AFRY E-DAP – An *end-to-end* web-app for industrial data engineering and analytics

Supporting companies in their digitalisation transformation

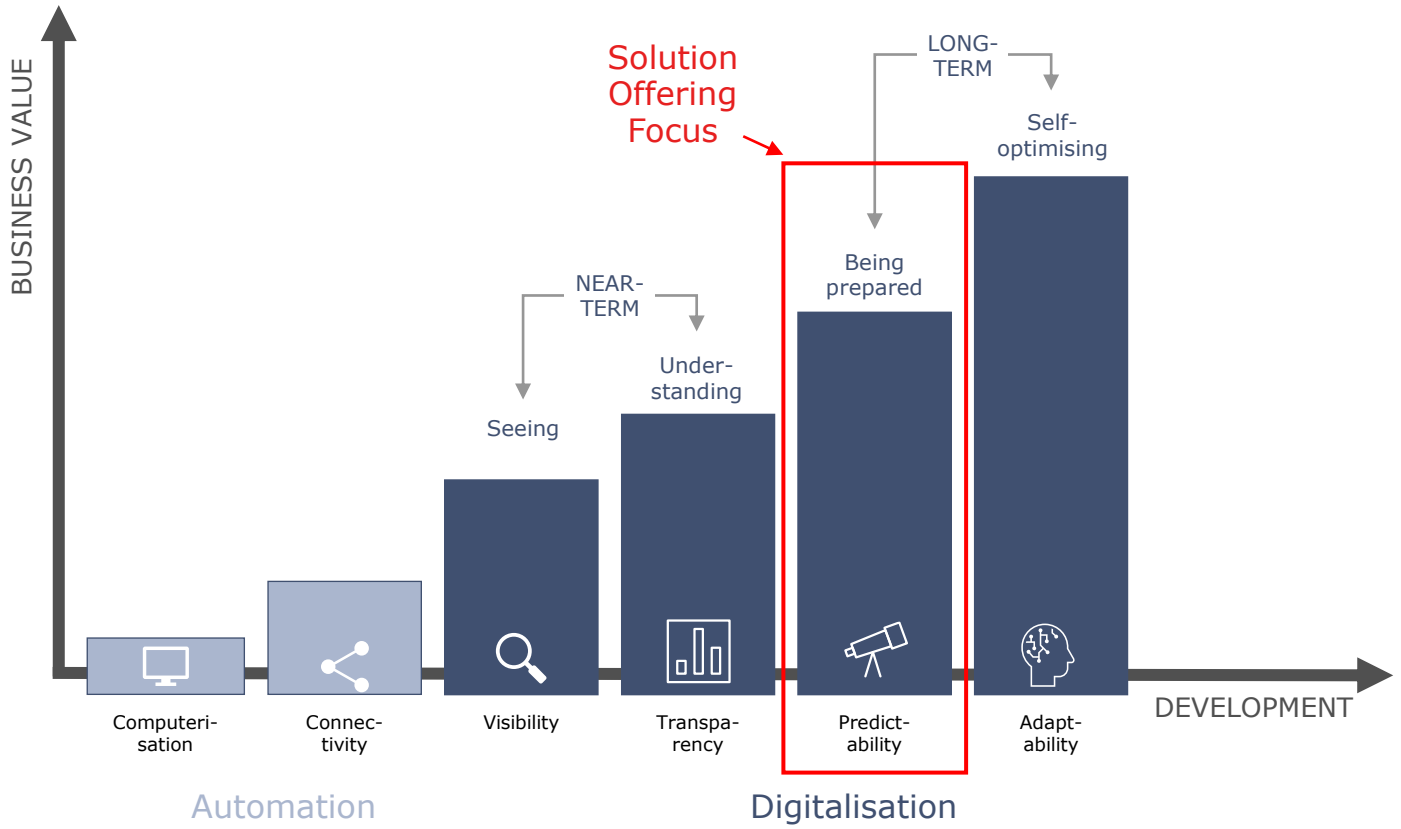
MARCH 2023

Why is E-DAP unique?

E-DAP VALUE ADD

AFRY has developed E-DAP to support asset infrastructure operators in their digital transformation journey by valuating their data

THE DIGITAL TRANSFORMATION JOURNEY



E-DAP KEY BENEFITS

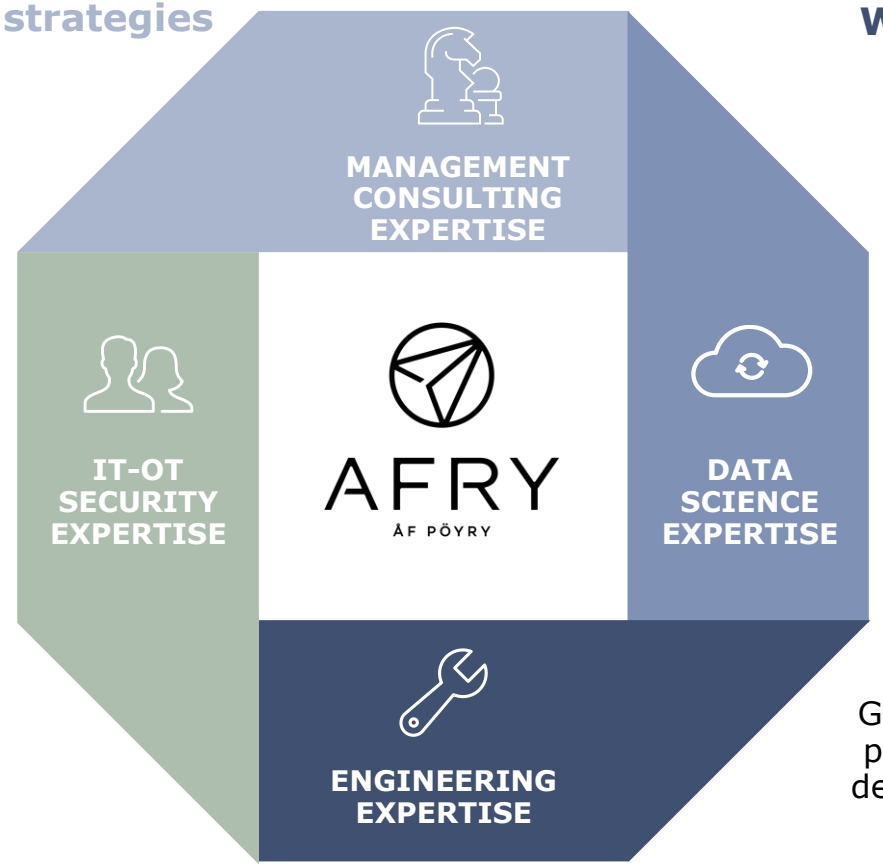
- A **fully integrated**, **modular** and **secure** data analytics platform that can **process live IoT** asset's data
- Identify new ways to control production, **optimize processes**, reduce variances, **predict asset's maintenance** and support with root-cause analysis
- Defer your investment and **improve your TOTEX margin** remuneration for improving your capital efficiency
- Gain the **capability to conduct sensitivity analysis** of your asset health index with respect to changes in operational and condition data

WHY AFRY

We are unique in combining management consulting, data science, engineering and IT-OT security expertise in one-house to serve our clients

We develop & implement digital strategies

Market-leading trusted advisor for transmission and distribution system operators, supporting them in reorganising their processes, evaluating business use cases, scouting for innovation or assessing impact of regulatory changes



We digitalise assets & processes

Proprietary digital solutions developed and managed by highly experienced data science professionals who master the art of extracting insights from big data analytics

We speak IT-OT security

Highly experienced technology consultants with leading corporate functions in IT and OT security departments of digital companies

We plan and build power grids

Global network of engineering experts for power lines, substations and transformer design, large EPC projects as well as asset operation and maintenance services

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E-DAP UNIQUE SELLING PROPOSITION

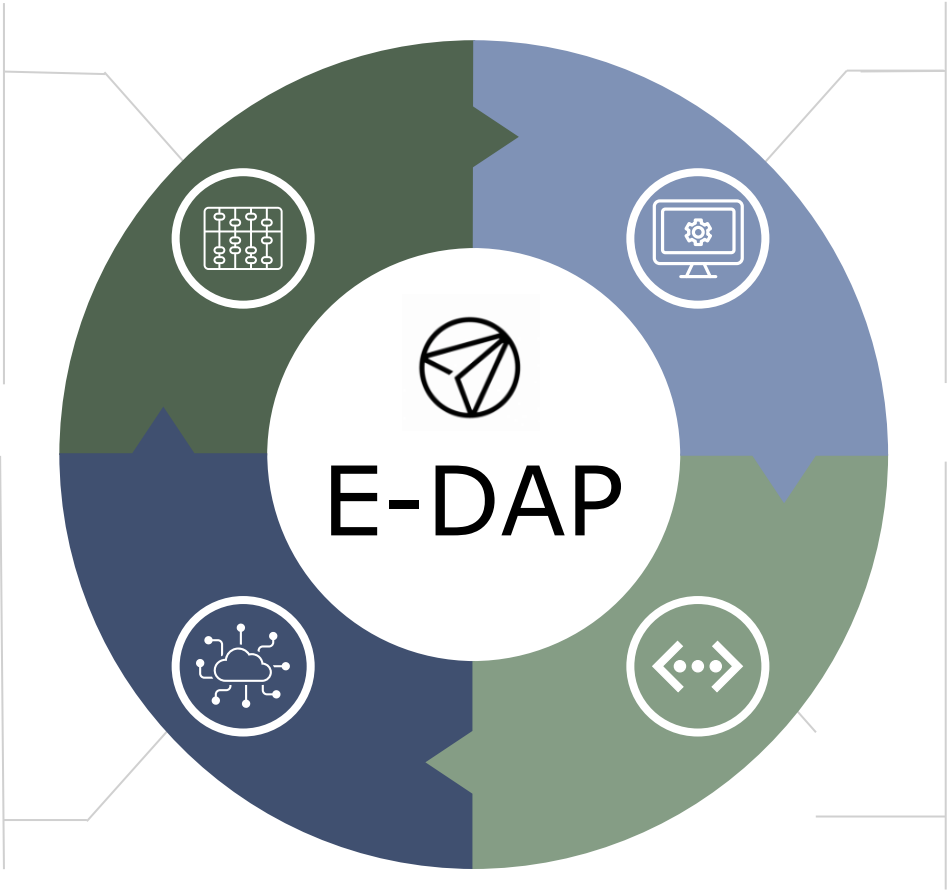
E-DAP is AFRY's data analytics platform designed for asset infrastructure owners seeking to optimise their O&M costs and capital efficiency

1 End-to-End architecture

- Encompassing all data analytics ingredients, without being distracted by other tools (Open BI, AI resources, notebooks...)
- IoT (Kepware, MQTT, Scada); data engineering & management, ML/AI, Digital twin, Insight page

4 IoT Ingestion and Live Dashboarding

- IoT data are not always sufficient
- Combine simulation & IoT data to enrich ML-training
- Create artificial faults and extrapolate application range
- Create simulation digital twins



2 Tailored Insight Hub

- A dedicated page for model and digital twin (DT) reporting
- The page reports KPI's specific to:
  a. *Operational Excellence*
  b. *Predictive Maintenance and anomaly/fault Detection*
- KPI's are either calculated on the IoT live data, or on the DT results

3 Extended Connectivity

Can connect to external platforms via

- Import standard ML/AI models
- Import FMU models (e.g. Modelica)
- Connect to data brokers with REST API
- Process-flowsheet & BIM configurations

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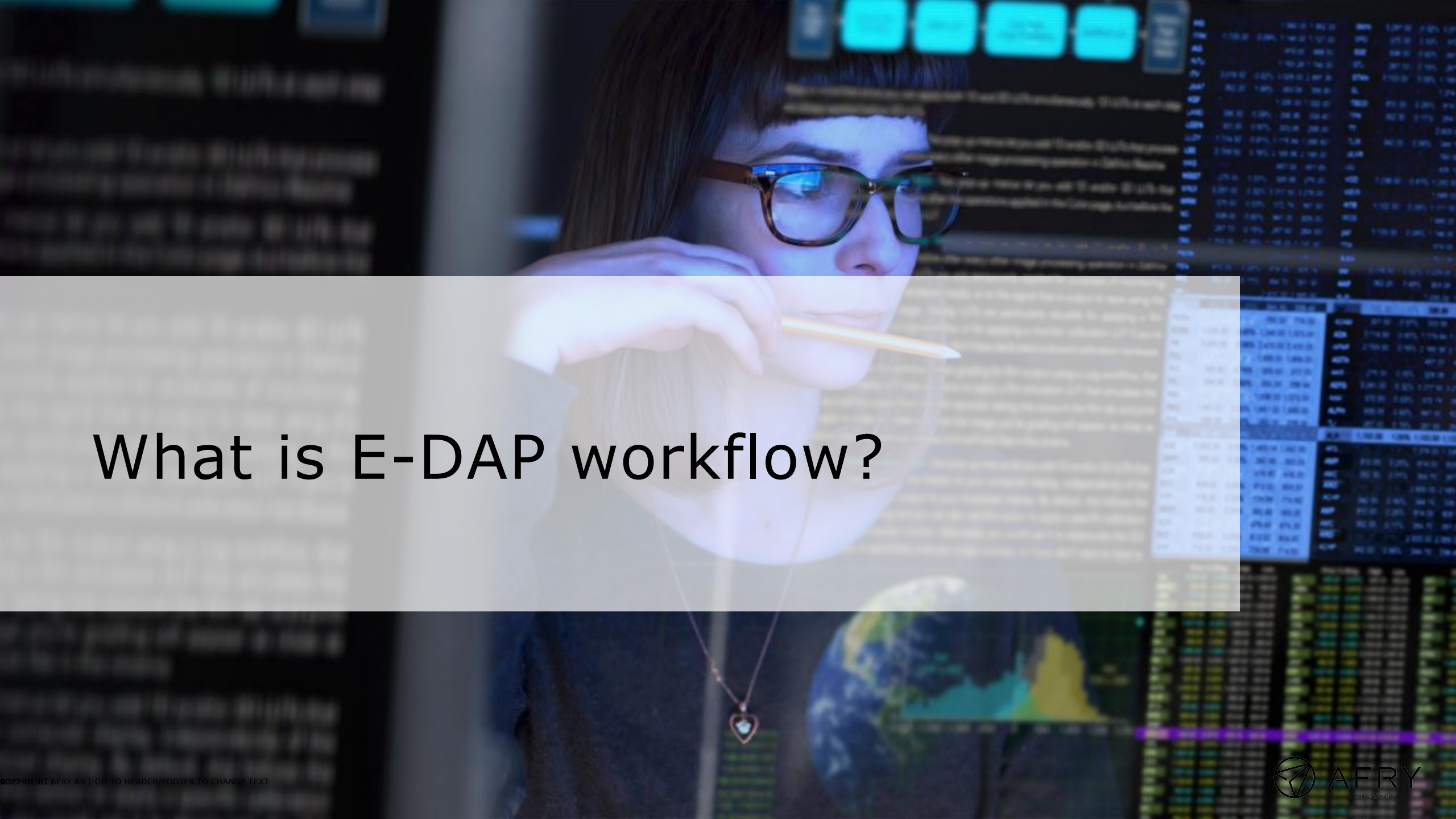
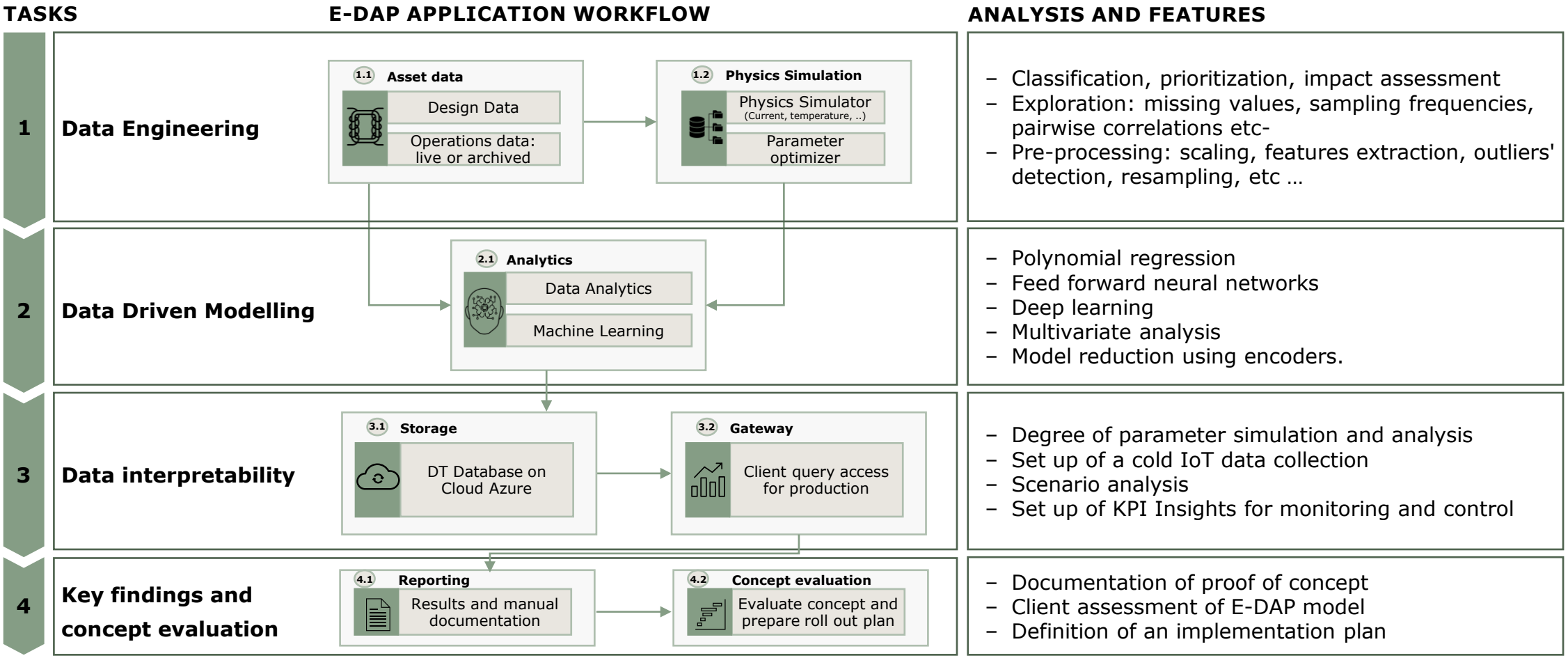


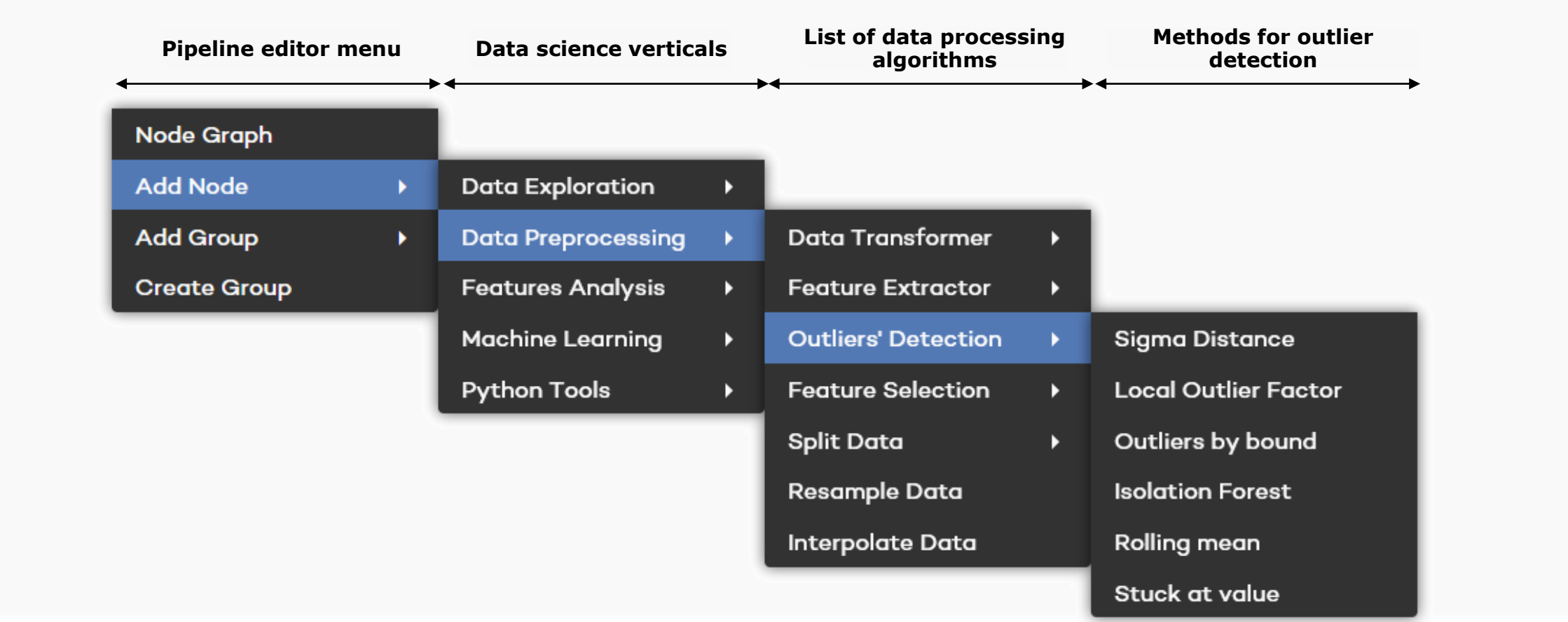
What is E-DAP workflow?

AFRY follows a structured workflow to engineer the data and build a digital twin of the asset with machine learning algorithms for behavior prediction



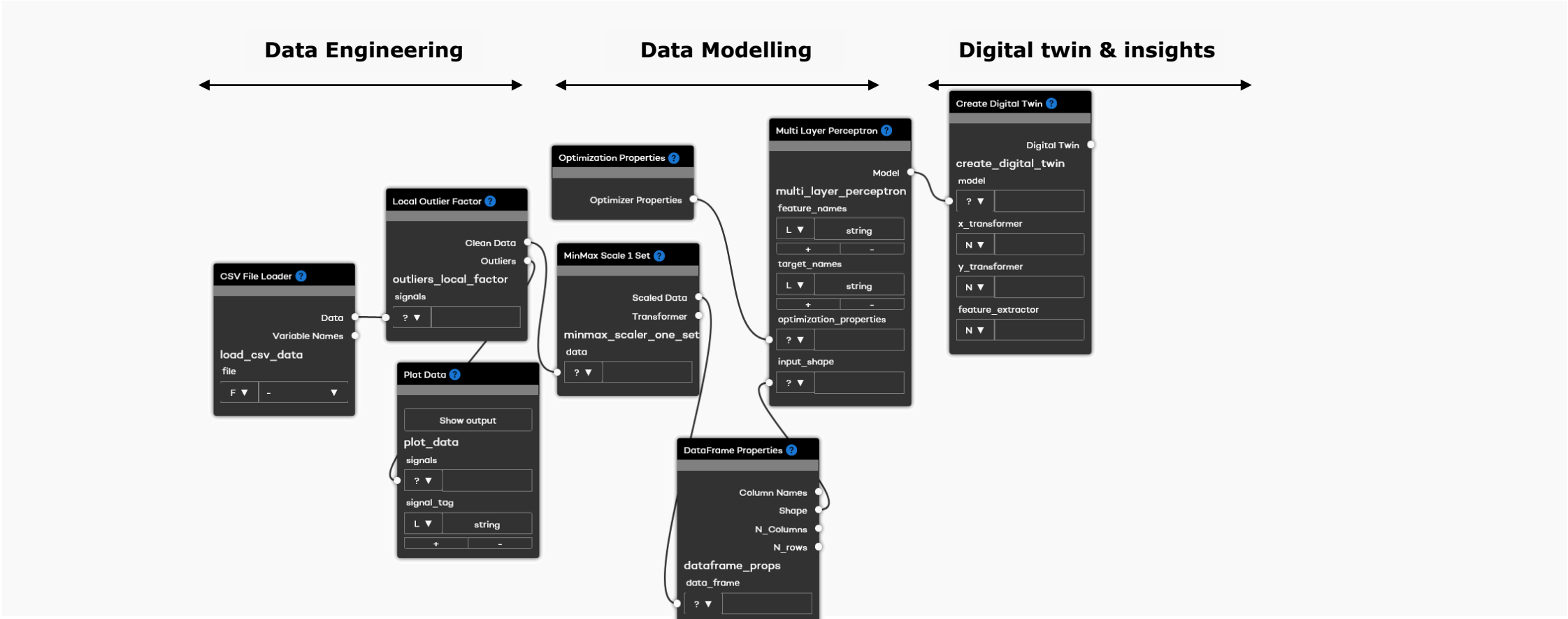
E-DAP enables our clients through a user-friendly GUI to construct and execute data analytics pipelines of their sensor measurements

E-DAP Pipeline Editor



Our clients can change parameters, test models, request for new models' implementation.. or update the model with new IoT data & other sensors

E-DAP Three Step Workflow represented in the pipeline editor



Our clients gain access to the models created, perform model inference on new input data and observe the results

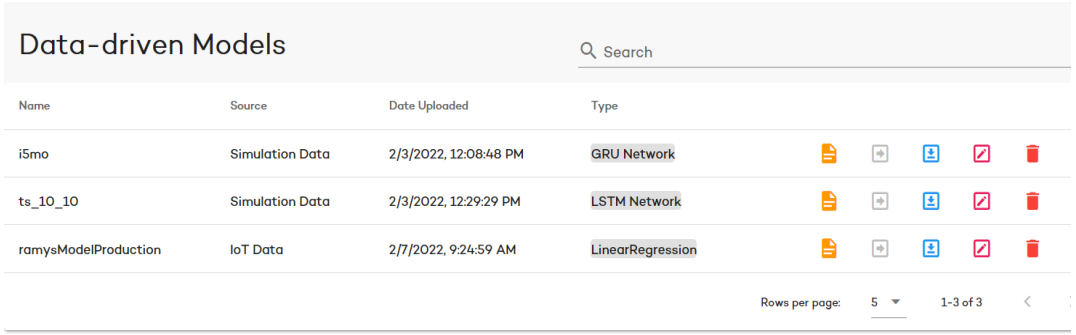
DATA DRIVEN MODELS

- List of all the models created through the Pipeline editor
- Information on models' performance, input and output
- Results graphs created are stored for later usage.

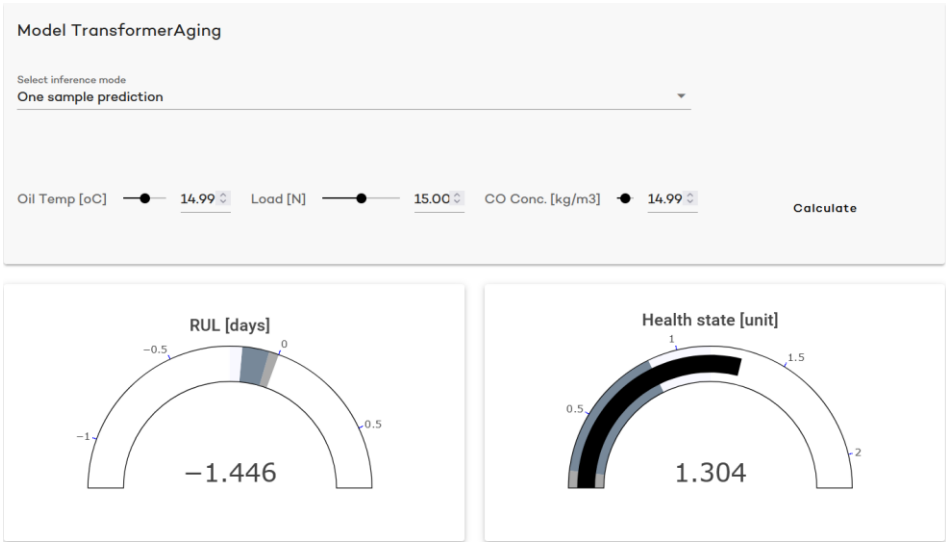
MODEL INTERFERENCE PHASE

- User will interact with the model by questioning it for new operating conditions of the system, or simulated conditions (not available through measurements)
- Manual interaction (Change input parameters by hand)
- Batch predictions (Provide a CSV file with new operating conditions of the system)

E-DAP list of data-driven models – e.g. from previous use cases



Model inference (user-model interaction) - example model

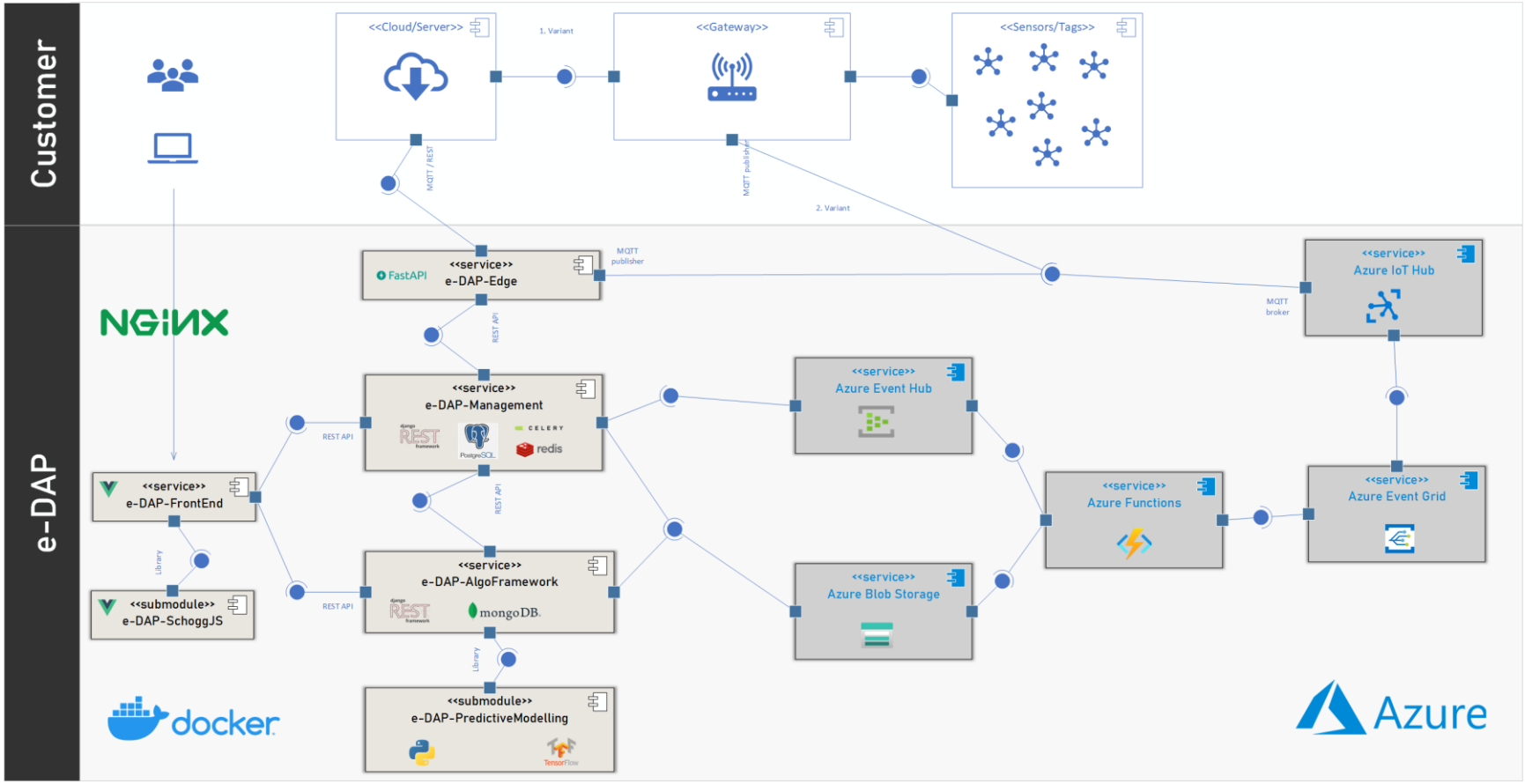


How we apply E-DAP?

LIVE DEMO, ARCHITECTURE, PROJECT REFERENCES

We use Microsoft Azure to connect E-DAP to our clients IT Enterprise Level through which IoT information of field devices can flow securely upwards to

E-DAP ARCHITECTURE



COMMENTS

- While e-DAP main architectural components are in-house developed, it uses Azure databases and functions
- We assume that your industrial control system security is equipped with data diodes that guarantees secure unidirectional information flow from OT field devices to the enterprise IT level
- We are developing an alternative on premise architecture for clients who have stringent OT data security requirements

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E-DAP REFERENCES

We have applied E-DAP across different sectors of the industry with different complexities and succeeded in demonstrating value add to our clients

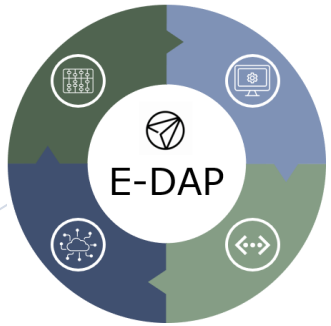
Engineering Data Analytics Platform (E-DAP) – overview

1 Process industry

- Chemicals & vegetal oil
- Food & Pharma
- Pulp & Paper

2 Energy industry

- Generation
- Distribution
- Transmission



3 Infrastructure assets

- Buildings
- Tunnels
- Transportation (road, train & airports)

4 Manufacturing industry

- Power plants
- Turbines & compressors
- High-tech & electronics

5 Environmental assets

- Wastewater Treatment
- Hydrology

REFERENCE: ENVIRONMENTAL ASSET

E-DAP for wastewater systems optimisation: From digital controlling to predictive maintenance and operational excellence

Project Metrics

- 2021-22
- AFRY AMS Zurich

Client

- WWPT CH

Service and Approach

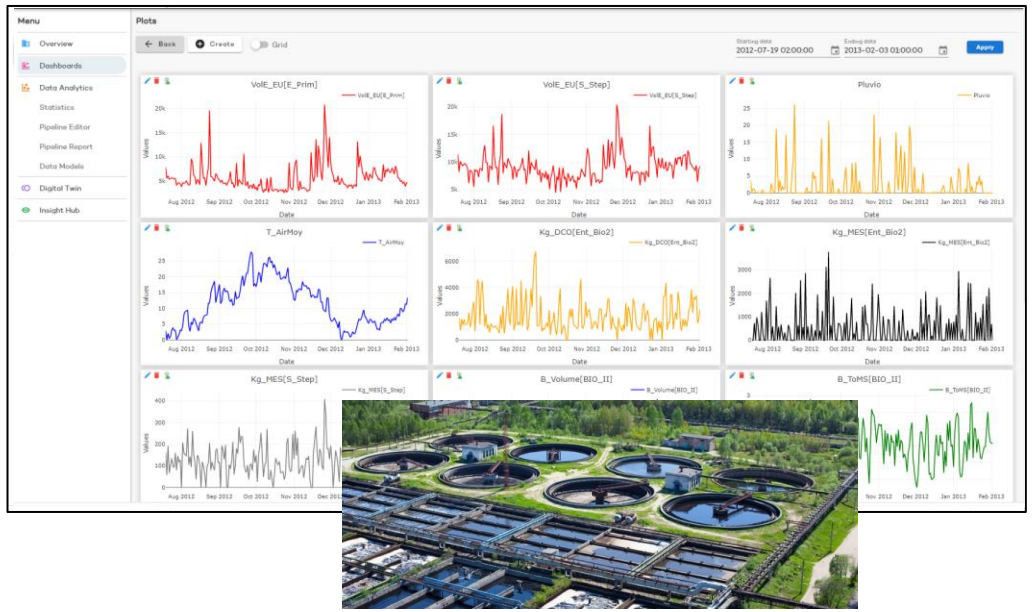
- AFRY's IoT system connects to the operator's data repository system via an MQTT protocol. Sensors can be placed then connected to e-DAP.
- The system collects and ingests live data in the platform (water and waste partition, temperature, humidity, energy consumption, bio-chemicals)
- Once sufficient data is collected and engineered, appropriate ML/AI algorithms are used. Legacy data can be used as well.
- The model - engine of the 'WWTP Digital Twin'- is then used to forecast daily operation in the future (energy and chemicals needs, sludge age…) and predict the water-quality KPI's : content of COD, N-NH4, N-NO3
- E-DAP is employed as an asset management tool of several WWTP's.

Client Impact and Value Added

- The client can access an on-line business intelligence tool for predicting and monitoring the operation and performance of its WWTP assets.
- The client is capable to monitor the operation parameters of the plants and take remedy decision in advance in response to external constraints.
- Next step is to onboard of several train/metro stations and tunnels.

Situation and Challenge

- Need to know the exact operation parameters of urban and industrial WWTPs, at the 04 main steps: primary & secondary treatments, bio treatment and sludge disposal.
- Need to respond to external constraints, e.g. evolution of treatment load due to increase of population, special events, meteorological conditions, changes in economics of operation.



REFERENCE: INFRASTRUCTURE ASSET

AFRY extends its train/metro/tunnel ventilation services during construction and operations: From digital controlling to predictive maintenance

Project Metrics

- 2022-23
- AFRY AMS Zurich

Client

- Highway Office CH

Service and Approach

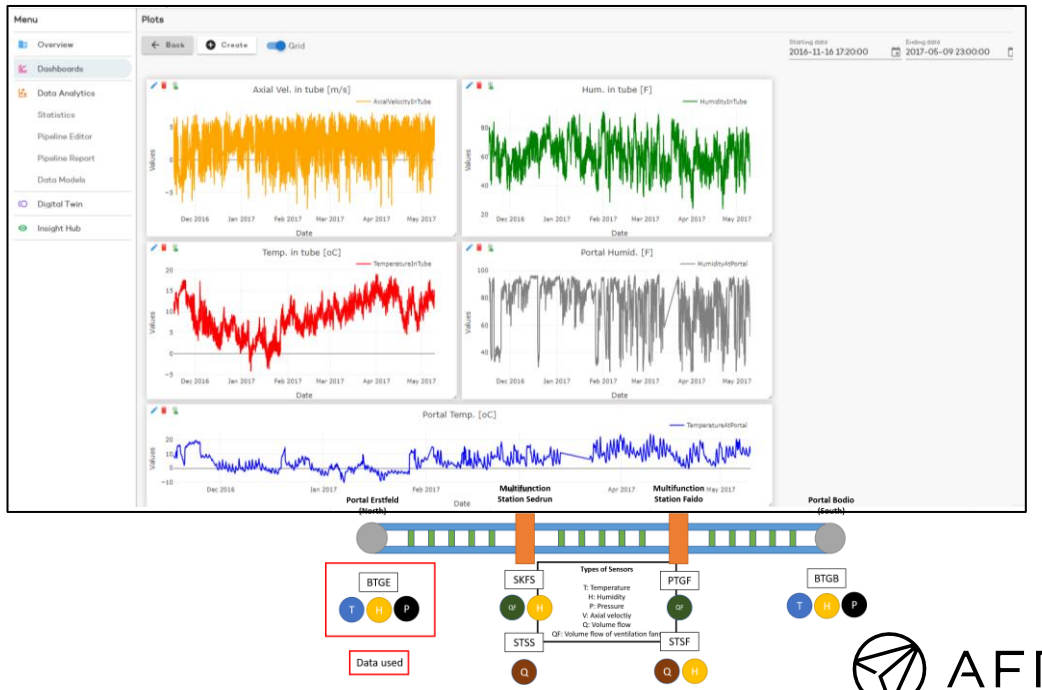
- AFRY's IoT system can be connected to the client's SCADA repository system via an MQTT protocol (or any other protocol).
- Sensors can be placed by AFRY then connected to e-DAP
- The systems collects and ingests live data in the platform at a modulable frequency (temperature, pressure differential, humidity, energy consumption)
- Once sufficient data is collected and engineered, appropriate ML/AI algorithms are used for the treatment of these legacy data
- We then use the model as the engine of the 'Tunnel Digital Twin', to be used to forecast the VAC & TVS daily operation in the future
- The platform is used as an asset management tool for various stations and tunnels along several lines at the same time.

Client Impact and Value Added

- The client now has on-line business intelligence tool for predicting and monitoring the operation and performance of all its assets
- The client is capable to live monitor the train/metro stations HVAC and tunnel ventilation systems (TVS), and take remedy decision in advance
- Next step is to onboard of several train/metro stations and tunnels.

Situation and Challenge

- Live monitoring of the climatic data in train/metro stations and tunnels, during construction and operations.
- Monitoring the daily operation of the train/metro stations HVAC and tunnel ventilation systems (TVS)
- Rely on a predictive maintenance tool to act in advance, covering all the assets of the client simultaneously.



REFERENCE: INFRASTRUCTURE ASSET

AFRY helps PHOENIX broaden its services in tunnel lighting: Our module serves as a digital control system and a predictive maintenance tool

Project Metrics

- 2020-23
- AFRY AMS Zurich

Client

- Phoenix, DE/CH

Situation and Challenge

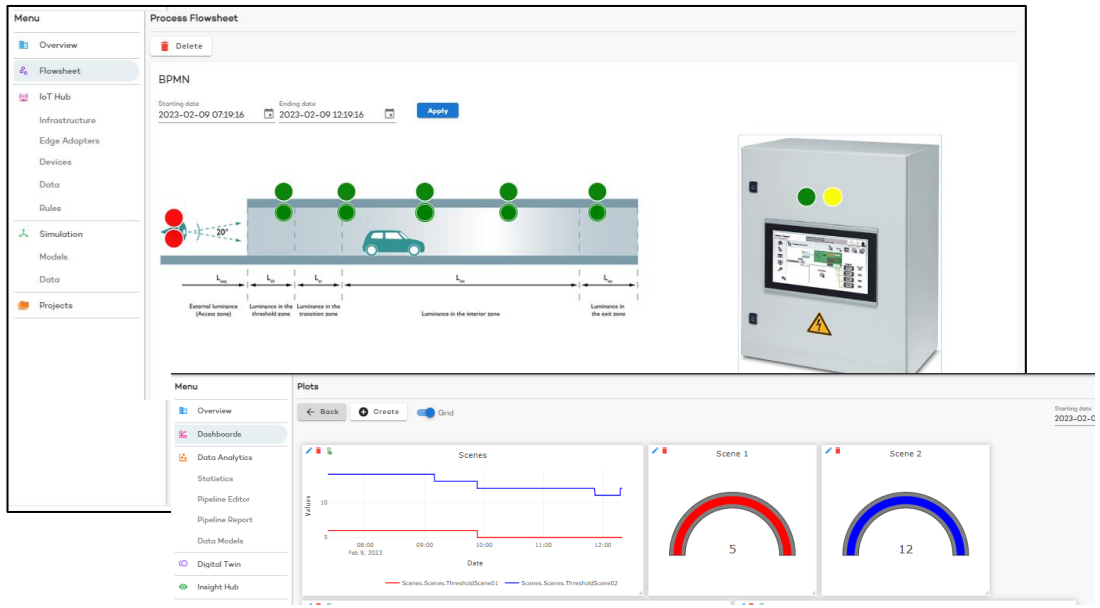
- Live monitoring of the lighting data in the tunnel and the aging of the light points.
- Monitoring the risk associated with aging and any anomalies
- Rely on a predictive maintenance tool to intervene in due time.

Service and Approach

- AFRY's IoT system is connected to the client's SCADA repository system via an MQTT protocol (coded into e-DAP).
- The systems collects and ingests live data in the platform at a frequency of 5-to-10 seconds (luminance, energy, scenes, lumgates)
- Appropriate analytical models for predictive maintenance were implemented, based on literature and regulatory norms
- AFRY used the model as the engine of the 'Tunnel Digital Twin' (TDT)
- The TDT is to be used to forecast the daily operation and probable health of the lighting system
- The platform is used as an asset management tool for various tunnels, with focus on predictive maintenance.

Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's performance
- The client is capable to live monitor daily operations and probable health of any tunnel lighting system equipped with its system
- Next step is to onboard of several tunnels worldwide.



REFERENCE: ENERGY ASSETS

AFRY designed for a Europe-based TSO a modular and reliable predictive maintenance model to optimize the maintenance plan of its HV transformers

Project Metrics

- 2022, 2 months
- AFRY Management Consulting Berlin & AFRY AMS Zurich

Client

- EU TSO

Service and Approach

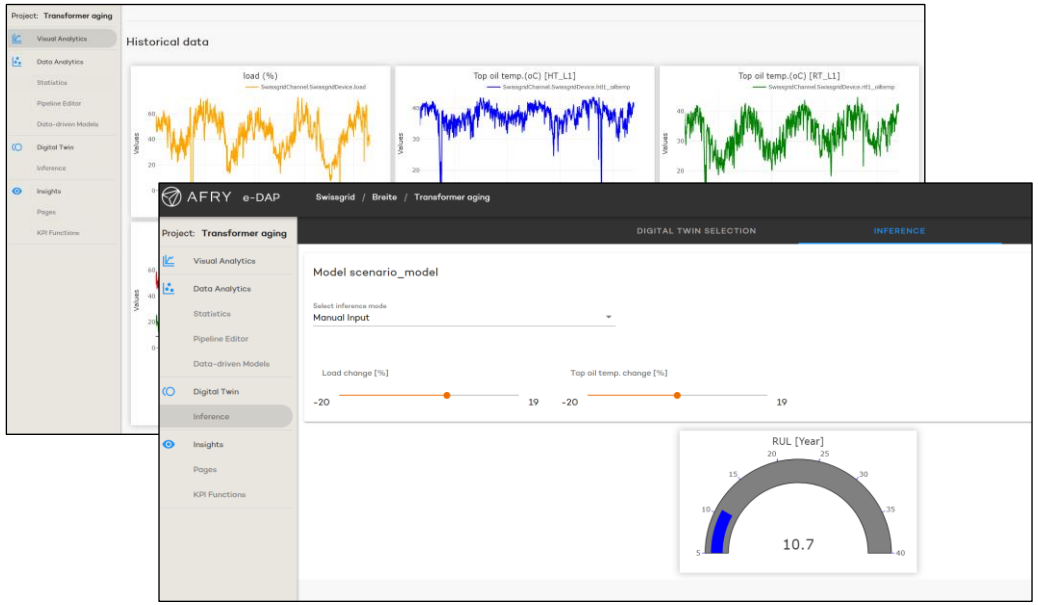
- AFRY used E-DAP to build a predictive maintenance model for the aging of the transformer
- AFRY used existing data (both frequent and seldom) to understand how the maintenance has been conducted over the last 40 years.
- AFRY analyzed any indication of oil degradation from the inspection analysis conducted by the client to feedback patterns in e-DAP
- AFRY identified the paper polymerization as the main cause of degradation for the transformer useful life
- AFRY used analytical modelling relating the collected data to the health index and resorted to machine learning to predict future trends

Client Impact and Value Added

- Swissgrid holds a license for a modular and reliable predictive maintenance model that can predict the remaining useful life of its HV transformers and optimize as such its maintenance plan
- Swissgrid is capable to conduct scenario analysis changing temperature, load, and oil cleaning periodicity and assessing their sensitivity to the asset health index update

Situation and Challenge

- The client has measured and stored the temperature condition of the oil windings and the load of the transformer every 5 minutes for the past five years
- It is unclear if and how the client can correlate the condition measurement data of its transformer with its physical aging and move to a reliable and holistic condition-based maintenance strategy !



REFERENCE: PREDICTIVE MAINTENANCE

AFRY designed for a swiss NPP a modular data predictive model to detect faults in the neutronics signal, augmented by a causality analysis module

Project Metrics

- 2021, 4.5 months
- AFRY AMS Zurich

Client

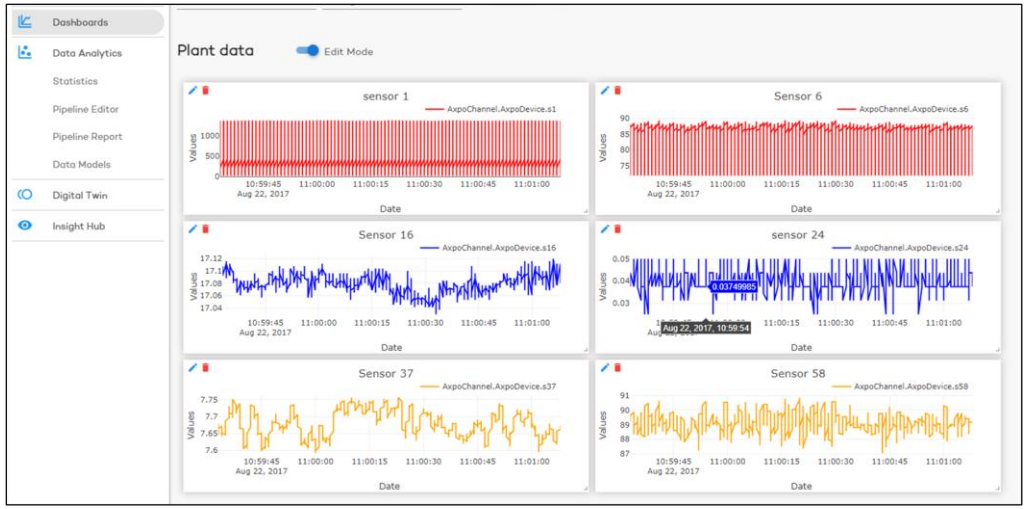
- NPP CH

Situation and Challenge

- AXPO had no proven framework for anomaly detection in neutronics signals during plant start-up, and its relationship with the steam production and plant instabilities.
- 'Deterministic' causality analysis has proven weak in predicting faulty signals relating to flow instabilities and potential dry-out in the reactor pressure vessel.

Service and Approach

- AFRY conducted on-site survey of plants and infrastructure, collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY created a unique (unpublished hitherto) fully-fledged anomaly detection module in e-DAP
- AFRY made use of 5 cycles and 1 cycle-startup data from the plant to show changes in the causality and cross-correlation in the system that occur over time
- AFRY built an online framework accessible to the client, in which both visual analytics of real data is provided, together with a live inference of the digital twin using sensor data.



Client Impact and Value Added

- AXPO gained disposal of on-line business intelligence tool, providing a daily inspection of operations and predicting and monitoring the asset's health under defined KPIs
- AXPO is capable to infer potential failure scenarios in the asset using real time data (once their IoT is connected to e-DAP Edge) as input to the asset's digital twin.

REFERENCE: PREDICTIVE MAINTENANCE

AFRY built a component digital twin for predictive maintenance of a gas turbine, Gas Turbine OEM, Switzerland

Project Metrics

- 2021, 1.7 months
- AFRY AMS Zurich

Client

- Gas Turbine OEM, Switzerland

Situation and Challenge

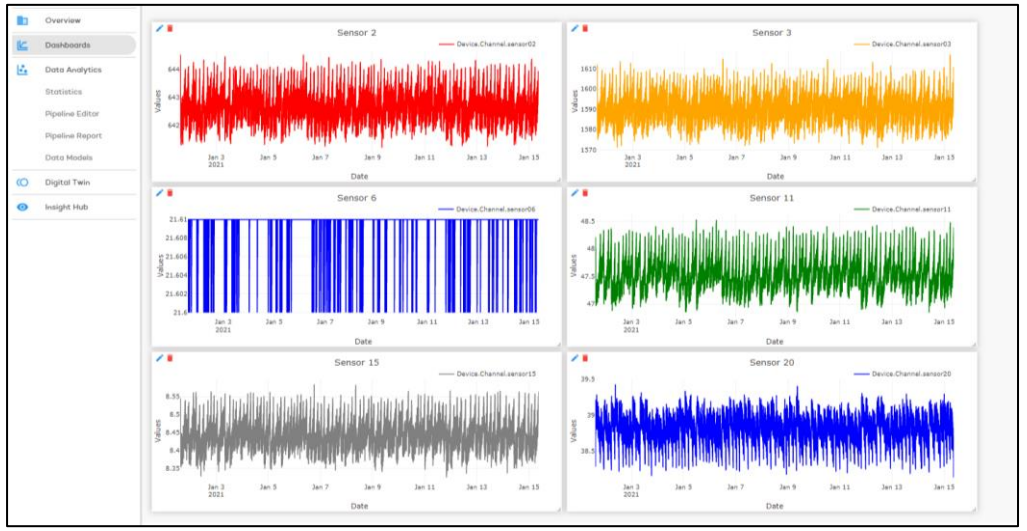
- The challenge is to determine the Remaining Useful Life (RUL) of the turbine before the next fault to occur
- The idea is to be capable to explore the effect on the production of changing operational conditions of the gas turbine : load, temperature, pressure, etc.

Service and Approach

- AFRY conducted on-site survey of plants and infrastructure, collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY used selected ML algorithms for predictive modelling, targeting the Remaining Useful Life (RUL)
- AFRY used the data-model to forecast RUL and predict when the turbine needs maintenance. Excellent results have been obtained
- AFRY designed an online workflow into e-DAP, embedding the data-model and the associated KPI's
- AFRY used the platform to infer RUL and KPI's for future conditions
- AFRY transferred the tool to the client and provided training of its users.

Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's health under defined KPIs
- The client can infer possible failure cases using real time data as input to the asset's digital twin. Next step is to connect the IOT to e-DAP Edge.



REFERENCE: OPERATIONAL EXCELLENCE

AFRY designed a component digital twin of a wind farm for operational excellence, Wind-Energy Operator, Sweden

Project Metrics

- 2022, 4.5 months
- AFRY Management Consulting Paris & AFRY AMS Zurich

Client

- Wind Energy Operator, Sweden

Service and Approach

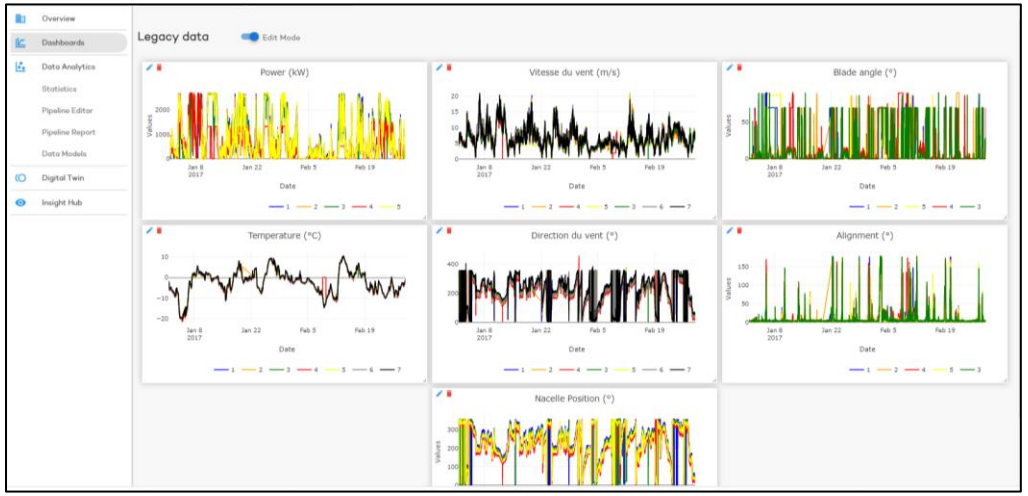
- AFRY conducted on-site survey of plants and infrastructure, collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY selected the appropriate ML algorithm for predictive modelling
- AFRY used the 5-years legacy data (wind direction and speed, blade angle, turbulence, orientations, etc.) to predict the power
- AFRY designed an online workflow into e-DAP, embedding the data-model, the digital twin and the associated KPI's in a dedicated insight page
- AFRY used the digital twin to analyze the production losses per turbine and determine other KPI's for future operational conditions.

Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's health under defined KPIs
- The client can act on the critical issues resulted from machine learning. It can infer potential failure scenarios using real time data as input to its digital twin.

Situation and Challenge

- The client's objective is to have a digital control system of the asset and predict the power within days.
- The client should be capable to identify and explain the deviations that appeared since the launch of the production : what went wrong in the meantime and where exactly ?
- The client should be capable to perform predictive maintenance.



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REFERENCE: OPERATIONAL EXCELLENCE

AFRY designed a component digital twin for a process engineering plant for operational excellence, Process Eng. OEM, UK

Project Metrics

- 2021-22, 6 months
- AFRY AMS Zurich

Client

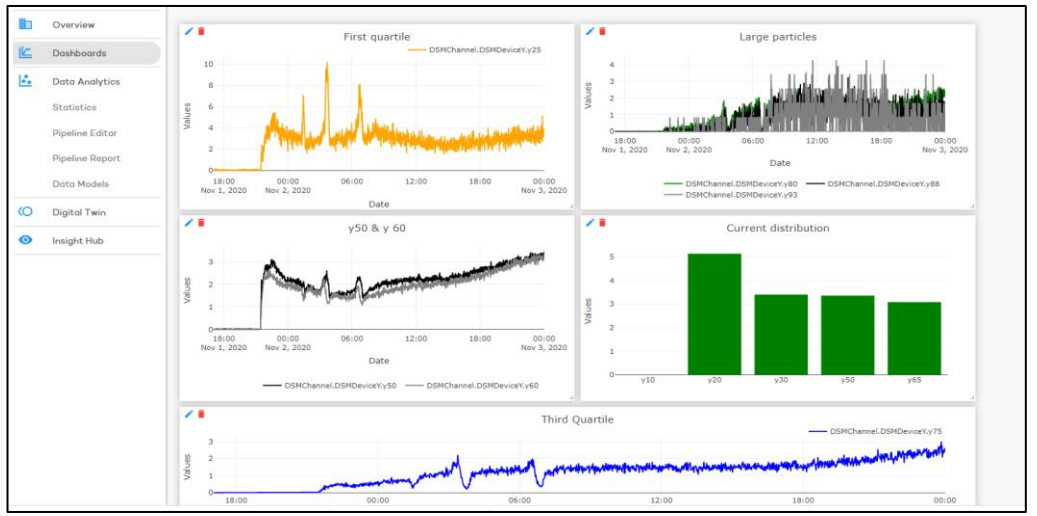
- Process Eng. OEM, UK

Situation and Challenge

- The challenge is to predict the particle distribution at each batch-phase of the crystallization process ahead of time, and thus the quality of the yield
- The case explores the effect on the yield of changing the raw material properties.

Service and Approach

- AFRY collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY selected the appropriate ML algorithm for predictive modelling, incl. developing a dedicated sensitivity analysis tool for the purpose
- AFRY used the model as the engine of the 'Component Digital Twin – CDT-' to predict the crystallization process of the raw material.
- AFRY used the CDT to forecast the particle distribution at each batch-phase (thus the quality of the yield), and other KPI's
- AFRY used the platform as an asset management tool, with focus on production control.



Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's performance
- The client is capable to control the production on a daily basis and optimize the process for the best outcome (act at the level of the process batch)
- Next step is to transition from a cloud-based to an on-premise solution.

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Documentation & demo:
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