Real-Time On Line Modeling of Upstream O&G Assets

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AGENDA

- Project Scope
  - Integrated Production Optimization
  - PI Connection: eDOF
  - Pi Connection: Architecture
  - Field Application
  - Conclusions & Further Developments
Project Scope

Build integrated production system models **fed by real-time data** and able to:
- represent field operating conditions
- monitor & optimize asset performances
Project Scope – Main Continuous and Real-time Features

1. Monitoring
2. Optimization
3. Updated Models
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Integrated Production Optimization

- **Primary objectives are:**
  - Maximise asset value defining best configuration and optimising operating parameters
  - Identify residual potential and bottlenecks
  - Minimise intervention time and costs
  - Minimise/avoid shutdowns
  - Minimise structural interventions

- **Focus on Production Facilities: from wells to sales point:**
  - Reservoir
  - Gathering Network
  - Wells
  - Treatment Plant
Integrated Production Optimization – e-rabbit

e-rabbit is the in-house developed optimization tool for a multi-objective fitness function:

- Equity production from wells to stock tank and Operating conditions;
- Consumptions, emissions, energy efficiency and operating costs;

Global maximum identified through the use of an evolutionary algorithm
Integrated Production Optimization – e-rabbit genetic evolution

Method for solving optimization problems that is based on natural selection: the process that drives biological evolution.

Individuals from the current population are used to produce children for the next one:

- Elite children
- Crossover children
- Mutation children

Over successive generations, the population "evolves" toward an optimal solution.
Integrated Production Optimization – Algorithm

**e-rabbit**: overcoming relative maximum

**Absolute maximum**

**Relative maximum**

97% of probability success to achieve global maximum

**e-rabbit**: operating variable example

Choke opening [/64”]

Stabilizer bottom T [°C]

Pump speed [rpm]

Separator P [bar]
Integrated Production Optimization – Standard Workflow

1. **Field Application**
2. **Network and Plant Modelling**
3. **Calibration and Run**
4. **Field Data**

- e-rabbit (risked algorithms for biogenetical balance integration tool)
Data Gathering from BU:
- Activity on demand. Discontinuous data availability

Site survey:
- Necessary information is collected through dedicated visits to the plant and meetings with the operator

Real time monitoring - Digital Oil Field
- Field data are available to the HQ in real time, through PI
- Potential to extend the study to available historical data, identifying trends and recurring events, through PI AF
Integrated Production Optimization – Simulations models

- **Wells/Network simulation**
  - Tools: GAP, OLGA, Eclipse
  - Wells and Flowlines configuration
  - Flow assurance

- **Integrated simulation**
  - Reservoir
  - Wells
  - Treatment Plant
  - Gathering Network
  - Able to capture interaction phenomena among all the asset elements

- **Process simulation**
  - Tools: Hysys (Dynamics)
  - Treatment plant configuration
  - Equipment optimal parameters
Integrated Production Optimization – e-rabbit historical development
Integrated Production Optimization – e-rabbit historical development

- On-line models & Scheduled Simulation
- Gas/Water injection
- Reservoir integration
- Auto-Calibration of model with real-time data
- Rabbit Dynamic
- Exploration of new Optimization Algorithms
- Speed-up with proxy models
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Mature technology adopted by O&G Industry various names: Smart Fields®, Field of the Future®, i-Field®, Intelligent Field or Integrated Operations;

Based on high frequency data acquired automatically in real time, integrated with lower frequency data (daily, monthly…), results of modelling and simulation and manually collected data to support better decision making processes;

Eni standard configuration is named eDOF:
- based on configuration of state-of-the art off-the-shelf components
- design, implementation and deployment activities are performed by Eni people, both from IT and business disciplines, incorporating Eni Intellectual Property.
- eDOF is actually acquiring/calculating $350 \times 10^6$ values every day, with an average frequency of 20 sec.
PI Connection – Standard eDOF infrastructure

Data from the asset are historicized at HQ Green Data Center.

Development of the system from HQ in tight collaboration with BU engineers.

Full support from Eni HQ.
PI Connection – eDOF

Asset Model

- Remote HMI Display
- KPI Dashboards
- Real-Time analysis pages for each FFU and well/field
- Mobile Dashboard
- Email Notification
- Facilitate Individual Analysis in Excel
- Facilitate Data export to other O&G Tools
- Chemical Package
**PI Connection – KPIs**

**DATA INFRASTRUCTURE**

More than 5’000 raw data per asset per second stored in different TAGs

- Pressure
- Temp.
- Level
- Flowrate
- ...

**KPI DEFINITION**

Raw data are elaborated in KPI through application of international standard

- API
- GPSA
- Best practice
- Standards

\[ KPI_{vibration} = \frac{\rho v^2}{\rho v^2 \text{ specific}} \]

**KPI MONITORING**

KPI Implementation and Monitoring (around 100 KPI per asset)
PI Connection – KPIs top/down logic

- Overall asset monitoring
- Fast identification of deviation from normal operation/design
- Notification/alert to dedicated person with suggestion to address the issue
- User defined dashboard
- Fast troubleshooting

- Focus on monitoring the entire asset or the digital twin
- KPI system with Top-Down logic (from asset to single equipment)
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- **Pi Connection: Architecture**
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Real-time based application

The new solution ensures data feeding in real-time and lets to use Rabbit for on-line monitoring and optimization via a user-friendly dashboard.
**PI Connection – eDOF to e-rabbit Optimization mode**

### Real-time based application

**Before**
- eDOF
- PI
- Manual input
  - Online data feeding
  - User Friendly naming
  - Preprocessed values

**Now**
- New real-time connection from eDOF to Rabbit
- Enabler for Rabbit on-line Optimization and Monitoring

**Optimization Algorithm - Solver**
- Node 1
  - Model files
- Node 2
  - Model files
- Node N
  - Model files
Real-time based application

Before

Manual Input:
NOT usable for automatic execution

Now

Online data feeding
User Friendly naming
Preprocessed values

New real-time connection from eDOF to Rabbit
Enabler for Rabbit on-line Optimization and Monitoring
PI Connection – User Friendly Naming for e-Rabbit

Site

Tags
- 881_MFPM_101_FO_031
- 881_U12_105_DPA_031
- 881_U12_114_CVP

Organized by Country & Site

eDOF (PI)

AF Elements
- well01.OilFlowRate
- well05.FLP
- wellE2.CvEqOp

Preprocessed Values

e-rabbit

Physical Variables
- Well 01 Oil Flow Rate
- Well 05 Flow Line Pressure
- Well E2 Choke Equivalent Opening
PI Connection – Preprocessing for e-Rabbit

**Raw Value**
Checking for:
- Bad Value
- Spikes (low and high limits)
- Stales (standard deviation)
- Minimum Good Values (percentage)

**Filtered Value and Status Value**
As configured:
- Noise reduction (moving average)
- UoM conversion
- Value Mapping (linear interpolation)

**toRabbit Value**

PI AF Analyses
*Periodic execution (5m)*
PI Connection – Central Architecture

- **High Availability Architecture**
  centred on a couple of servers for each of the 4 main components
  - 2 servers for PI Data Archive (PI Collective)
  - 2 servers for PI Asset Framework (load balanced)
  - 2 servers for PI Vision (load balanced)
  - 2 servers for MS SQL (Always-On)

- Hosted inside **Eni GDC (Green Data Center)** in Northern Italy
  - 2 completely separated and independent buildings
  - 3 Data Rooms for each Building

- For each HA couple, the servers are located in a different GDC buildings

More details in Gothenburg
PI World EMEA...?!
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Field Application – Operating Advantages of Near Online Models

- Integrated asset optimization
- Availability of simulation model up to date:
  - Link of real time data to simulation models
  - Data reconciliation
- Scheduling of Network and process simulation
- Identify deviation from expected behavior
Field Application – Simulation Set up

Rabbit Simulation Details

Define Simulation

- General Parameters
  - Simulation Name: 20190328.00195_Ang_EHL_SIN_RealTime
    - Country: Angola
    - Business Unit: Eni Angola
    - Asset: East Hub
  - Process File Path: [File Path]
  - Gap File Path: [File Path]

Simulation setup

- Optimization Environment
  - GAF-Hysys
- Run Type
  - Single Solve
  - Hysys
  - Optimization
  - Monte Carlo

Model input

Notes
### Field Application – Mapping of AF elements with GAP input

#### Table:

<table>
<thead>
<tr>
<th>Field</th>
<th>Code</th>
<th>Value</th>
<th>Type</th>
</tr>
</thead>
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<td>77.589</td>
<td>Well</td>
</tr>
<tr>
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</table>

#### Diagram:

- **Run Simulation**
- **Schedule**

**Schedule Settings**:
- **Date**: 29/03/2019
- **Hours**: 00:00

**Options**:
- **Cancel**
- **Confirm**
Similarly to the KPI structure, we need to define a **new** indicator that relates field data quality and model outputs with the real plant operating configuration.

$$MFF = \frac{RT \ value - \ model \ output}{RT \ value}$$

**GAP sim. output**

**AF element value**

**Threshold definition**

**Comparison**

**Field Application – Output Comparison for Monitoring and Tuning**
rabbit - Risked Algorithms for Biogenetical Balance Integration Tool

rabbit is a tool developed by PROD department which integrates subsurface models and surface production models, in order to optimize the production system with a global perspective. A powerful bio genetic algorithm searches for the solution that maximizes the oil production (or any desired objective function) according to the system constraints. The operative variables represent the genes that compose the genetic material of the solution. The operational steps for the development and implementation of rabbit are represented in the following workflow.
Operating Workflow – Results Examples

Surface & Subsurface Sensors
- Downhole P&T
- Well Head P&T
- Multiphase flow meter & ASD
- Prod. Network P&T
- Topside process (manifold, separator, compressors)

Production Optimization
(Choke up, gas lift, debottlenecking)

+60% oil rate
Operating Workflow – User Friendly Interface/Collaborative Environment
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**ENI**

Real-Time On Line Modeling of Upstream O&G Assets

The project has been developed with a team of integrated professionals: HQ Process Engineers, ICT Specialists and Site Engineers. The final framework has been implemented on Eni 4.0 Assets (Digital Lighthouse Project)

<table>
<thead>
<tr>
<th>CHALLENGE</th>
<th>SOLUTION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of updated simulation models for:</td>
<td>Near on-line digital twin based on advanced algorithm (e-rabbit, KPIs), simulators and PI (eDOF) system</td>
<td>Real-time monitoring of the assets through simulated results based on real-time data and Updated model for scheduled Asset optimization</td>
</tr>
<tr>
<td>• <strong>Diagnosis/Monitoring</strong> of (manifest or possible) production system</td>
<td>• <strong>PI tools</strong>: PI AF, PI DA</td>
<td>• Significant <strong>reduction of time</strong> during model updating process (2-3 working days)</td>
</tr>
<tr>
<td>• <strong>Design / verification of particular production modes</strong>, often temporary/transient</td>
<td>• <strong>Simulators</strong>: GAP/Prosper, Hysys</td>
<td>• Early and continuous support to detect <strong>issues</strong>, <strong>bottlenecks</strong> and <strong>optimization</strong> opportunities</td>
</tr>
<tr>
<td>• <strong>Check of operating procedures</strong> for special conditions</td>
<td>• <strong>Orchestrator</strong>: e-rabbit</td>
<td>• <strong>Licenses optimization</strong> and model tuning standardization</td>
</tr>
<tr>
<td>• <strong>Debottlenecking and production optimization</strong> new field operating conditions/constraints</td>
<td>• <strong>Test Field</strong>: on-shore south Europe, off-shore West-Africa</td>
<td>• Support to daily and long term <strong>asset management</strong></td>
</tr>
<tr>
<td></td>
<td>• <strong>Potential application</strong>: asset served by eDOF (PI based system)</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions – Central & Local Sites

Centralized system, collecting worldwide data from near to 40 different local data sources
Thank you for the attention

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Thank You!!

Q&A
PI Connection – KPIs scope and architecture

**KPI Separation unit** = \((f_1 \, Dp \, H2O \, 1^\circ st + f_2 \, Dp \, H2O \, 2^\circ st) \times P1^\circ st \times P2^\circ st\)

**KPI:**

- **Water Oil droplet diameter** 1° and 2° St

  \[ KPI_{\text{water-oil-droplet}} = \frac{\text{Droplet diameter}}{\text{Target droplet diameter}} \]

  Where \(\omega\) is light or heavy phase

- **Nozzles vibration** 1° and 2° St

  \[ KPI_{\text{nozzle}} = \frac{\rho v^2}{\rho v^2 \, \text{specific}} \]

**KPI Definition**
- Process and Historical Analysis
- Setting performance requirements

**KPI Upgrading & Tuning**

**KPI Implementation & Monitoring**

**KPI Analysis Value Creation**
- Root Cause Analysis
- Troubleshooting
- Optimization
Questions?

Please wait for the **microphone**

State your **name & company**

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