Holistic Process Digital Twins
Benefits of integrating pipeline and top-side process models

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Agenda

- Inprocess at a glance
- Process Digital Twin
- Multi Purpose Dynamic Simulator (MPDS)
- Case Study
  - Project Overview
  - Operation Scenarios Results
  - Comparison
- Conclusions
Inprocess in Brief

Since 2006 helping the processing industries in solving design and operational issues by applying process simulation

our core business is Process Simulation

enthusiastic about sharing our knowledge with our clients

technology neutral (process simulator or control system)

Operations Insights and optimization

Engineering Studies: De-bottlenecking Flare System, etc.

Operator Training

Engineering Training

Inprocess Solutions & Services

2006
est. in Barcelona by domain experts

Projects in 55 countries
worldwide presence

70+
simulation engineers

400+
executed projects

OTS Projects

>70

330+
training courses
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• Benefits of MPDS
The Process Model is a *first-principles* virtual representation of the plant that contains:

- all the **process** layout and streams conditions (Compositions, Pressure, Temperature, Flow, etc);
- Selected **equipment** geometric data (dimensions, elevation, tray sizing, sensor location, etc);
- Selected equipment manufacturer **performance** data (pump curves, compressor curves, heat exchanger rating data, etc);
- Selected actuated **valves** (valve pressure drop, sizing, characteristic, etc); and
- Selected **control and instrumentation** (control loops, PID algorithms, instrument ranges, tuning constants, etc).

All this information is combined in a Process Model, built in a **high-fidelity** simulation tool like Symmetry or OLGA.
### Lifecycle Process Digital Twin

#### Plant lifecycle

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<th>Basic Design</th>
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<td>Design Simulation</td>
<td>Virtual commissioning and simulation-based engineering</td>
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#### Off-line

- Engineering Design validation
- Control Narrative & Procedures validation
- ICSS validation & tuning
- Operator Training Simulators (OTS)

#### On-Line

- Equipment Load & Efficiency Monitoring
- Inferentials
- Bad Actors Detection
- Look-ahead & What-if

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**First-Principles Models**

- Communication
- Sensors Data

**IIS**

**Cloud Database**

**Asset**
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Transient Scenarios during Detailed Engineering Phase
- Emergency Scenarios: Equipment and Instrumentation design check in front of trips, blocked lines, changes in production
- Control Philosophy: Control loops, alarms settings

Start-Up Operations
- Facilities Start-Up, wells management
- Early Production Simulation
- Transition to Normal Production

Daily Operations and Maintenance
- Analysis for future production rates & operational constraints
- Online Process Digital Twin
Multi Purpose Dynamic Simulator (MPDS)

- **Process Unit Dyn. Models**
  - Analysis of critical units
  - Engineering Data
  - Plant Data
  - Model from engineering Studies

- **Complete Dynamic Model**
  - Additional equipment, ICSS/UCP Control Narrative, CEMs, interlocks
  - External packages logic and sequence implementation

- **Process Trainer**
  - ICSS HMI Emulated wth inprocess Instructor Station
  - Early Operator Training

- **Virtual Commissioning**
  - Instructor Station, Training Scenarios, Additional ICSS Consoles VR
  - PID Control tuning DCS Check-Out

- **Direct Connect OTS**
  - OTS Training

- **Online Digital Twin**
  - Connectivity to Plant Data Base
  - Define Applications – e.g. hydrates or chemicals monitoring
  - Operational Insights, What-If Analysis, Bad Actor Detection

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Multi Purpose Dynamic Simulator (MPDS) offers continuous value during the project lifecycle:

- De-Risking Start-Up through Virtual Commissioning
- Effective Operator training when required (even with DCS delays)
- Process & Control insights during Project Execution
- Resilient Benefits from Simulator investment → Online Process Digital Twin
- Aligned with Digitization Strategy
- Future-proof Investment → >80% of Inprocess OTS are still under Maintenance
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Holistic Dynamic Model Overview
Scenarios WITH / WITHOUT model integration

**Models not integrated**

- **Dynamic pipeline Model**
- **Dynamic Topside Model**

**Integrated Models**

- **Dynamic Pipeline Model**
- **Dynamic Topside Model**
Start-up After ESD* - Procedure

Objectives
- Ensure trips are avoided during the start-up
- After ESD some liquid remains in the piping. During start-up this leads to a surge of liquid to downstream separators

Dewatering Initial conditions
- Isolation Valves Open
- Controllers in Auto

Stage Separators Initial Condition
- Isolation valves open
- Pressure controllers in auto
- Other Controllers in Manual

Procedure
1. Open inlet bypass valves
2. Open dewatering main isolation valve
3. Export oil from slug catcher
4. Export from 1st stage separator
5. Export from 2nd stage separator
6. Open full feed

*ESD - Emergency shut down

Start-up After ESD – Results (independent models)

Start-up After ESD – Results (integrated models)

From: "Transient Behavior of Pipelines Through Holistic Dynamic Models"; K. Jain et al.
General conclusions

- Updated control set-up avoided trips in the facilities during start-up
- Dewatering section was enabled to start-up in automatic mode

Facilities - Flowline Model integration benefits for start-up

- Optimized start-up procedure reduces the start-up time by around 40% (for a typical black start-up)
  - A net saving of 4 days can be achieved for steady state operation
  - Considering around 100,000 bbl/day production / oil price of $50/bbl, this results in savings of $20MM
- A surge to liquid reaches the facilities
  - Stage separators surge of liquid is quite high.
  - Controllers had to be more aggressive than expected during startup modelling without integration.
    Slugging behavior at dewatering station is observed. It is shown that facilities are able to handle the fluctuations produced.
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Your takeaways

World Oil article about applying Lifecycle modelling to Yinson JAK FPSO in Ghana

Visit our webpage, or Google "FPSO lifecycle modelling"

Easy to read Whitepaper about Best Practices to request and exploit Lifecycle OTSs / MPDS

Visit our webpage, or Google "request lifecycle OTS"

Excel file with a configurable business case to justify a lifecycle Digital Twin investment

Send email to: michael.brodkorb@inprocessgroup.com
Thank you!

Q&A

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