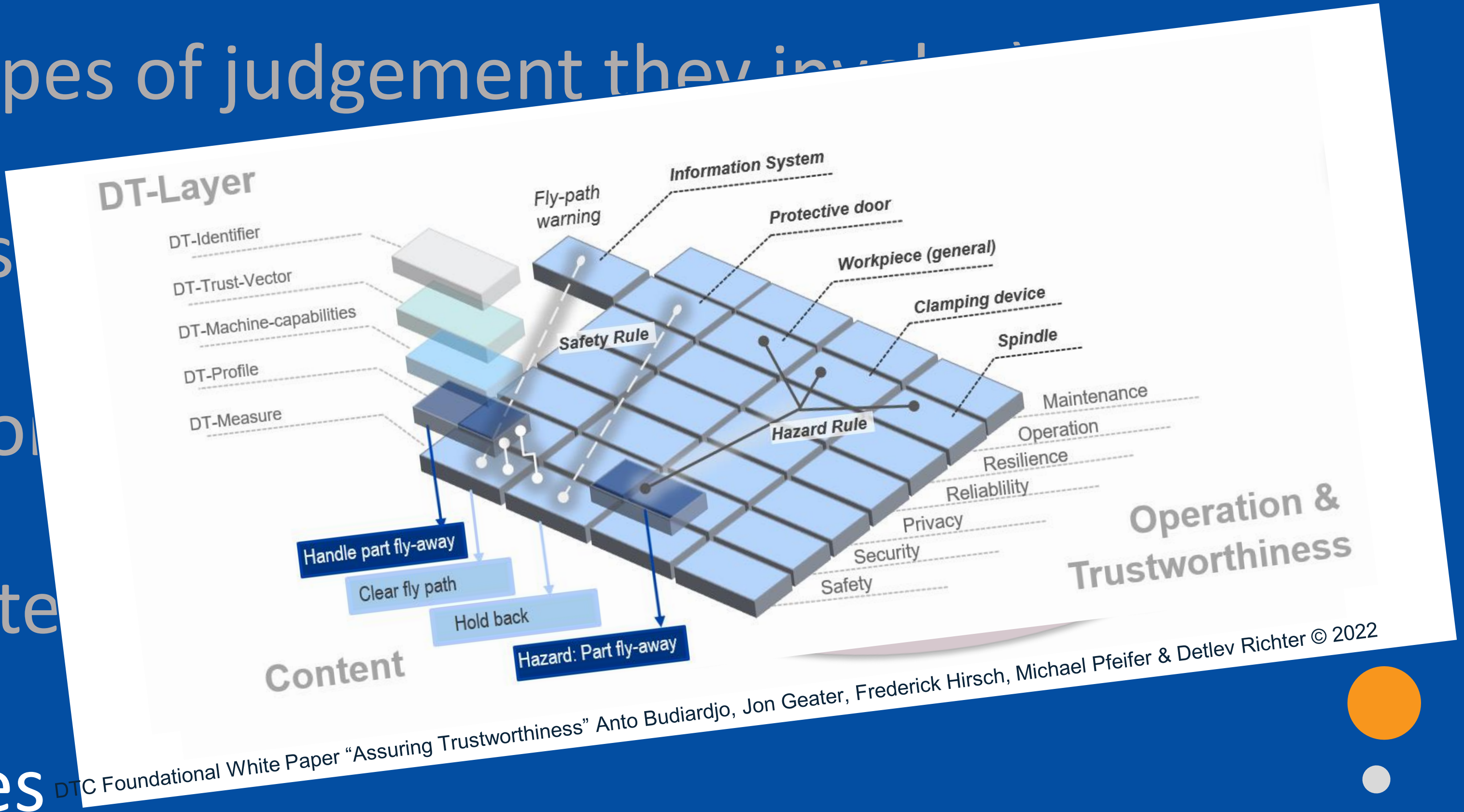
Assumptions (which types of judgement they inv

Assurance (approaches

Risks (wrong assumptio

Composition of charecte

Trustworthiness profiles

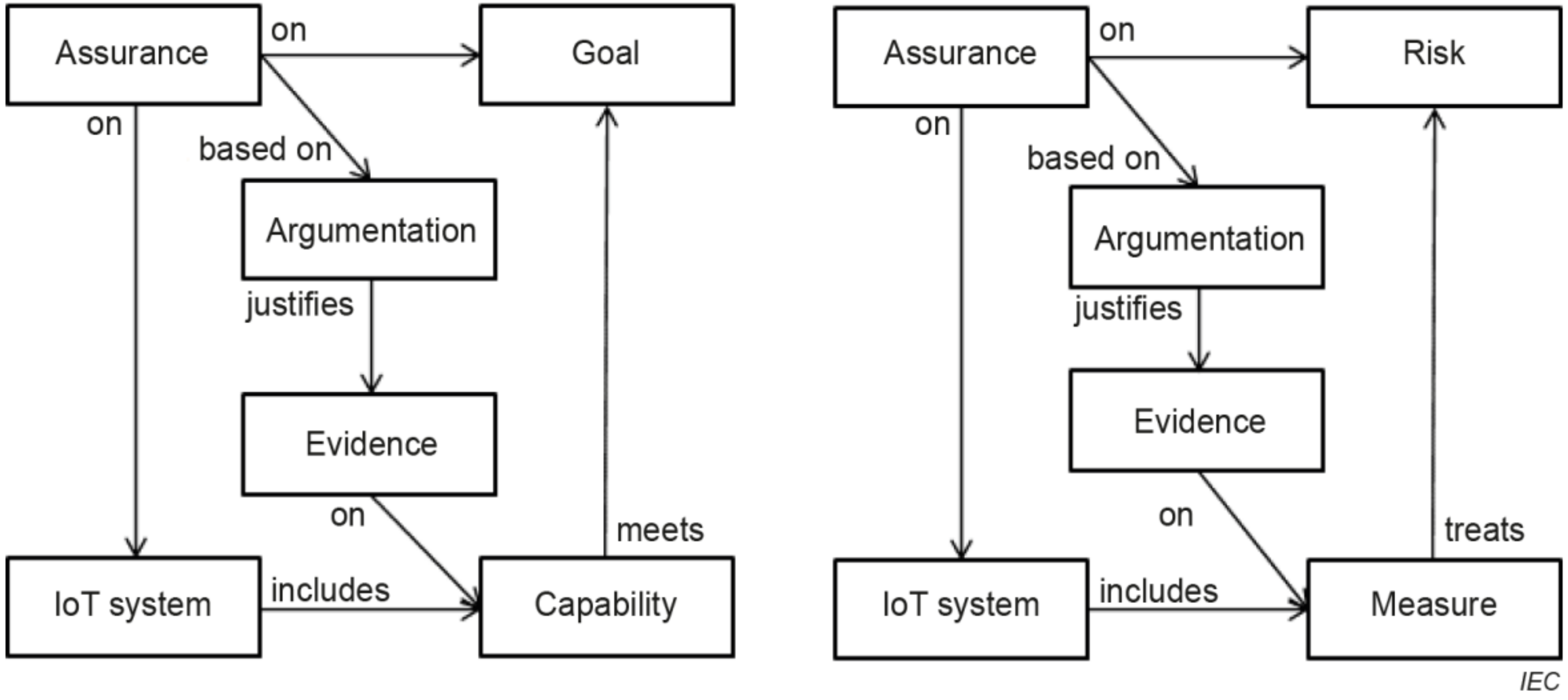


Source: WG presentation by Ekaterina Rudina summarizing the impact of ISO 30149

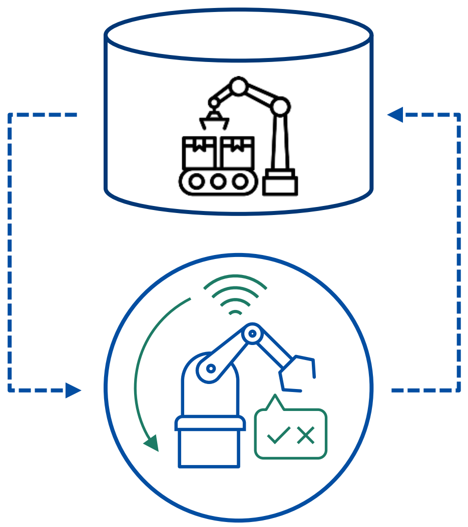
Managing Trustworthiness → Assurance cases
Analyse existing standards & add specific DT capabilities if needed

Assurance viewpoint

- **Goal orientation** approach by designing capabilities
- **Risk orientation** approach through a risk analysis and the identification of measures



Digital Twin



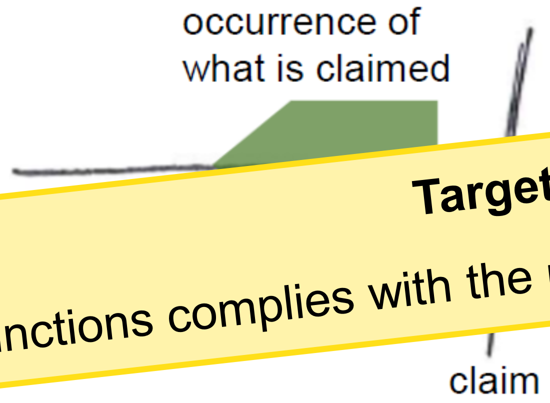
Managing Trustworthiness → Verification

Definition acc. to ISO/IEC 17029

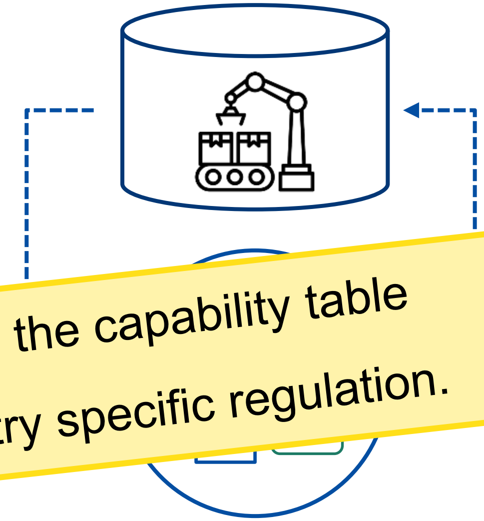
- *The claim can represent a situation at a point in time or could cover a period of time.*
- *The V/V outcome reflects only the situation at the point in time it is issued as V/V statement.*
- *Review and decision shall be made by personnel different from those who carried out the V/V execution*.

<u>Differentiation from each other</u>:

- **verification** – confirmation of a claim through the provision of objective evidence, that specified requirements have been fulfilled (confirmation of **truthfulness**)



Digital Twin



Targeted Digital Twin Function .. E.g. derived form the capability table

Verify - this functions complies with the requirements for industry domain and for country specific regulation.

Managing Trustworthiness → Validation

Definition acc. to ISO/IEC 17029

- *The claim can represent a situation at a point in time or could cover a period of time.*
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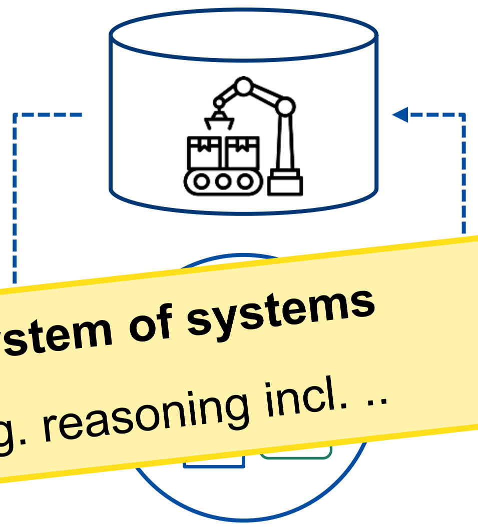
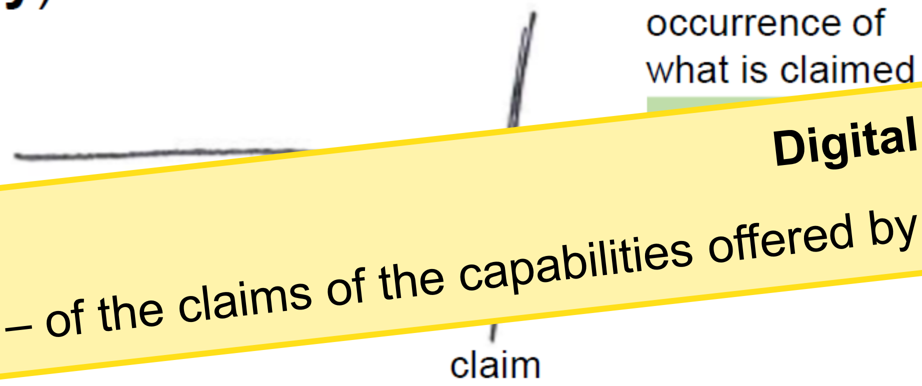
Digital Twin



Differentiation from each other:

- **validation** – confirmation of a claim through the provision of objective evidence, that the requirements for a specific intended future use or application have been fulfilled (confirmation of **plausibility**)

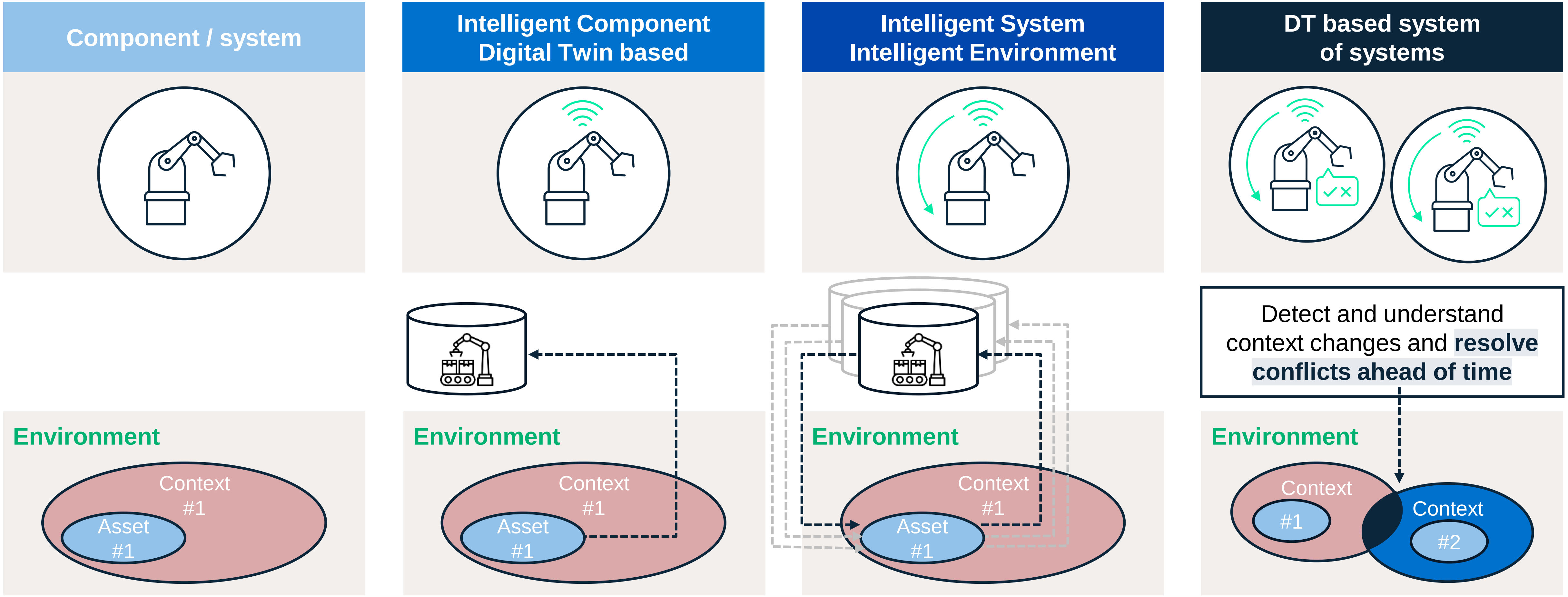


Digital Twin Capabilities within a system of systems

Validation – of the claims of the capabilities offered by this digital twin functions … e.g. reasoning incl. ..

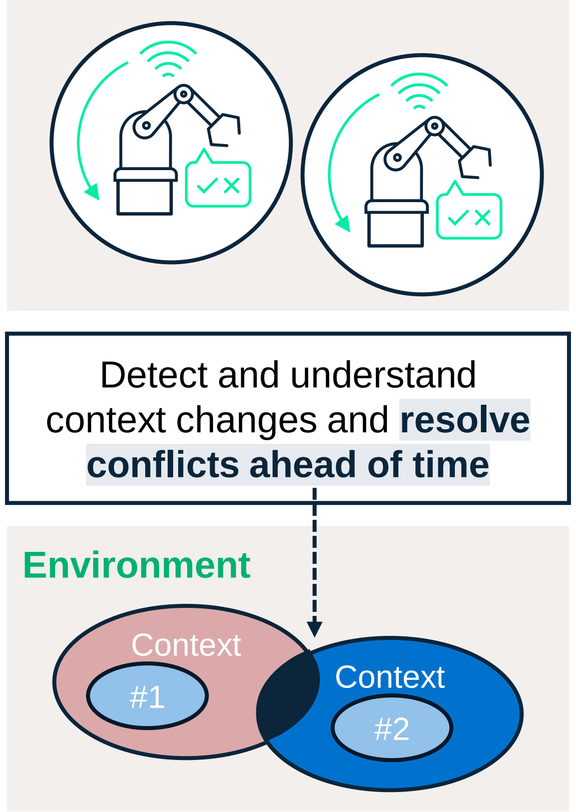
Verification and Validation

Trust is based on context understanding – how to master this?



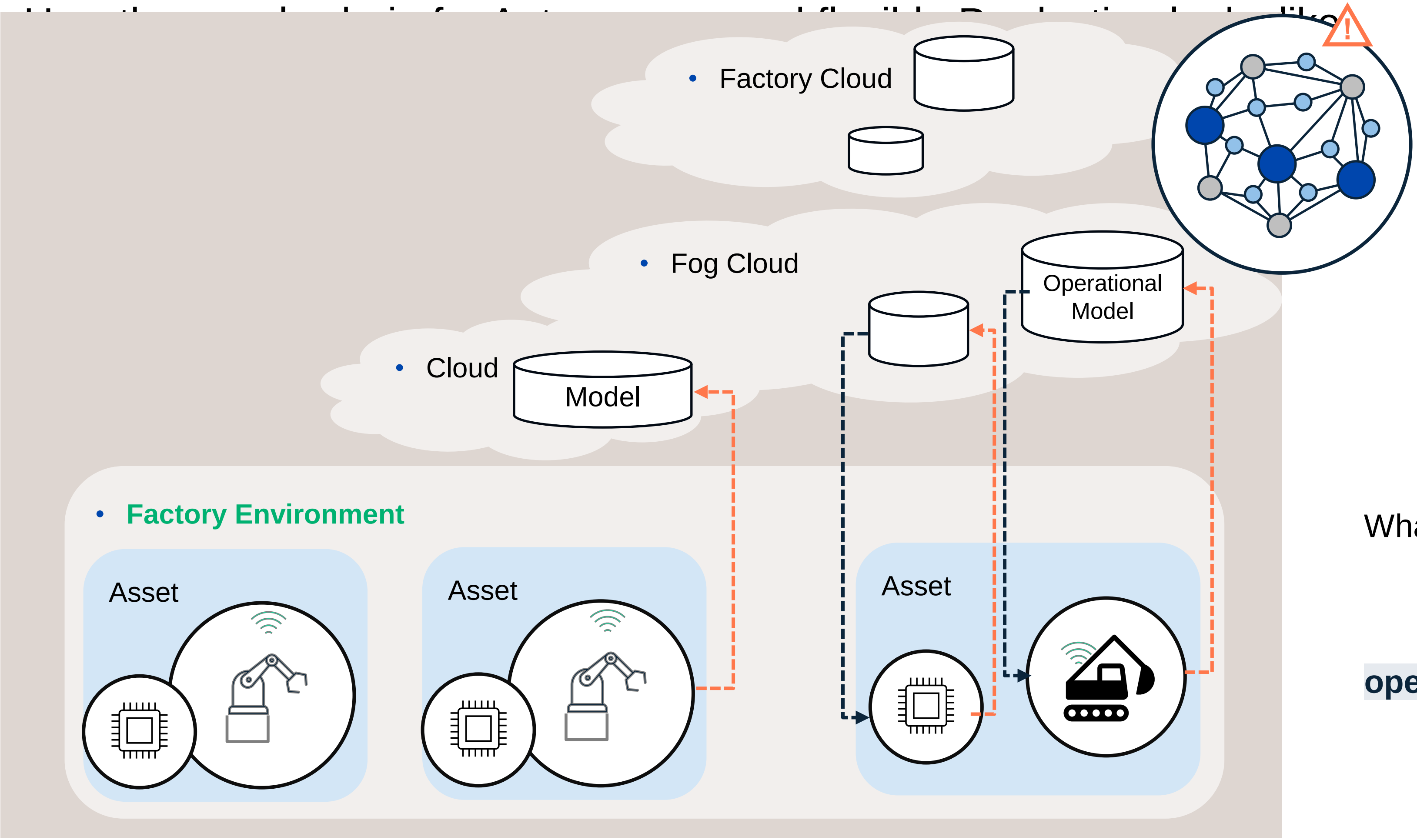
Digital Engineering → Verification & Validation

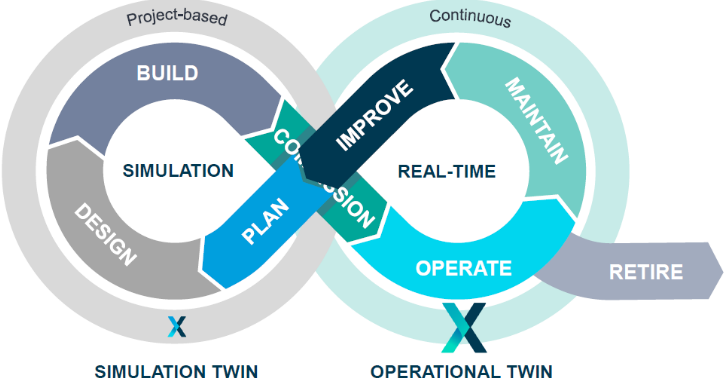
Solution Statement: Intelligent Digital Twins have to offer a **methodology** to ensure **trustworthiness for system of systems**:



Knowledge Economy requires Digital Engineering

Fundamental difference between IIoT & spatial digital twins





What is the business target (KPI) for the Operational Digital Twin?

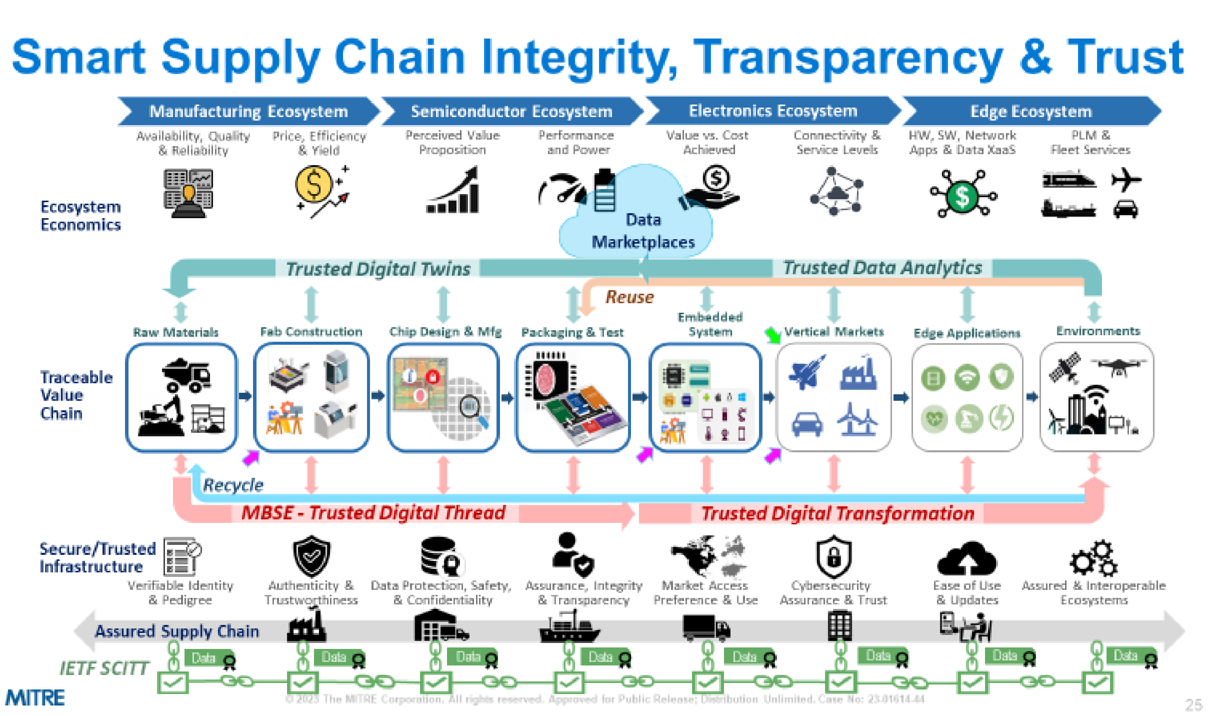
The **Digital Twin** is the **master** for **specific operational decisions .. only systems of systems of twins** could deliver a value stream**.**

-

TÜV SÜD: Operational Safety Intelligence

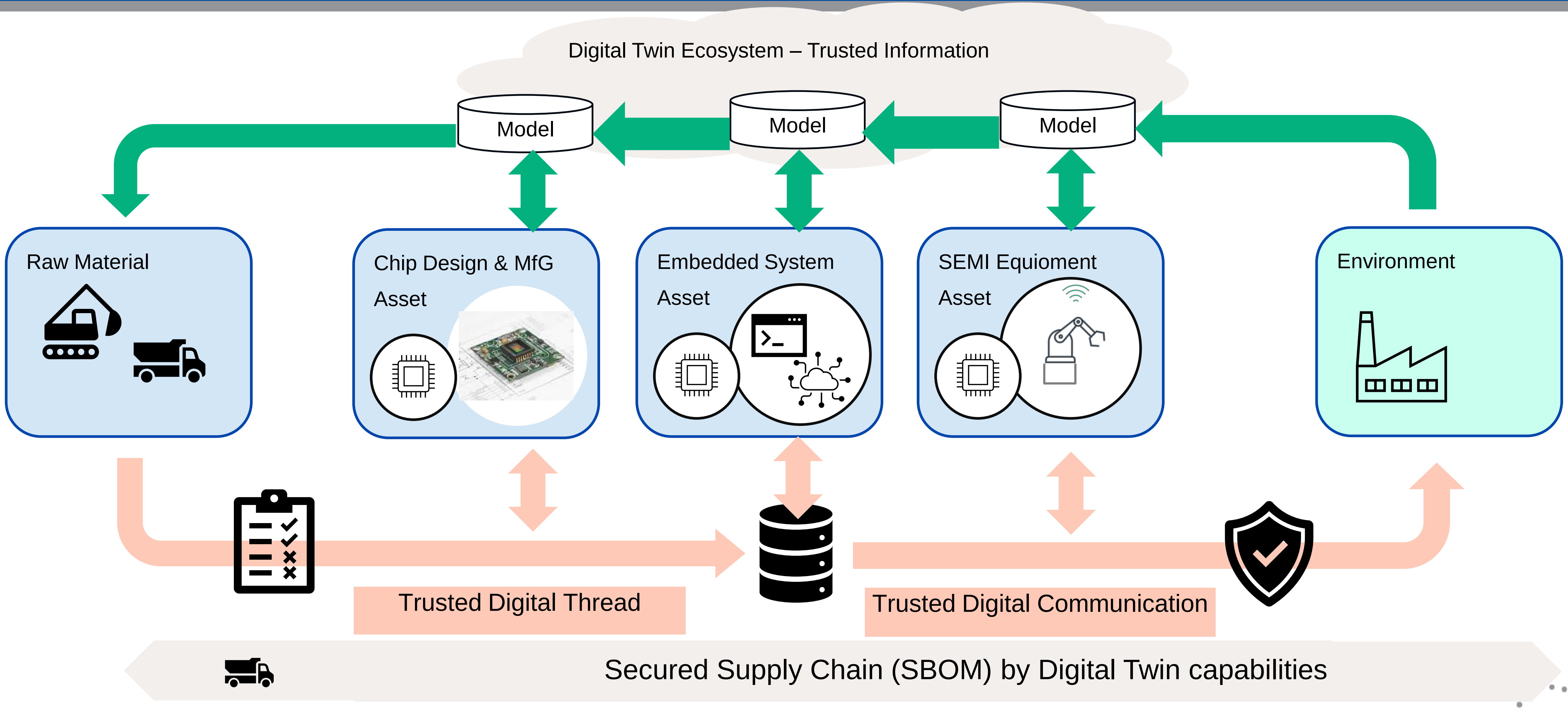
Trust into the IoT & DT development and Supply Chain

- Operational Assurance of Systems and Digital Twins through Supply Chain Security Enhance Systems
  - How to integrate development, product and process twin and supply chain topics into a holistic trustworthy engineering setup for the complete lifecycle



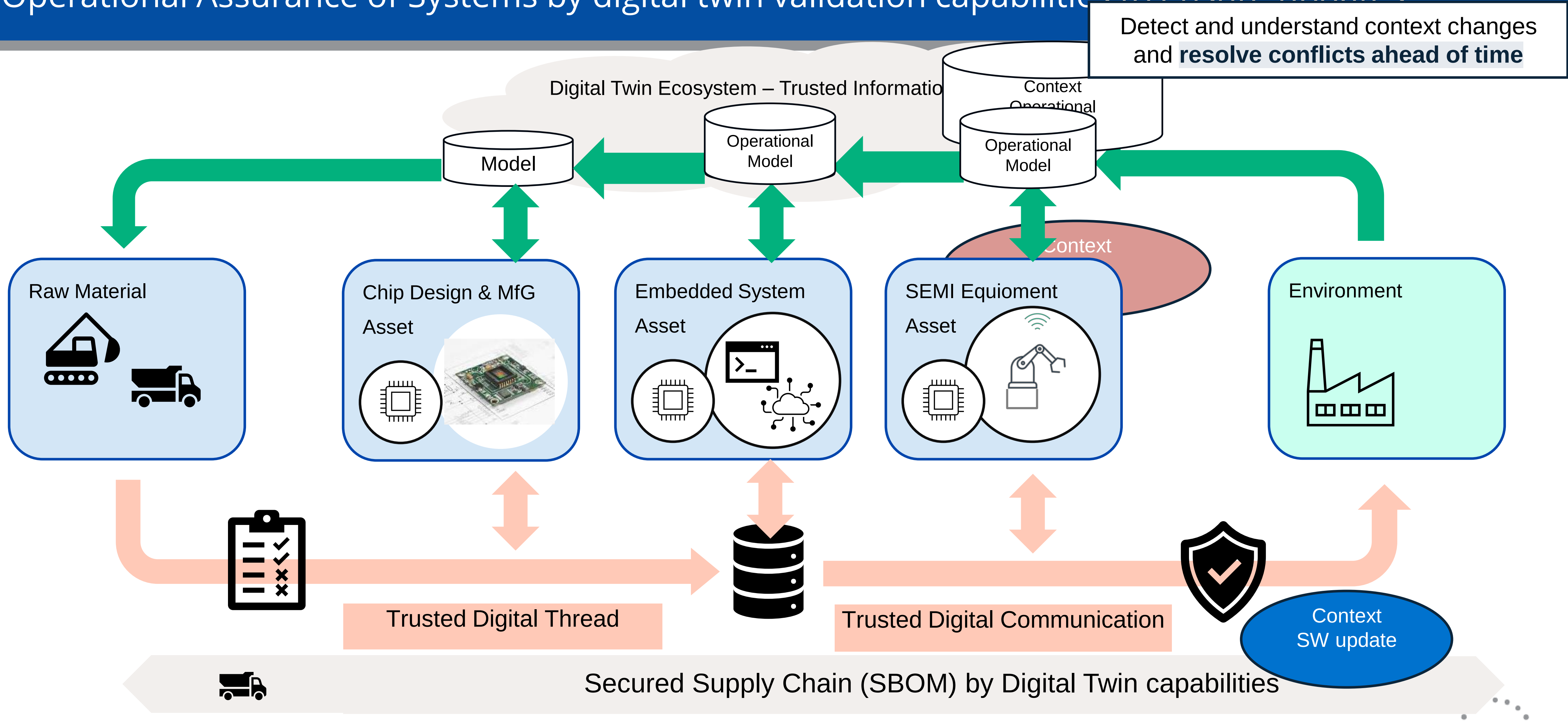
Knowledge Economy requires Digital Engineering

Operational Assurance of Systems requires Information Integrity and Transparency along the complete Supply Chain and Trust in System behaviour and context understanding

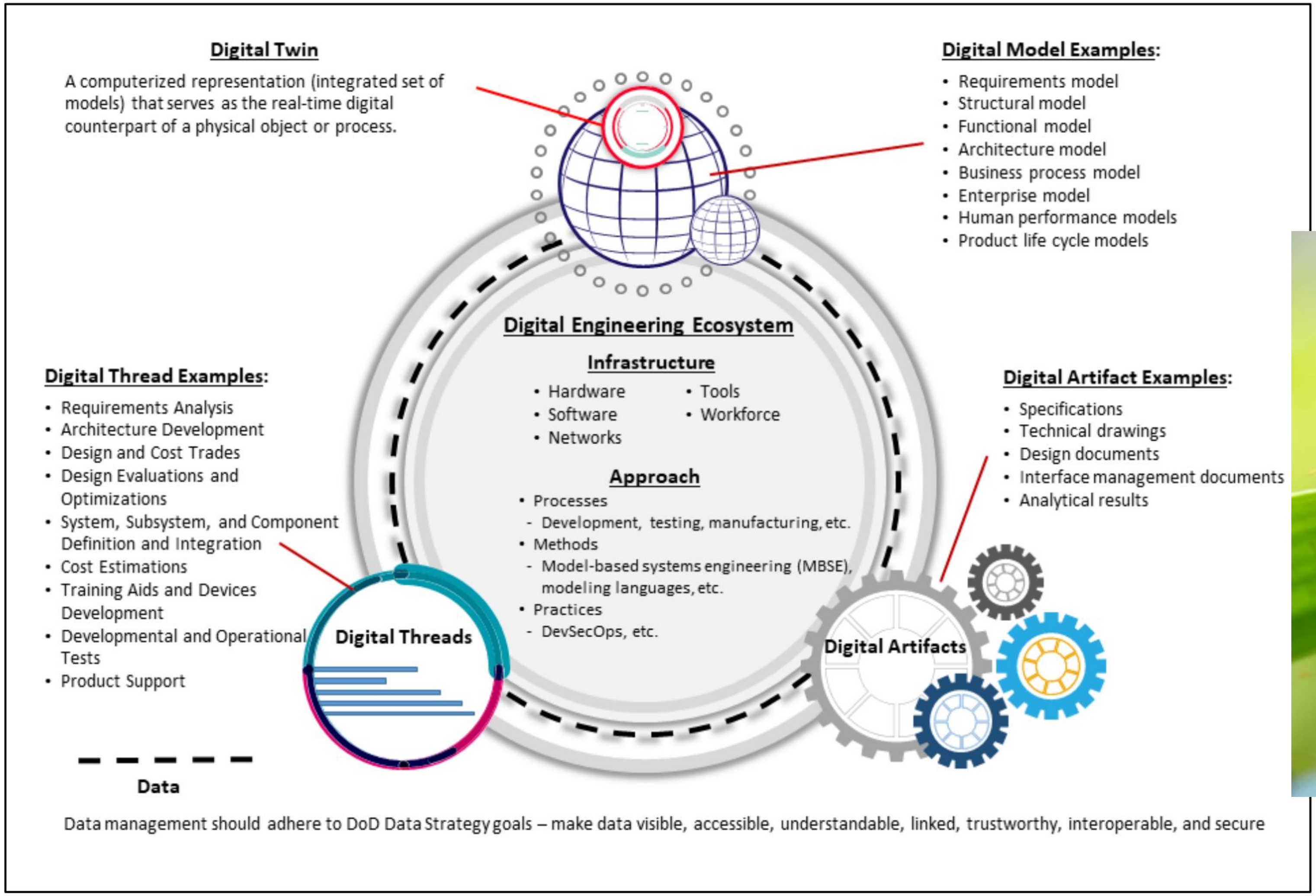


Knowledge Economy requires Digital Engineering

Operational Assurance of Systems by digital twin validation capabilities to ensure updates



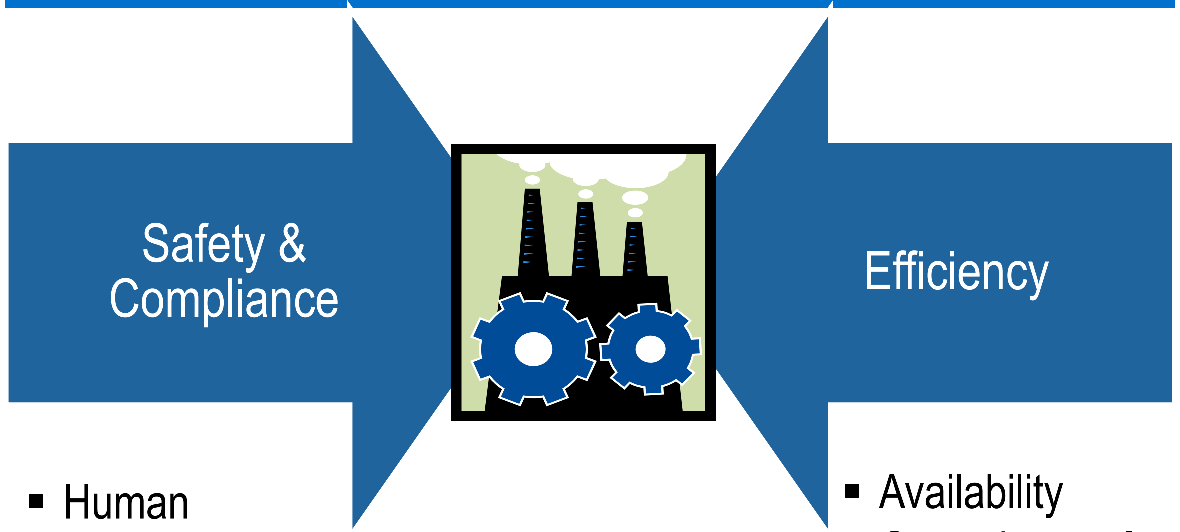
Digital Engineering → Verification & Validation



It's all about verification & validation

Smart Manufacturing – Risk Management → Digital Twin Safety Engineering

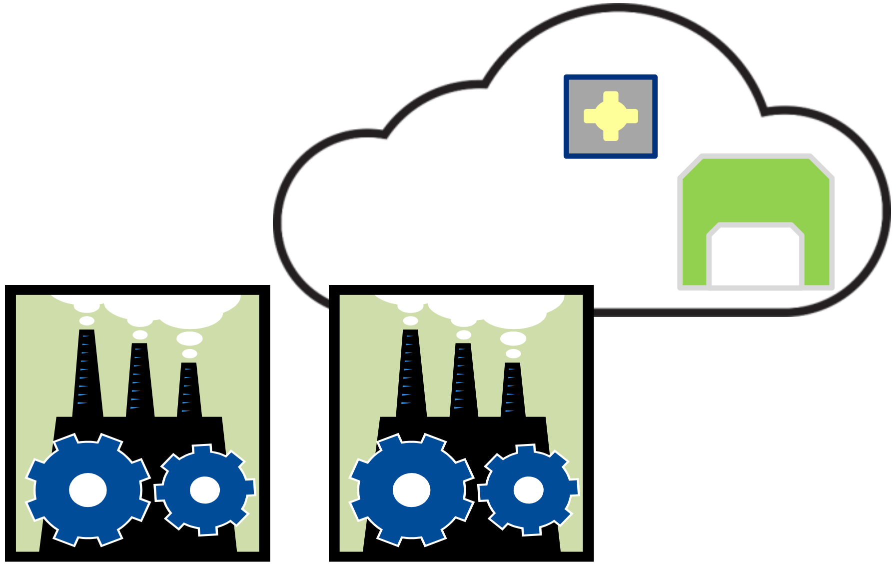
From a world of not connected things …



- Human
- Environmental
- Legal

- Availability
- Operating performance
- Energy efficiency

… to the Industrial Internet of Things



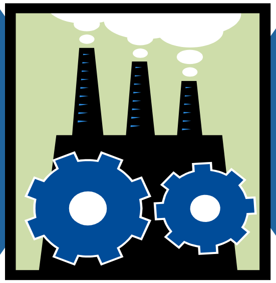
- ***Machinery Directive*** has consequences on machine modules, machines and production lines
  - *Risk evaluation starts with d*etermination of limits of machines and identification of hazard
- **Safety architecture:** Observe and consider always the **complete safety chain**

Manufacturing – Risk Management ➔ Digital Twin Engineering

industrial internet CONSORTIUM

From a world of not connected things …

Safety & Compliance

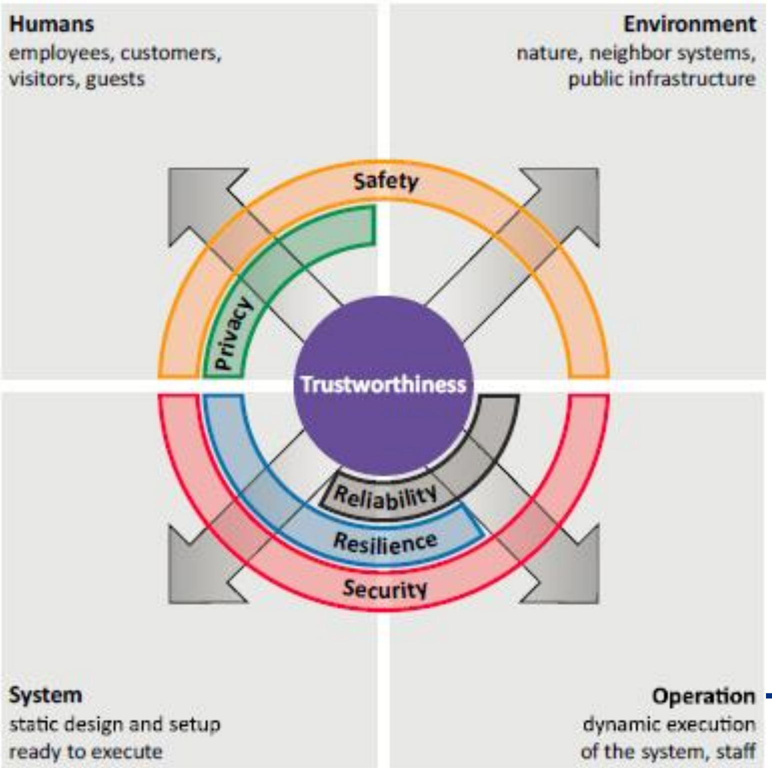


Efficiency

- Human
- Environmental
- Legal

- Availability
- Operating performance
- Energy efficiency

… to the Industrial Internet of Things



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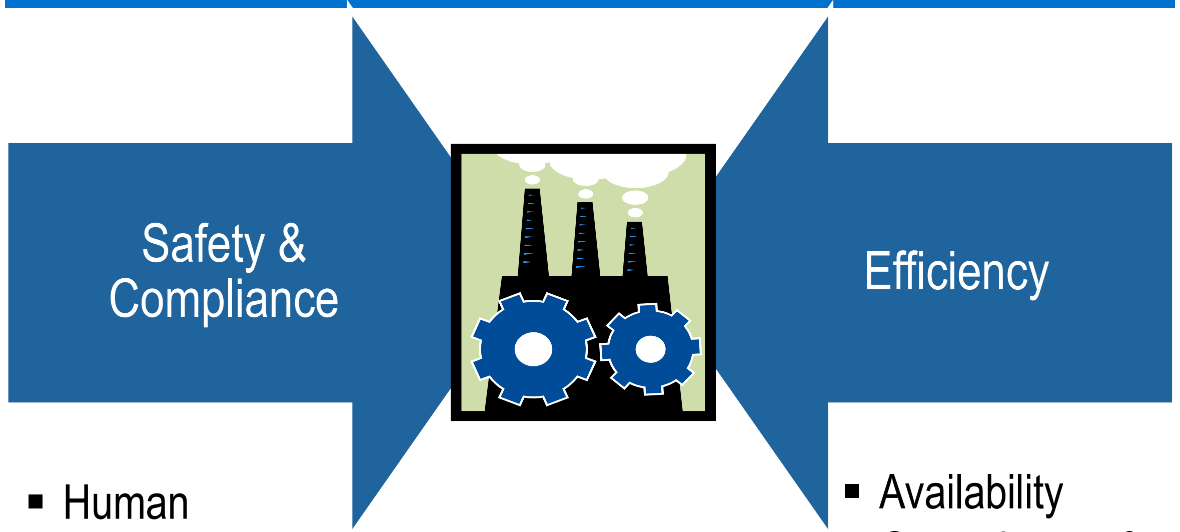
Manufacturing – Risk Management ➔ Digital Twin **Safety** Engineering

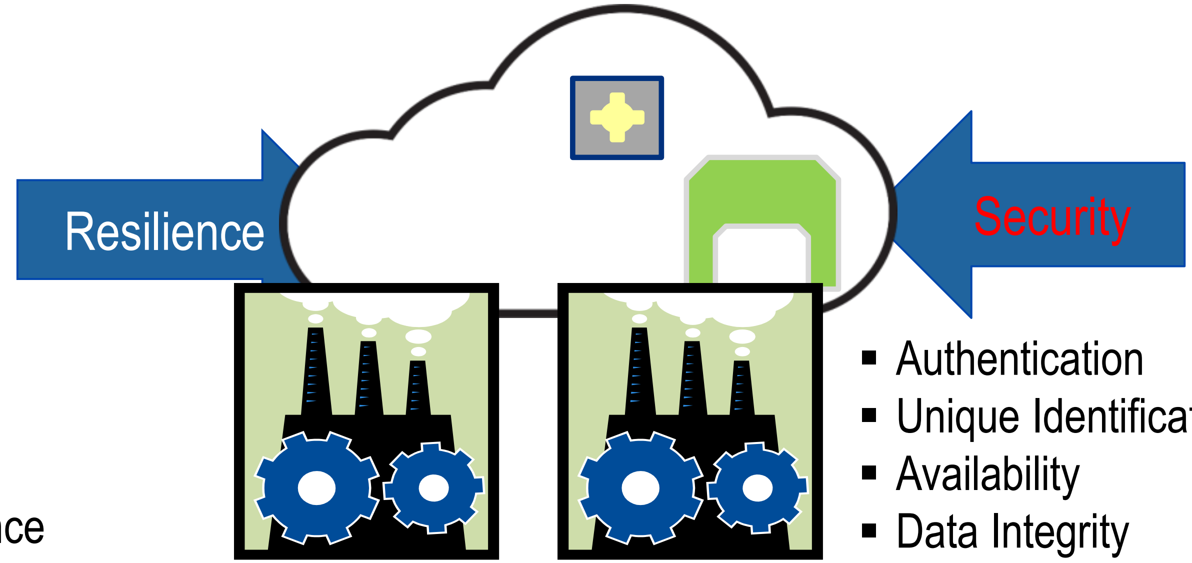
From a world of not connected things …



- Human
- Environmental
- Legal

- Availability
- Operating performance
- Energy efficiency

… to the Industrial Internet of Things



- Authentication
- Unique Identification
- Availability
- Data Integrity
- ..
- Privacy

- ***Machinery Directive*** has consequences on machine modules, machines and production lines
  - *Risk evaluation starts with d*etermination of limits of machines and identification of hazard
- **Safety architecture:** Observe and consider always the **complete safety chain** **/ embedded in a secure environment**

Agenda of Verification and Validatiom

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▪ DTC Trustworthiness WG & Verifcation and Validation WG	
▪ - short intro	Detlev
▪ **Starting Point: Risk Analysis – important point**	Jens
▪ TÜV SÜD – Digital Risk and Compliance Management	Michael
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▪ Break	
▪ DNV- Digital Trust by DNV	Ove

Starting Point: Risk Analysis during Product Development

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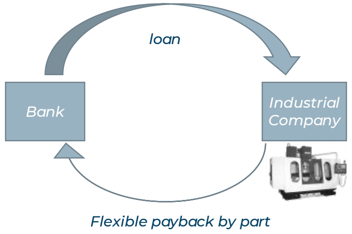
<u>Product Lifecycle</u>

Product-planing → Require-ments → Product Develop-ment → … → Production → Product Usage → Recycling / Decomis-sioning

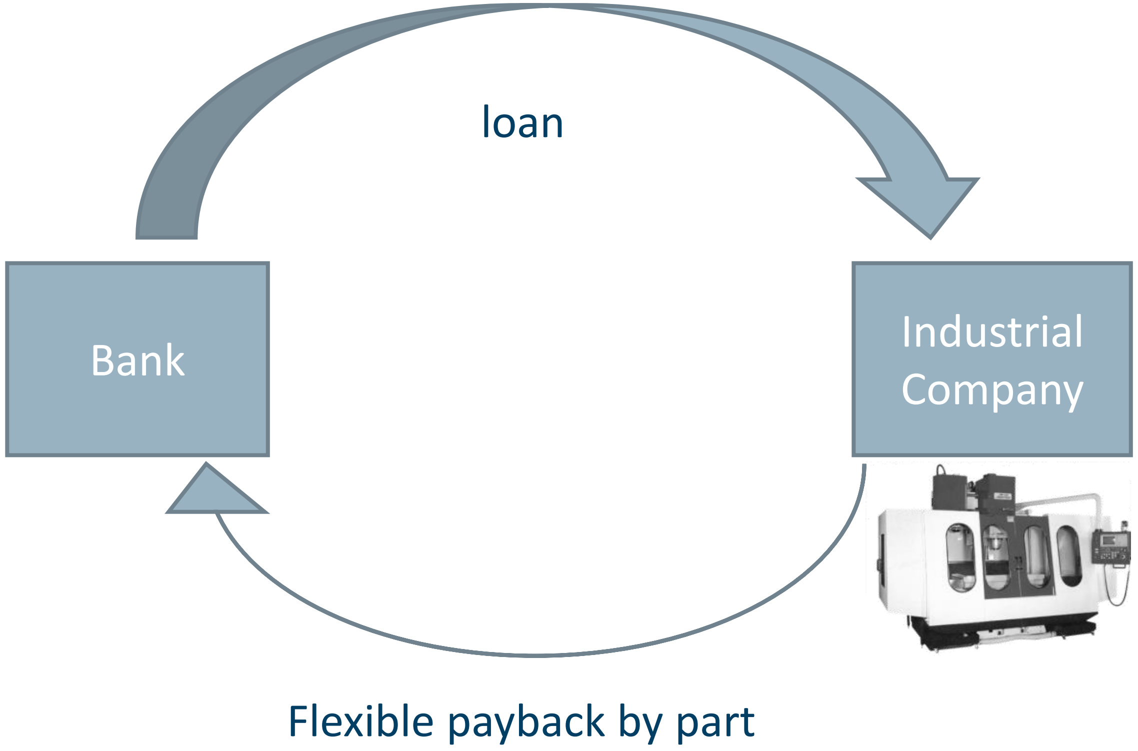
Changes

Example Products:
- Case A: A vehicle
- Case B: surveillance solution that identies people that are drowning in the water
- Case C: A flexible financing service for mashine, with pay-per-part back payment

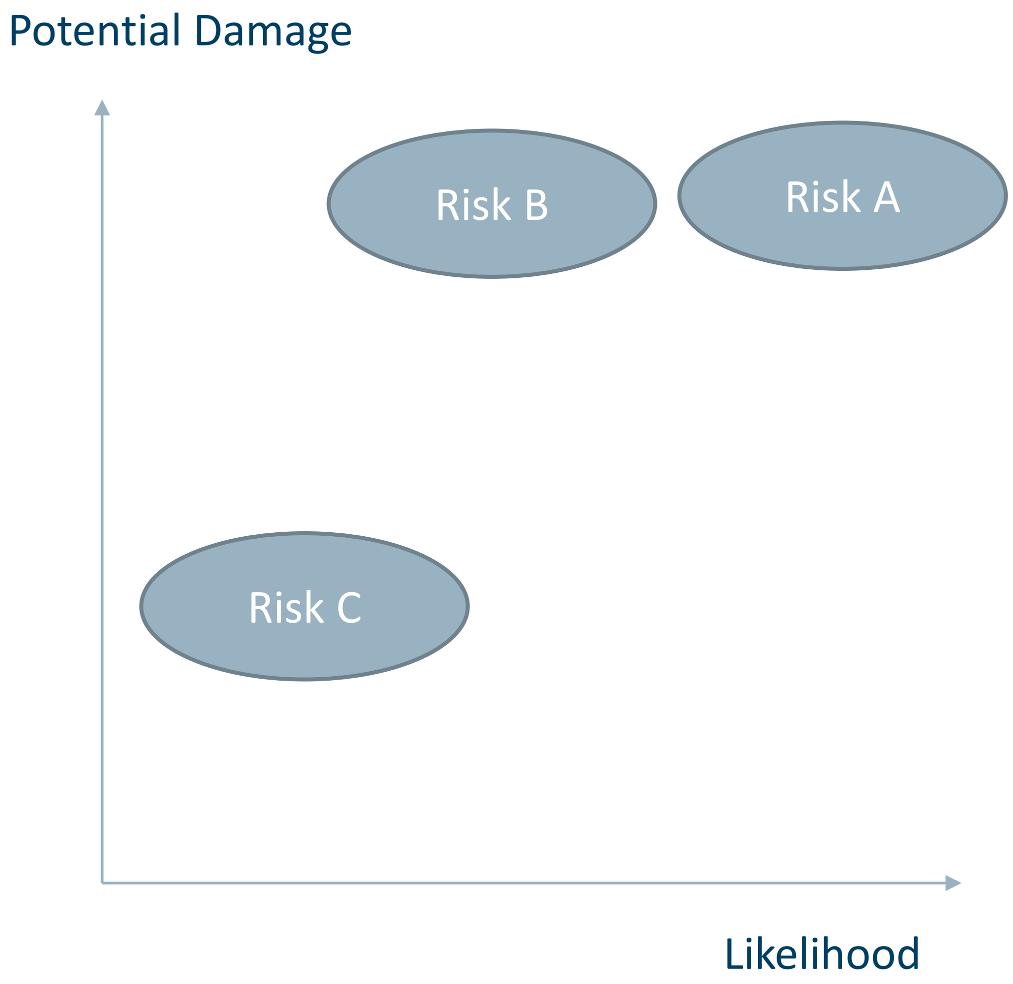


Risk Analysis
(e.g. FMEA)

Risk Analysis


loan
Bank
Industrial Company
Flexible payback by part

Risk Analysis and Risk Mitigation



- Examples of risks:
  - Case A (car): risk of break degradation (high likelihood over time, and high potential damage)
  - Case B (surveilance): risk of non-availiablity (medium likelihood, high potential damage)
  - Case C (finance): risk of not getting correct numbers on goods produced (low likelihood, medium damage)

- Example risk mitigation:
  - Case A:
    a) recommend maintenance procedures or b) design a digital twin to analyze the behavior of the car (DT capability)
  - Case B: add a watchdog that pings the drone
  - Case C: Unknown

Claims and Trust

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- The company behind the product will make claims:
  - Case A:
    a) If maintaned according to recommendations, the breaks will not fail.
    b) we can detect problems with the breaks
  - Case B: We have a reliable surveillance solution.
  - Case C: You pay according to what you actually produced

TRUST: Do „we“ trust those claims?

Yes. → Fine

No. → Need for Validation&Verifaction
Because:
- Unaceptable risk
- Not-knowing the business partner
- Innovative solution
- …

Requirements for Verifaction, Validation (based on case criticality and required certainty)

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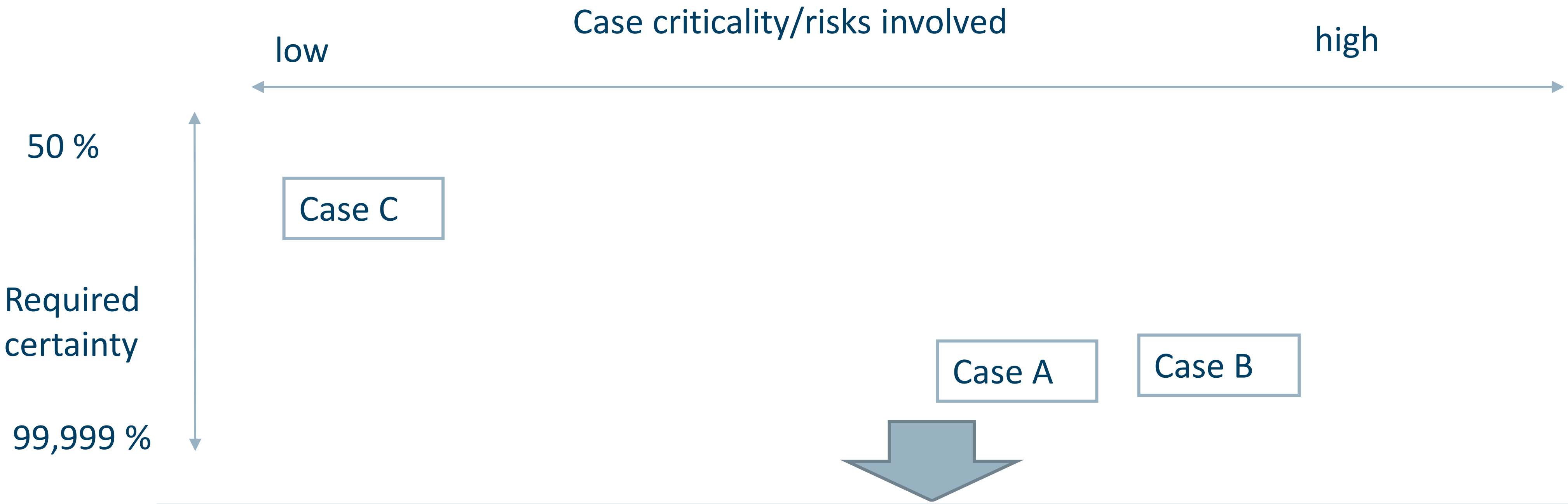

Requirements for Verification and Validation			
Frequency of V+V	once	with each update	continuous
Data basis for V+V	additional sensoor data	Data from company information systems	…
Auditor	Independent 3rd party	No external audit required	…

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Digital Risk and Compliance Management

From show-stopper to supporter through technological innovations using the example of iaHAZOP

Michael Pfeifer

Munich, 23rd January 2025

Add value.
Inspire trust.

Situation across Industry Sectors

Challenges

- Demographic change
- Changing market requirements / supply chain turbulences
- Increasing bureaucracy
- Sustainability
- Events and KPI

Consequences

Industry needs to solve challenges of the future

- with fewer and less skilled workforce
- in higher frequency
- under more complex regulations
- and with high pressure to operate sustainable, financial efficient and resilient.

“We have to digitalize and automate more. Otherwise, our business will be disrupted.”
[customer citation]

Customer Conclusion

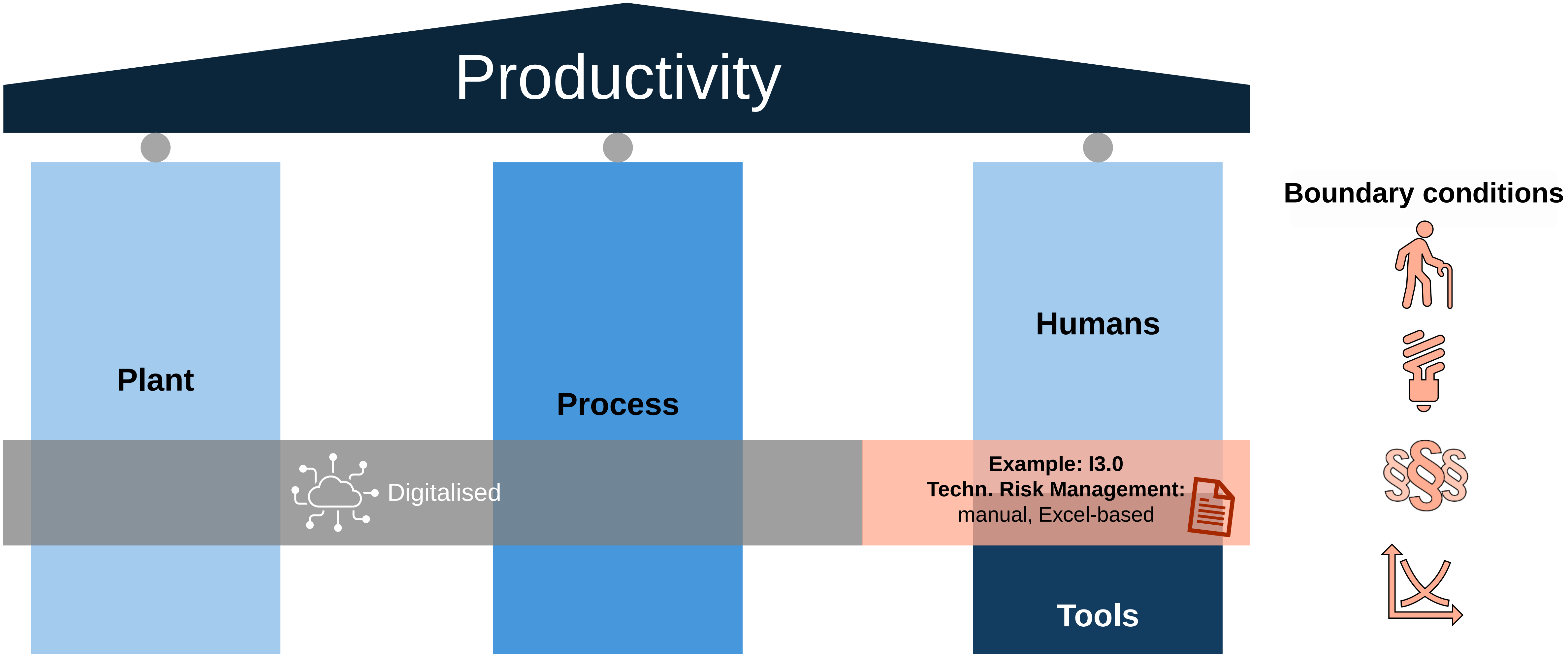
“We will be

4 times

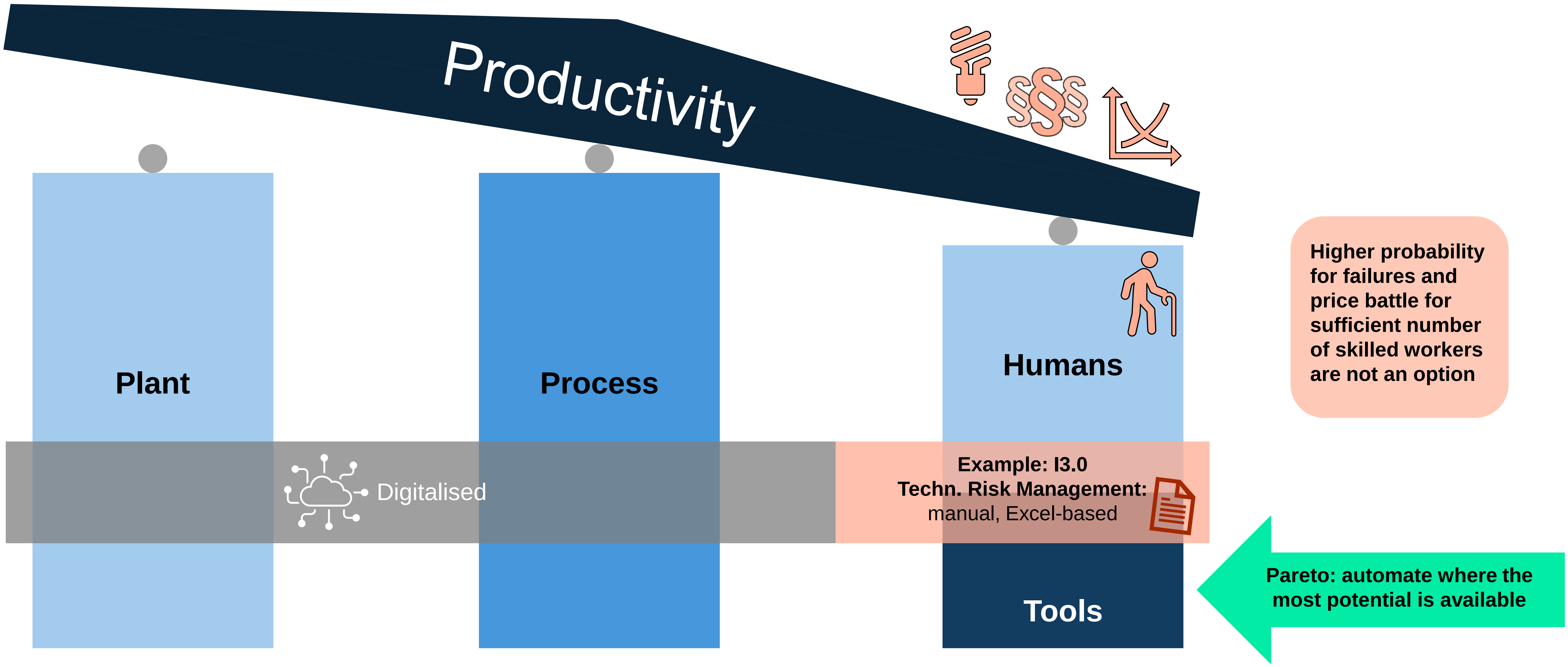
less efficient as today.”*

*assumption: if, there is no increase in the failure rate

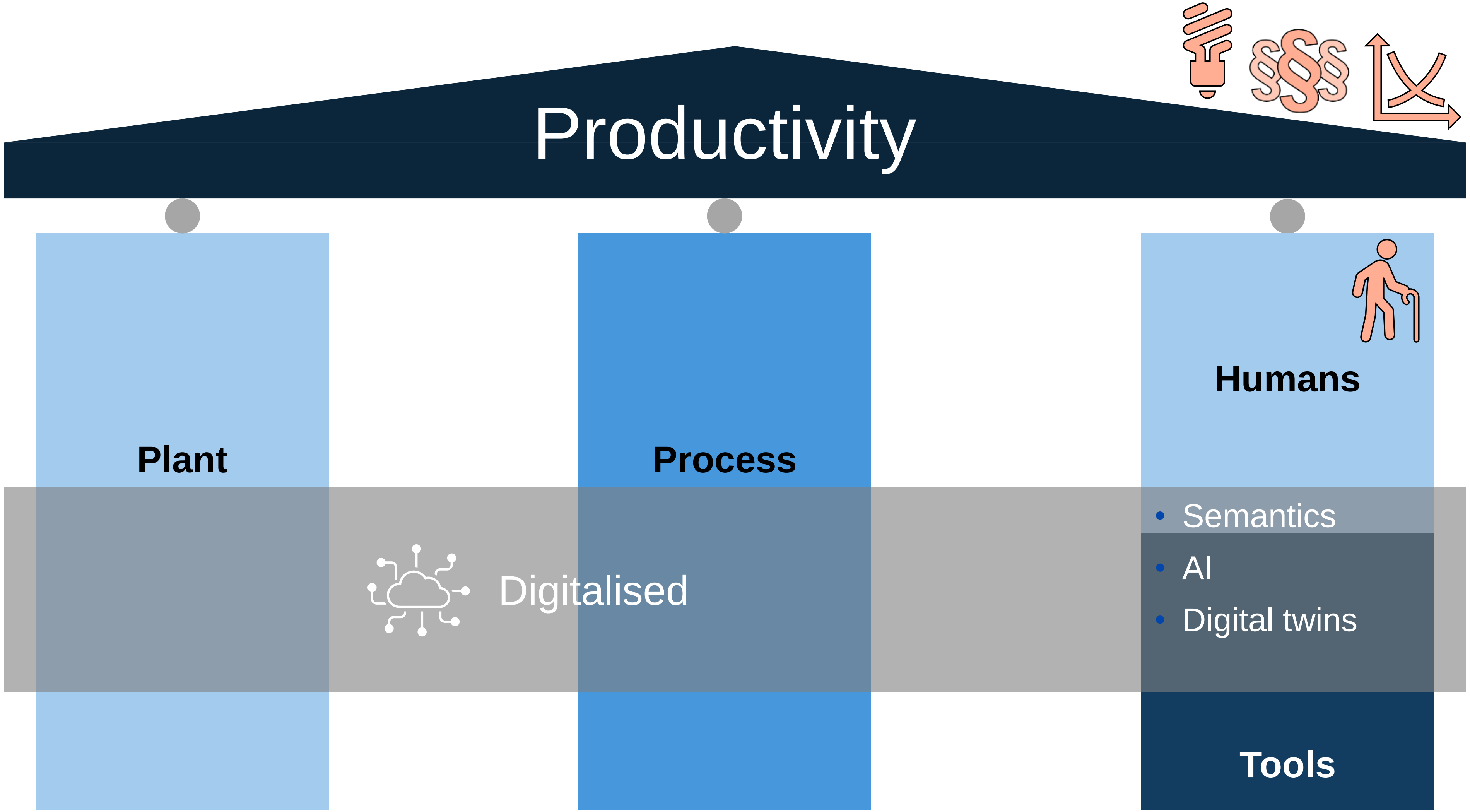
Why Risk and Compliance Management?



Why digital Risk and Compliance Management?



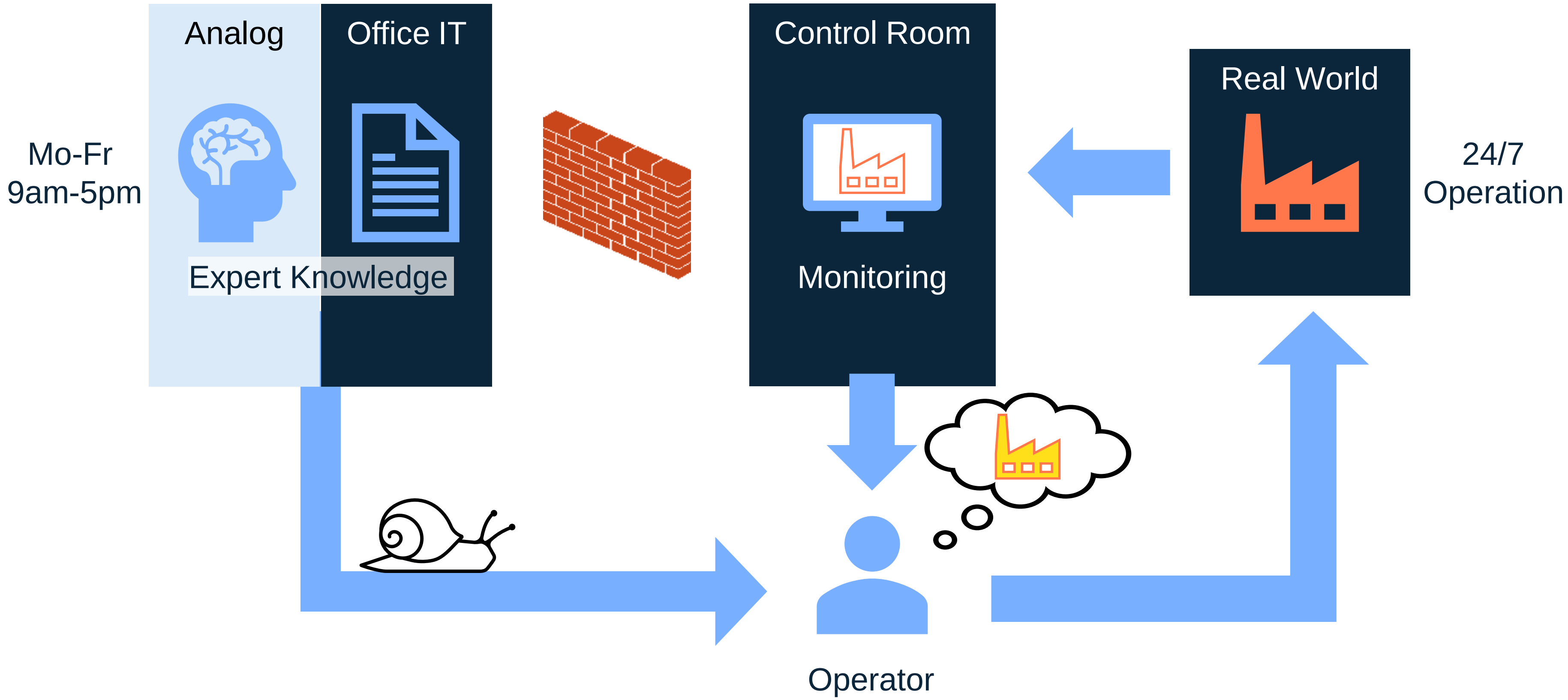
What do we need?



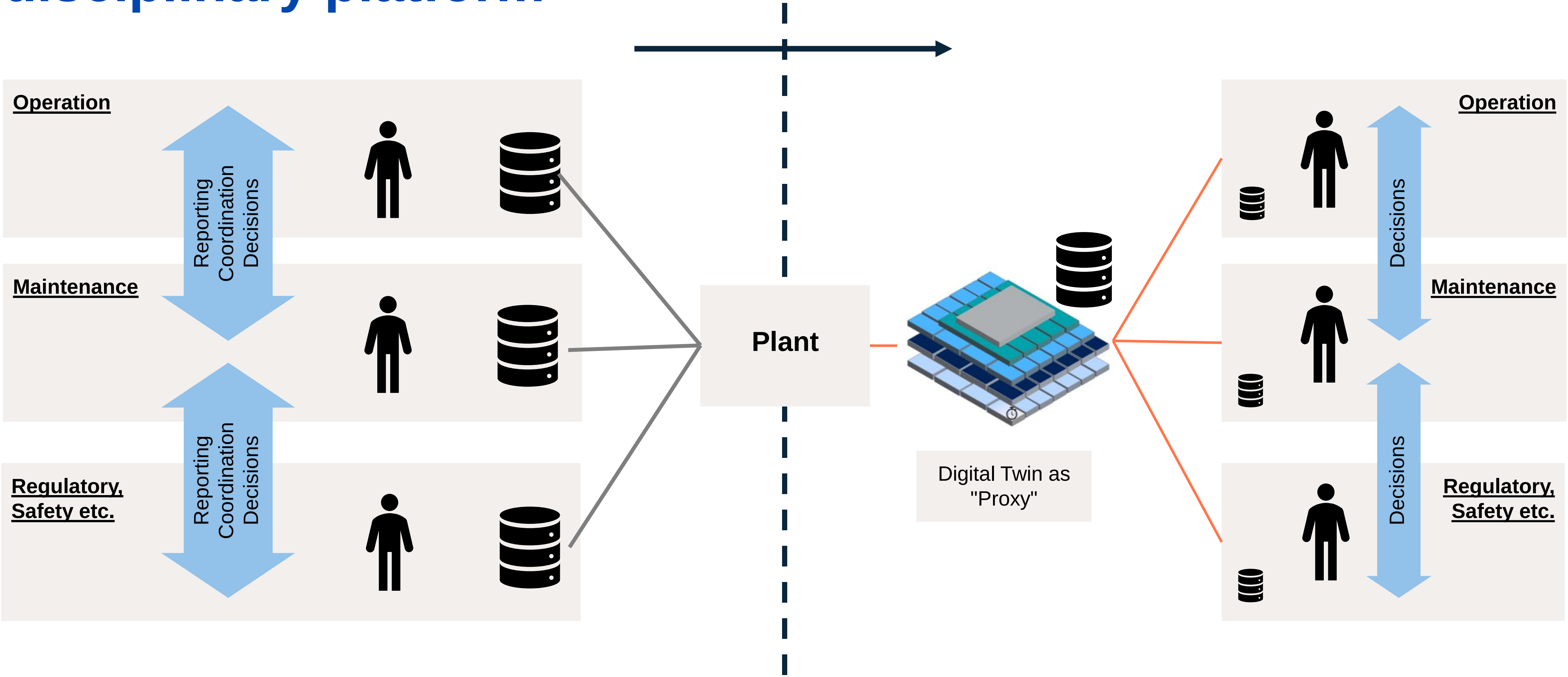
- ✓ **Motivation**
- ✓ **Concepts**
- ✓ **Technology**

➢ **Let's do it!**

Today: Interrupted Information Flow

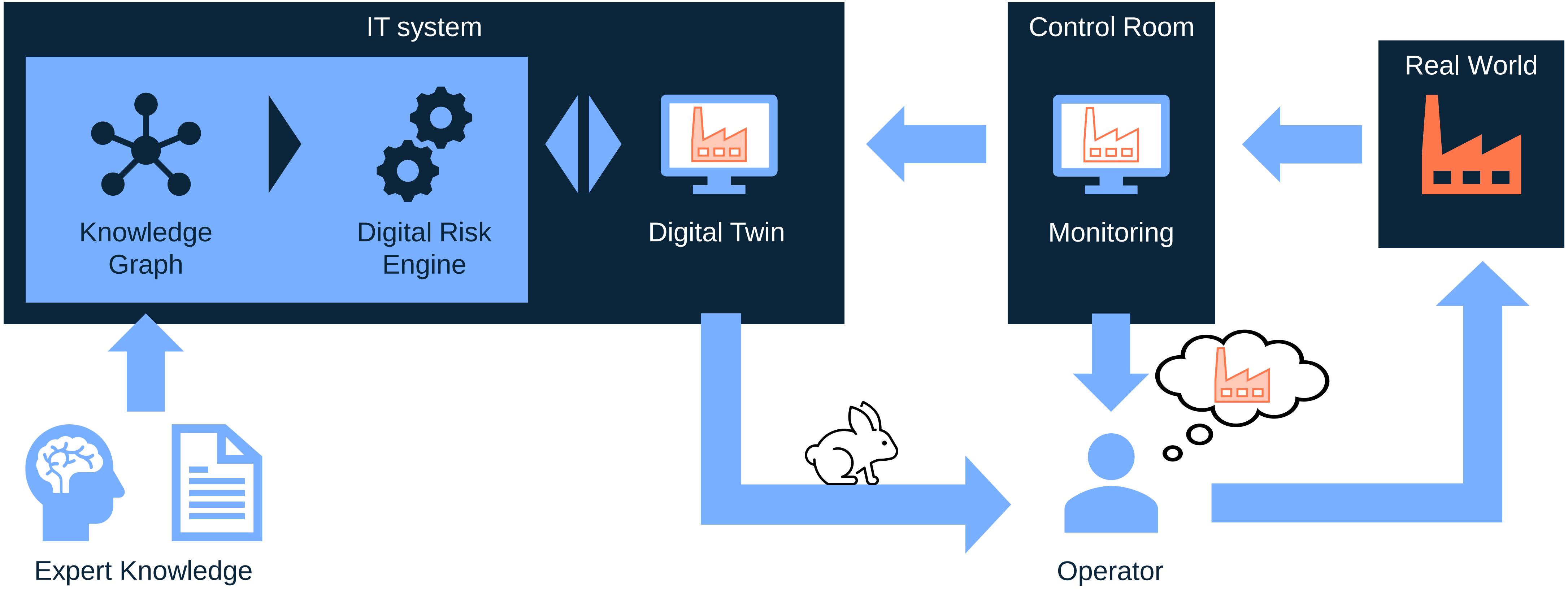


From separate data silos to a central, cross-disciplinary platform



Interactive HAZOP

for fast information flow, high quality decisions and resilient operations



Formalizing the Language of Risk

Today's Risk Assessment

Traditional methods tailored to human needs

Digitalization

Human's risk processing **bottlenecks** Digital twin's performance

Risk Assessment for Digital Twins

Express hazards based on parameters

➔ **Machine processable**

Use the full potential

Maintenance, Technology, Risk Management Hand in Hand - Example

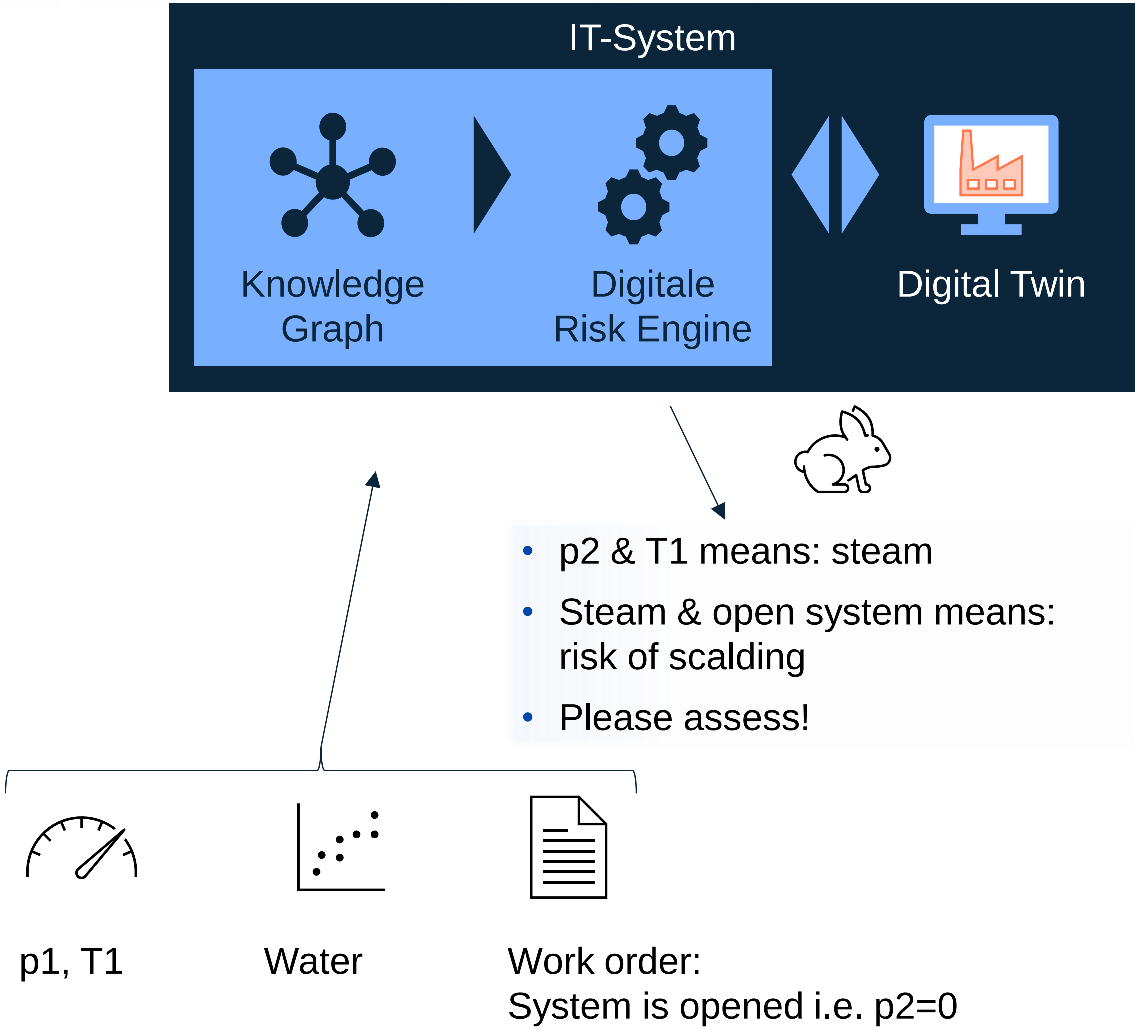
Maintenance on a valve:

- Boiler still hot, contains water
- Low residual pressure was overlooked
- LMRA → OK
- Maintenance staff → hospital (scalded by steam)
- Work had to be compensated by others

→ **Longer unplanned maintenance time**

→ **Liability event & damage** **> - 50 000 000 €**

→ Small cause,
big (avoidable) effect

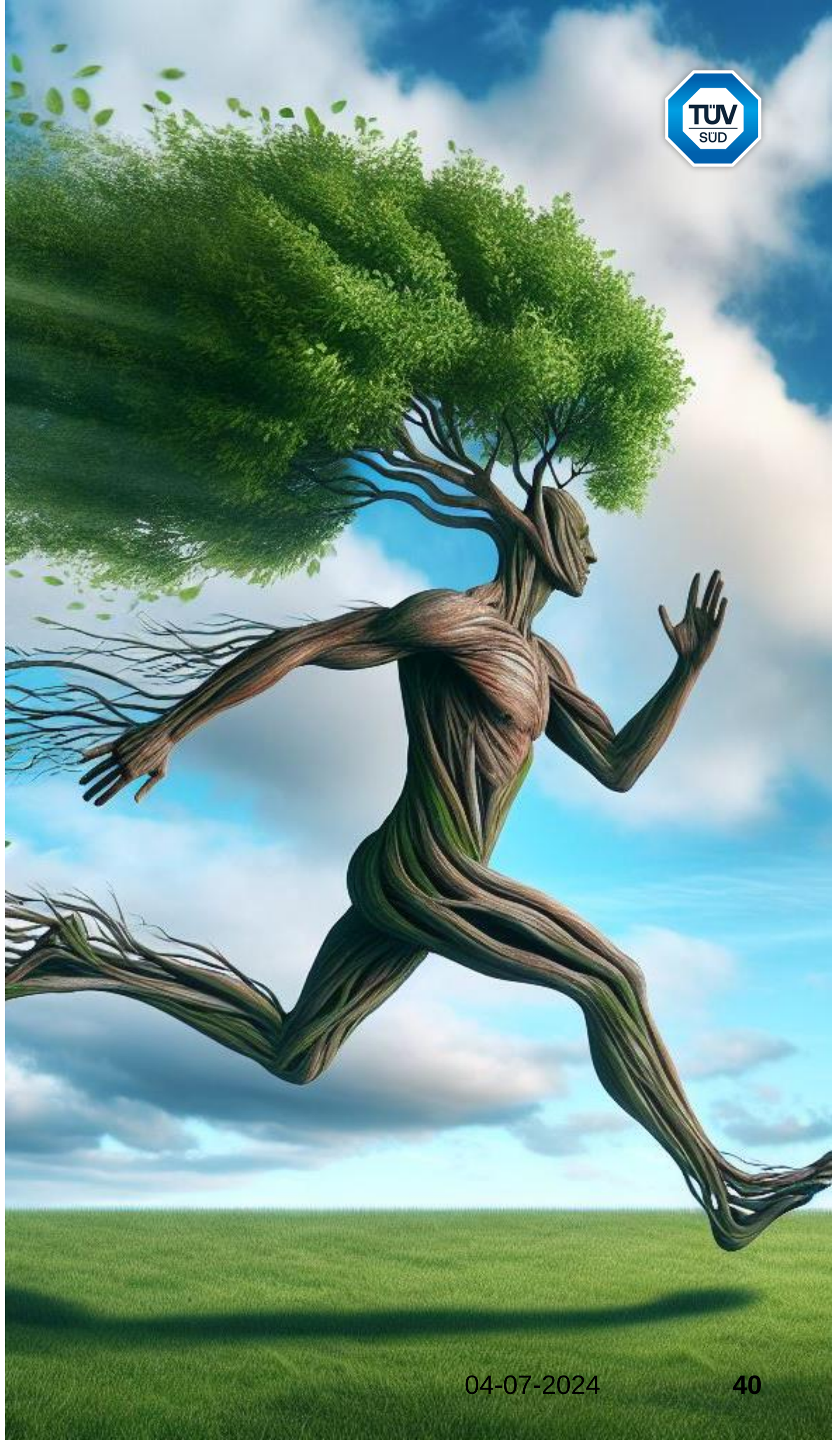


Need for Verification and Validation

- Run time simulations and decision support helps to solve the upcoming challenges.
- But human **perception of risk is very subjective**, especially when it comes to new methods or technologies. **To do business**, customers must be **able to trust**.

	The tree is running.	**The dog is running.**
Information	v = 15 km/h	
Assessment	v & “running” = ✓	

For V&V we need to know the **asset’s properties** and **semantic description of information.**



What else?

Information: The tree has yellow leaves.	
Grammar	✓
Information Assessment	✓

The **relevance** of an information **depends on the context!**

What **depth of investigation** for V&V? Depends on the sector and requires **community alignment**.

iaHAZOP: Digital Risk & Compliance Management
Benefits

- **Time to market - 4x faster**
  Plant Modifications
  → **Immediate update of risk assessment**

- **Up-time - up to 10%**
  Improved decision support and LMRA
  → **Less incidents**

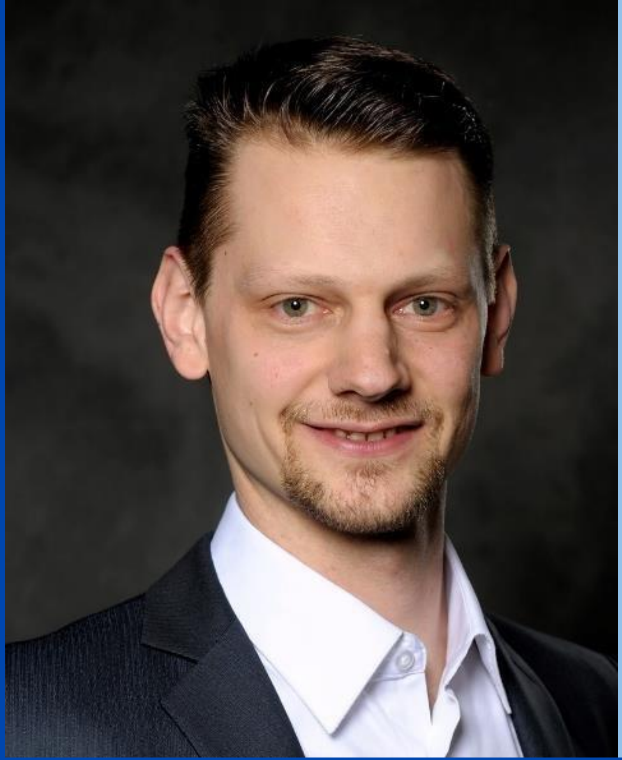
- **Efficiency - up to 200%**
  Use of resources incl. high qualified staff

- **Faster - 1.5x faster in MTTR etc.**
  Fewer events grow into incidents or accidents
  → **Less liability events**

➔ Transform from reactive to **predictive risk management**

It’s time for the next level…

…now, together!



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Data-driven intelligence by digital twins
– The Verification and Validation Task Group

- DTC Trustworthiness WG & Verifcation and Validation WG
  - Dr. Detlev Richter – TÜV SÜD Product Service GmbH
- Risk Analysis – Important points for digital twin based systems
  - Prof. Jens Lachenmaier – Ferdinand-Steinbeis-Institut
- TÜV SÜD – Digital Risk and Compliance Management
  - Michael Pfeifer – TÜV SÜD Industrie Service GmbH
- Intel – Semantic Data Verification and Validation
  - Marcel Wagner - Intel
- DNV - Digital Trust by DNV
  - Ove Heitmann Hansen - Senior Principal Digital Trust DNV

Thanks a lot for your time