The MOL Story

A Journey with IIOT, Advanced Analytics, & Big Data

$1B EBITDA enabled by Strategic use of the PI System and PI AF as an OT Data Model

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Team of 16 Process Information & Automation Engineers (APC/RTO & PI Systems)
Reports to the Technology & Development Manager
Distributed in the 6 plant locations
IT in a supportive role…minimally involved – Operating Systems and SQL Servers
Outline

• MOL at a Glance
• MOL’s Digital Transformation Journey
• Infrastructure Approach to Apps & Solutions
• Advanced PSM and CBM
• Extending Advanced Analytics with ML
• Best Practices & Perspectives
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:
    - ~300 smart templates
    - ~21K elements & growing
  - Notifications:
    - ~150K templates
    - ~6K notifications
    - ~61K event frames including dynamic

- **PI Coresight is primary visualization tool**
Focus areas of New Downstream Program (NDP) and Next Downstream Program (NxDSP)

NDP Delivered $500M 2012-2014  NxDSP Delivered +$500M 2015-2016

**GOALS**

- **Specific Energy Consumption**
  - Base: 3.13 GJ/t
  - NDSP: 3.01 GJ/t
  - Plan: 2.94 GJ/t
  - 2%

- **Loss**
  - Base: 0.53%
  - NDSP: 0.45%
  - Plan: 0.37%
  - 30%

- **Operational availability**
  - Base: 95.19%
  - NDSP: 95.81%
  - Plan: 96.19%
  - 1.1%

- **White Product (Yield)**
  - Base: 79.11%
  - NDSP: 82.02%
  - Plan: 83.07%
  - 5%

Use the PI System to generate KPIs

**Efficiency**  **Trust**  **Innovation**  **Safety**  **Proficiency**

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IIOT Integration with Existing OT Data Fabric & Analytics

IIOT Data

DCS SCADA

Yield Accenting P&S Unit Models

Financial Data

ERP

Equipment data

EAM

Laboratory data

LIMS

NICE

Natural Info Center

OT Data Model/Infrastructure

E-Logbook

Microsoft Azure

OT Integrator for Azure

* Initially done via .csv files
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
- Increased use of opportunity crudes

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 the 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
Digital Transformation 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.;
MOL Downstream Integrated OT Data Model

Normalized & Standard OT Data Models

Danube  Bratislava  Rijeka  Sisak

Danube  Slovnaft

Refineries  Petrochemicals

Value Chain  Logistics

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Digital Transformation of New & Next Downstream Program

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

Safety & Asset integrity (PSM)
- Interlock statuses
- Integrity Operating Windows
- Corrosion control (HTHA)
- Alarm management
- Preventing coke steam eruption

Yields
- Product quality
- Analysers 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

Operational Efficiency
- Column energy efficiency

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

Yield improvement
An Infrastructure Investment Approach - “OT Data Utility”

- Machine Learning
- Yields & HCL
- Advanced PSM
- Advanced CBM

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Moving Applications to & Integrating Solutions with the Data Infrastructure – Simplification & Standardization

**ENTERPRISE RESOURCE PLANNING – HYDROCARBON MANUFACTURING**

**SAFETY**
- SMS: Safety & Alarm Management
- CEMS: Continuous Emissions Monitoring System
- SMS: Safety & Alarm Management

**ENVIRONMENT**
- CEMS: Continuous Emissions Monitoring System
- M&MV: Measurement & Meter Validation
- ARM: Analyzer Reliability Monitoring

**QUALITY**
- PT/QM: Production Tracking / Quality Monitoring
- M&MV: Measurement & Meter Validation
- ARM: Analyzer Reliability Monitoring

**PRODUCTION & OPERATION MANAGEMENT**
- APC/RTO MES: Planning & Scheduling / Yield Accounting
- EMS: Energy Management Systems
- OIA: Operational Intelligence & Analytics
- OEE: Overall Equipment Effectiveness
- CBM: Condition Based Monitoring

**ASSET AVAILABILITY & REL.**
- EHM: Asset Reliability / Availability Monitoring
- PSM: Performance Systems Management (KPIs)
- OIA: Operational Intelligence & Analytics
- OEE: Overall Equipment Effectiveness
- CBM: Condition Based Monitoring

**PEOPLE**
- KMS: Knowledge Management Systems
- OTS/LMS: Operator Training / Learning Management
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- OTS/LMS: Operator Training / Learning Management

**Simplification & Standardization**
- SCADA
- DCS
- Other Control
- Other Data

**Unified Real-time Integration and Applications Infrastructure**
Moving Applications to & Integrating Solutions with the Data Infrastructure – Simplification & Standardization
Leverage of the PI System as an Integration & Applications Infrastructure to Simplify & Standardize the Applications & Solutions Portfolio

Production (Refinery & Petchem) & Logistic Standardization

Production Process Standardization level
Past State <2014

Production Process Integration level AS-IS
Coordinated (low standardization, high integration)
Diversified (low standardization, low integration)

Replicated (high standardization, low integration)
Unificated (high standardization, high integration)

Coordination
Production Mng. & Reporting & Performance Mng.

Performance Monitoring Mng.
Production acc.
Energy mgng.
Maintenance
Quality mgng.
Operation
Road, Rail, Barge, Pipe, Trans.

Coordination
Energy mgng.
Storage op.
Road, Rail, Barge, Pipe, Trans.
Quality mgng.

Production Process Standardization level
Current State 2015+

Production Process Integration level TO-BE

Coordination
Prod. Mng. & Reporting & Performance Mng.

Performance Monitoring Mng.

Coordination
Production acc.
Maintenance
Operation
# MOL Downstream OT Data Model Based Applications

### Safety (PSM) and Asset Integrity
- Interlock governance/DCS role tracking
- Operating envelopes
- Integrity Operating Windows (IOWs)
- Advanced Alarm management

### Energy
- Energy Monitoring and Management
- Energy KPI breakdown (6 tiers)
- Column Energy Efficiency Dashboards
- Hydrogen, Utilities, and Energy balances
- Flaring

### CBM Asset Reliability
- All critical rotating equipment
- Hydrogen Pressure Swing Absorbers

### Yields
- Crude Blending Control
- Yield Optimization/Reporting
- Product Quality
- Analyser Reliability

### Operational Optimization
- Plan vs Actual Analytics with Future Data
- NG and Fuel Demand gas forecasting
- Peak Electrical forecasting
- Normal mode of control loops
- APC monitoring
- PI AF and Sigmafine (PI AF) used for yield accounting & Material Movement

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Value Prop for Migrating from Tag/Excel to Asset/Web

1. **Inconsistency** in analytics/calculations
2. Tag based
3. **Static** analytics/calculations
4. Limited Trending & Visualization
5. Local

1. **Consistency** in analytics/calculations
2. Asset based Smart objects
3. **Dynamic, real-time** analytics/calculations
4. **Powerful, flexible** Trending, Visualization. Events, alerts
5. Web based access and collaboration
Energy Monitoring & Reporting

Benefits

- Continuous monitoring of the parameters
- Normalized, unified, and quality information leveraging PI AF
- Easy maintenance and Governance of the PI AF templates
- Structured format
- Increased production as a result of improved energy and environmental constraint visibility and forecasting
PI Event Frames – Energy Over consumption events

Event 1 Cost 1
Event 2 Cost 2
Event 3 Cost 3
Natural Gas Consumption Prediction

**BackGround**
- Huge saving possibilities in the decrease of contracted natural gas daily maximum amount

**Problem**
- High penalty on daily amount exceedance
- Alerting system was needed

**Solution**
- Consumption prediction calculations in PI Analysis
- Detailed information on PI Coresight display (about consumption, prediction, contacts of decision makers)
- E-mail alerting system in Notifications
Advanced PSM & CBM
Supporting Strategic Business Initiatives – Refinery Safety Excellence – Enabled by the PI AF Data Object Model

Asset Safety integrity

Advanced Process Safety Management

Refinery Safety Excellence

- On-line analyzers
- Interlock monitoring & governance
- Flare
- Integrity Operating Windows (IOW)
- Operation Envelopes (OW)
- Advanced Corrosion Analytics

- Proactive/Predictive analytics with PI AF
- Reports – PI DataLink
- Displays
- Notifications

- Safe operation
- Reduced shut-downs
- Availability/Utilization
- Integrity
- Loss of containment
Integrity Operating Window - Using PI AF

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

- Critical Limit High: Failure occurs quickly
  - Standard Level High: Failure occurs with sustained operations
  - Stable, Reliable, Profitable
  - Target Range High: Safe to Operate Indefinitely

- Critical Limit Low: Failure occurs quickly
  - Standard Level Low: Failure occurs with sustained operations

Requires attention within specified timeframe:
- Heater Tube Skin Temperature
- Crude Fractionator Dew Point Temperature
- pH of Crude Tower Overhead
- Desalter Outlet Salt Content

Requires drastic and/or immediate action:
- Boiler Feed Water Level
- Hydro-process Reactor Temperature
- Heater Tube Skin Temperature
- Sulfuric Acid Strength in Alkylation

Elements
- APC
- ARGUS
- Control loops DR
- Danube Refinery
- DCS Felhasználói szint
- DUFI Struktra
- Energy Consumption Predictions
- Energy KPI System
- Energy Monitoring
- EzIttEgyTeszt
- Flare Monitoring
- FlareSource Monitoring
- Interlock Monitoring
- IOW
- DAV3 Desalting
- DBK5 IOW
- DETBE IOW
- DGK3 IOW
- DHDS IOW
- DHGY2 IOW
- DKBI IOW
Advanced PSM
– High Temperature Hydrogen Attack (HTHA) – Hydrogen Embrittlement
Improving Asset Integrity with Advanced Corrosion Analytics

- High Temperature Hydrogen Attack (HTHA)
- f*(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
- All plants in 2015 < 2 months – 50+ nodes

Effect of Hydrogen on Carbon Steel and Low Alloyed Steels at High Temperature
Results of Action – Attitude & Culture

- Ability to optimize alloy selection based on empirical data
- Determine if equipment needs to be replaced or inspected in turnaround
- Maintenance team has a continuous monitoring tool to make better decisions
- Better teamwork & communication between operations & maintenance
Challenge – Critical Availability Problems

- Hydrogen Production Plants (HPP) are critical units in the refinery
- Pressure Swing Adsorbers (PSA) are critical equipments in unit operation
- Cyclic operation – Heavy load on valves (9-10 open-close hourly)
- $1.2M loss in three years due to PSA valve failures
- UPTIME program: 97 % Operational availability
Architecture – Roles of components

**PI Server**
- Process database
- Online analysis of process information
- Calculation of asset health
  - Asset condition
  - Running hours
  - Performance
- User Interface
  - PI Coresight
  - PI DataLink

**Connection (WebLogic)**
- Calculated asset health
- Maintenance related information

**SAP PM**
- Technical database
- Management of maintenance processes
- Creation of work orders or notifications
- Trigger maintenance strategies based on asset health
PI AF Structure

- Structure for calculation:
  - Adsorber
  - Valve positions
  - Valves

- Structure for moving data into SAP:
  - Adsorber
  - Measuring Points
Extending Advanced Analytics with ML
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 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
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 of continuous improvement

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
Thank You