MOL's Journey to Advanced Business Intelligence & Reporting

Building on Advanced Operational Intelligence with the PI System

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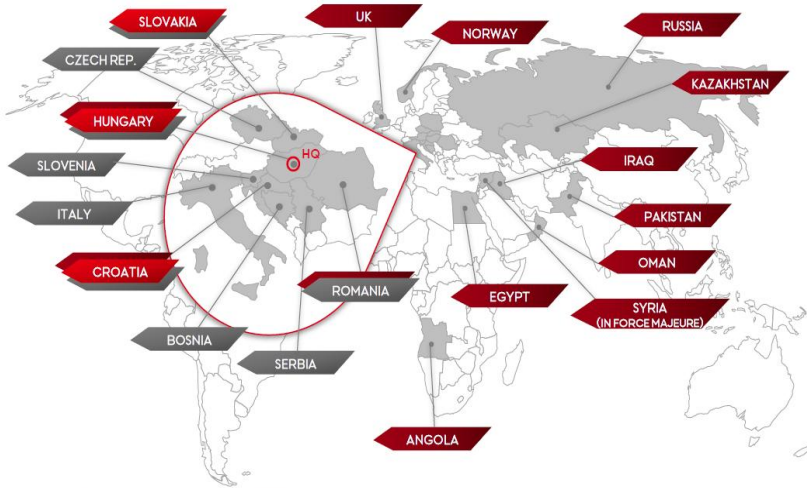
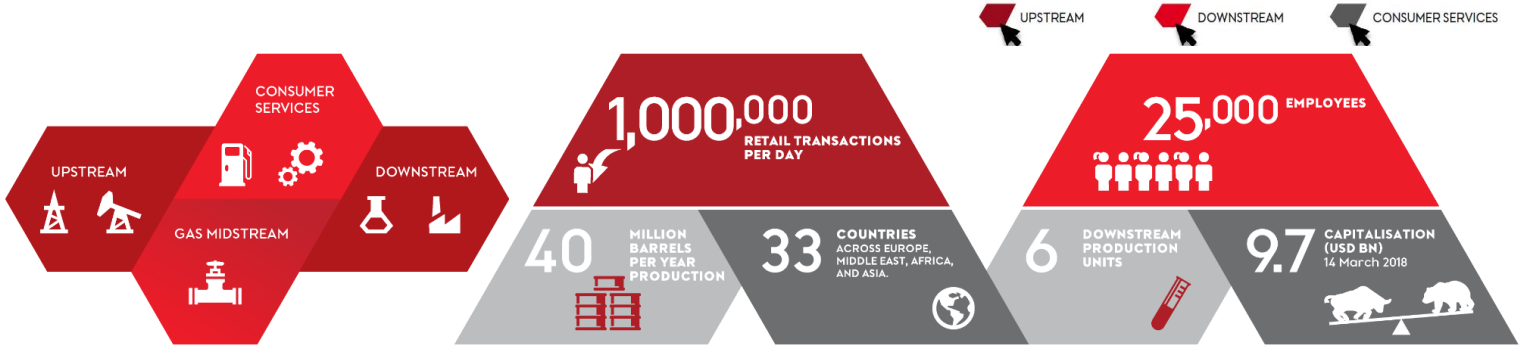
Agenda

- Introduction
- Data Ingestion in Refining
- How Can We utilize the Advanced Techniques
- Implementation of a Enterprise Data Hub
- Results
- Example of an Application Development with New Capabilities
- Summary

The MOL Group at a Glance

- MOL GROUP IS AN INTEGRATED, INTERNATIONAL OIL AND GAS COMPANY, HEADQUARTERED IN BUDAPEST, HUNGARY
- ACTIVE IN OVER 30 COUNTRIES
- INTERNATIONAL WORKFORCE OF OVER 25,000 PEOPLE
- TRACK RECORD OF MORE THAN 100 YEARS IN THE INDUSTRY





An Integrated Downstream Value Chain

- **Integrated Fuels Value Chain:**
  - 4 refineries, 2 Petrochem plants
  - Logistics including 2,000 retail stations

- **PI System Overview:**
  - 4 HA collectives, ~400K tags
  - Elements:
    - ~350 element templates
    - ~23K elements & growing (65x scale)
  - Events:
    - ~6K Notifications
    - ~10K Event Frames analyses
    - ~50K Event Frames (exception based operations)

- **PI Vision is the primary process visualization platform**

Process Information & Automation (PI&A) Team's Focus

ARCHITECTURE DEVELOPMENT OF REFINERY INFORMATION SYSTEM

DEVELOPMENT HUMAN CAPABILITIES IN AUT. & INFORMATION

PROCESS CONTROL DEVELOPMENT

PROJECT & CHANGE REQUEST MANAGEMENT

PROVIDING BI APPLICATIONS & SOLUTIONS FOR OPERATION IMPROVEMENT

CYBER SECURITY COMPLIANCE

ADVANCED EFFICIENCY APPLICATIONS	REFINERY INFORMATION SYSTEMS	ADVANCED SAFETY & RELIABILITY APPLICATIONS
▪ ADVANCED PROCESS CONTROL ▪ KPI SYSTEMS ▪ SOLOMON CALCULATION ▪ ENERGY MONITORING ▪ ADVANCED ANALYTICS	▪ NICE (NATURAL INFO CENTRE) ▪ **PLANT INFORMATION (PI SYSTEM)** ▪ SHAREPOINT DEVELOPMENTS ▪ SIGMAFINE (MATERIAL BALANCE) ▪ OPRALOG (E-LOGBOOK)	▪ ALARM MANAGEMENT ▪ INDUSTRIAL NETWORK ▪ HUMAN MACHINE INTERFACE ▪ OPERATOR TRAINING SIMULATOR ▪ CONTROL PERFORMANCE MONITOR

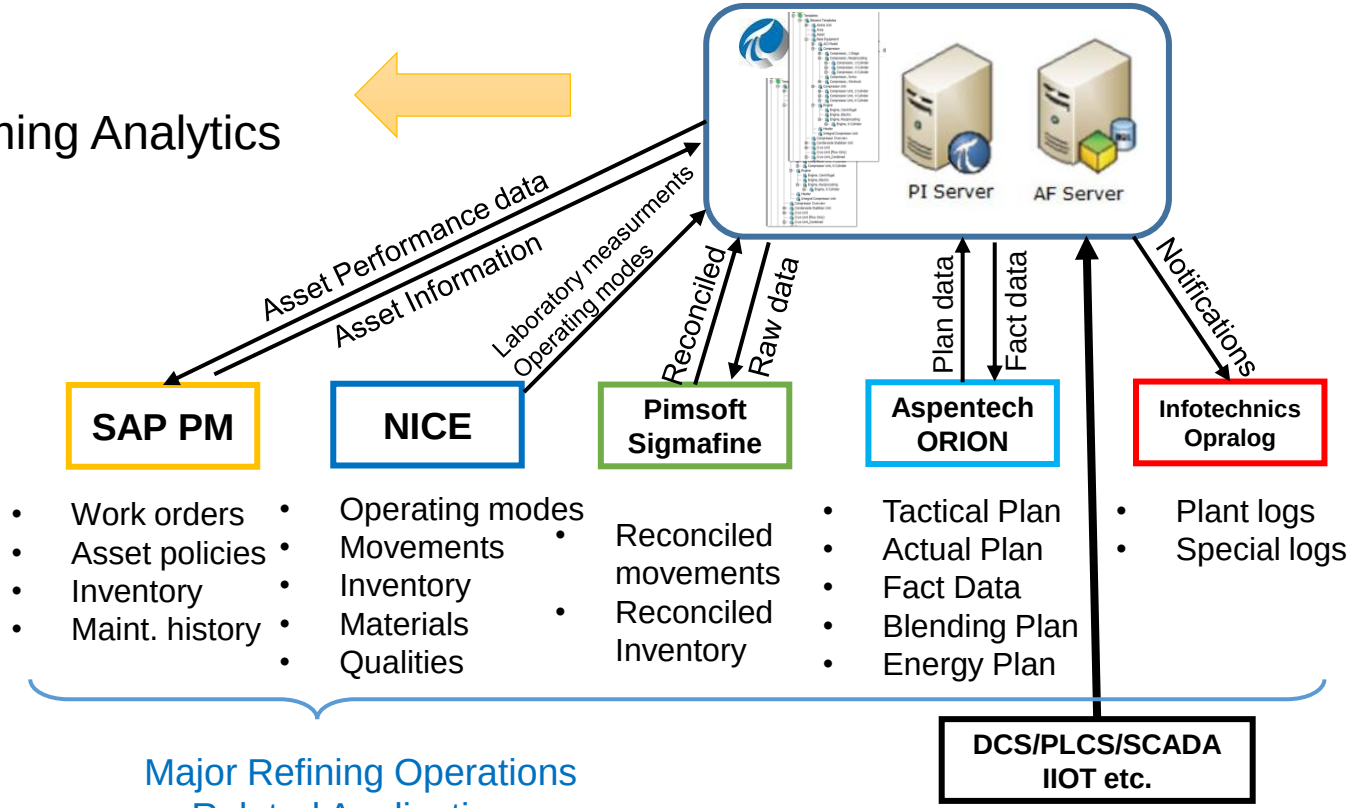
Typical Site “Operational Data Hub”

Human Analytics
Real Time Streaming Analytics

PI Vision

PI Notifications

PI Datalink Reports



Major Refining Operations Related Applications

“Operational Data Hub” Typical Applications

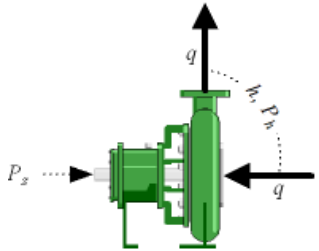
KPI system

- White product yield
- Energy consumption
- APC utilization

Asset monitoring

+notification

- Operation envelope
- IOW monitoring
- HTHA monitoring
- Analyzer validation
- SAP PM integration for CBM
- Flare monitoring
- Environmental reporting
- Control loop mode monitoring
- Failsafe mode monitoring
- Natural gas consumption forecasting (Predictive analytics)



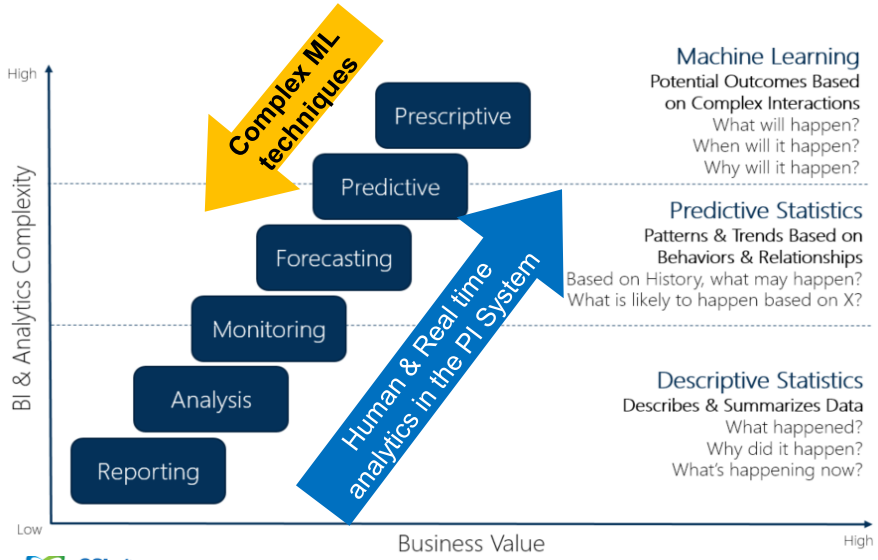
Equipment / Asset models

- Pump efficiency
- Exchanger Fouling
- PSA valve monitoring
- DCU feed composition calculation

Utilization of Advanced Analytics & Reporting

Data Models

- Available Data
- Emerging Methods / Architectures / Applications
- Improve Technological Efficiency



Advanced Reporting

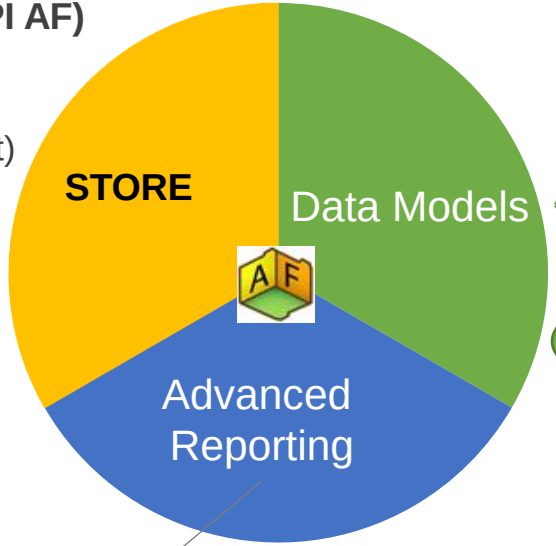
- Increase user satisfaction
- Increase collaboration
- Improve business efficiency

- Integrated data source
- Deeper information processing
- Escalation
- Self Service Goal
- Visual Techniques

Vision – PI System (PI AF) is the Foundation

- Time-series sensor data
- **Time-series pre-processed data (PI AF)**
- Production management data:
  - material/energy streams (plan, fact)

    inventory, movements
- Laboratory data
- Text data: logs
- Asset Monitoring System data
- Alarm data



Supervised
Regression, Classification

Predict outcomes
- Unit level production models (yield energy prediction)
- Asset level production models (quality calculations, predictive maintenance calculations)
- Anomaly detection

Unsupervised
Clustering, Association

Find hidden patterns
- Anomaly detection
- Operation classification for further analysis

Business Impact	Ease of Use & Implement	Depth of Information
★ ☆ ☆	★ ★ ★	★ ☆ ☆

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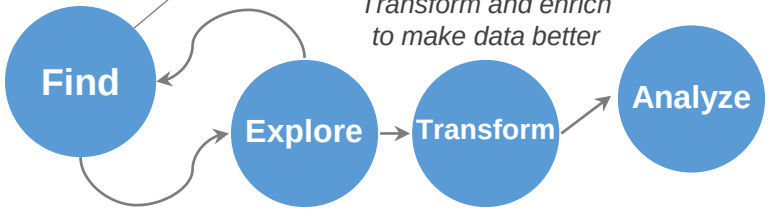
★ ★ ★	☆ ☆ ☆	★ ★ ★



Identify relevant data and understand its potential

Transform and enrich to make data better

Blend and Analyze to Discover New Insights

New Advanced BI Implemetation Program in MOL Refining

Architecture Stream

Design, procure and implement on-premise data storage system.

Technogy: Cloudera Enterprise Data Hub (Hadoop technology)

Early 2018

Primary system integration and data ingestion setup:

- ***Sensor Data***
- ***Laboratory Measurements***
- ***Operating modes***
- ***Reconciled Data***
- ***Plan Data***
- ***Smart Data***

2018

Deployed all scheduled jobs to production, handover for operation team

Early 2019

Integration of Opralog and NICE systems to

- ***Movements***
- ***Inventory***
- ***Materials***
- ***Daily Unit Logs***
- ***Dispatcher Log***
- ***Special Entries***

Analytics Stream

Development and deployment of an energy nomination support application

2018

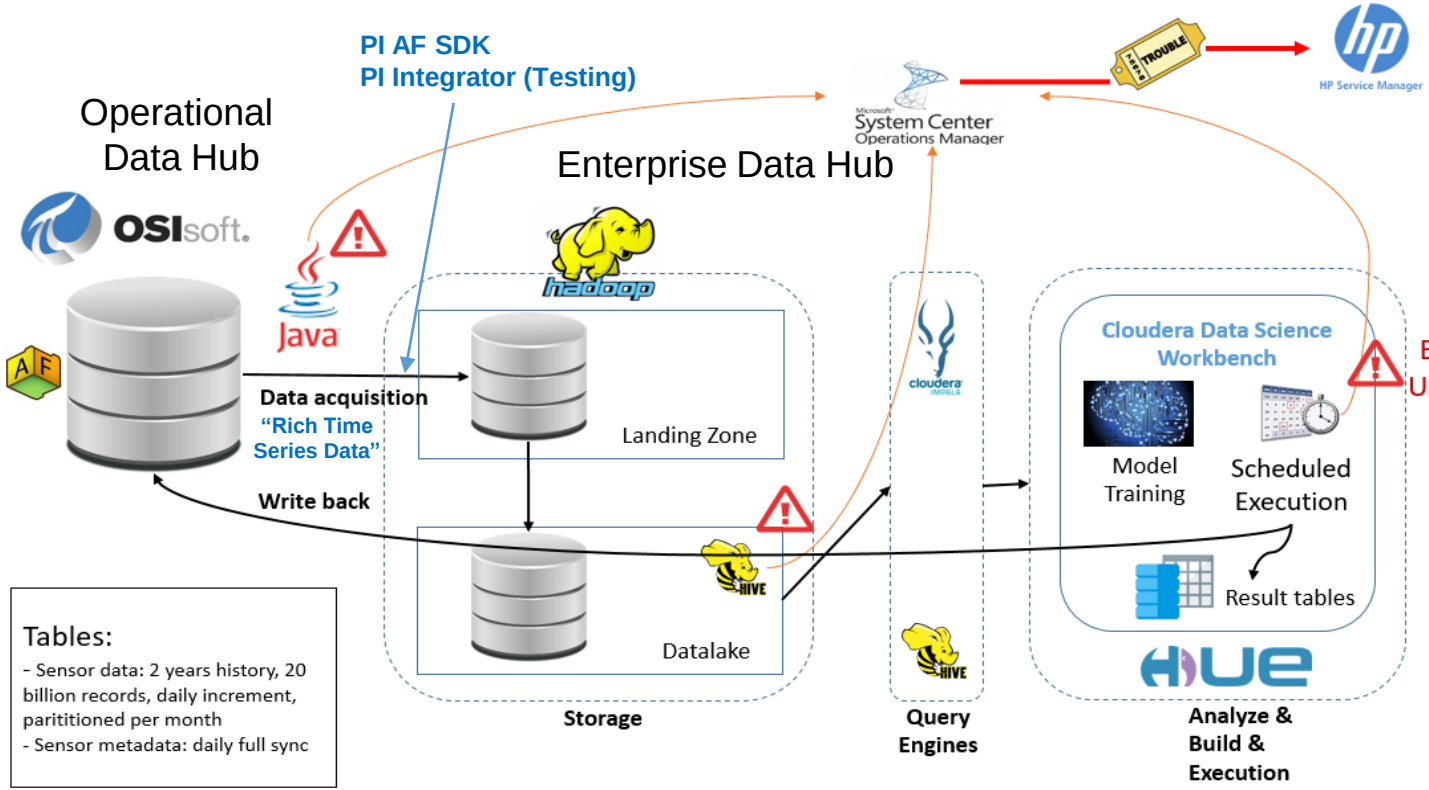
New Analysis Cases (Ongoing)

2019

Design and implement production management related reports, dashboards

2020

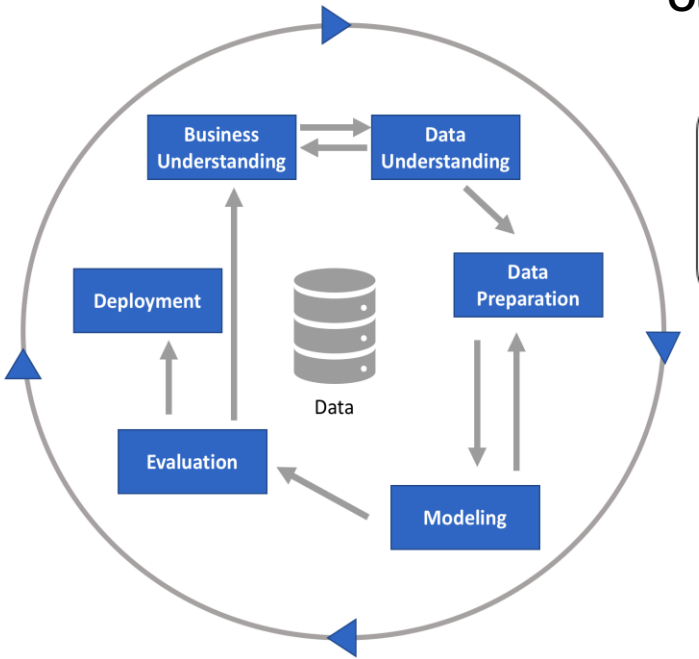
Introducing the Enterprise Data Hub



Features

- Daily upload
- Streaming
- Model Building
- Model Execution
- Supervised by IT
- PI&A enabled

Analysis Process – A Partnership Between OT and IT



Our Team

Domain knowledge
- *Correlations*
- *Preconceptions*
- *Data scoping*

Operations — PI&A

Operations User

Operations Side Data Analyst

ENTERPRISE ANALYTICS & DATA INNOVATION

Data Scientist

Data Engineer

MOL IS

Operator

Operational & Data, PI System Understanding

Explore & Analyze & Build → Deploy → Operate

Cloudera Enterprise Data Hub

Expected **Defined Business** Case Delivery Time <3 months

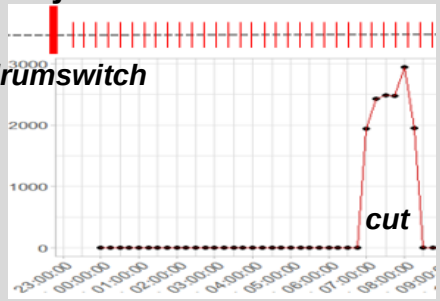
Results

Pilot Analysis Case

Delayed Coker electricity demand forecast model

Objective

Predict coke cutting time 8h before the procedure



Result

Forecast model **implemented in PI-AF**

New process: **Intraday energy trade**

Ongoing / Planned Developments

New Analysis Cases (2019)

Analysis of opportunity crude processing effect on energy consumption and other operations such as corrosion, OW & IOW limits

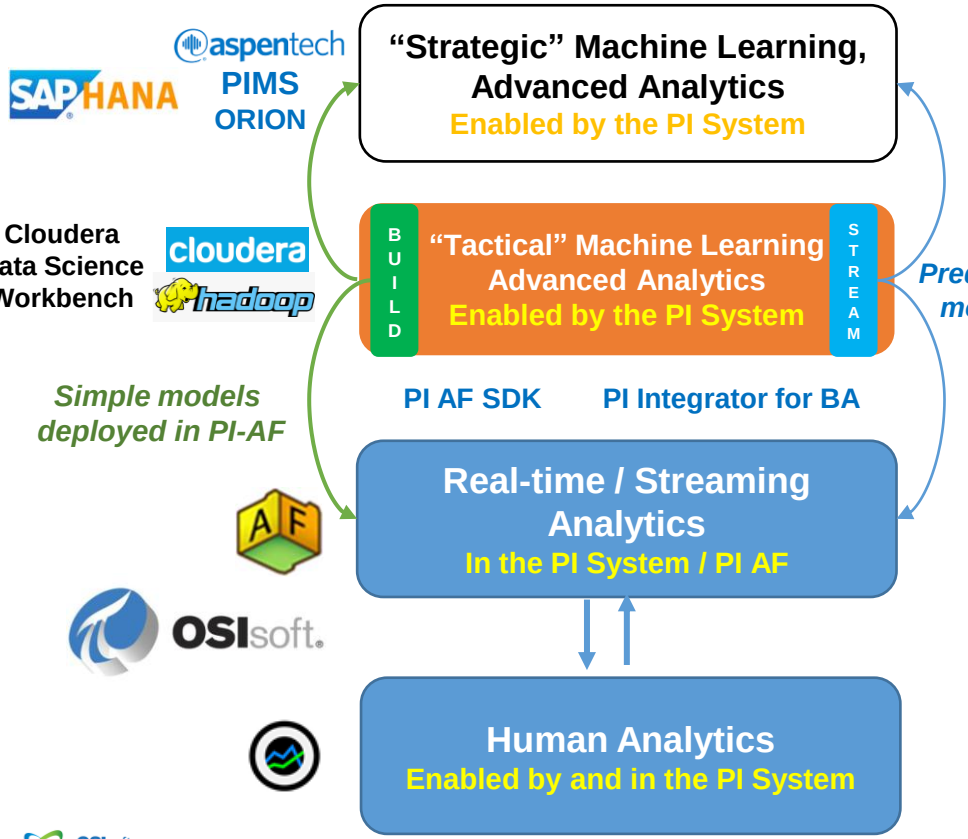
Implementation of quality calculation for distillation process

Build up Asset Degradation models for Heat Exchangers

Advanced Reporting Pilots

- *Capacity Utilization Report*
- *IOW Report*

Analytics Landscape – A Layers of Analytics Strategy



Process developments:

- Predictive maintenance
- Value chain optimization (Crude optimization, Product Line Optimization)

Think Phase

Analytics cases:

- Inferential developments: Hydrotreater Cloud Point, Cut Points
- Exploration of negative production phenomenons (Coke eruptions, Inrcreased coke yield, Increased bromine index)
- Development of equipment degradation models
- Tuning of planning & scheduling models
- Development of energy forecasting models

5+ Analytical Cases

Calculation of:

- Product Line Optimization Dashboards
- Energy / Yield KPI systems
- Forecast models: Natural gas & electrical peak
- Asset Monitoring: Tech. envelope, IOW, HTHA
- Equipment models: PSA Valves, Rotating equipment, etc.
- Analyzer Validation

20+ Applications

Enablement of:

- Data based decision
- Real time situational awareness
- Management by Exception

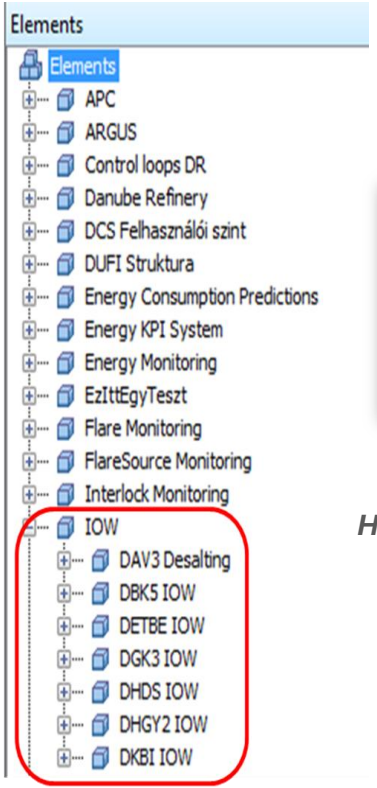
61,000 configured event frames across 6 prod. blocks

Example of an Application Development with Advanced Features: IOW

Business Need, Definition of IOW

IOW - Established limits for process variables (parameters) that can affect the integrity of the equipment if the process operation deviates from the established limits for a predetermined length of time – All in PI AF

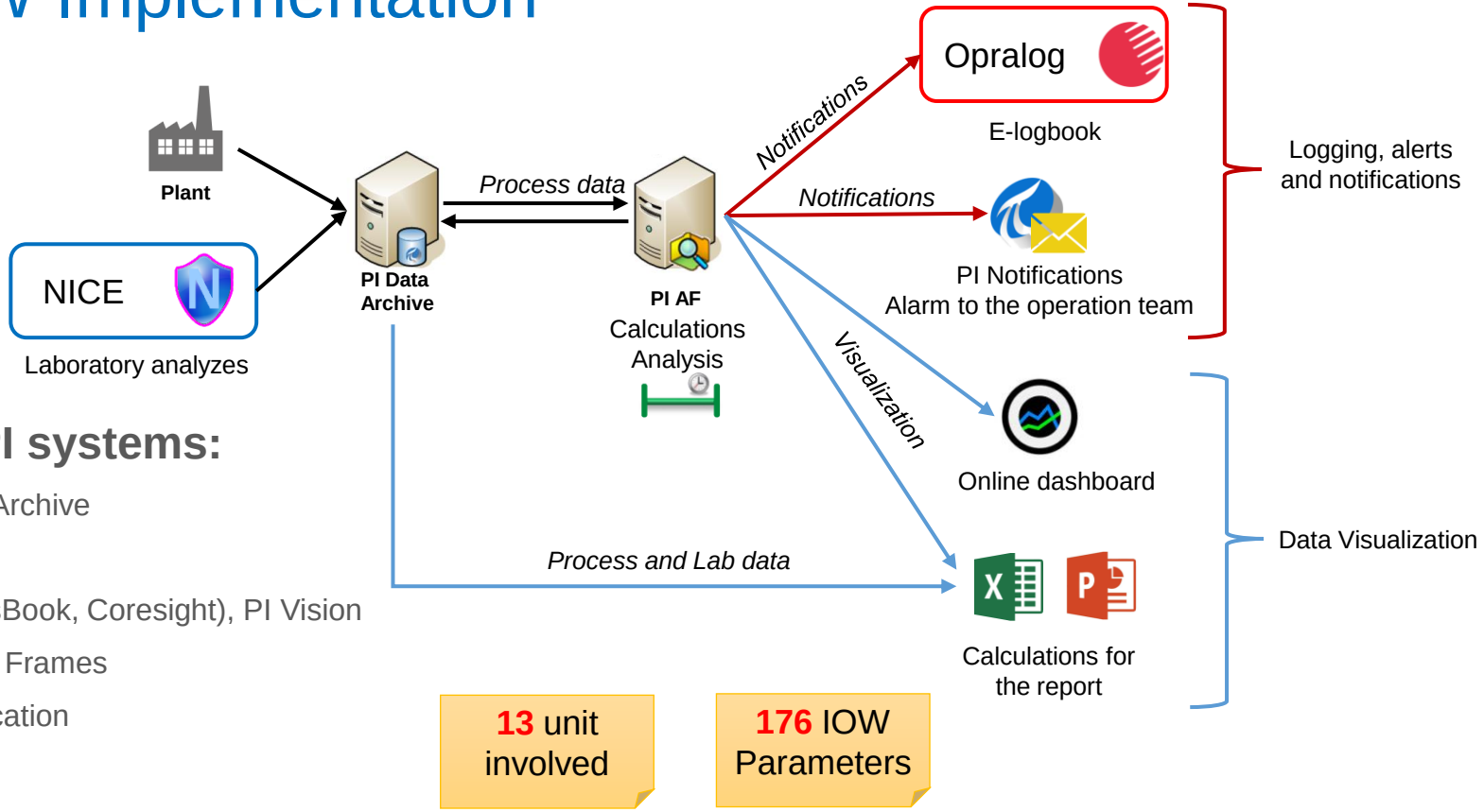
Requires attention within specified timeframe	Requires drastic and/or immediate action
Standard	**Critical**
Heater Tube Skin Temperature	Boiler Feed Water Level
Crude Fractionator Dew Point Temperature	Hydro-process Reactor Temperature
pH of Crude Tower Overhead	Heater Tube Skin Temperature
Desalter Outlet Salt Content	Sulfuric Acid Strength in Alkylation



High Temperature Hydrogen Attack (HTHA)

Tesoro, Anacortes Refinery 2010

IOW Implementation



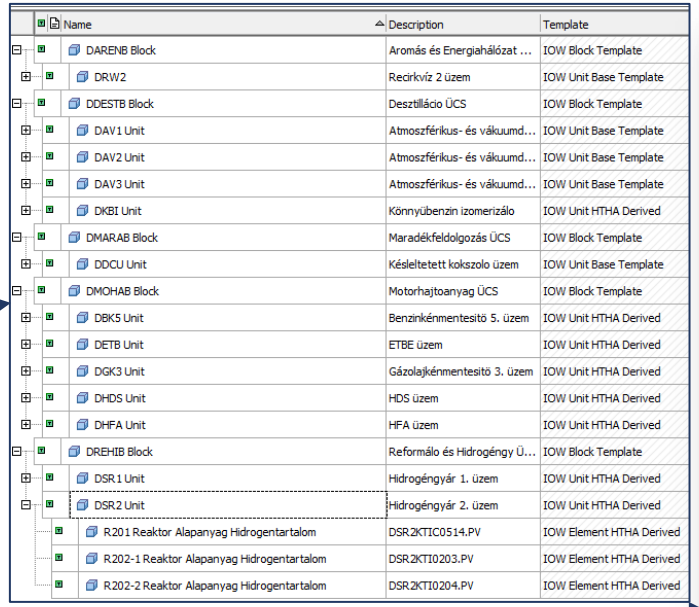
Used PI systems:

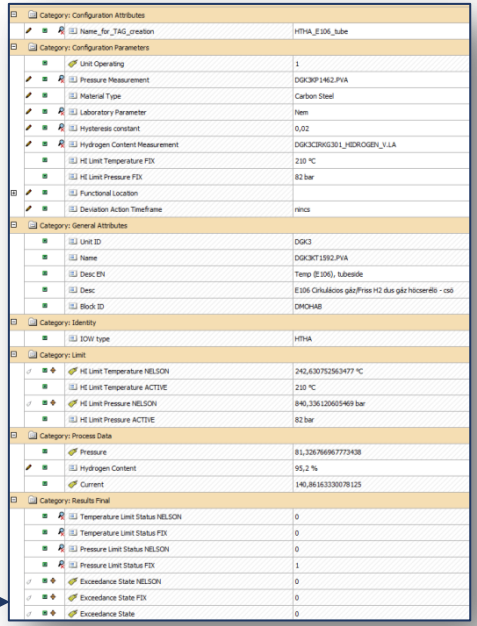
- PI Data Archive
- PI AF
- (ProcessBook, Coresight), PI Vision
- PI Event Frames
- PI Notification

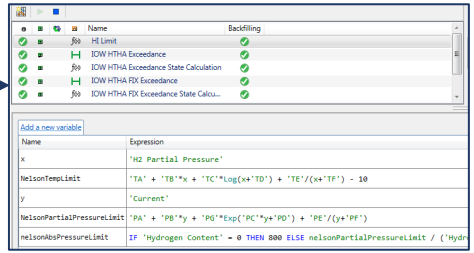
IOW Implementation

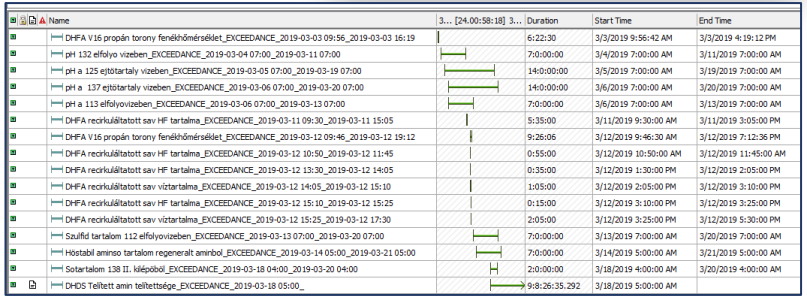
- Integrity Operating Windows
  - IOW Block Template
    Aggregate the IOW exceedances per Unit Blocks
    - IOW Unit Base Template
      Aggregate the IOW exceedances per Units
      - IOW Element Base Template
        - *Shows the IOW Parameters*
        - *Analysis*
        - *Event Frame*
        - *Notifications*

176 IOW Parameters

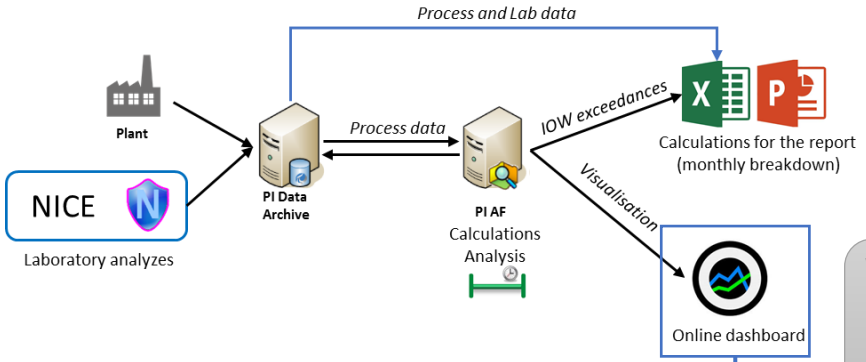








Visualising for Continuous Monitoring



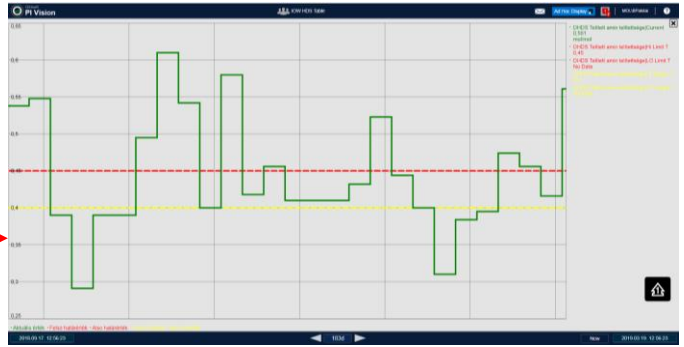
- IOW exceedances are downloaded by PI Datalink from PI AF database and processed in Excel
- The objective is to check the effect of the action taken on the number and duration of exceedances on monthly basis

What are we expecting from the continuous monitoring?

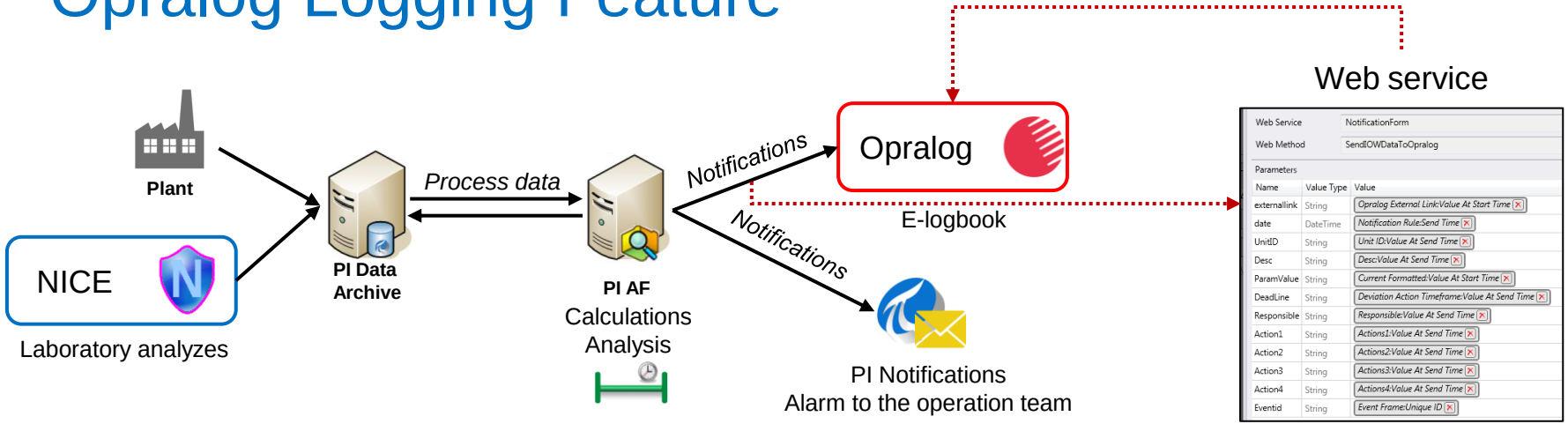
It is not enough to monitor our system, but we have to make actions as well!

DS Termelés MOL - IOW HDS — IOW OVERVIEW

Üzemnév	IOW Paraméter Leírása PI Tag	IOW LO	Target LO	Aktuális	Target HI	IOW HI	Trend
DHDS	DHDS AAG kén tartalom DHDSAAG_S_TART.LA	Undef.	Undef.	2,01	2,5	2,64	
DHDS	DHDS beadagolt mosóvíz DHDSHFI1024.PV	13,5	14	17,76	Undef.	Undef.	
DHDS	DHDS Savszám (TAN) alapanyagból DHDSAAG_SAVSZAM.LA	Undef.	Undef.	0,09	1,5	5	
DHDS	DHDS Telített amin telítettsége DHDSTMDEAK101_SZULF_TART_MOLH2S_MOLMDEA.LA	Undef.	Undef.	0,56	0,4	0,45	
DHDS	DHDS W104 1-4 belépő hőmérséklet (HT1177) DHDSHT1177.PVA	Undef.	Undef.	201,29	220	230	



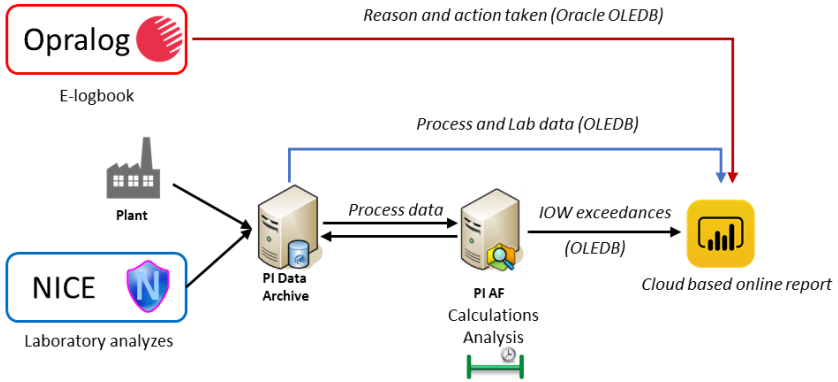
Opralog Logging Feature

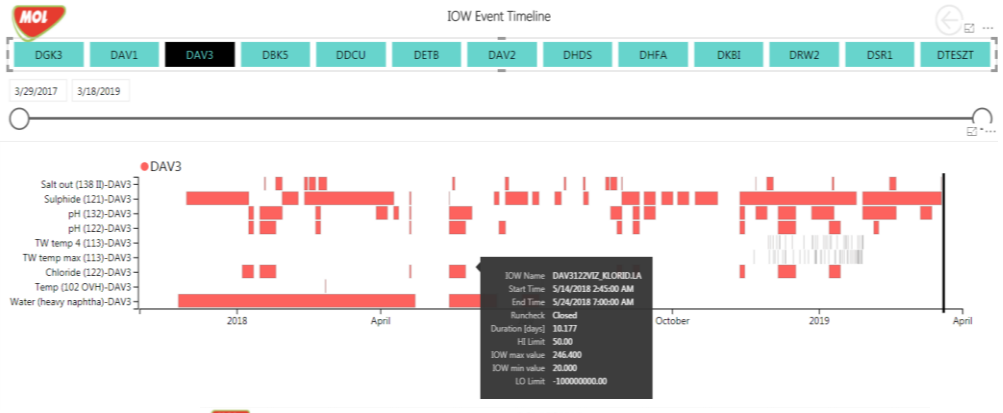


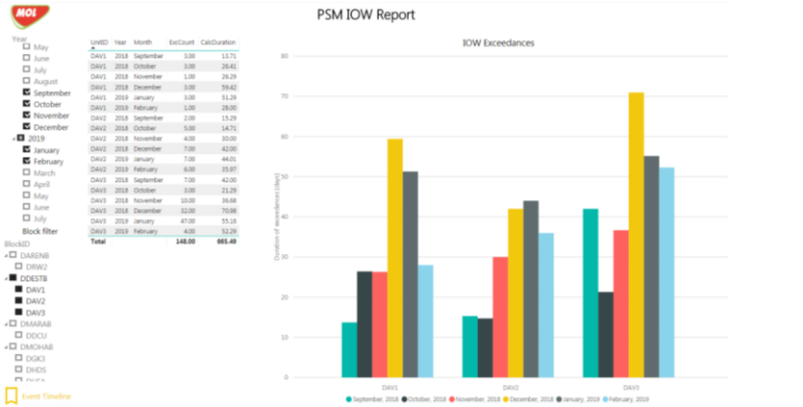
Work initiation:

- Create effective actions
- Clear responsibilities
- Well-defined tasks
- Using actions to handle defined damage mechanisms

Development of IOW Advanced Reporting

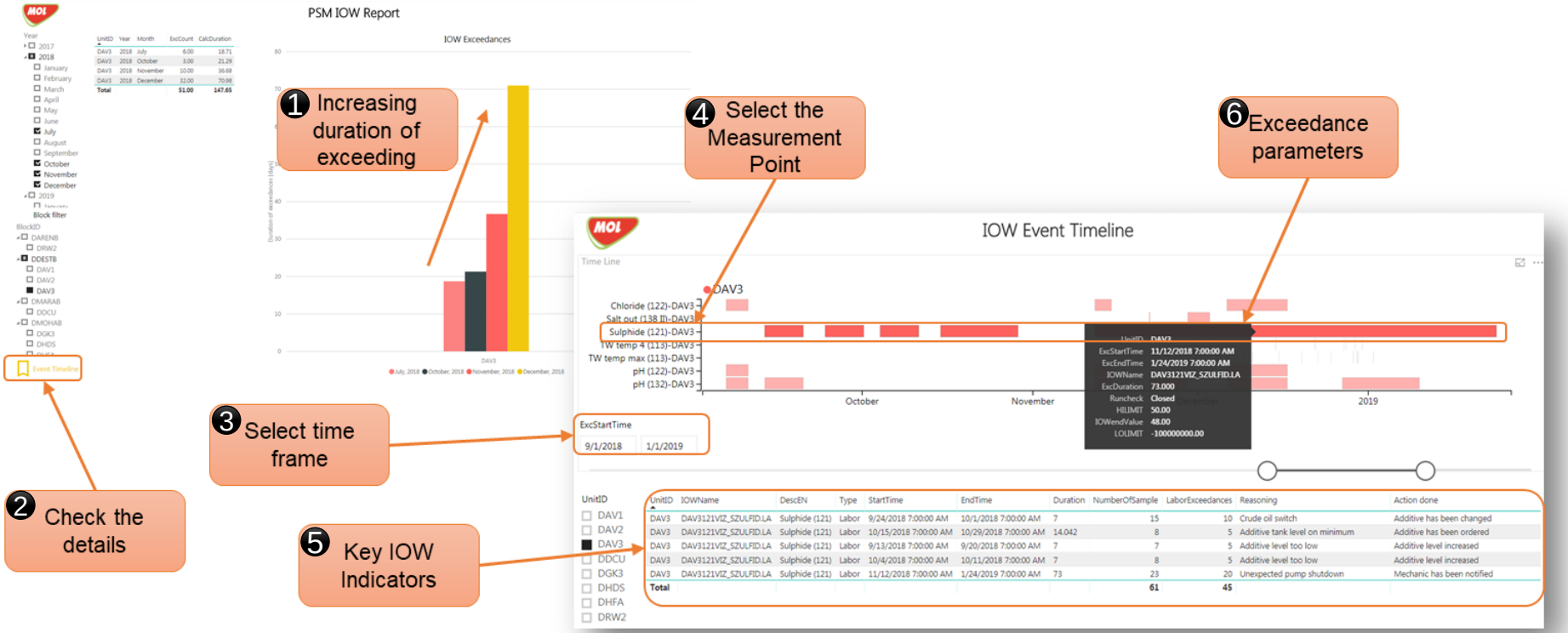




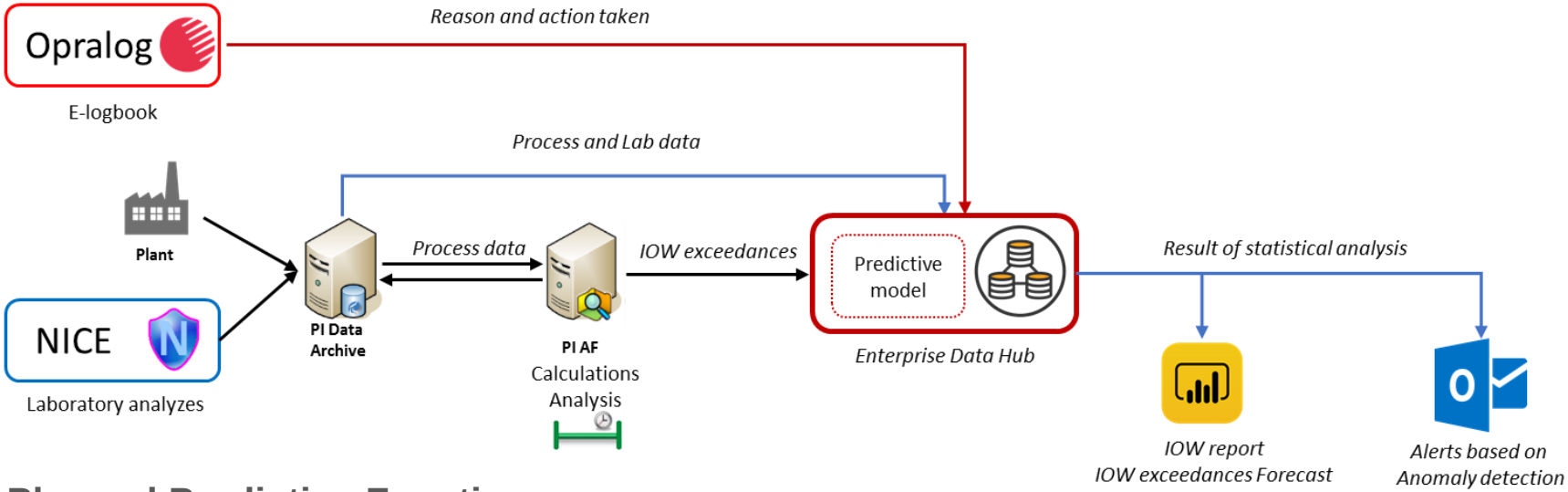


- Transform data into stunning visuals and share them with colleagues on any device.
- Up-to-date data model due to automatic update.
- Collaborate on and share customized dashboards and interactive reports

Example of Advanced IOW Reporting



Advanced IOW Reporting Enterprise Data Hub Integration



Planned Predictive Functions:

- Prediction of exceedance number rates in different operating modes
- Anomaly detection feature

MOL GROUP

Extending “Layers of Analytics” with Advanced BI and Reporting Capabilities with PI AF &Hadoop/Cloudera

CHALLENGE

Difficulty of implementing advanced BI and reporting that included transactional data

- Advanced operational analytics and real-time analytics in PI AF, while widely used, did not address more advanced BI and reporting needs
- Issues with SME and PI System knowledge with IT lead BI/reporting projects

SOLUTION

Expanded the “Layers of Analytics” via PI AF/Azure to include advanced BI & reporting with Hadoop/Cloudera

- Developed new work flow that improved the OT/IT partnership
- Leveraged PI AF/PI EF to develop “rich data” stream to Hadoop / Cloudera environment
- Integrated with current IOW for advanced reporting

RESULTS

Laid the foundation for rapid, sustainable development and deployment of a wide range of advanced BI & reporting projects

- Implemented forecast model for Coke cutting and electrical energy demand prediction
- Mitigated electrical trading penalty: 150 k$ / year
- Developed & implemented prediction model in 3 months

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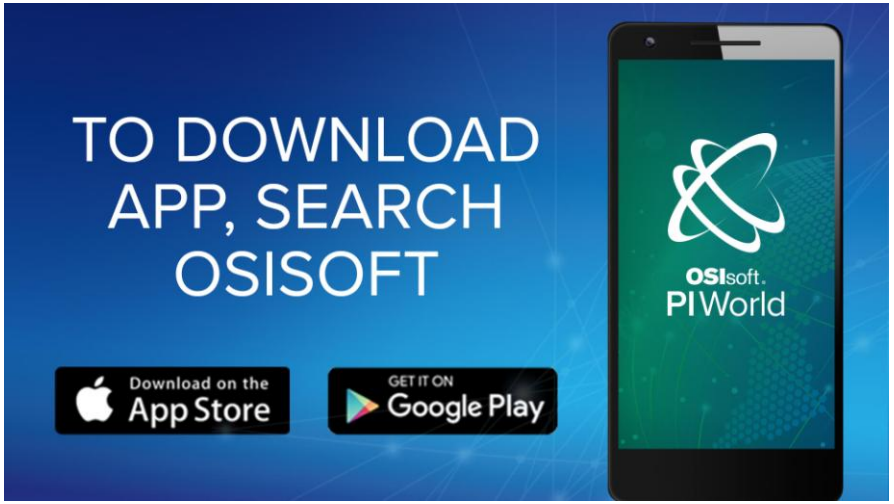
Questions?

Please wait for the **microphone**

State your **name & company**

Please remember



IOW Implementation

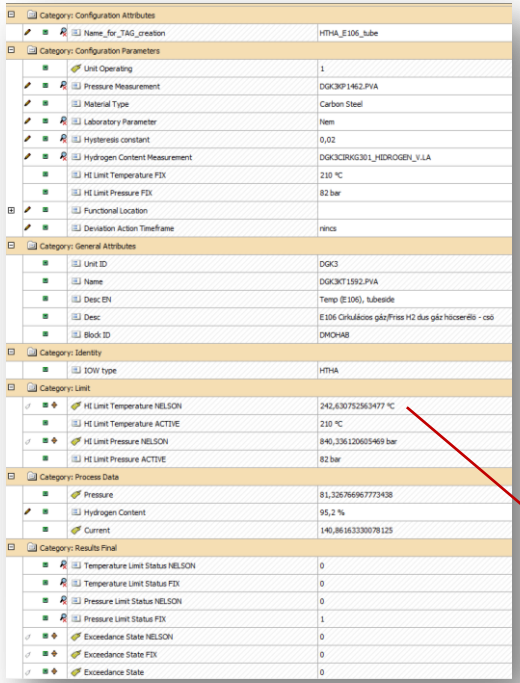
IOW Block Template

- Aggregate the IOW exceedances per Unit Blocks
- Stucture in Asset Framework (PI AF)

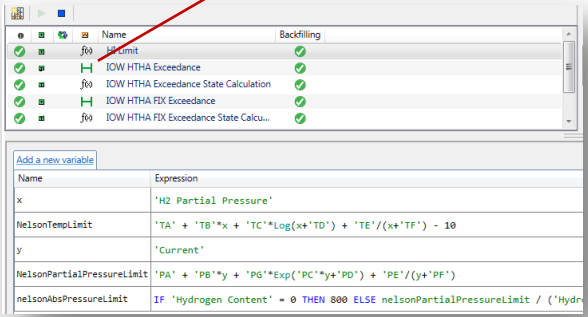
Name	Description	Template
DARENB Block	Aromás és Energiahálózat ...	IOW Block Template
DRW2	Recirkvíz 2 üzem	IOW Unit Base Template
DDESTB Block	Deszttillácio ÜCS	IOW Block Template
DAV1 Unit	Atmoszférikus- és vákuumd...	IOW Unit Base Template
DAV2 Unit	Atmoszférikus- és vákuumd...	IOW Unit Base Template
DAV3 Unit	Atmoszférikus- és vákuumd...	IOW Unit Base Template
DKBI Unit	Könnyübenzin izomerizálo	IOW Unit HTHA Derived
DMARAB Block	Maradékfeldolgozás ÜCS	IOW Block Template
DDCU Unit	Késleltetett kokszolo üzem	IOW Unit Base Template
DMOHAB Block	Motorhajtoanyag ÜCS	IOW Block Template
DBK5 Unit	Benzinkénmentesitö 5. üzem	IOW Unit HTHA Derived
DETB Unit	ETBE üzem	IOW Unit HTHA Derived
DGK3 Unit	Gázolajkénmentesitö 3. üzem	IOW Unit HTHA Derived
DHDS Unit	HDS üzem	IOW Unit HTHA Derived
DHFA Unit	HFA üzem	IOW Unit HTHA Derived
DREHIB Block	Reformálo és Hidrogéngy Ü...	IOW Block Template
DSR1 Unit	Hidrogéngyár 1. üzem	IOW Unit HTHA Derived
DSR2 Unit	Hidrogéngyár 2. üzem	IOW Unit HTHA Derived
R201 Reaktor Alapanyag Hidrogentartalom	DSR2KTIC0514.PV	IOW Element HTHA Derived
R202-1 Reaktor Alapanyag Hidrogentartalom	DSR2KTI0203.PV	IOW Element HTHA Derived
R202-2 Reaktor Alapanyag Hidrogentartalom	DSR2KTI0204.PV	IOW Element HTHA Derived

IOW PI AF Element Base Template

- Calculation, limit evaulation
- Advanced analytics and Event Frames
- Notifications



IOW HTHA Exceedance state calculation



HI limit Calculation