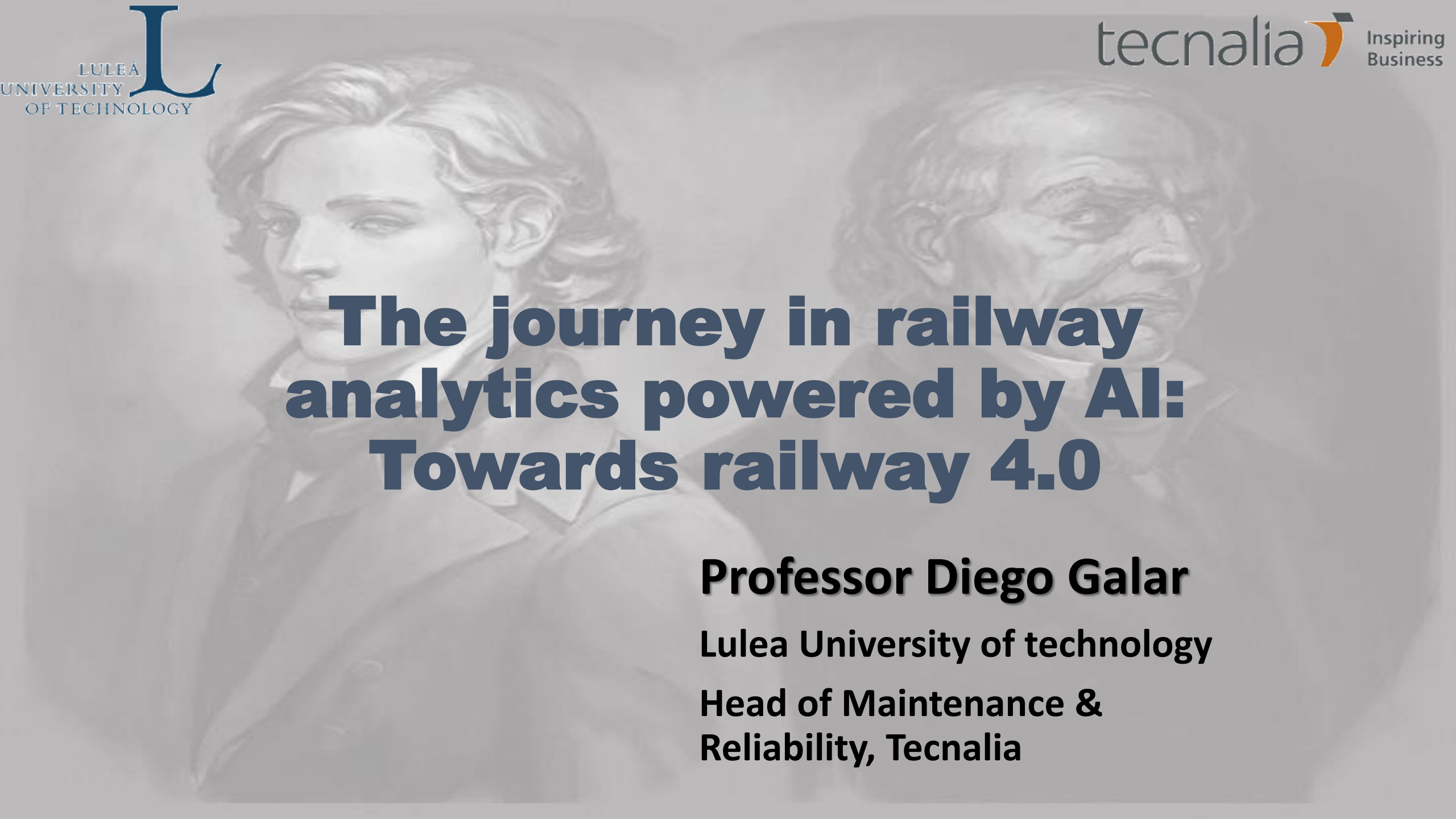


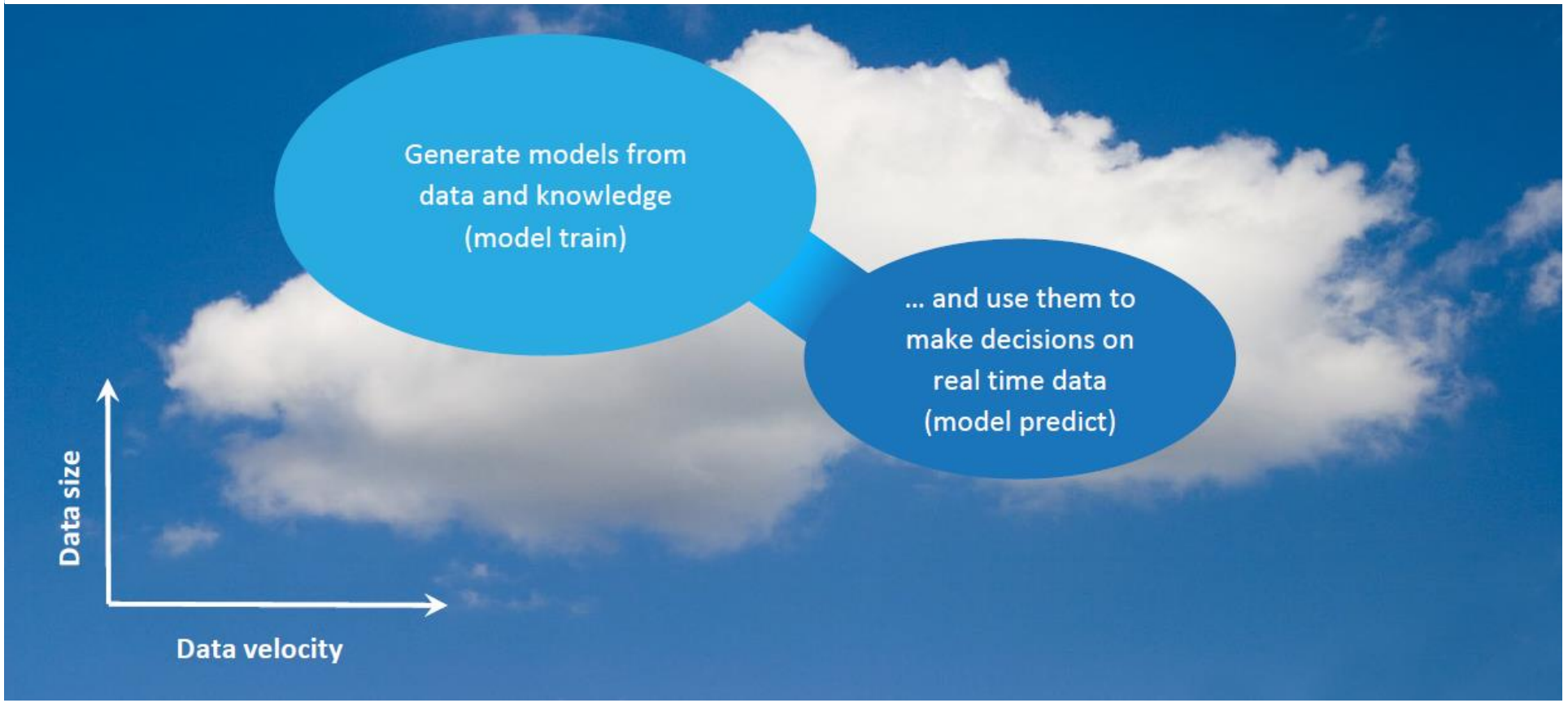
# The journey in railway analytics powered by AI: Towards railway 4.0


**Professor Diego Galar**

**Lulea University of technology**

**Head of Maintenance & Reliability, Tecnalia**

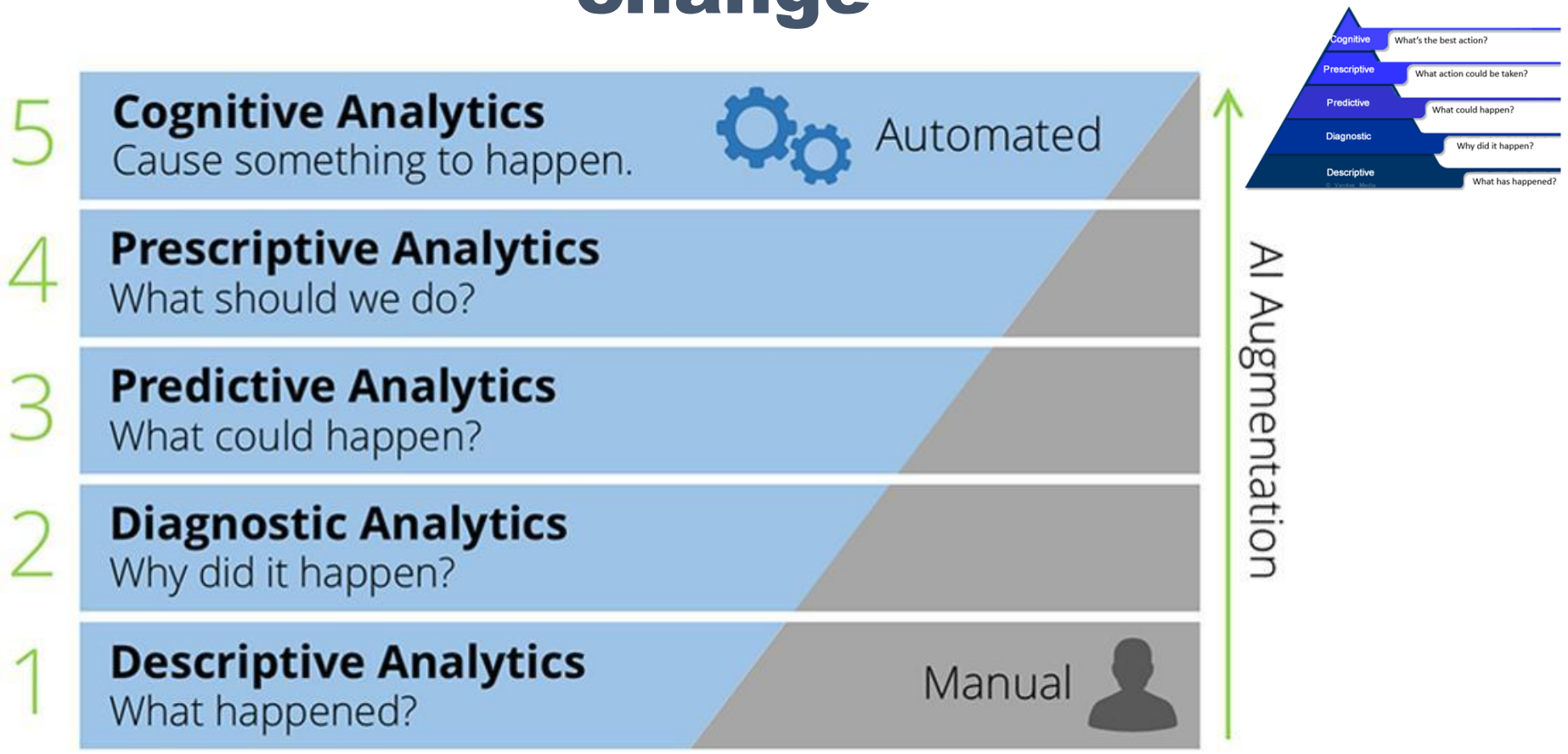
# Data driven models in railway is well trodden territory



# But here be the dragons!!, approaches fail to scale

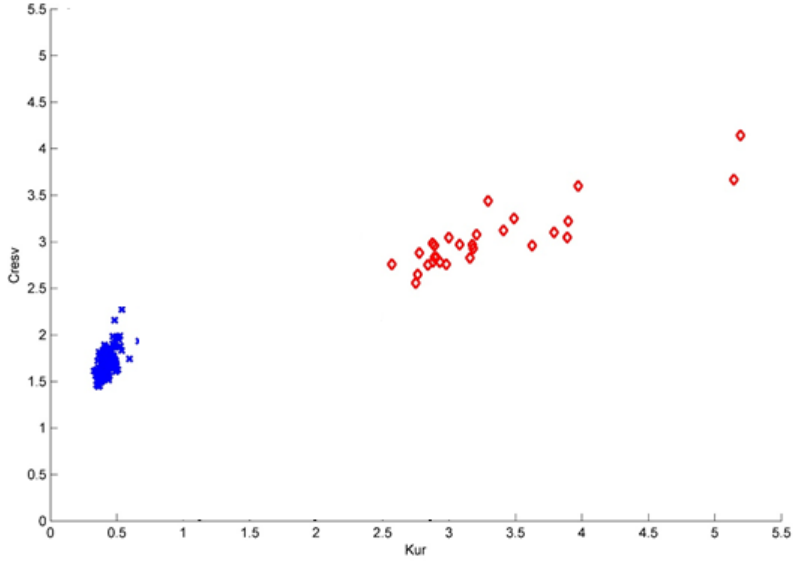
# What analytics can be performed on railway?

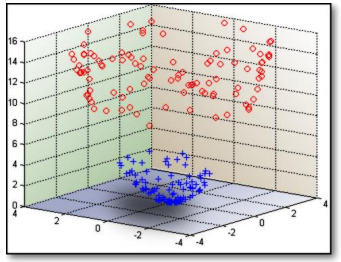
# Analytics and expectations also change



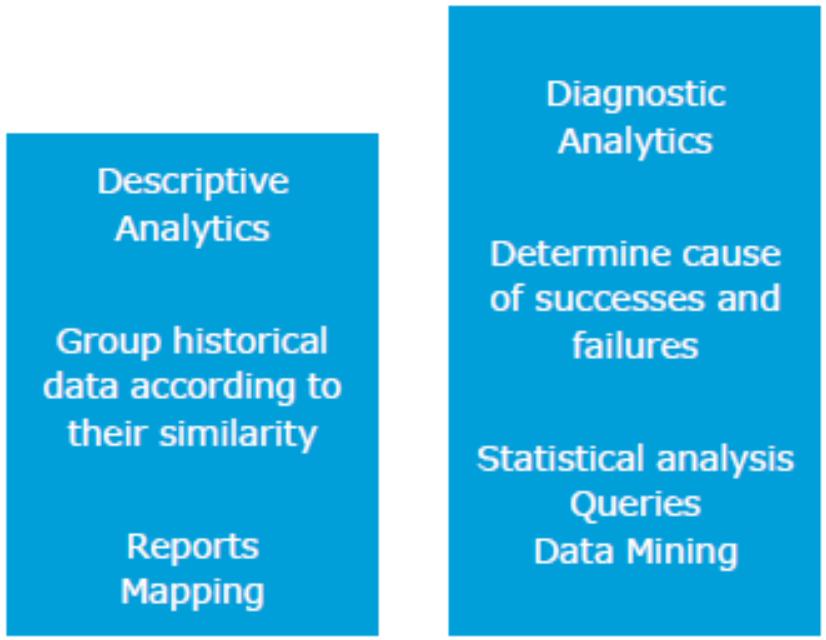
# Types of data analytics

# Descriptive analytics

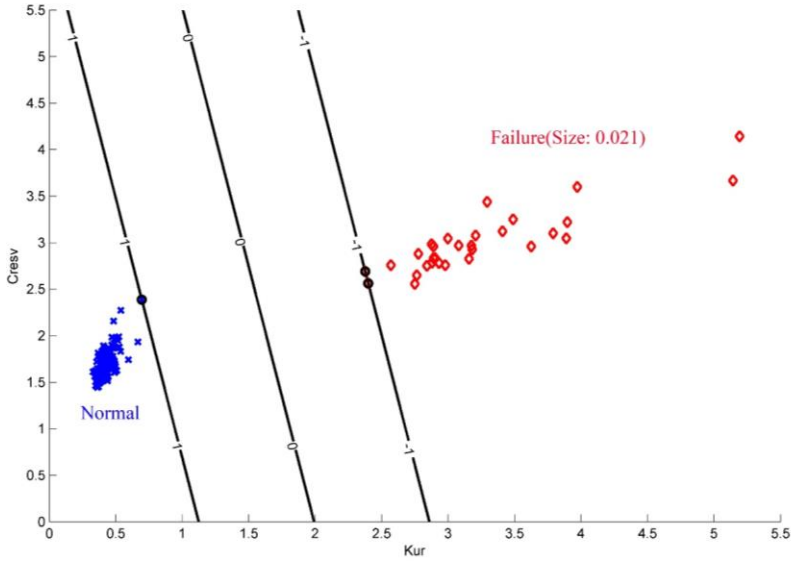


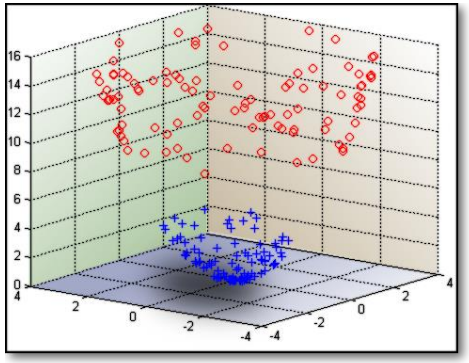



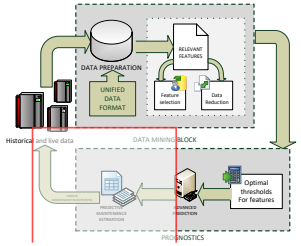
# Types of data analytics



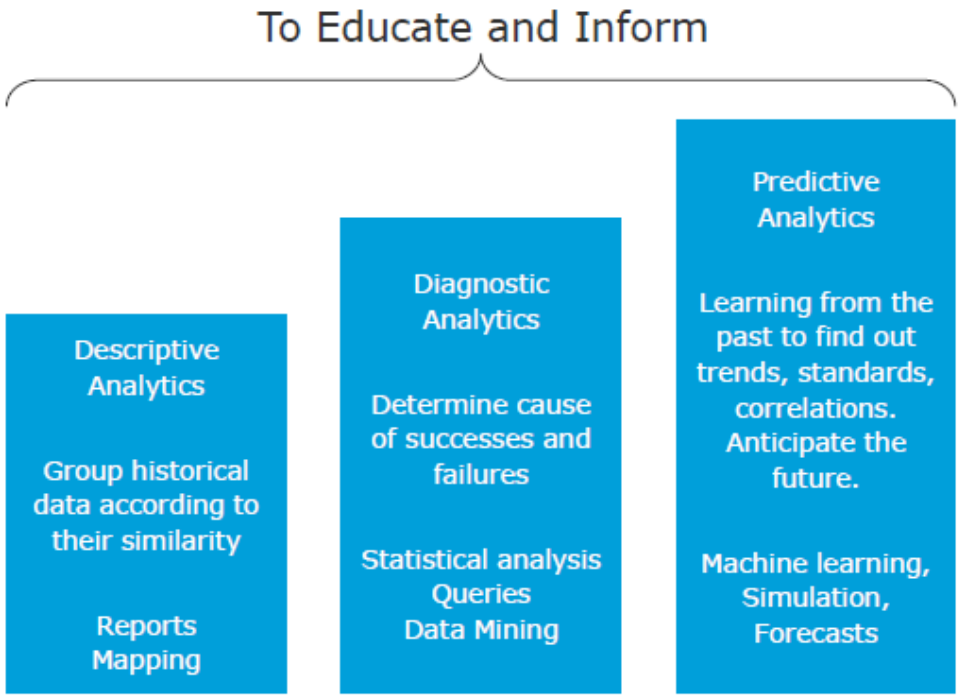
# Diagnostic analytics





# Types of data analytics

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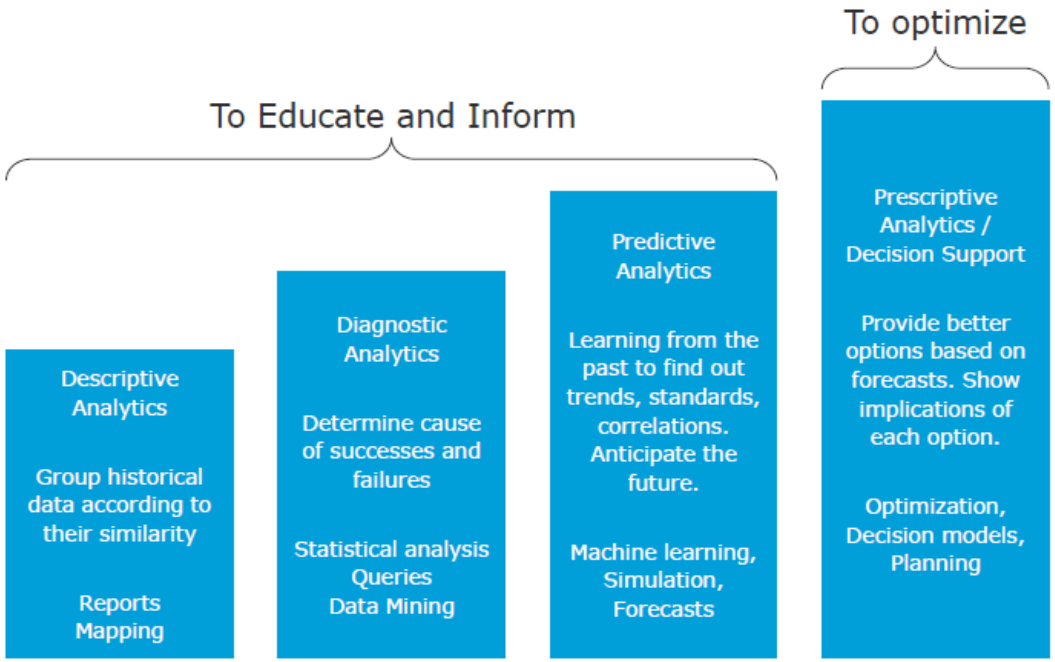
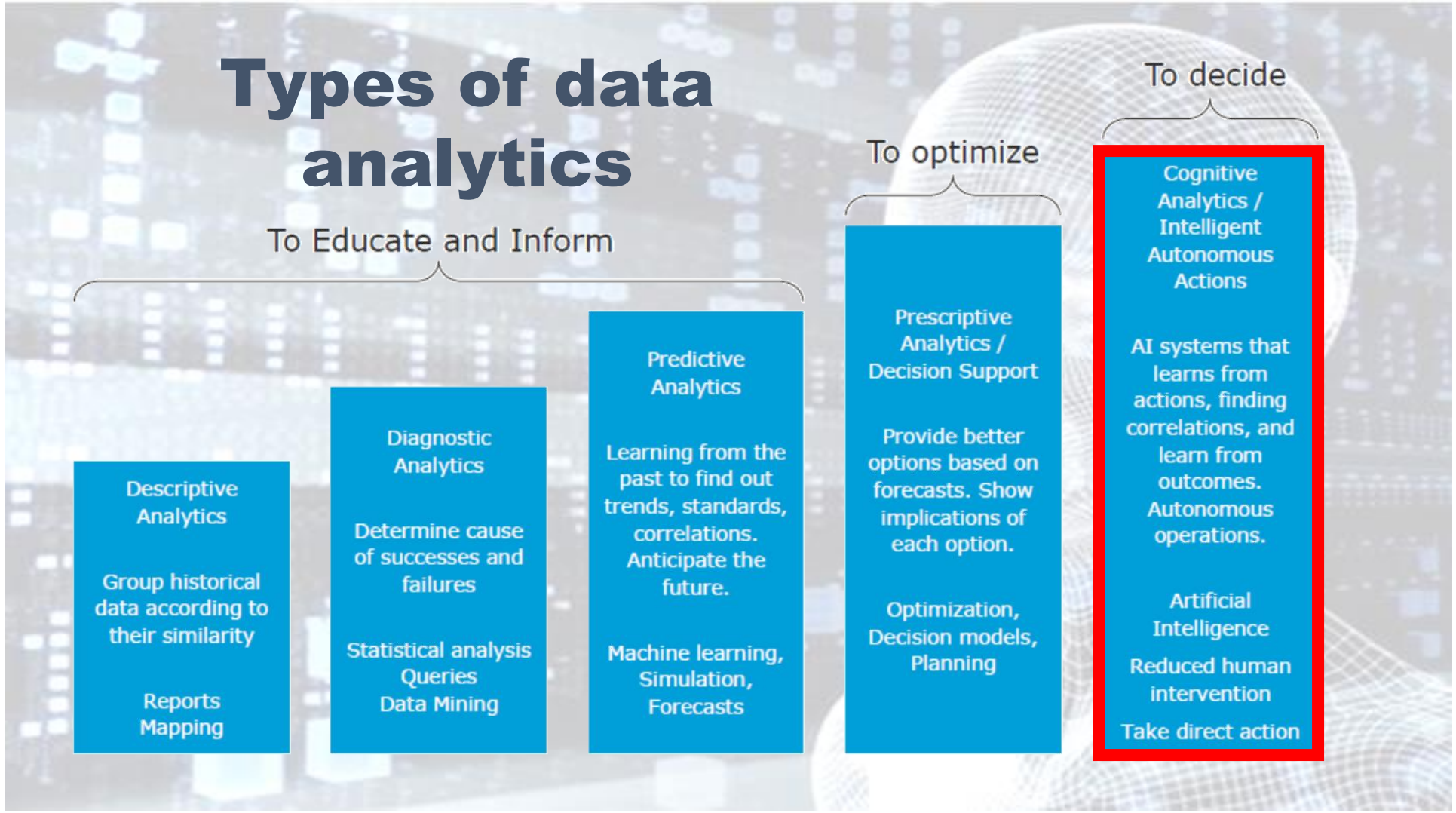
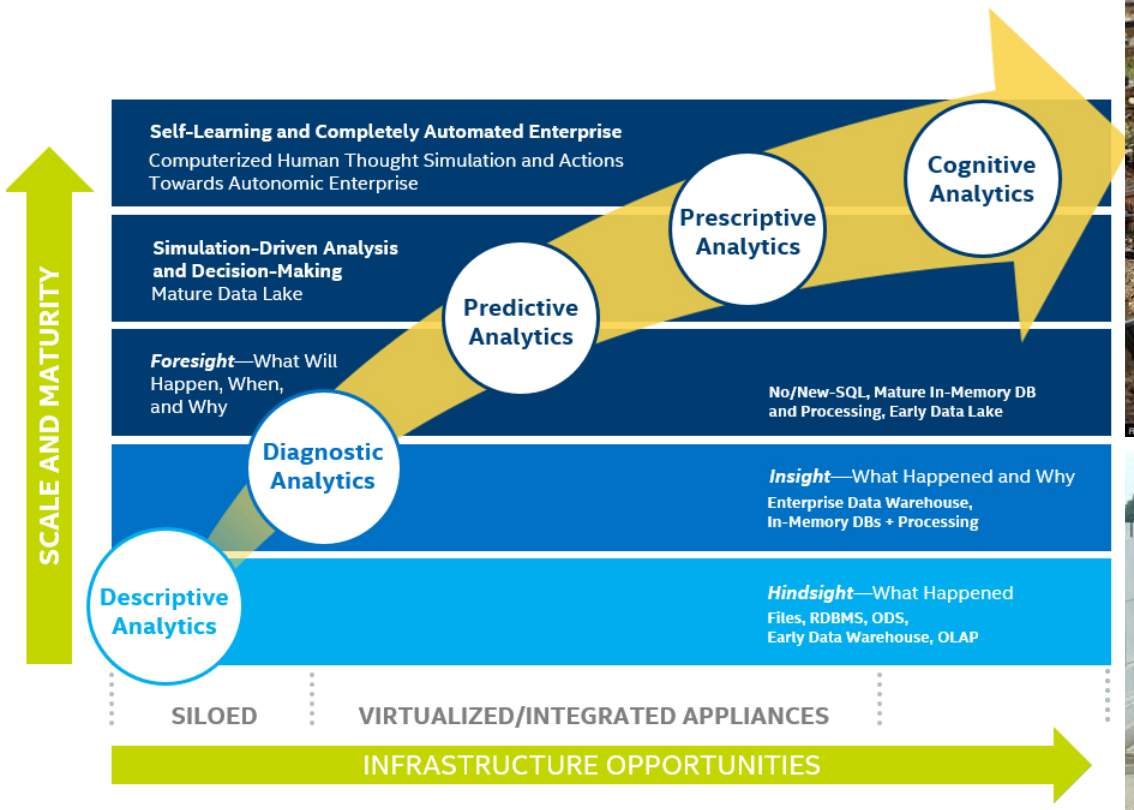
# Types of data analytics



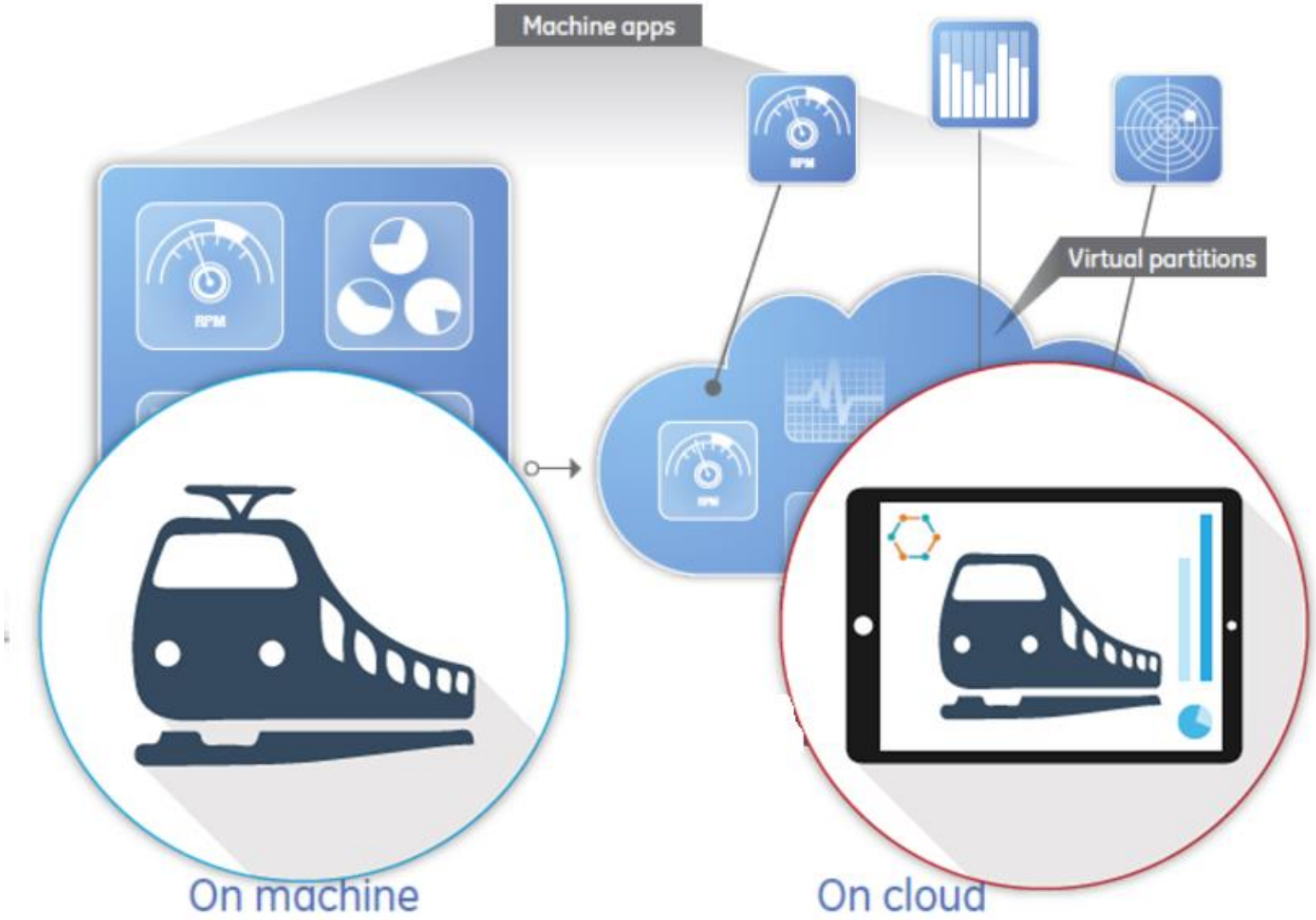
# Types of data analytics



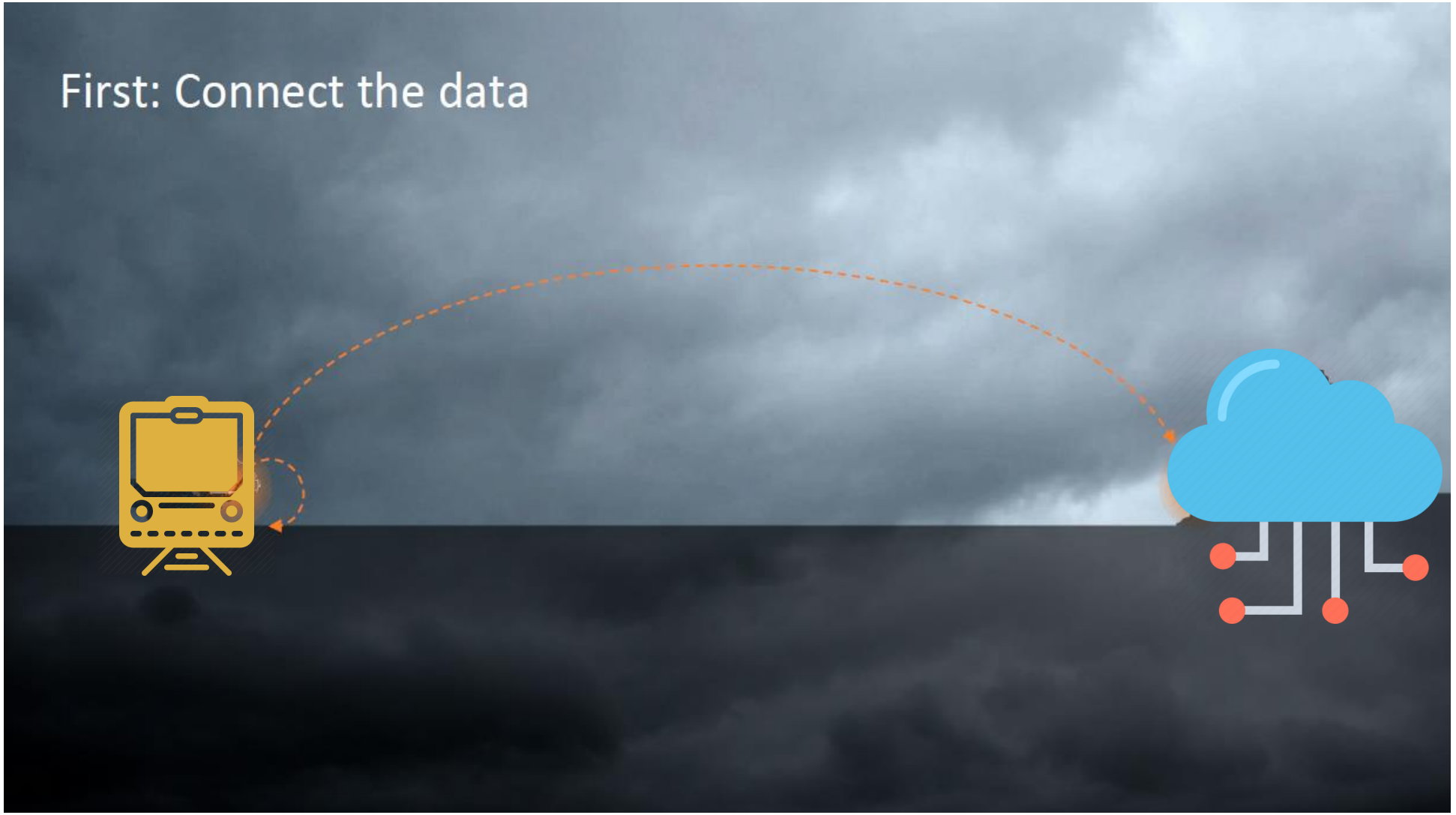
# The way forward




# Where analytics should be performed?

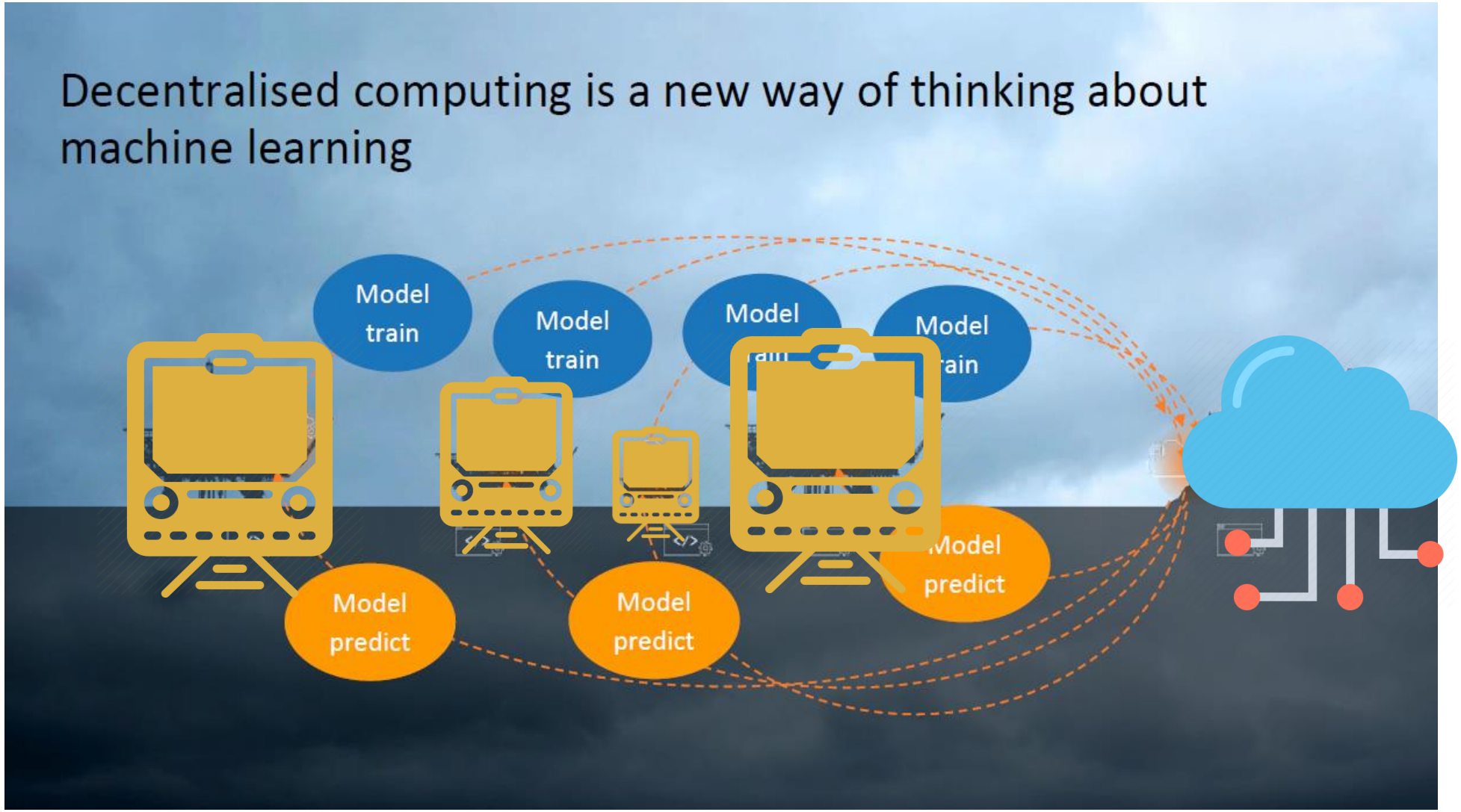


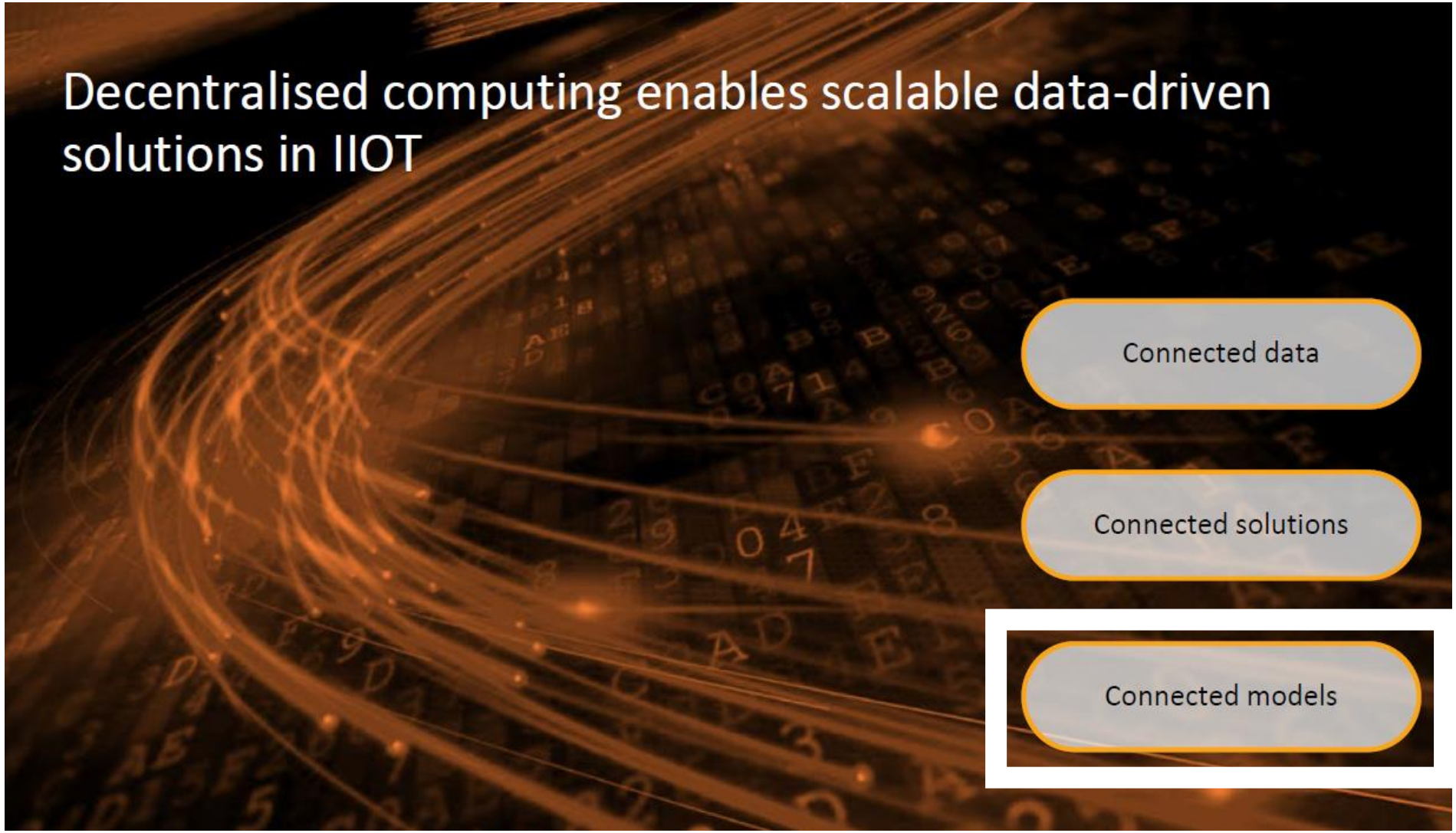
# Edge agents versus cloud centralized


First: Connect the data

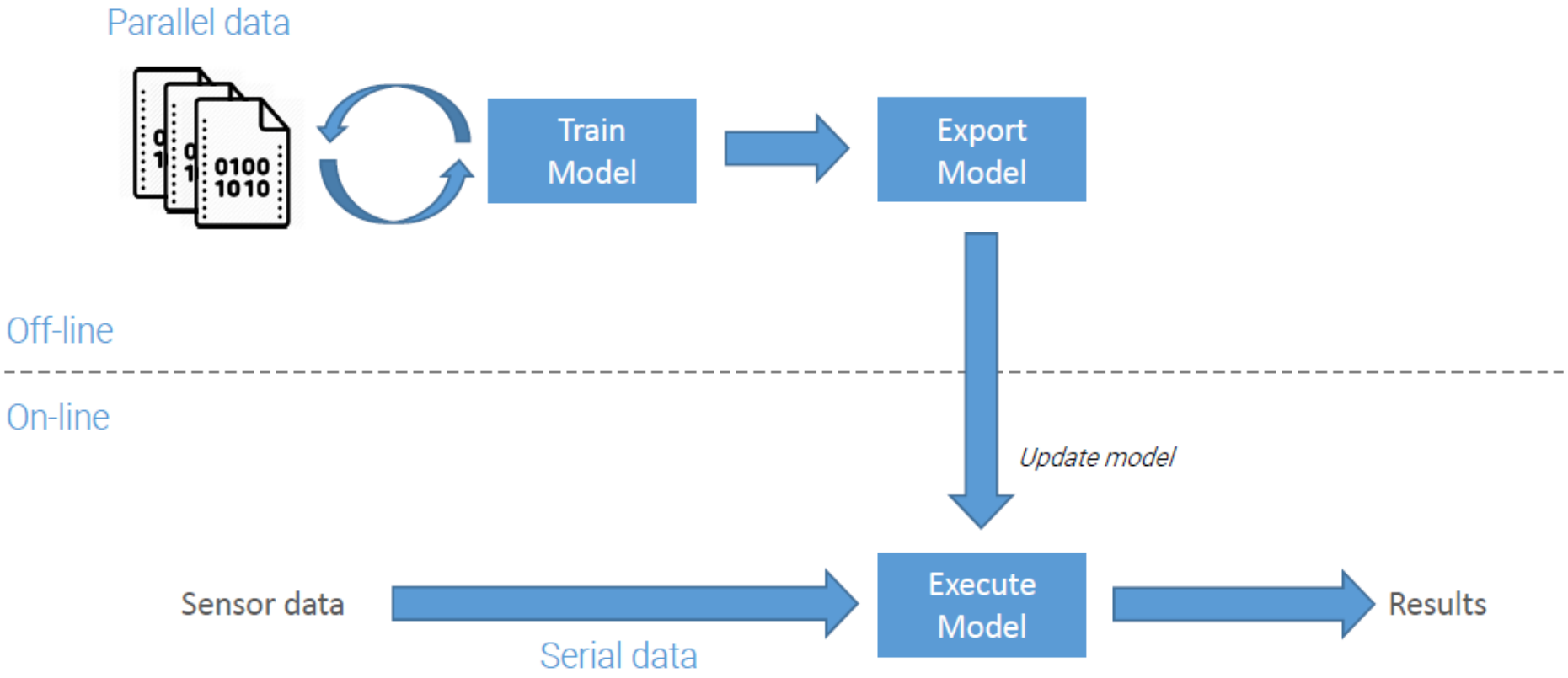

Next: Connect the solutions


Finally: connect the fleet


Decentralised computing is a new way of thinking about machine learning
Model train
Model train
Model train
Model train
Model predict
Model predict
Model predict


Decentralised computing enables scalable data-driven solutions in IIOT
Connected data
Connected solutions
Connected models

# AI workflow @edge



# Huge gap between data science and O&M


"I need to deploy models into live business environments."


"I need strong, transparent insights to improve my daily decisions."

# What can I see in my data?

## Now casting

1) What has happened
2) What is happening

## Forecasting

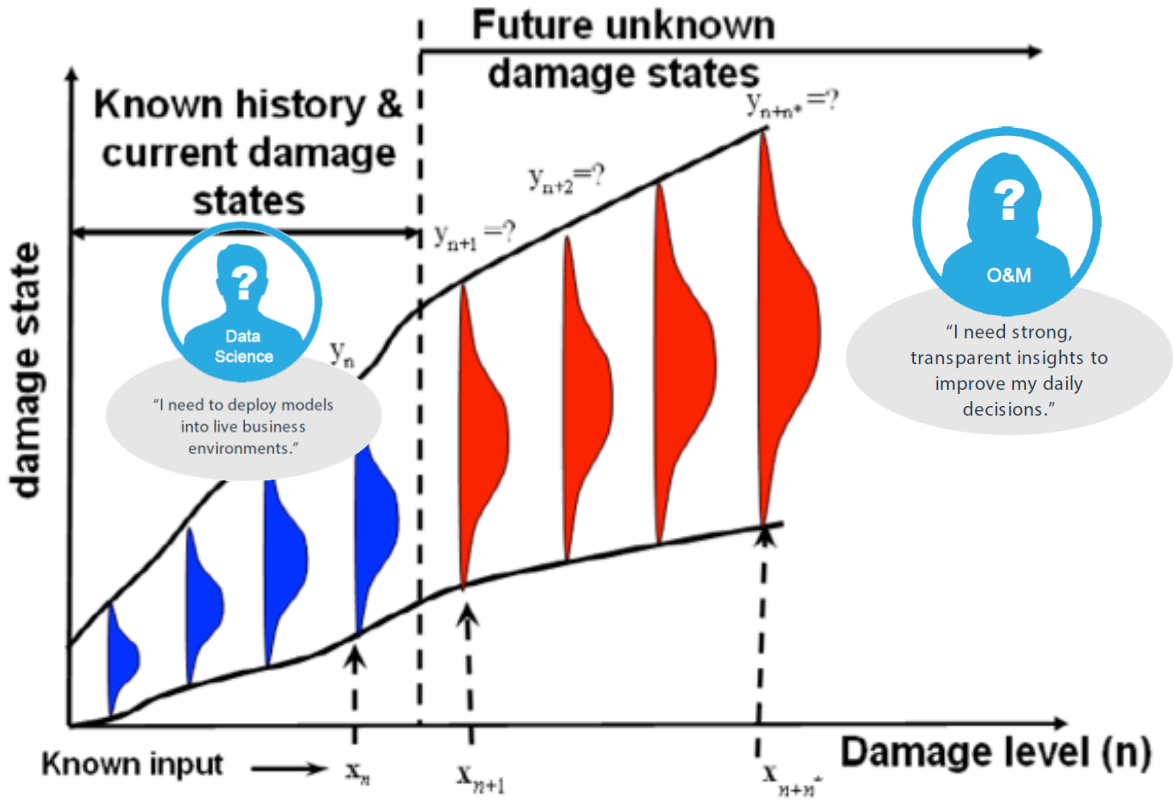
3) What will happen in the future
4) When will it happen

Health index calculation

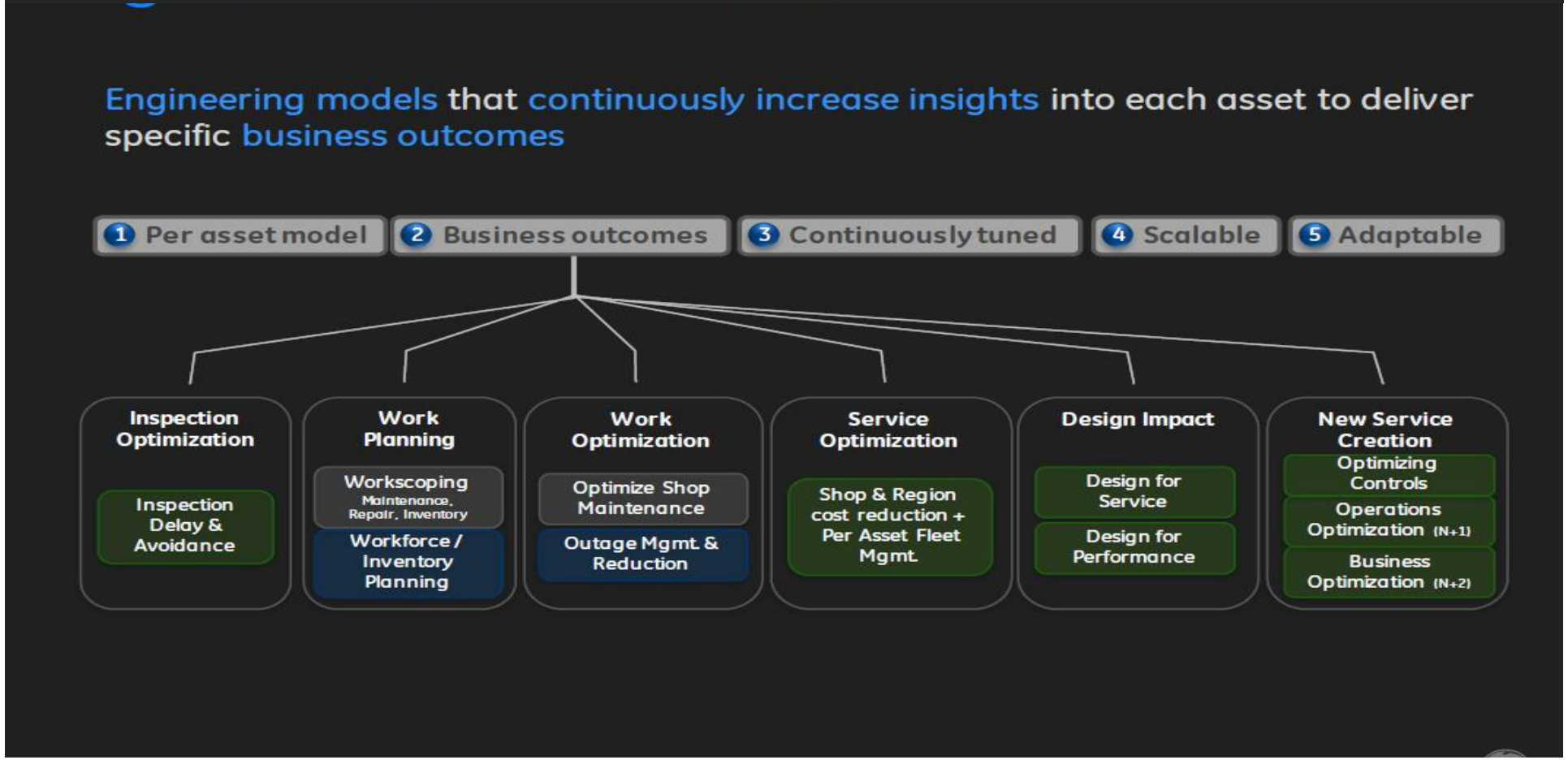
Remaining useful life prediction


Maintenance, when needed

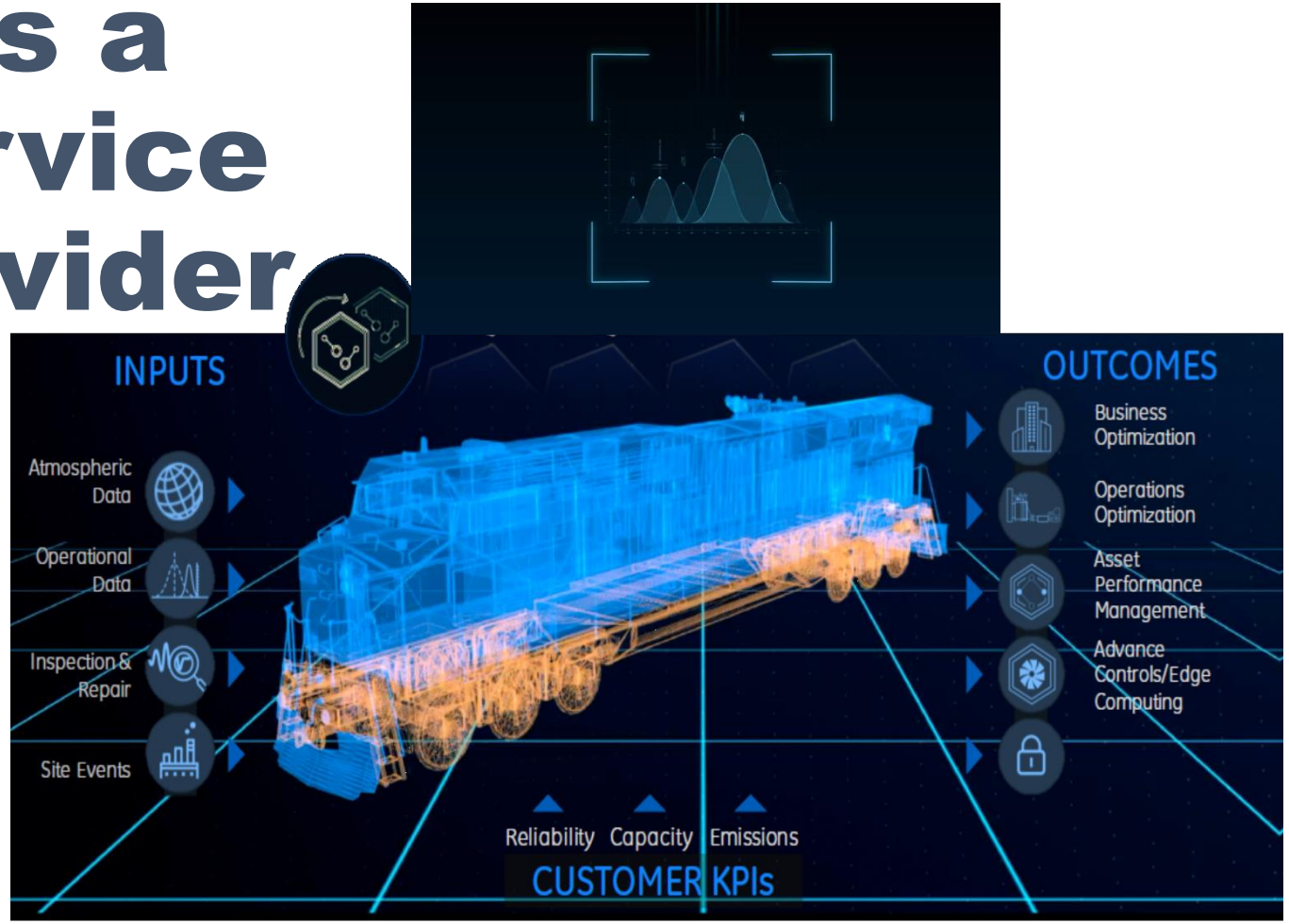
# Domain knowledge and physics sometimes is not in the data



# The method, let us twin reality

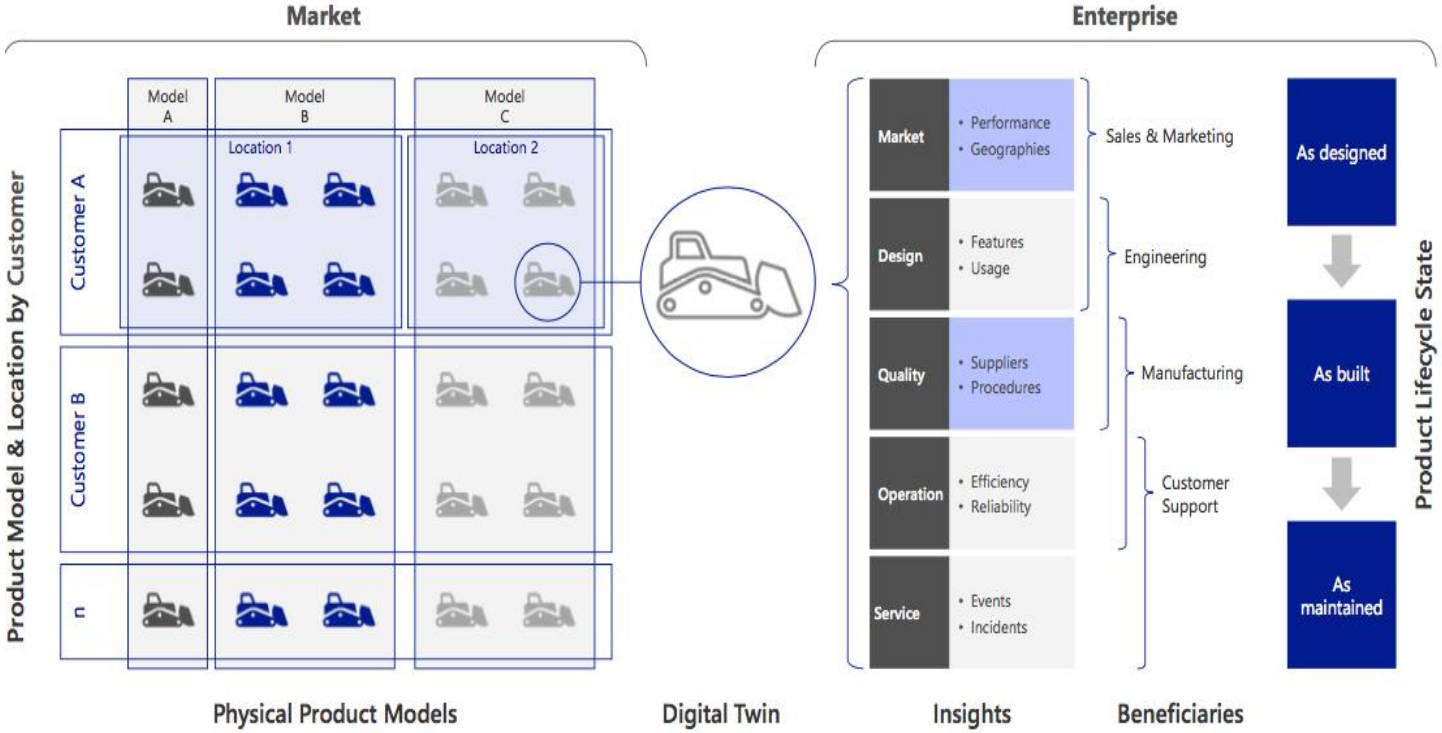


# The twin as a service provider

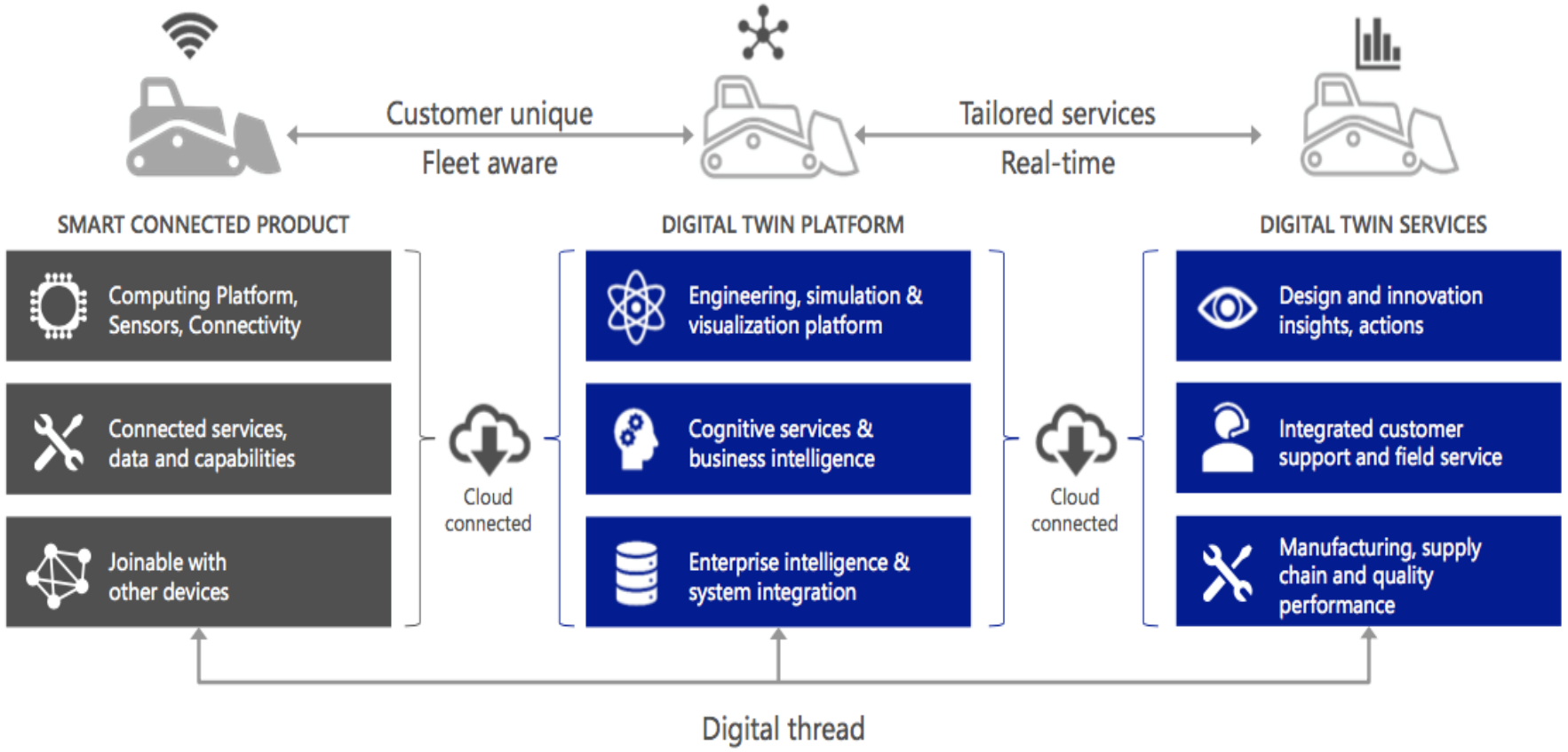


# The picture of Dorian Gray

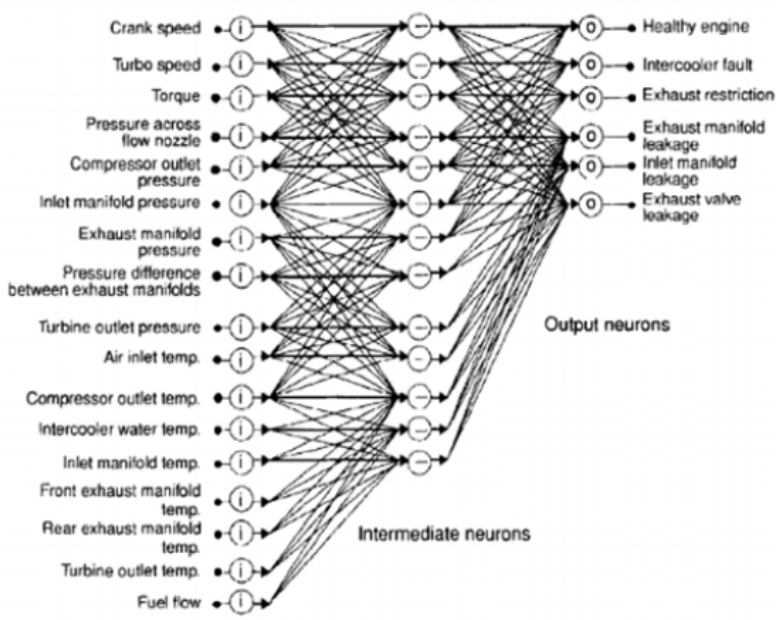
# Digital Twin: A virtual instance for services

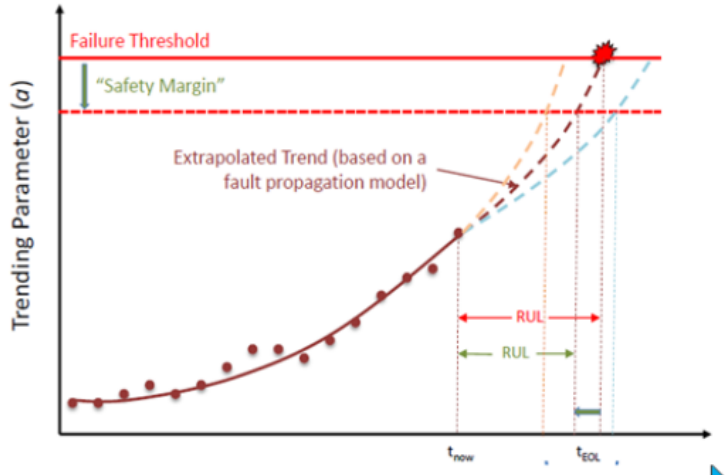


# Digital Twin Solution Architecture



# Digital twin based on OT

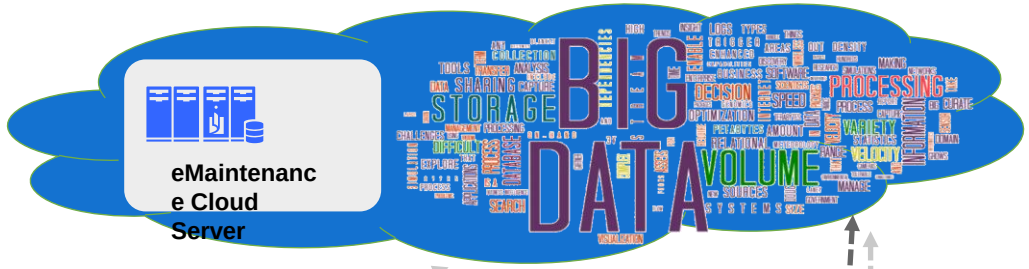


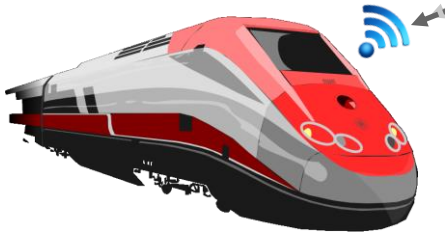




Diagnostics

Prognostics

# Digital twin based on OT

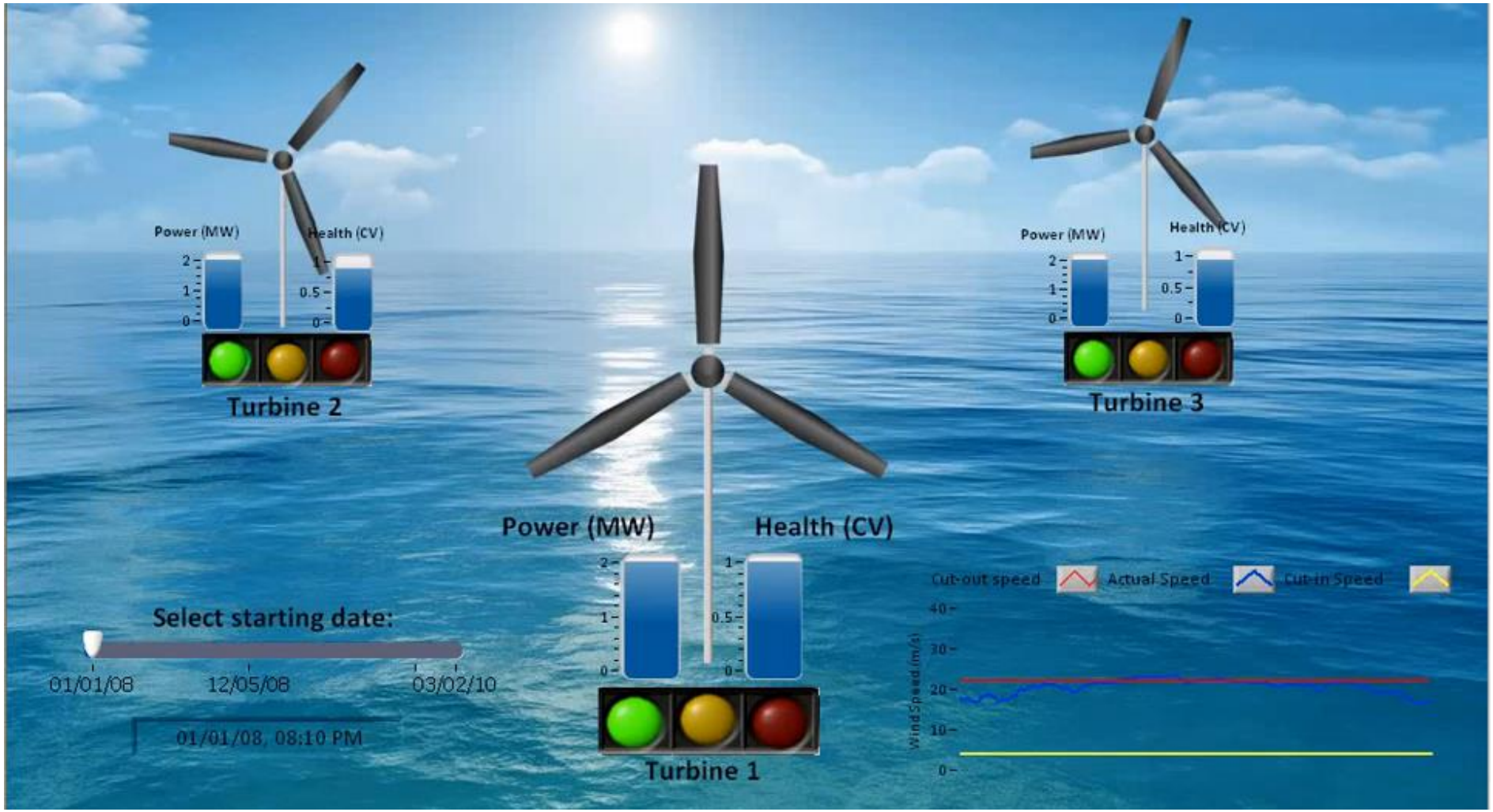


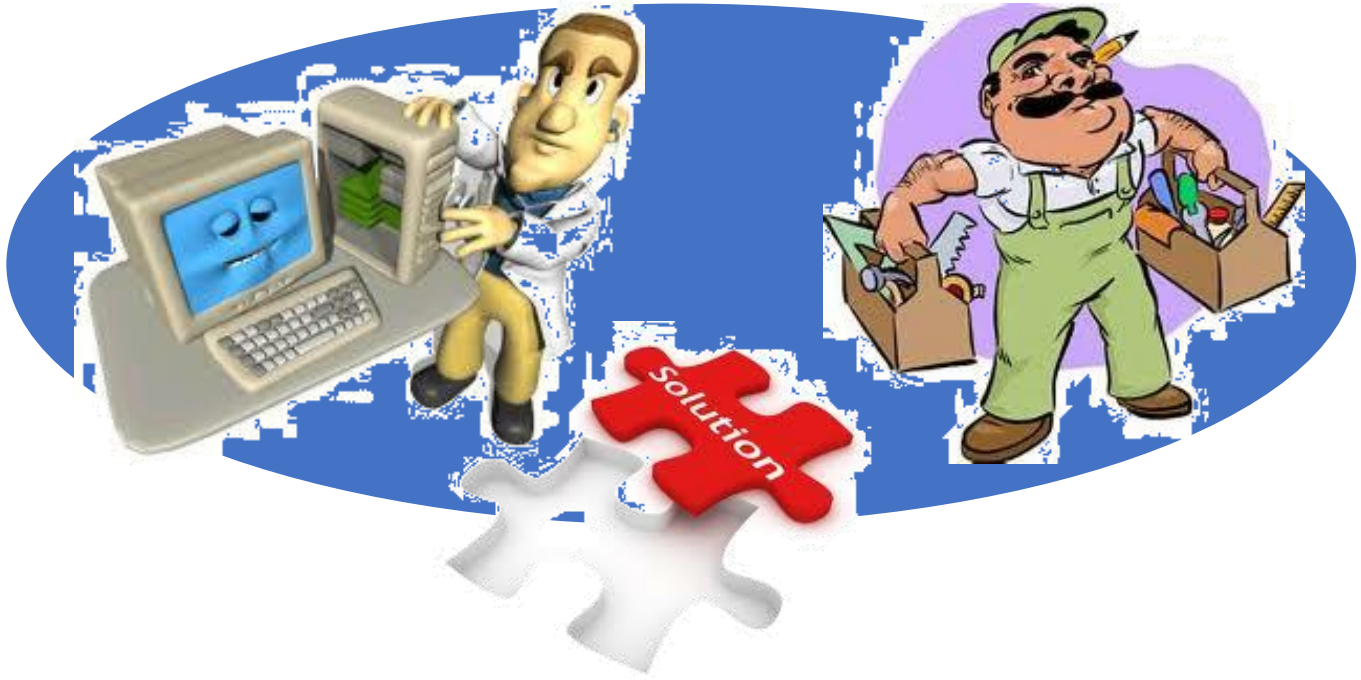
On board Wireless System

Machine Maintenance
Analytics

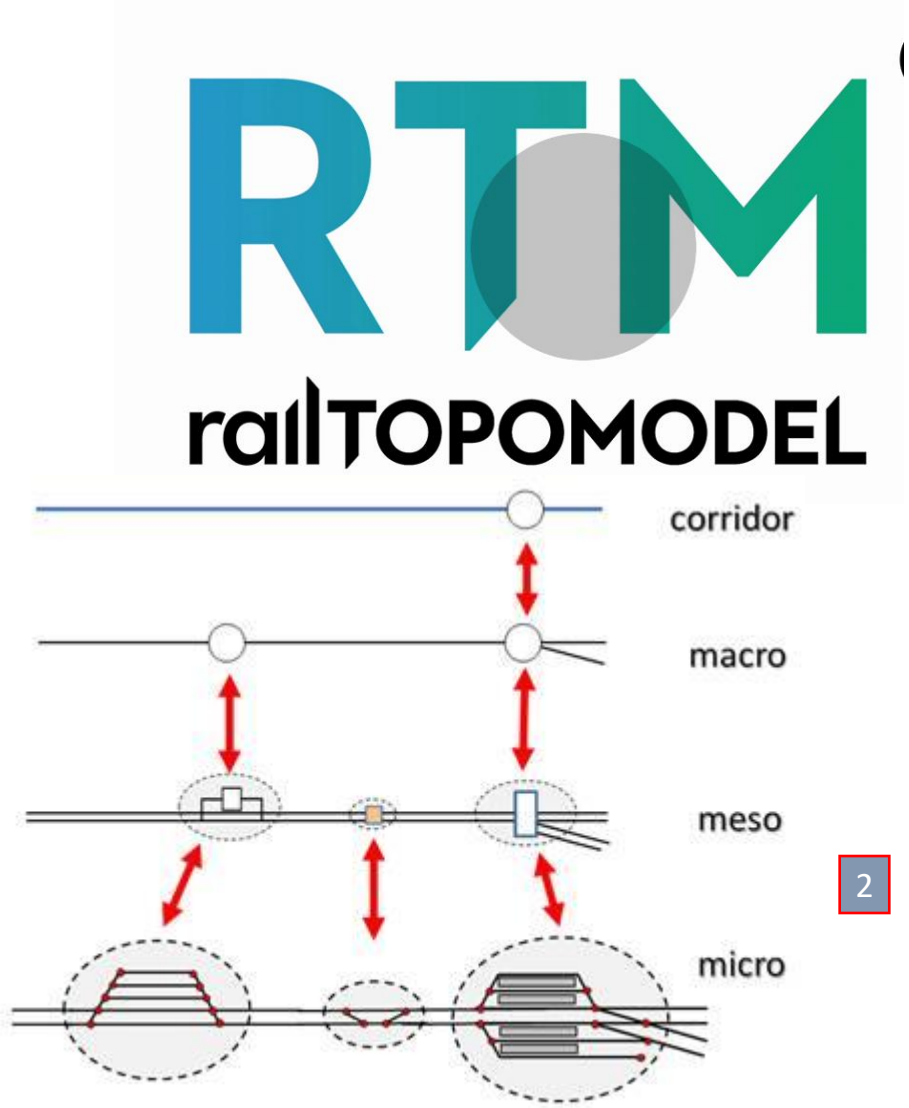
# Digital twin based on OT

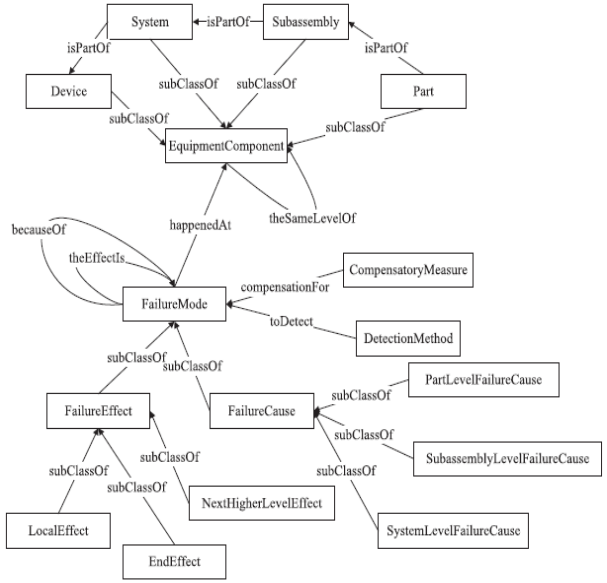


# What about IT systems?



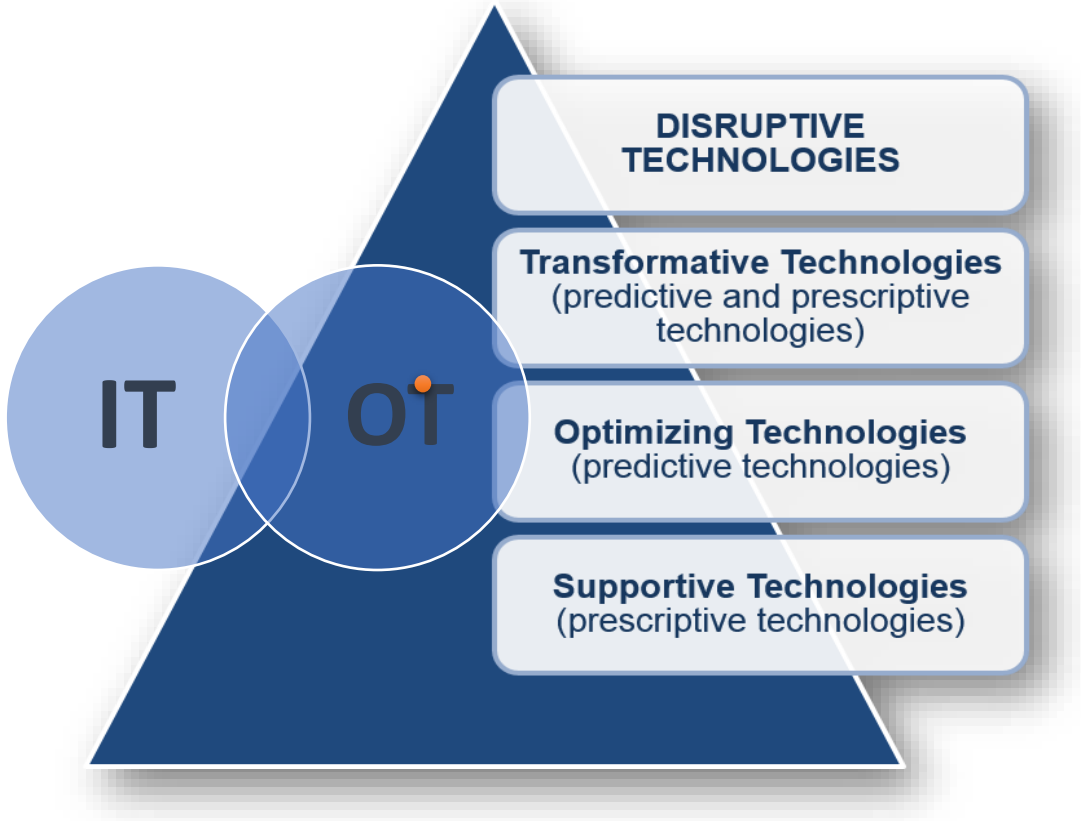
# Taxonomies and ontologies



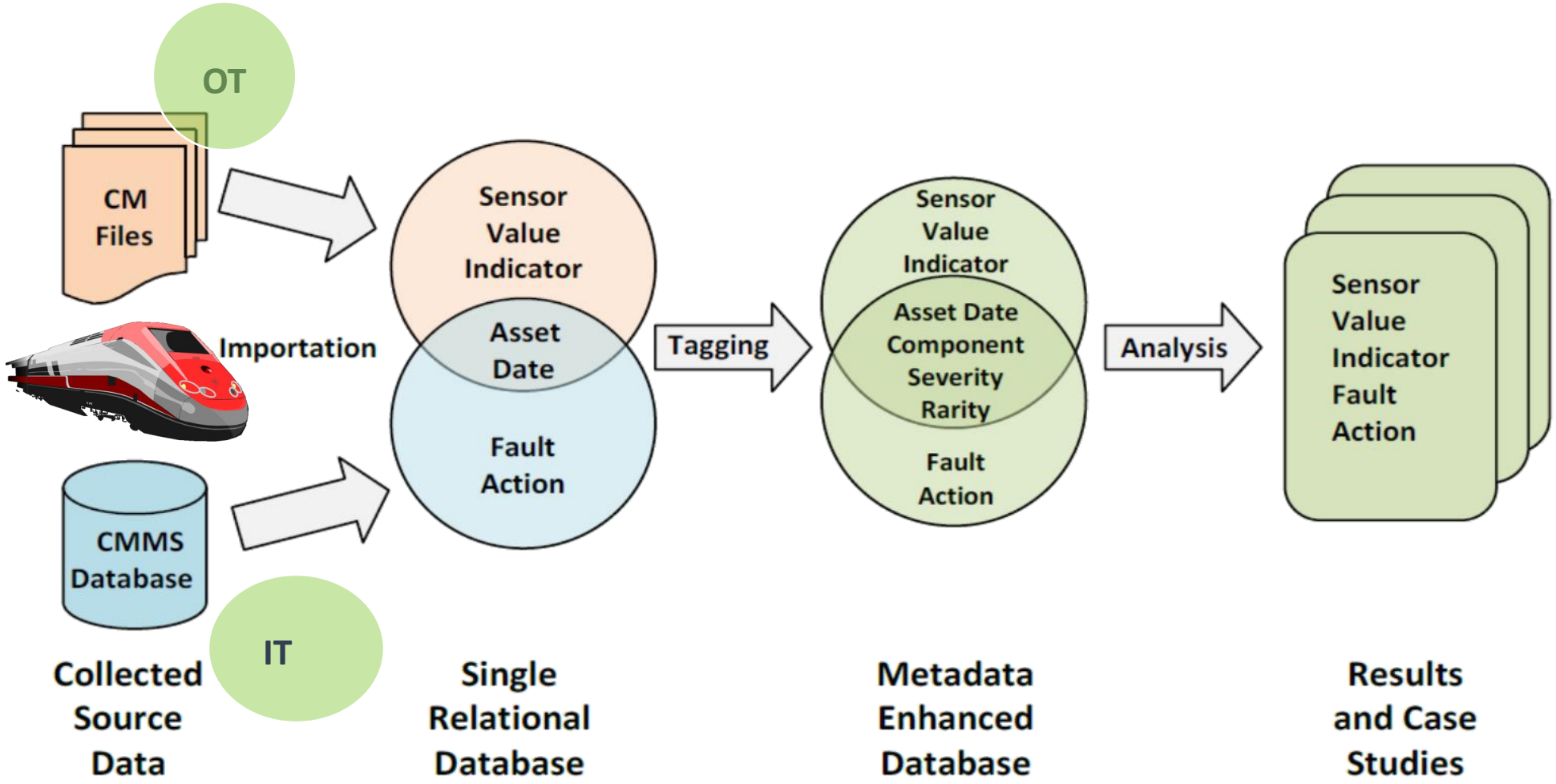




Rule-1
FailureMode(?x) ^ hasHappened(?x, true) ^ Device(?y) ^ happenedAt(?x, ?y) ^ FailureMode(?z) ^ theEndFffectIs(?z, ?x) ^ FailureMode(?a) ^ theHighEffectIs(?z, ?a)?theDirectFailureCauseIs(?x, ?a) ^ hasHappened(?a, true)

# TRANSFORMATIVE MAINTENANCE SOLUTIONS Integration & Application of Technologies



# Digital twin OT/IT integration



# Digital twin OT/IT integration


On board Wireless System

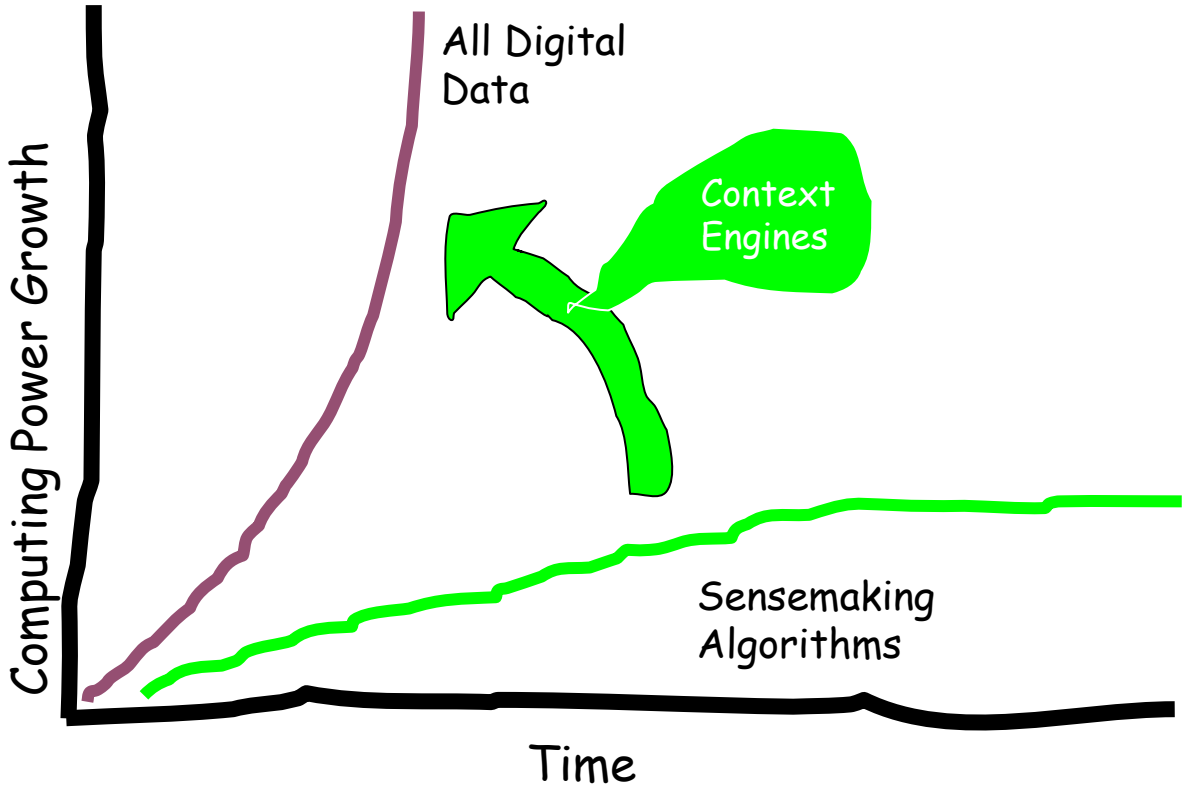
Machine Maintenance
Analytics

Truck scheduling



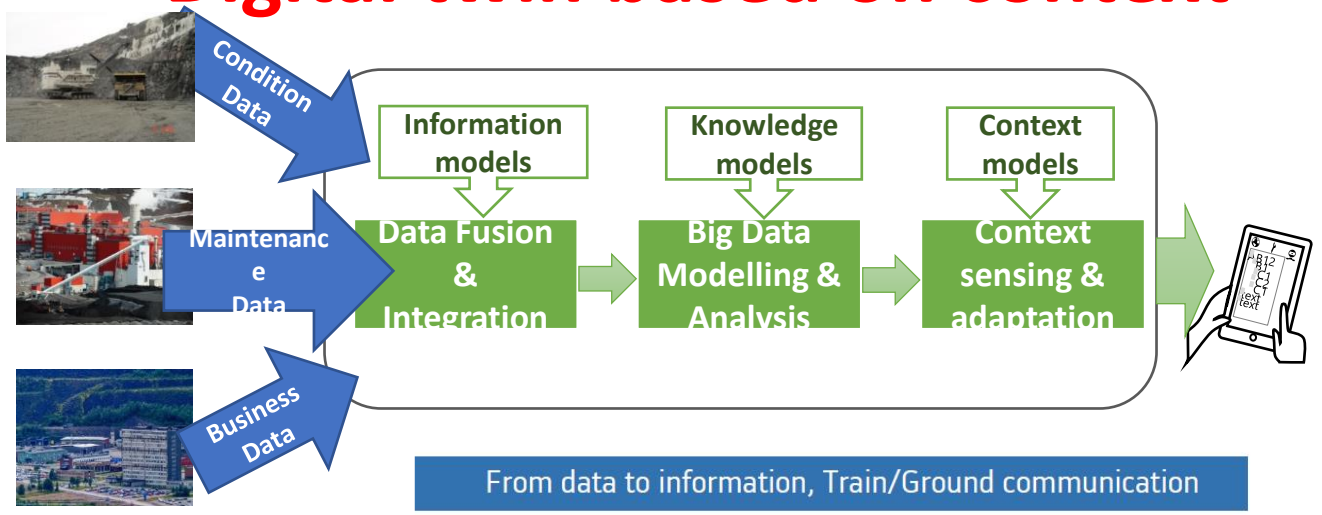
Technical services

# The Way Forward



# Context-aware Maintenance Decision Support Solution

## Digital twin based on context

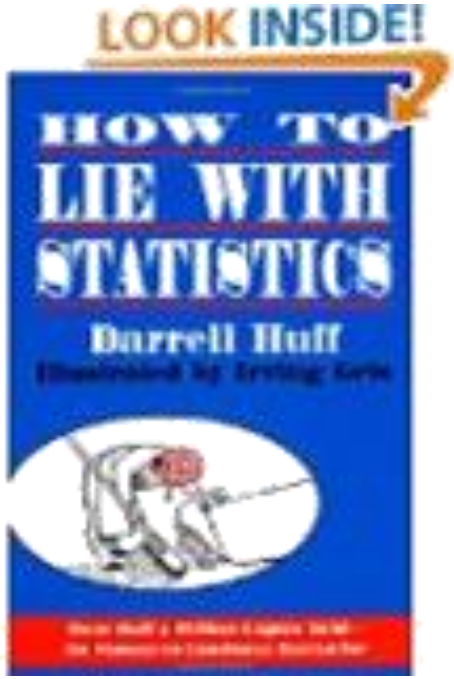



From data to information, Train/Ground communication

Train events
Train status
Train position

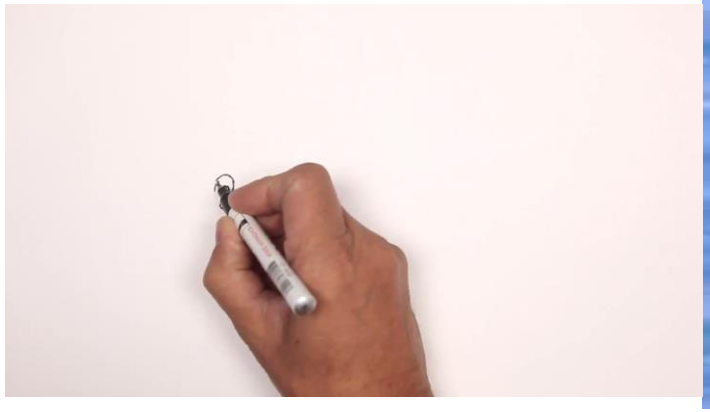
# Let us be careful bigger = smarter?

- tolerate errors?
- **discover the long tail and corner cases?**
- more data, more error (e.g., semantic heterogeneity)
- still need humans to ask right questions, lack of analytics



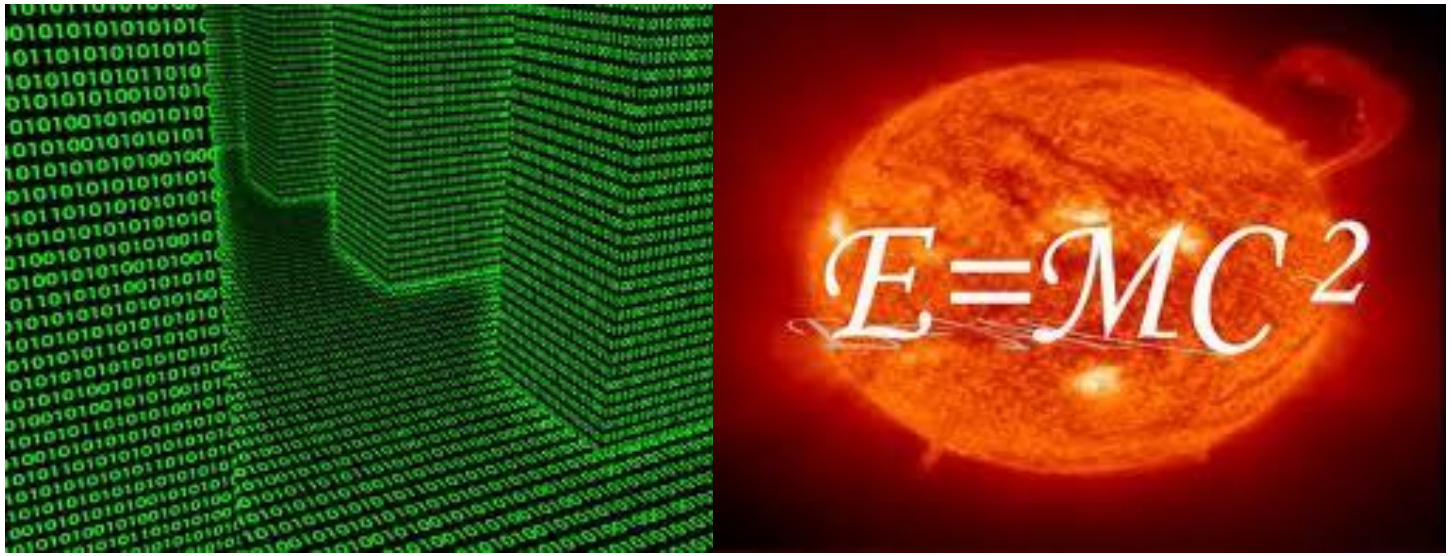
# Black Swan Losses

- Loss Distribution
  - Tail events are rare – very little data
  - Typically strong model assumptions

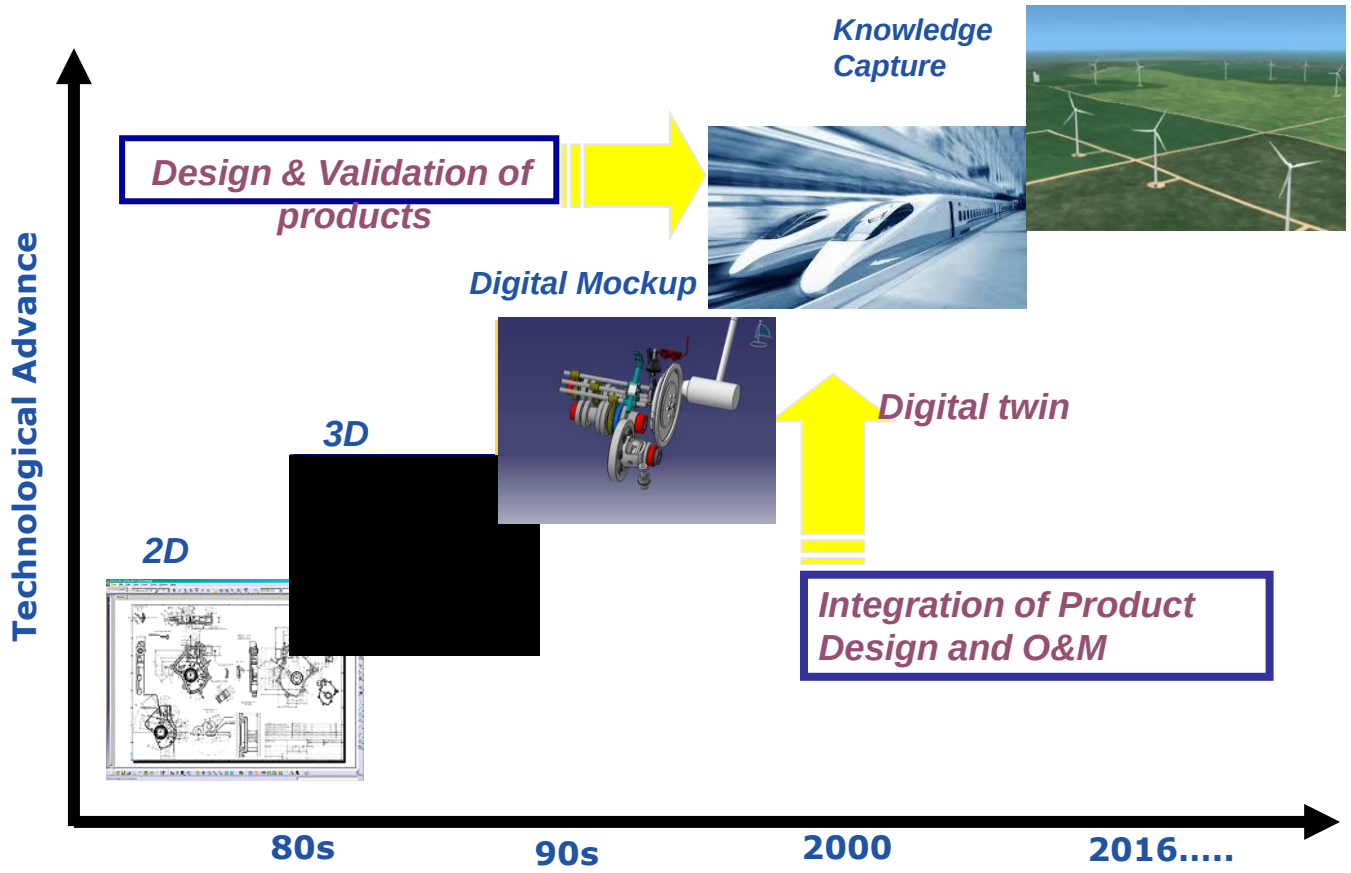


# Data driven or model based?

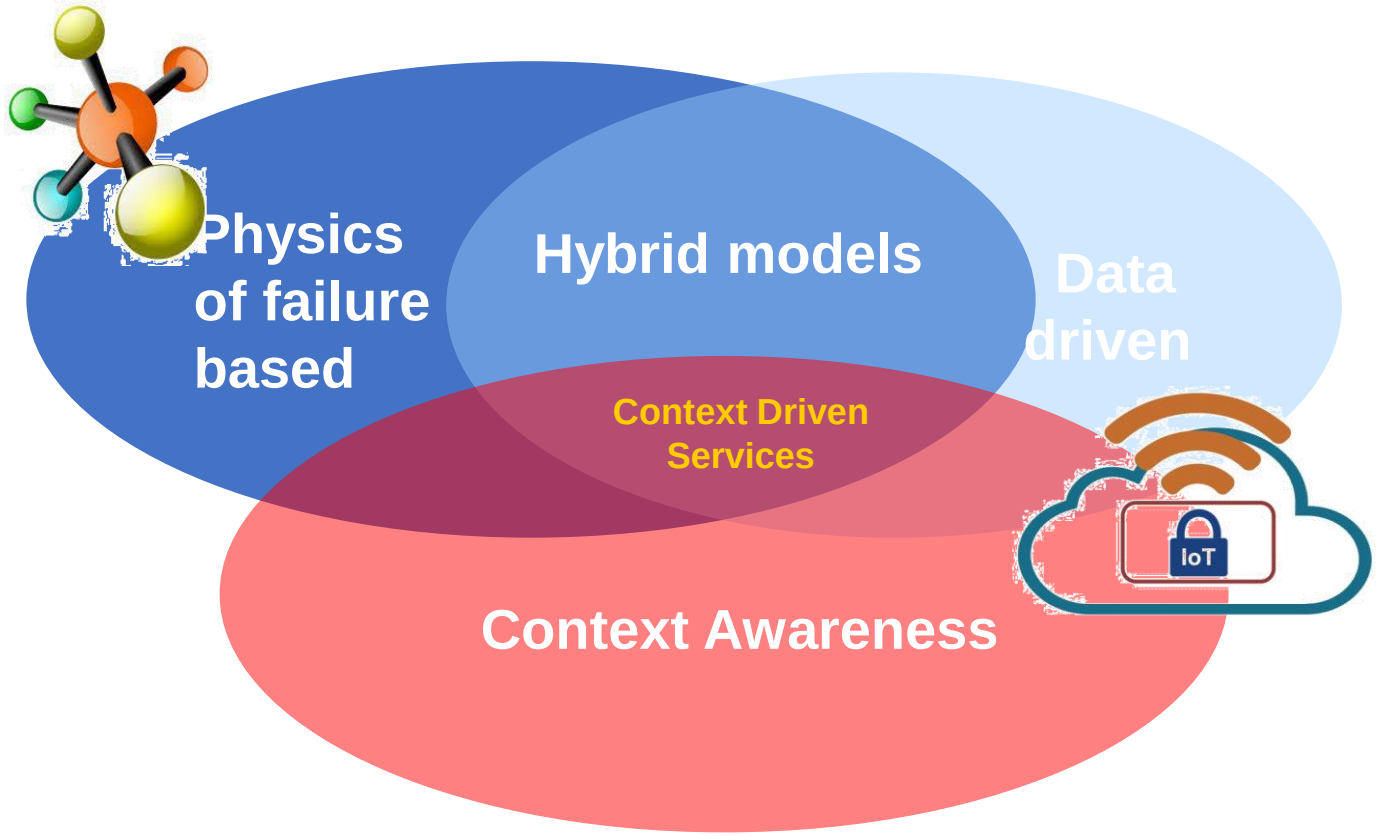
Data-Based or Physics-Based Models? – That is the question!



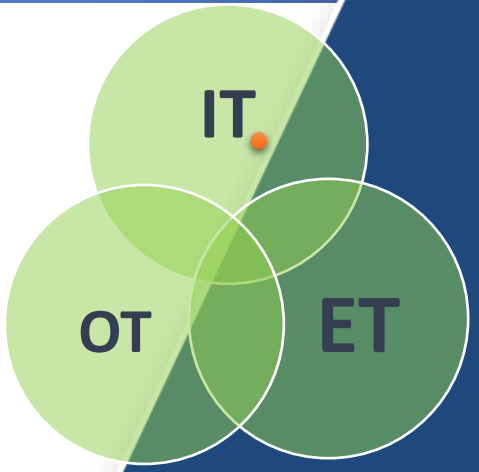
# Evolution of the Process



# Hybrid & Context Driven Services



# Digital twin hybrid




**DISRUPTIVE TECHNOLOGIES**

**Transformative Technologies**
(predictive and prescriptive technologies)

**Optimizing Technologies**
(predictive technologies)

**Supportive Technologies**
(prescriptive technologies)

# Digital twin hybrid

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## Digital Turnout Management

Vossloh focuses on Digital Turnout Management and inspires with digital innovations and platform solutions. Forwardlooking IoT sensors not only serve as a data source for realtime analysis that reflects the current state of rail and track systems: their microprocessors prequalify the raw data. Virtual images of physical components or systems - so-called "digital twins" - provide insights into the functional and service diversity of tomorrow using the example of the Easyswitch MIM-H point machine.

Digital Twin

# Methodology

Rolling stock

HVAC

- Taxonomy
- FMECA Analysis (failure mode identification)
- Relate available variable with failure modes
- Identification of possible modeling methods for failure identification
- Critical system, sub-system, component identification
- Diganosis/Progonosis
- Condition Monitoring
- Maintenance Planning

Identify failure modes of Equipment units, Subunits, Components and Parts based on the Taxonomy

Analyze failure effects / causes

Classify failure effects by severity

Perform criticality calculations

Rank failure mode criticality

Determine critical items

Identify means of failure detection, isolation and compensating provisions

Document the analysis. Summarize uncorrectable design areas, identify special controls necessary to mitigate risk.

Make recommendations

Follow up on corrective action implementation / effectiveness

Identification of the **system** for the analysis

Survey for the functionality of the system

Identification of the Equipment units, Subunits, Components and Parts

Complete Taxonomy creation

Identify the measurements for the detection of failures

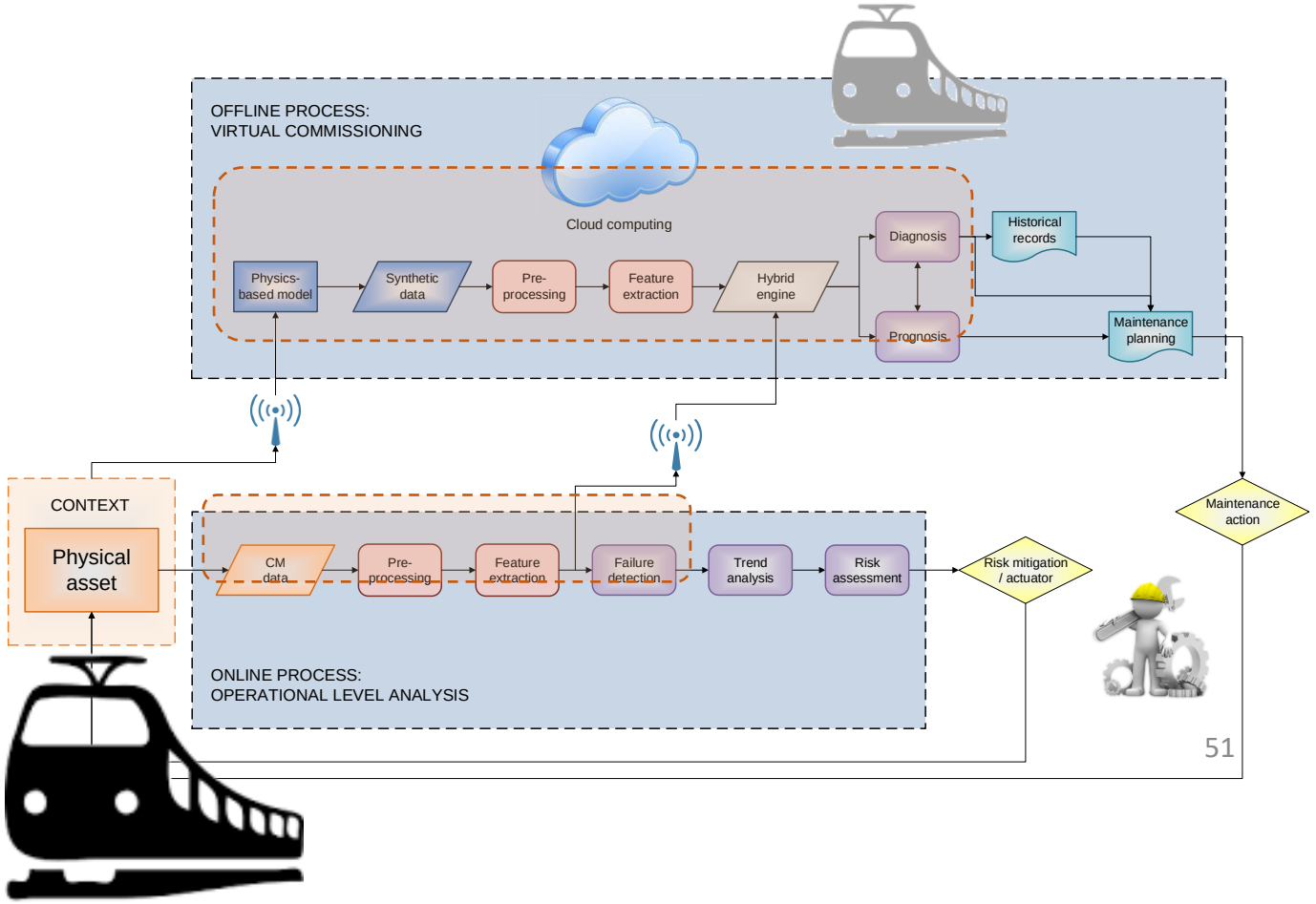
Identify the available variables and parameters in the system

Exploration of possible data extraction form variables

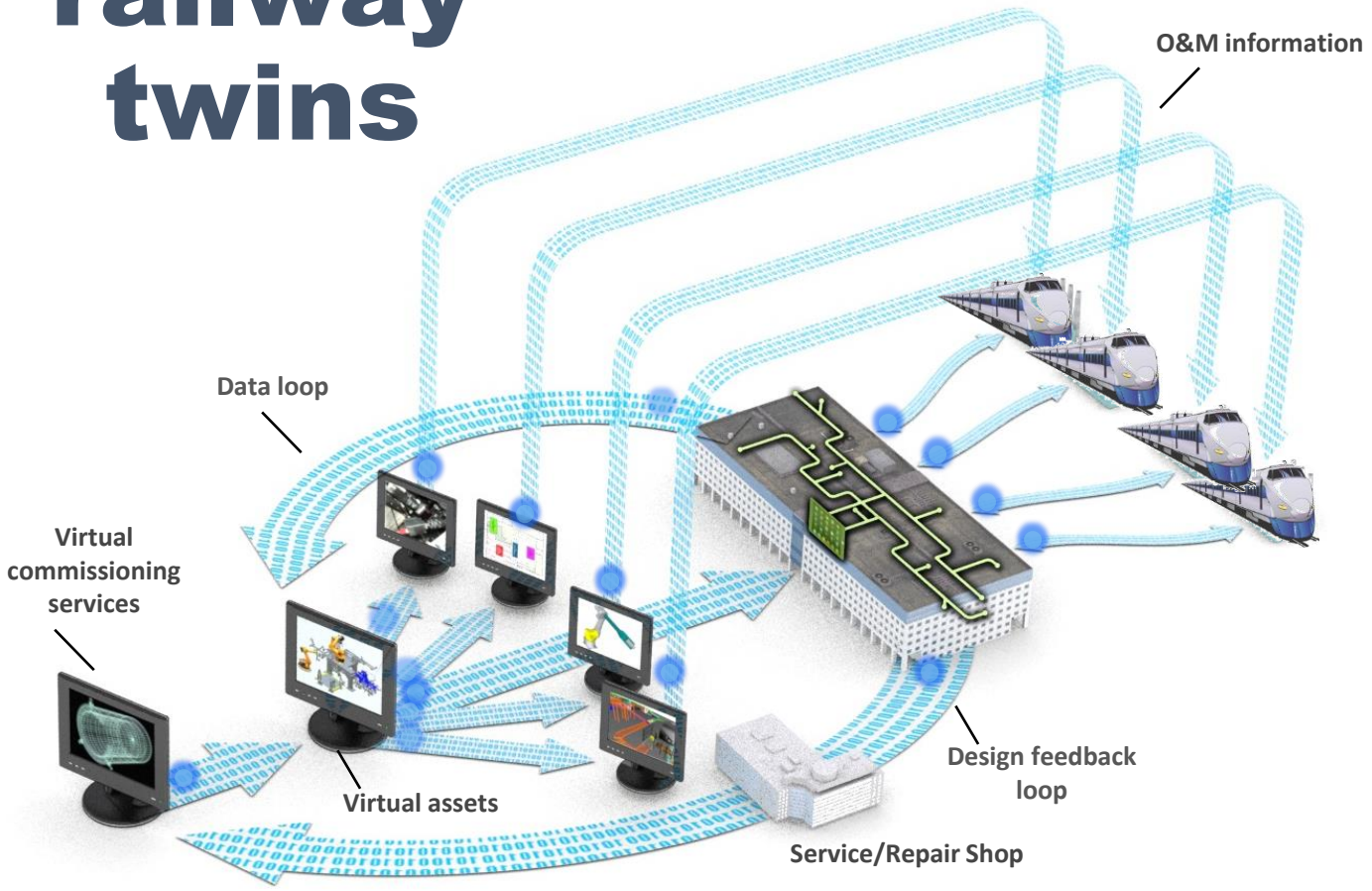
Sensitivity analysis for the detection of failure modes from available variables

Analysis of indirect monitoring of failure modes through variables

# Hybrid Digital Twin



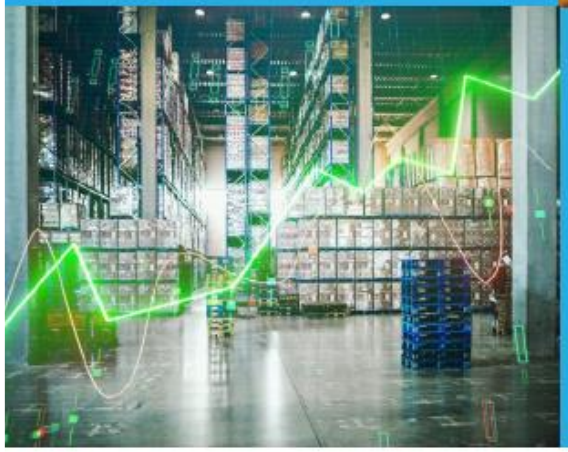
# Application of railway twins



# Some hints

Focus on value & speed of delivery

Ensure the ML output adds value to the O&M staff



Good, well labelled data is important, but don't wait for perfection.

Complex ML models are not always the best place to start

# Concluding remarks

- Digital twins and Hybrid models are needed for virtual commisioning to deliver O&M services
- O&M based on Data driven solutions can lead to catastrophic failures
- Life extension is not possible with big data analytics
- Manufacturers must provide the integration of systems and data
- Digital twin 4.0 will consider evoltionary models and normality dynamics


Thanks
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diego.galar@tecnalia.com