Delivering Business Value from Digital Transformation

The Journey Continues with Advanced Analytics and Machine Learning

Presented by **Tibor Komróczki**

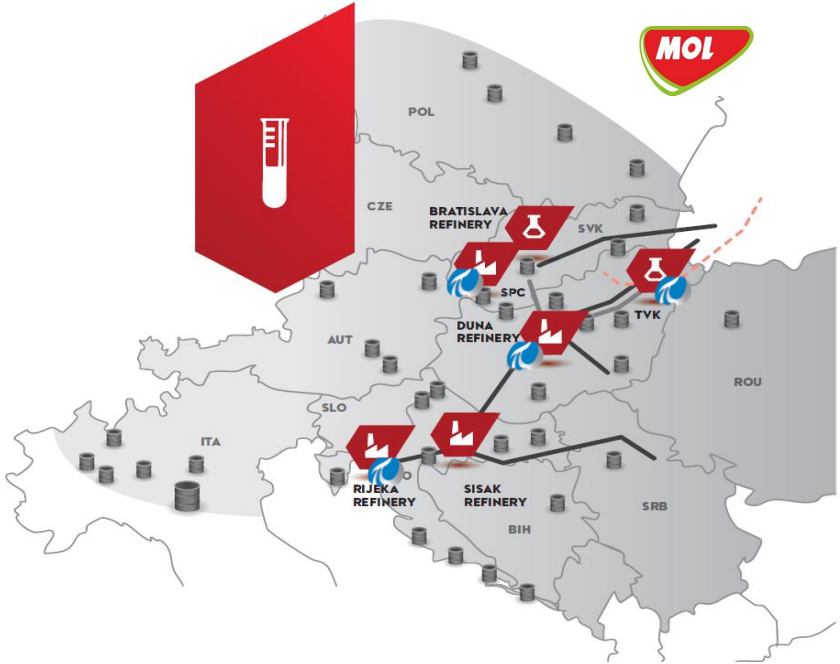
Delivering Business Value from Digital Transformation

- MOL Downstream Overview
- Perspective on Digital Transformation
- Delivering Business Value
- The Importance of the OT Infrastructure
- The Journey Continues- Advanced Analytics & Machine Learning:
  - Defining Advanced Analytics
  - Predicting Diesel Sulfur in Diesel Hydrotreater
  - Predicting & Optimizing Coke Yield & eliminate steam eruption in a DCU
- Closing Comments
- Q&A

MOL Downstream at a Glance

An Integrated Downstream Fuels Value Chain

- Integrated Fuels Value Chain:
  - 4 refineries, 2 Petrochem plants
  - Logistics including 2,000 retail stations,
  - 8 brands, 13 countries
- PI System Overview:
  - 4 HA collectives, ~400K tags
  - Elements:
    - ~300 smart templates
    - ~21K elements
  - Notifications:
    - ~150K templates
    - ~6K notifications
  - ~61K event frames including dynamic
- PI Coresight is primary visualization tool
- Advanced Analytics and Microsoft Azure



MOL GROUP AWARDS

Petroleum Economist Award 2016 for Best Downstream Company of the Year

The Petroleum Economist Awards aim to celebrate the people, companies and projects which epitomize the best of the energy industry and to identify and reward examples of innovation and excellence.

In 2015 MOL Group's Downstream delivered its strongest ever performance with a Clean CCS EBITDA of USD 1.65bn alongside with strong free cash flow generation of more than USD 1bn.

The New Downstream Program (2012-2014), which targeted USD 500mn EBITDA was successfully complemented, MOL Group decided to react to further boost its profitability and competitiveness by launching the Next Downstream Program 2015-2017 (NxDSP).

The significant incremental improvement of the NxDSP may realize a 3 USD/bbl profitability boost by 2017.

FieldComm Group's Plant of the Year

FieldComm Group's Plant of the Year award is given annually to recognize the people, companies and plant sites around the world using the advanced capabilities of FOUNDATION Fieldbus, HART Communication and/or FDI technologies,IOT,IIOT,ML in real-time applications to improve operations, lower costs and increase availability.

This is a supplier and industry independent awards program.

To qualify, nominees must be able to supply documented examples of real-time integration of device diagnostics and multi-variable implementations with control, safety and plant information / asset management systems that have delivered significant benefits to the operation.

Perspectives on Digital Transformation

Triad of Digital Transformation

Enablement of Contextual Data Based Decision Making & Management

Improving skills

knowledge capture

changing paradigms about data

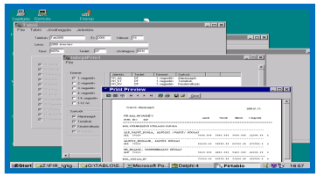
leading by example

Reengineering the workflow around enhanced & consistent data

Revised roles/Responsibilities

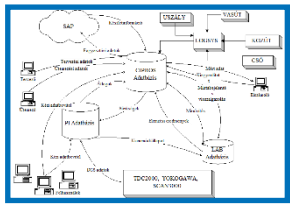
Tactical to Strategic Tags to Assets

1998



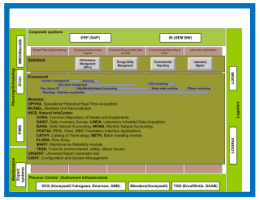
Individual

2002



Team

2006



Division

2010

Enterprise

2016

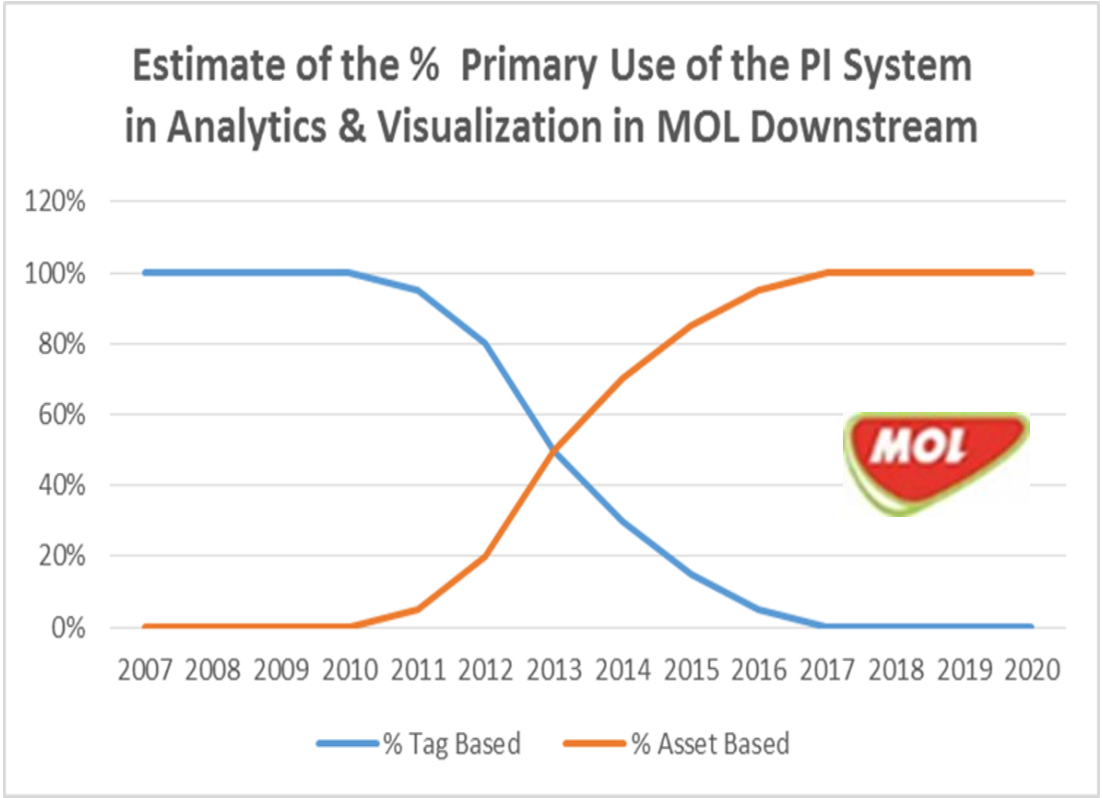
IoT

Machine learning

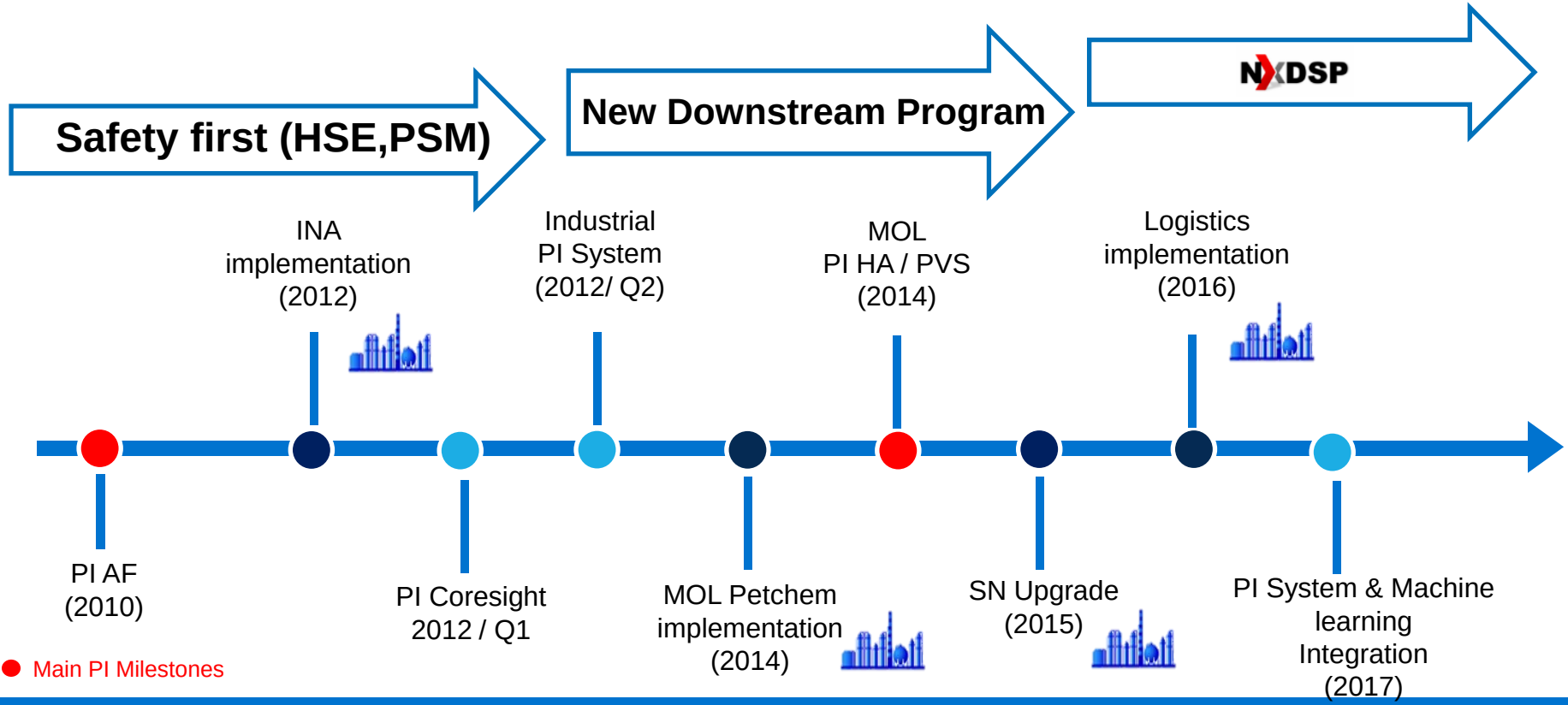
Digital Transformation is a Journey

Moving to PI AF is a Vision and a Journey…..”Just do It!”

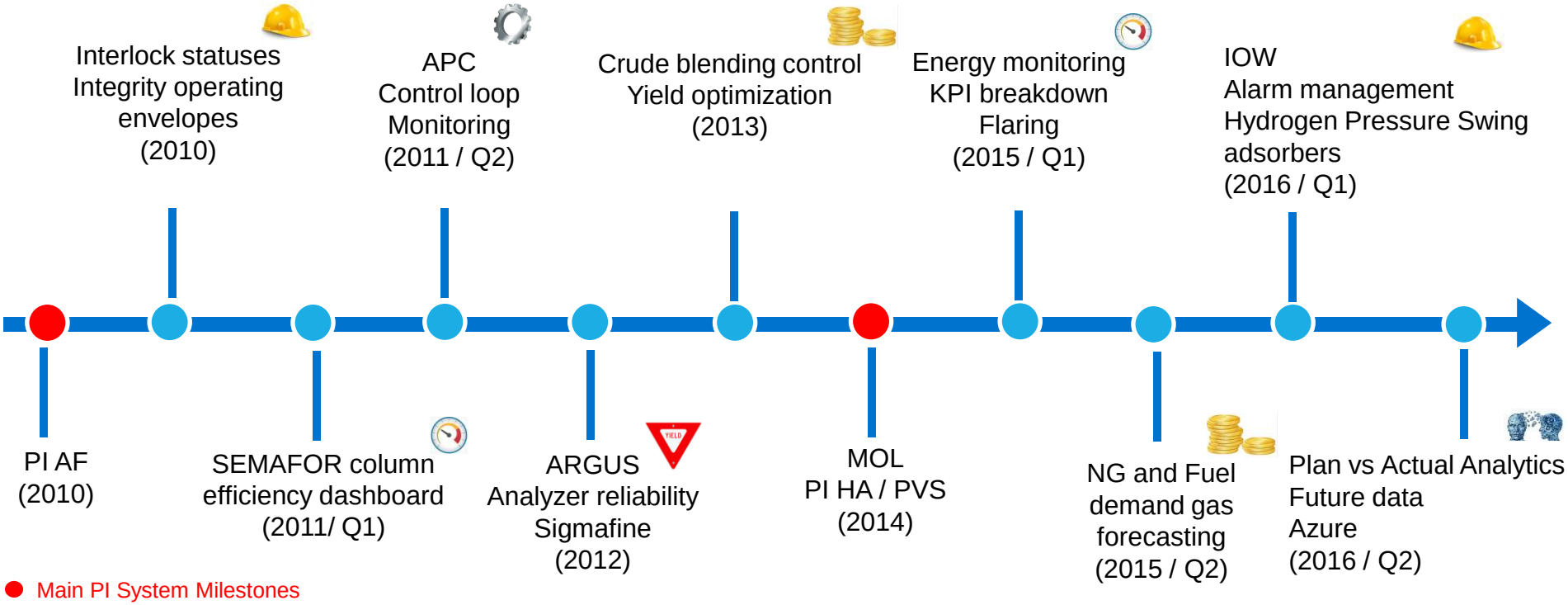
- **Start PI AF with a key business initiative** and build, capability, momentum and awareness;
- **Market PI AF vision**, capability, and value to leadership with **alignment to strategic initiatives;**
- Leverage PI AF Jumpstarts, OSIsoft consultation, PI AF templates, SIs, etc. to **lower the barriers to PI AF use**;
- **Once PI AF critical mass** is achieved, adoption will accelerate and be seen as **transformative and strategic**;
- **MOL sees PI AF as enabling** to many PI System capabilities like PI Coresight, PI Connectors, Integrators, etc.;



Tactical Historian to Strategic Infrastructure Supporting Strategic Business Initiatives



Digital transformation with PI AF

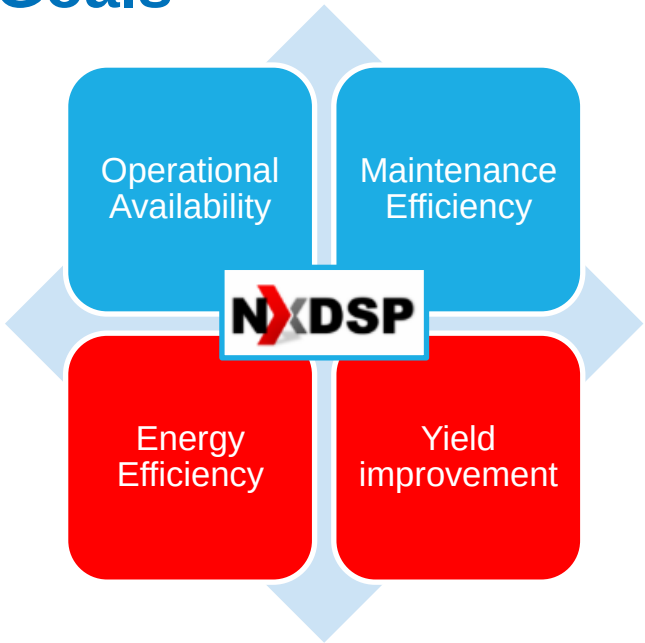


Delivering Strategic Business Value

Next Downstream Program Objectives/Goals

+ 2.5 % white product yield by 2017
- ► Increase conversion
- ► More efficient crude distillation

Adapt yields to volatile market trends
- ► Diesel / Mogas ratio from 2.4 to 2.8
- ► Motor fuels vs. Petchem products



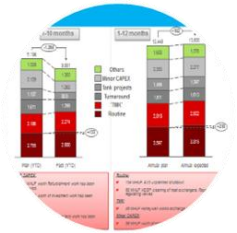
Hydrocarbon Loss Management
- ► Flare gas recovery
- ► Slop reprocessing
- ► Regular Monitoring & Reporting

- 0,15 GJ/t Specific Energy Consumption
- ► Energy KPI Breakdown
- ► Energy monitoring System

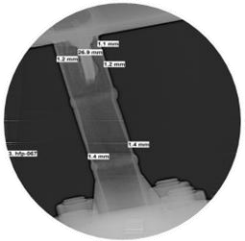
Delivering Business Value: $500M + $500M = $1B in 5 years

+ 1% Operational availability by 2017
► Optimize maintenance cost
► Asset Integrity and
Process Safety Management

Monitoring & reporting
►CMS controlling
►SAP development



Corrosion management
► Corrosion Upgrading program (CUP)
► Authority compliance



New DS program **delivered USD $500M Clean EBITDA improvement** in 2014 vs 2011 targets

ADDITIONAL $500M
increase by end of year 2016 vs 2014

Digital Transformation of New & Next Downstream program

Safety & Asset integrity (PSM)

- Interlock statuses
- Integrity Operating Windows
- **Corrosion control (HTHA)**
- Alarm management
- Preventing coke steam eruption

Yields

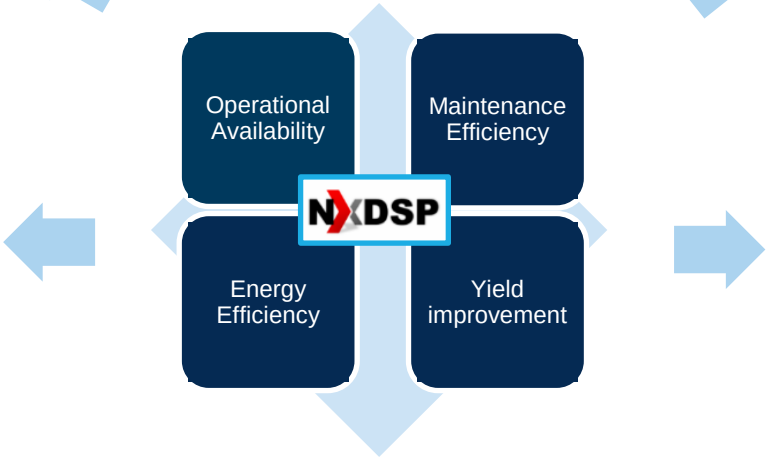
- Product quality
- Analyser reliability (Argus)
- Yield Accounting via Sigmafine (PI AF based)

Operational optimization

- Operating envelopes
- NG (natural gas) and fuel gas demand forecasting
- Normal mode of control loops
- APC control monitoring
- Diesel sulphur optimization
- Coker yield optimization

Energy

- Energy monitoring and management
- Energy KPI breakdown
- Column energy efficiency dashboard
- Hydrogen, utilities - energy balances
- Flaring



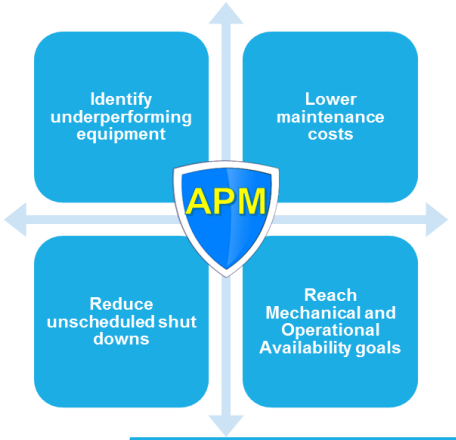
Asset Reliability from Proactive & Predictive Advanced Analytics

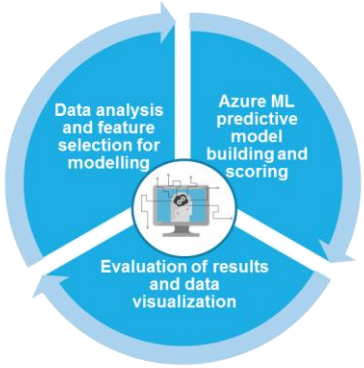
- SAP PM Integration
- Health Score in PI AF
- CBM on all rotating equipment
- PSA – Pressure Swing Adsorbers
- Chillers
- Heat Exchangers
- Electrical Infrastructure

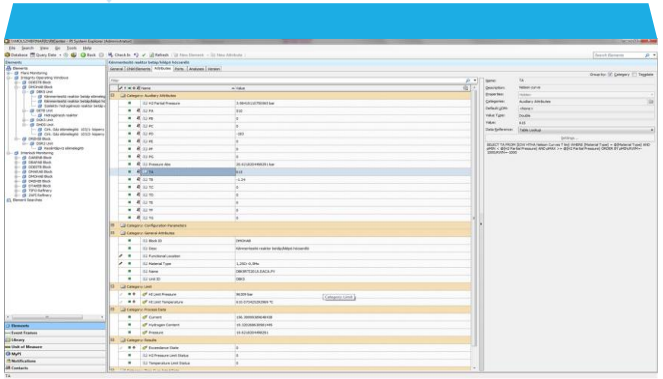
The Journey Continues: Advanced Analytics & Machine Learning

The Importance of Having an OT Data Infrastructure

- Rapid development and scalability of applications
- Reinforce the use of data and analytics based decision making
- Support cultural change and normalization
- Leverage advanced technologies including advanced analytics and IOT to accelerate business value
- Enable sustainable business value in the 21st century





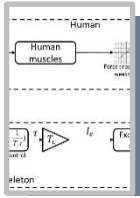


What can Advanced Analytics and IoT do for Oil & Gas Downstream?

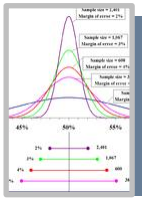
Increase productivity and efficiency across all major business units through the best practices for data harmonization

Condition based & predictive maintenance

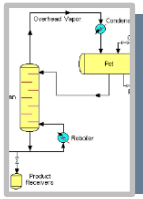
Alarm Management System (alarm rationalization) – Mode Base alarm , new alarm logics



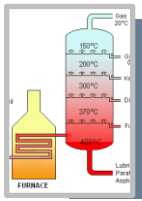
Analyze control loops behavior



Inferential and descriptive statistics

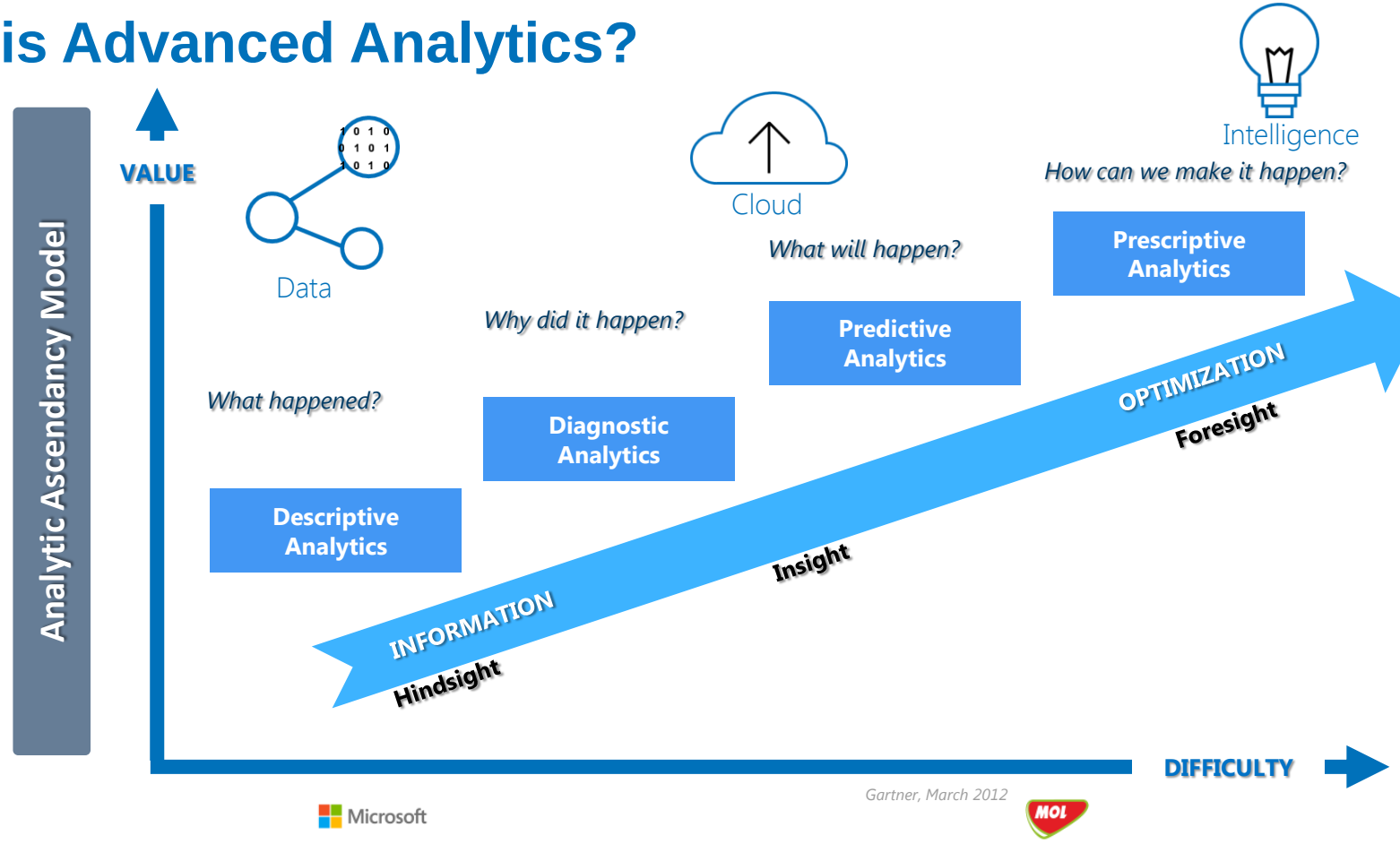


Energy modelling optimization

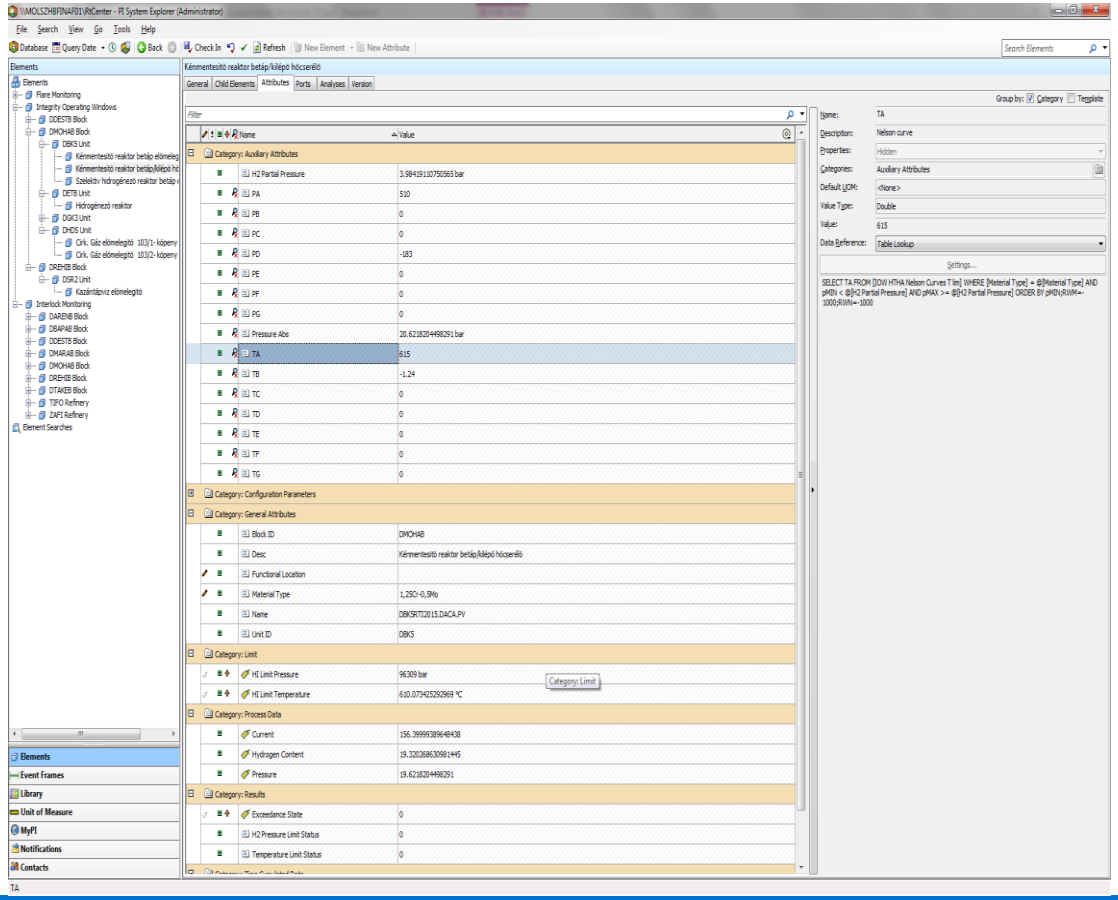


Deeper understanding of technological processes - Alternative crude oil usage as feed; yield optimization

What is Advanced Analytics?



Improving Asset Integrity with Advanced Corrosion Analytics

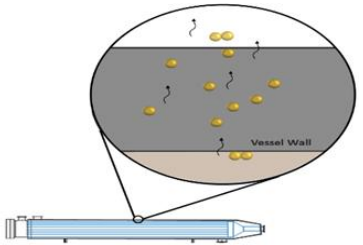


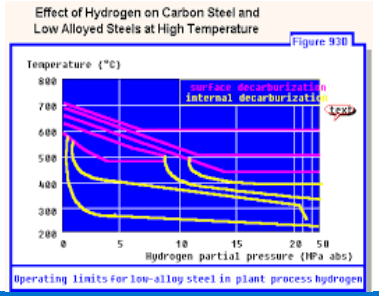
- High Temperature Hydrogen Attack (HTHA)
- f^x (metallurgy, temperature, hydrogen partial pressure(PP), length of exposure)

Developed PI AF template that:

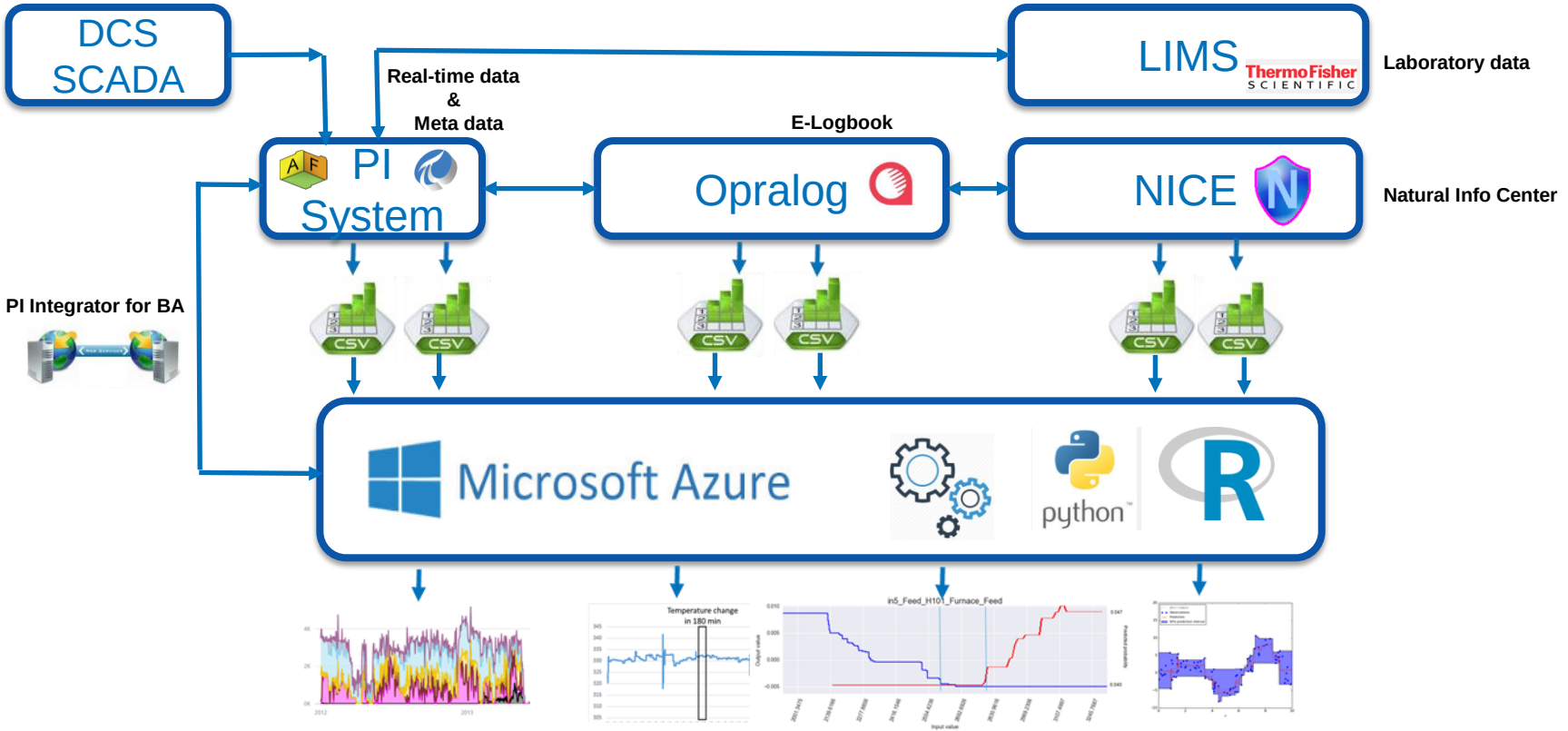
- Determine partial pressure
- Attribute of pipe class
- Temperature and length of exposure limits
- Total time above Temp and PP
- Alerts/notification/event frame

- Tested and rolled out in 6 units < 1 week
- Expanded to all plants in 2015.





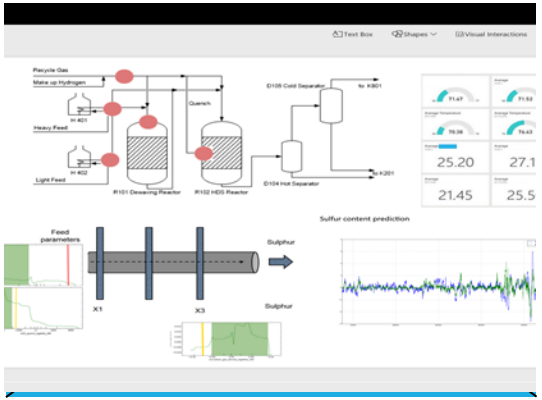
Machine Learning Architecture – Current & Future



Improving Sulfur in Diesel Prediction from Azure Machine Learning

COMPANY and GOAL

Replace RTO and offline modeling with Azure based Machine Learning to improve the prediction and optimization of sulfur in diesel in a diesel hydrotreating unit



CHALLENGE

Off line and rigorous on line RTO models were **slow**, difficult to maintain, and produced inconsistent results in predicting the sulfur in the diesel **resulting in lost benefits in excess of $600K/yr & growing.**

- RTO systems were expensive and difficult to maintain
- Off line models were to slow
- Lost benefits of ~$600K/yr in 4 units
- Growing potential loss from decreased specifications of sulfur in diesel

SOLUTION

Leverage **existing OT data infrastructure** to enable Azure machine learning to predict sulfur in diesel by:

- Analysis of data to determine the control variables which has the highest effect on sulfur content
- Determine the desired intervals for each variable to control the output sulfur content
- Advanced model to (time window based) to predict the changes of the sulfur based on the changes in the control variables

RESULTS

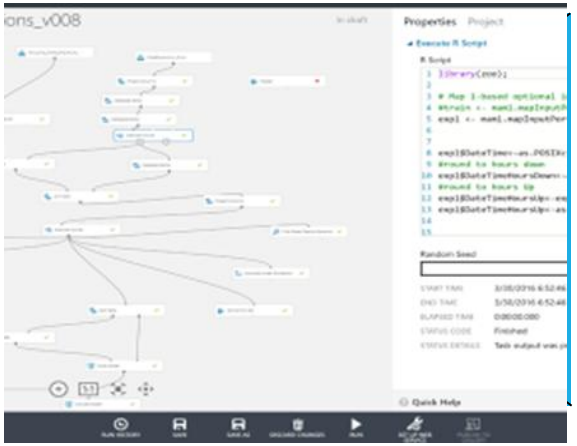
Ability to identify and control (open loop) the key variables in **predicting sulfur in diesel**. Expanding to other hydro treating units. **Initial savings ~600K and growing**.

- Enhanced the maintenance of existing empirical inferential calculations (Other Hydrotreater Sulfur content, Cloud point, Pensky Martens FP, Gasoline EBP)
- Enabled the determination of new empirical inferential calculations (E.g. NHT, Amine systems….)

Improving DCU Yield and Safety with Azure Machine Learning

COMPANY and GOAL

Improve Delayed Coking Unit yield and Reduce the risk of coke hot spot steam explosions from feed and operational variability by using Azure machine learning.



CHALLENGE

Opportunity crudes provided incentive to raise DCU yields but resulted in an increase likelihood hot spots **resulting in steam eruption events while decoking.**

- Economic incentive to run opportunity crudes $6M for each 1% increase in DCU yield
- Increase feed variability to the DCU
- Increased risk of hot spots and steam explosion events during decoking – 4X increase in Q1 2016

SOLUTION

Leverage **existing OT data infrastructure** to enable the use of **advanced analytics and machine learning** to **improve yields and reduce the risk of steam eruption**.

- PI AF infrastructure in place from prior digital transformation from tags to assets
- Use Microsoft Azure Machine Learning to do massive high fidelity data correlation of DCU feed properties to yields and explosions

RESULTS

Reduced DCU steam explosion events while improving DCU yields from the processing of more opportunity crudes

- *Enabled the sustainability of increased DCU yields of over 2% by processing opportunity crudes*
- *Reduced steam explosions by 75%*
- *Calculated savings for 1 DCU unit = $6M/yr for each 1% yield = $12M/yr*
- ***Rapid rollout** to other DCUs*

Conclusion

Key Takeaways…..

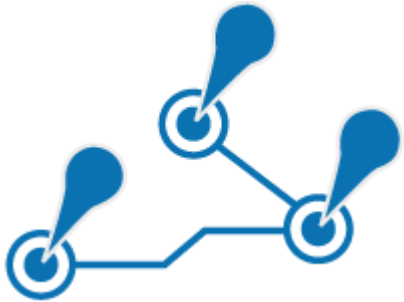
1. Focus on rapid extension of the PI System across the enterprise

2. Migrate to the use of PI AF quickly by support of key business initiatives and leadership…it is a journey

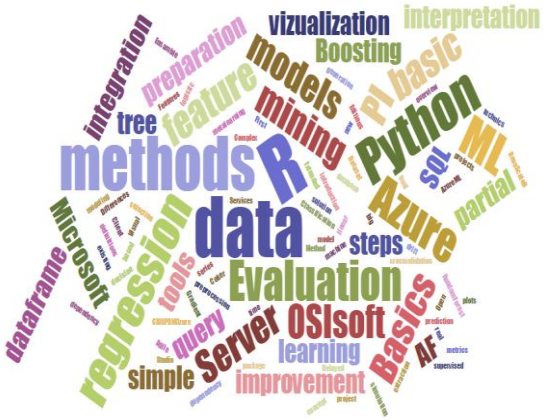
3. Link to support of strategic business transformation strategy and vision if possible, gain executive awareness and support

4. Develop PI AF core competency and organizational awareness

5. Once in place, the OT infrastructure can and will enable rapid and scalable applications to business issues & opportunist



Delivered $1B Business Value from Digital Transformation in last 5 years



COMPANY and GOAL

Delivered $1B in EBITDA by a business transformation enabled by a digital transformation leveraging the PI System as a strategic OT data infrastructure for advanced predictive and proactive analytics

CHALLENGE

Deliver strategic business value to respond to increasing competitive threats; **Change a diverse culture** to **"act as one"** with Operational Excellence & continuous improvement enablement.

- Increasing competitive environment in Eastern Europe
- Variable cracked spread
- Diverse culture across 8 countries
- Low use of data and analytics
- Poor and business performance

SOLUTION

Evolved the use of the PI System as a tag based historian to an asset based infrastructure to **support cultural change** and **data based decision making and support** with advanced predictive and proactive analytics.

- Evolved from Tag to PI AF based infrastructure across the MOL fuels value chain
- Normalized tag, asset, UOM, and time using PI AF as an abstraction layer
- Used data and information to support business transformation

RESULTS

Delivered on the MOL Downstream business transformation goal of $1B and more importantly, a sustainable **cultural change based on data and information** to drive **operational excellence** going forward into he 21st century.

- *Leading Process Safety Management*
- *1st Quartile in energy, yields, loss, and utilization*
- *OT infrastructure enabling time to value and value momentum with advanced analytics including machine learning*

Contact Information

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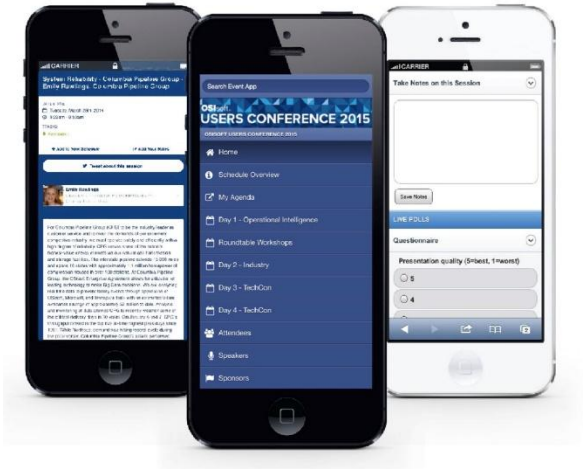
Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please don’t forget to…

Complete the Online Survey for this session



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谢谢

Danke

Gracias

Merci

Thank You

ありがとう

Köszönöm

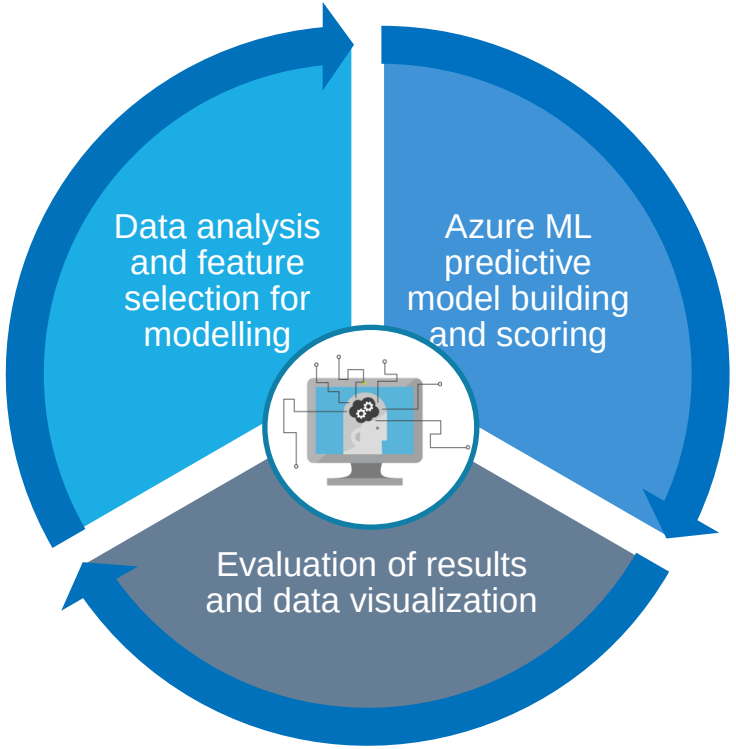
Спасибо

Obrigado

Backup slides

Machine Learning- Use Cases

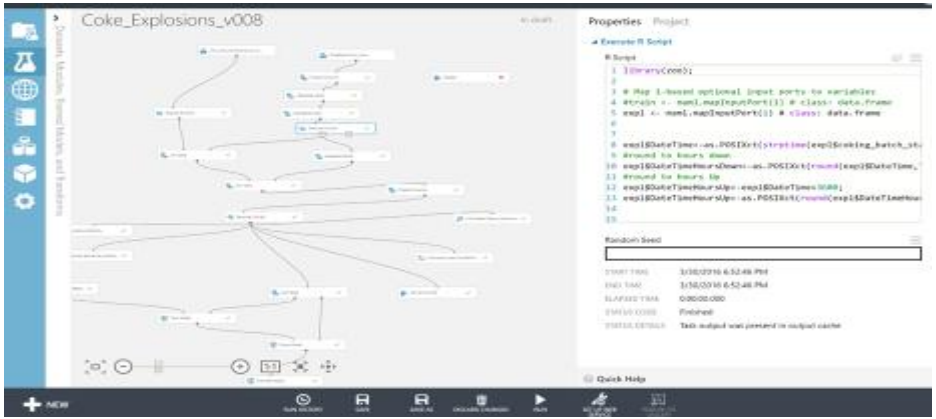
- Find the optimal mixture of different feeds into the Delayed Coker process
- Achieve minimal level of coke yield
- Diesel Hydrotreater unit product sulfur content estimation based on available data
- Azure ML technology adaptation compare laboratory, online analyzer, APC soft sensor and ML data



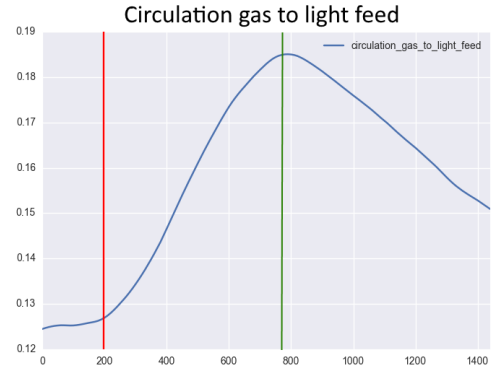
Predicting Diesel Sulfur in a Diesel Hydrotreater

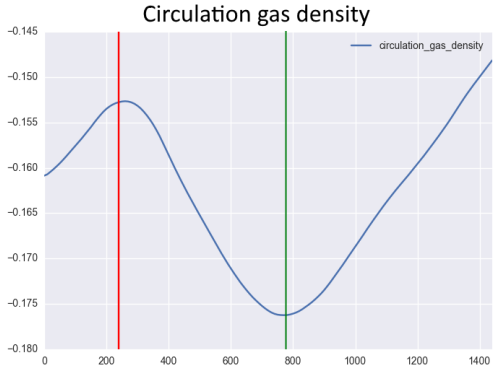
Project Scope – Rough Method to Optimize Sulfur in Diesel

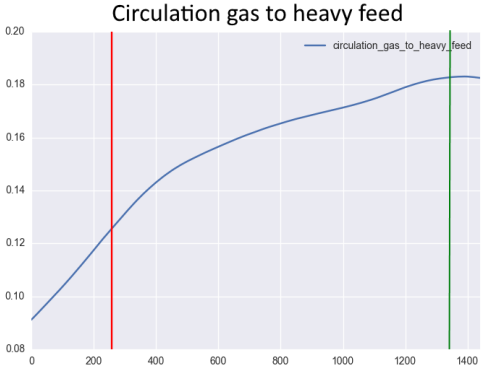
- Analysis of data to determine the control variables which has the highest effect on sulfur content
- Determine the desired intervals for each variable to control the output sulfur content
- Advanced model to (time window based) to predict the changes of the sulfur based on the changes in the control variables

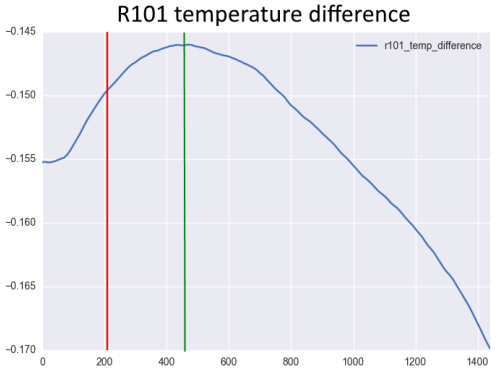


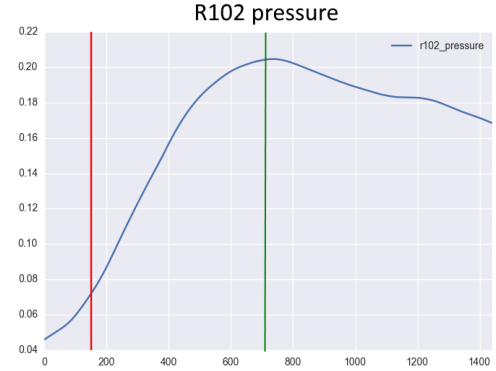
Time shifted correlation with sulfur content

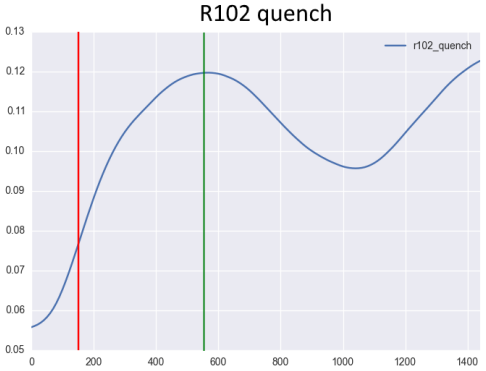




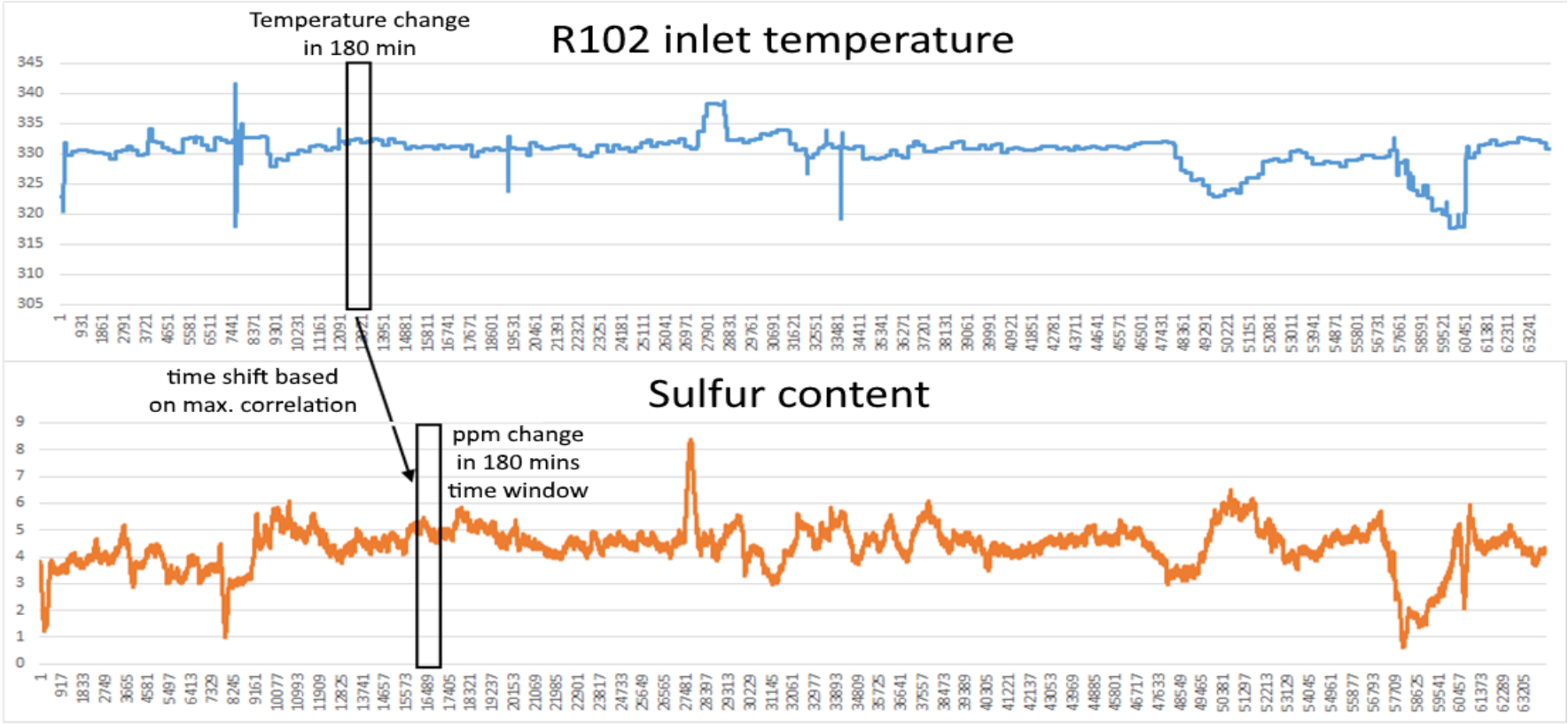




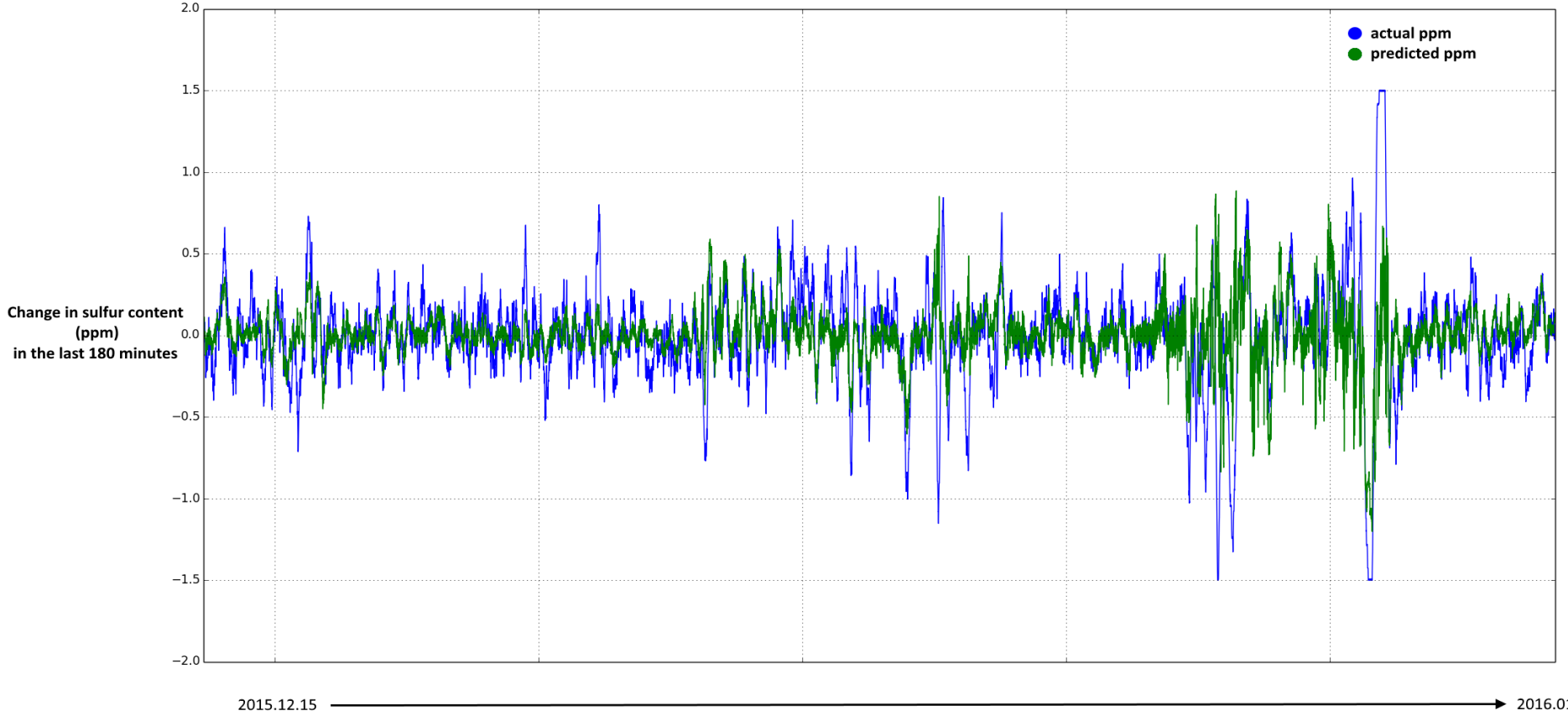




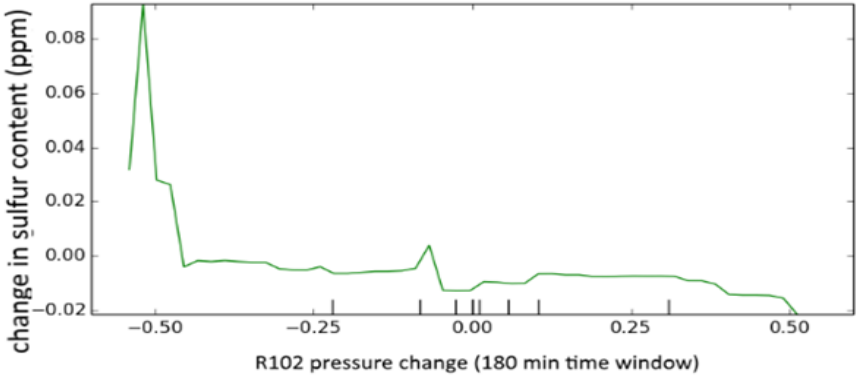
Predicting Output Based on Changes During a Time Period

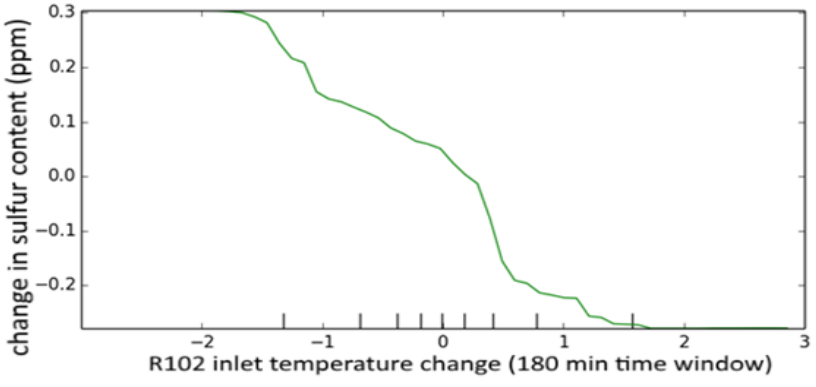


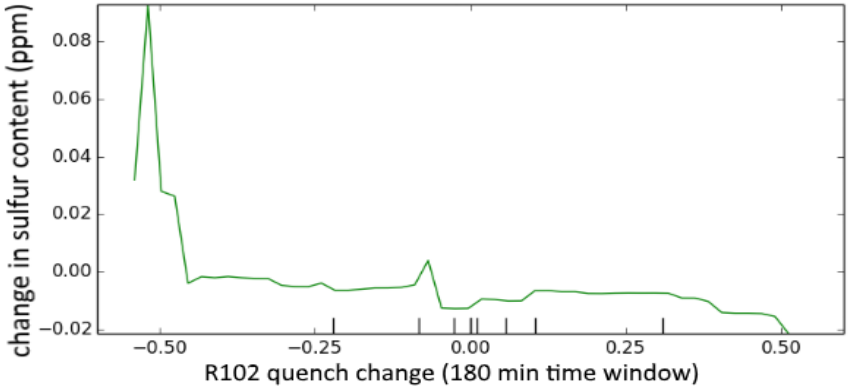
Prediction and Control Model

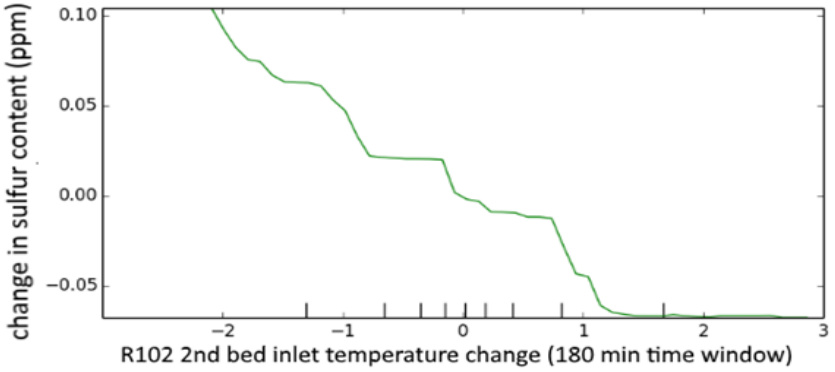


Influence of Sulfur Content



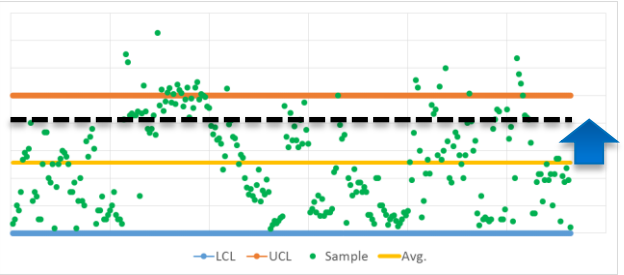






Benefits from Production Support

Other Diesel & Gasoline product sulfur content



Tighter quality control

Quality giveaway decrease	3	ppm
Operation time (in feasible operation mode)	20	%
Fuel gas decrease	4495	GJ/Year
Benefits from decreased fuel gas consumption	47. 000	$/Year

Effect of other empirical inferential

Maintenance of existing empirical inferential calculations (Other Hydrotreater Sulfur content, Cloud point, Pensky Martens FP, Gasoline EBP)	28. 000	$/Year
New empirical inferential calculations (E.g. NHT, Amine systems….)	70.000	$/Year

- Sum of possible benefit ~ $140K/Year per unit X 4 units = $560K/yr

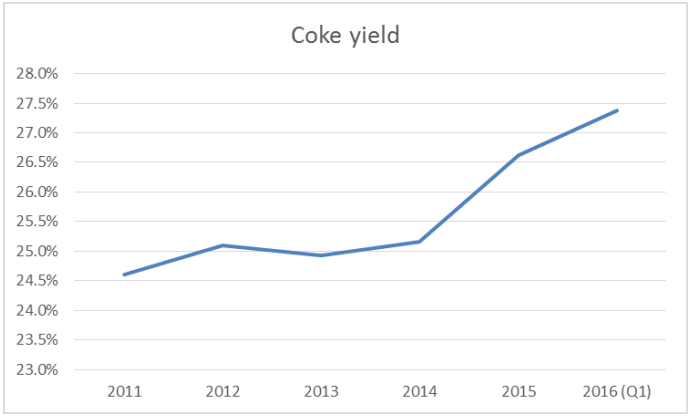
Predicting and Optimizing Coke Yield and eliminate steam eruption in a Delayed Coker Unit

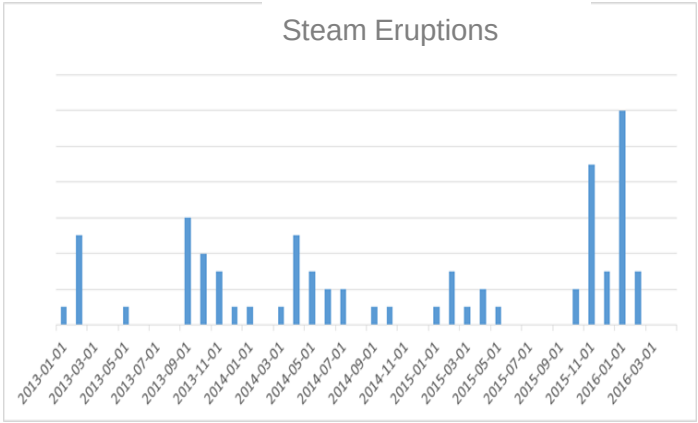
Business issues in Delayed Coker Unit

- Increasing coke yields from 25.39% to 27.43% (**+2.04 %**) from 2012.01.01 and 2016.03.01.
- Average monthly steam eruptions in 2012-2015 period was 3.85, in the first month of 2016 it was 15.5 (**4X increase**)

1 % Coke yield decreasing

~ $6M/year benefit in Danube Refinery!

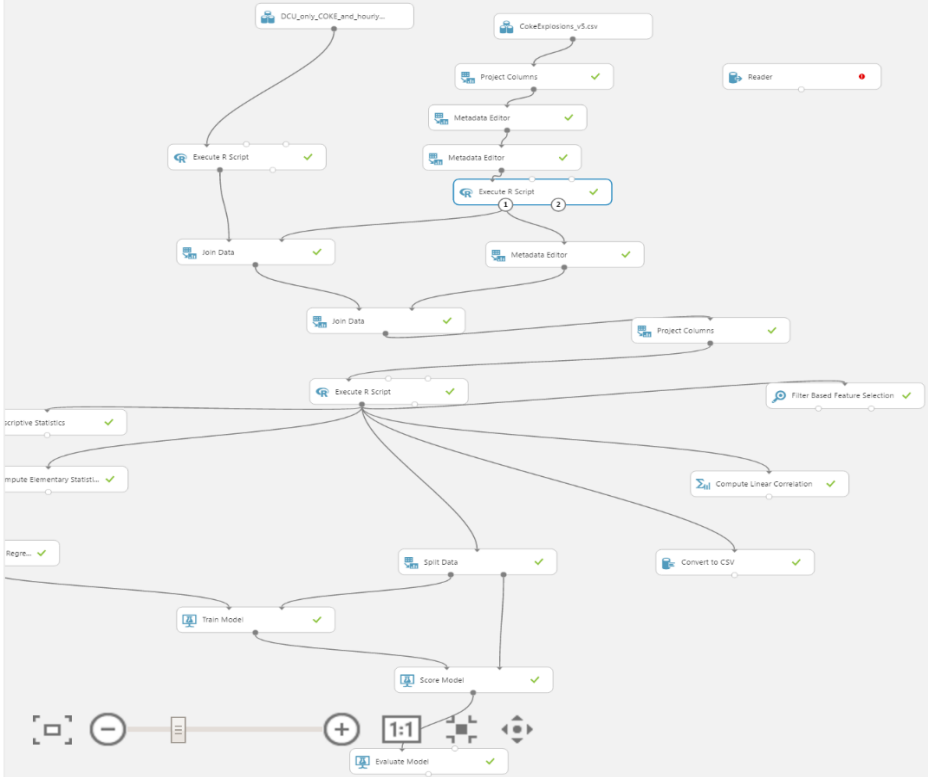




Datasets, Modules, Trained Models, and Transforms

Coke_Explosions_v008

In draft



Properties — Project

Execute R Script

R Script

```
1  library(zoo);
2
3  # Map 1-based optional input ports to variables
4  #train <- maml.mapInputPort(1) # class: data.frame
5  expl <- maml.mapInputPort(1) # class: data.frame
6
7
8  expl$DateTime<-as.POSIXct(strptime(expl$coking_batch_sta
9  #round to hours down
10 expl$DateTimeHoursDown<-as.POSIXct(round(expl$DateTime,'
11 #round to hours Up
12 expl$DateTimeHoursUp<-expl$DateTime+3600;
13 expl$DateTimeHoursUp<-as.POSIXct(round(expl$DateTimeHour
14
15
```

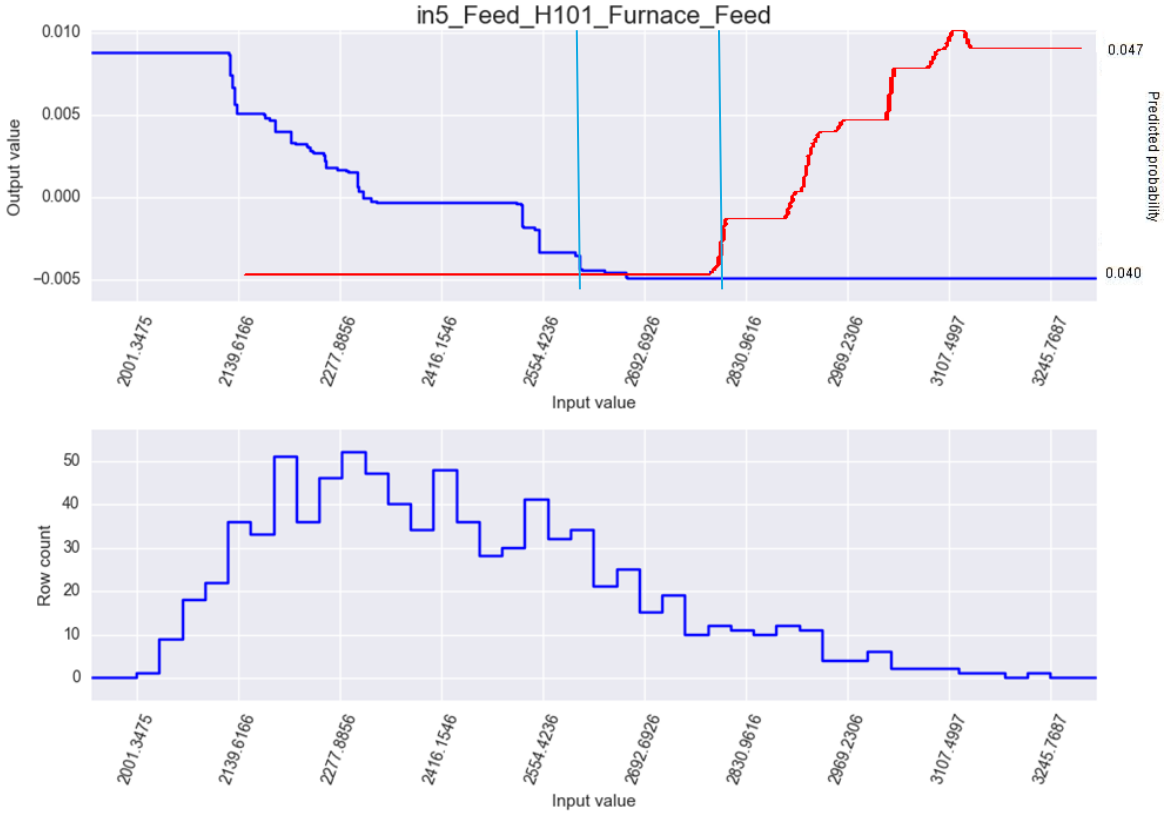
Random Seed

START TIME	3/30/2016 6:52:46 PM
END TIME	3/30/2016 6:52:46 PM
ELAPSED TIME	0:00:00.000
STATUS CODE	Finished
STATUS DETAILS	Task output was present in output cache

Quick Help

NEW | RUN HISTORY | SAVE | SAVE AS | DISCARD CHANGES | RUN | SET UP WEB SERVICE | PUBLISH TO GALLERY

Coke Yield & Explosion



Blue: coke yield (output value)
Red: steam eruption
~In case of > 3100 t Furnace feed input the coke explosion likelihood is increasing

Blue histogram:
Row count coke cycle

Between the 2550 -2800 t intervallic the coke yield could be decreased without coke explosion

PI Event Frames as monitoring tool

Azure ML Competence development and deeper analyses

Training series
Competence improvement

- Improve Azure ML and Data Analyst competences
- Participants: Process technologist, Developer technologist, Automation, operation and energy management; IT specialist (with superlative PI and statistics knowledge)
- Overview of tools (Azure ML environment , R, Python)
- Regression methods, interpretation of models, regression tree, linear regression, evaluation methods
- Steps of real data mining projects
- Deeper analyses of Delayed Coker unit
- Support Delayed Coker Feed Blender project