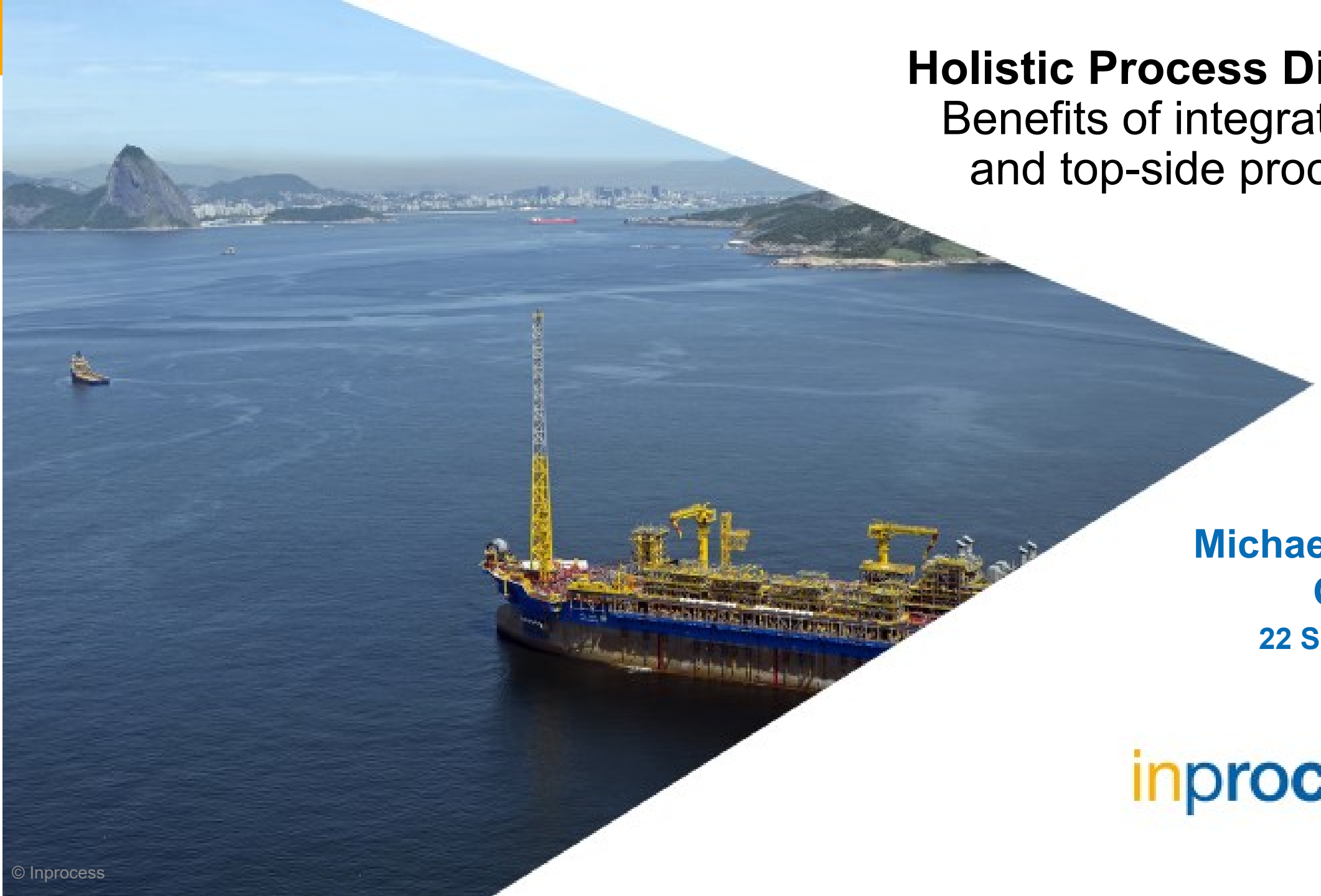


Holistic Process Digital Twins

Benefits of integrating pipeline and top-side process models

Michael Brodkorb
Oriol Millan

22 September 2022

inprocess

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)

2006
est. in Barcelona by domain experts

Projects in 55 countries
worldwide presence

70+
simulation engineers

400+
executed projects

>70
OTS Projects

330+
training courses

Inprocess Solutions & Services

Operations Insights and optimization

Engineering Studies: De-bottlenecking Flare System, etc.

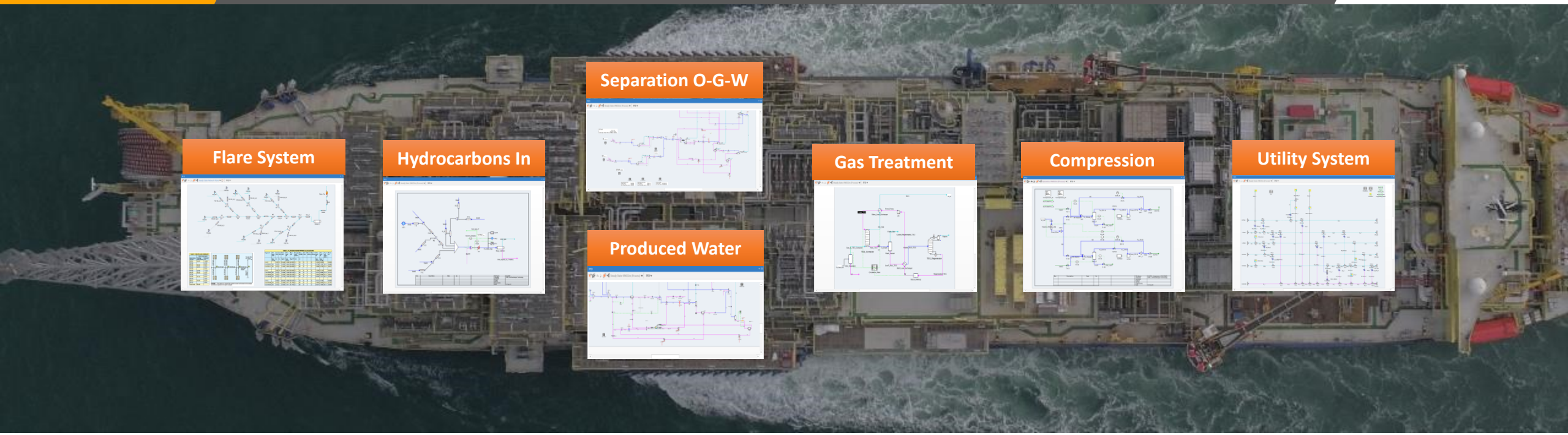
Operator Training

Engineering Training

Agenda

- **Inprocess at a glance**
- **Process Digital Twin**
- **Multi Purpose Dynamic Simulator (MPDS)**
- **Case Study**
  - Project Overview
  - Operation Scenarios Results
  - Conclusions
- **Benefits of MPDS**

Process Model = 1st step to a Process Digital Twin



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

Conceptual Design | Basic Design | Detailed Design | Set-up | Commissioning | Operation | Maintenance and Modernization

1 Design Simulation

2 Virtual commissioning and simulation-based engineering

3 Operators Training

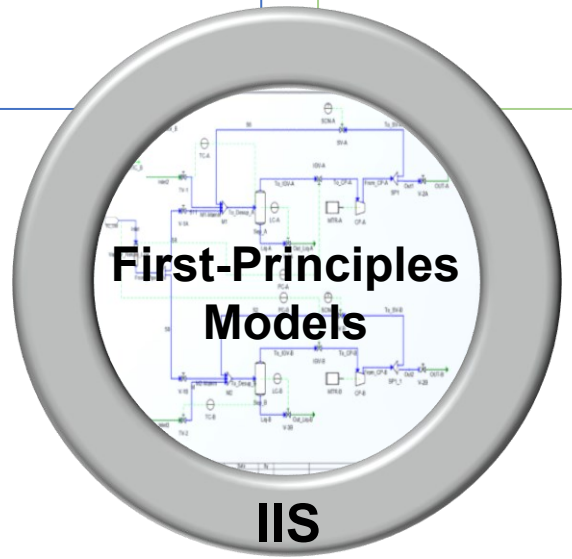
4 Operation-associated decision support and optimization

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



Communication

CLOUD DATABASE

Sensors Data

ASSET

Agenda

- **Inprocess at a glance**
- **Process Digital Twin**
- **Multi Purpose Dynamic Simulator (MPDS) applied**
- **Case Study**
  - Project Overview
  - Operation Scenarios Results
  - Conclusions
- **Benefits of MPDS**

Process Digital Twin during Project Lifecycle

Transient Scenarios during Detailed Engineering Phase

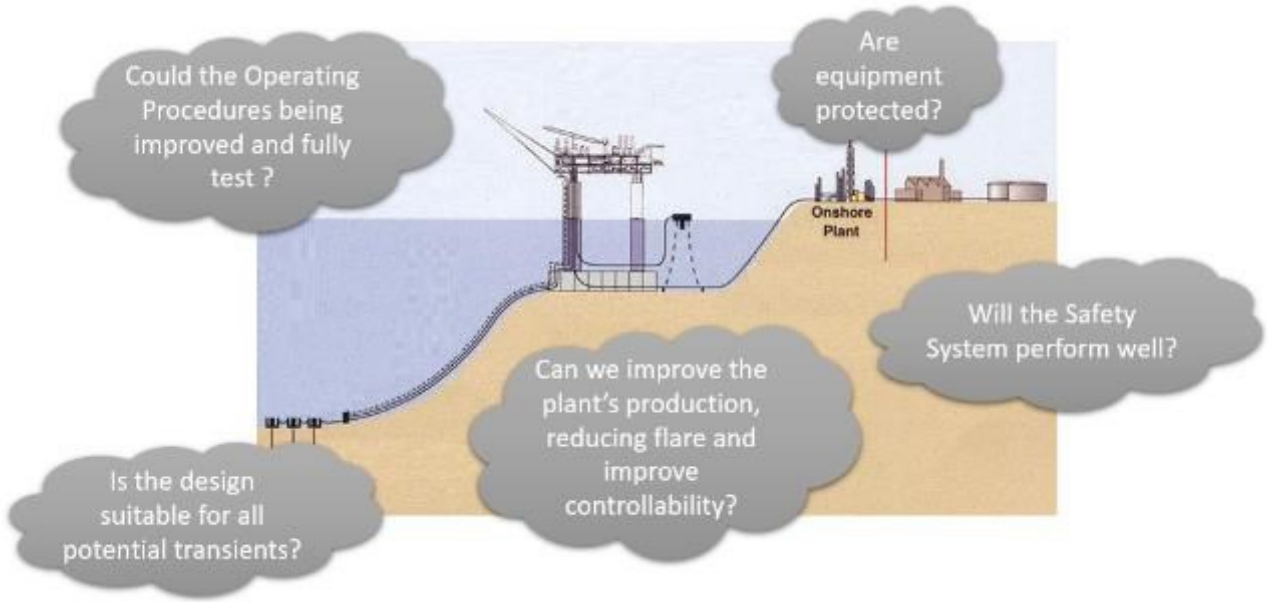
- Emergency Scenarios: Equipment and Instrumentation design check in front of trips, blocked lines, changes in production
- Control Philosophy: Control loops, alarms settings

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



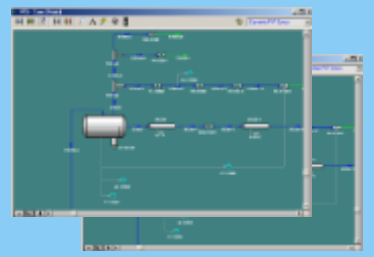
Multi Purpose Dynamic Simulator (MPDS)

Process Unit Dyn. Models

Engineering Data

Plant Data

Model from engineering Studies

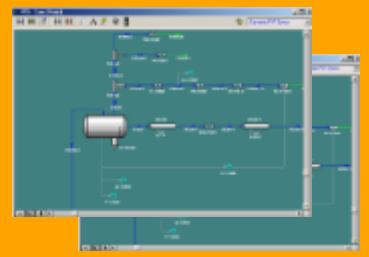


Analysis of critical units

Complete Dynamic Model

Additional equipment, ICSS/UCP Control Narrative, CEMs, interlocks

External packages → logic and sequence implementation



Control Narrative and Procedure Verification

Process Trainer = Emulated OTS

ICSS HMI Emulated with Inprocess Instructor Station

Early Operator Training

Virtual Commissioning

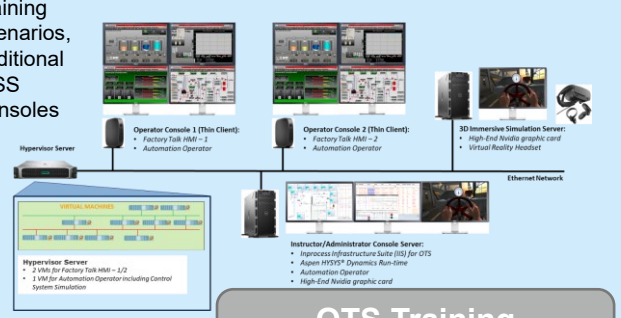
ICSS Database Control Logic

ICSS HMI displays

PID Control tuning DCS Check-Out

Direct Connect OTS

Instructor Station, Training Scenarios, Additional ICSS Consoles VR

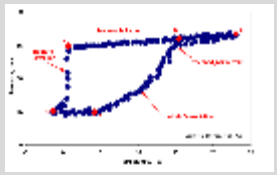


OTS Training OTS Maintenance

Online Digital Twin

Connectivity to Plant Data Base

Define Applications – e.g. hydrates or chemicals monitoring



Operational Insights What-If Analysis Bad Actor Detection

Why Owner Operators engage with Inprocess for MPDS?

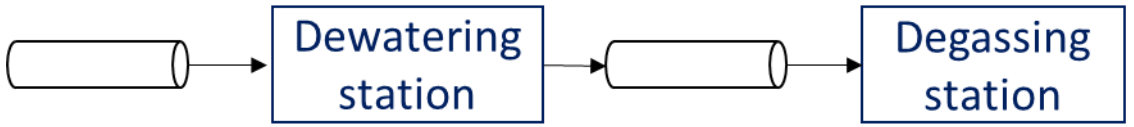
Multi Purpose Dynamic Simulator (MPDS) offers continuous value during the project lifecycle:

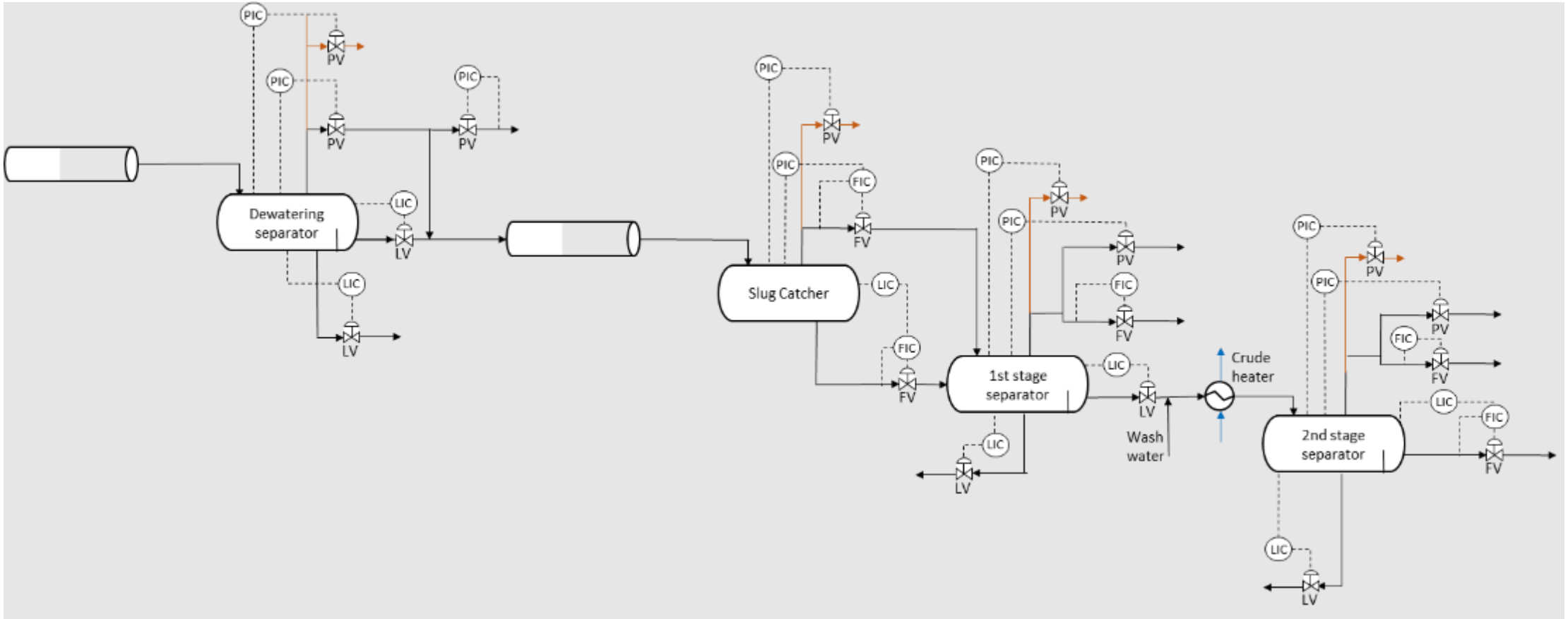
- De-Risking Start-Up through Virtual Commissioning
- Effective Operator training when required (even with DCS delays)
- Process & Control insights during Project Execution
- Resilient Benefits from Simulator investment → Online Process Digital Twin
- Aligned with Digitization Strategy
- Future-proof Investment → >80% of Inprocess OTS are still under Maintenance

Agenda

- **Inprocess at a glance**
- **Process Digital Twin**
- **Multi Purpose Dynamic Simulator (MPDS)**
- **Case Study**
  - Project Overview
  - Operation Scenarios Results
  - Conclusions
- **Benefits of MPDS**

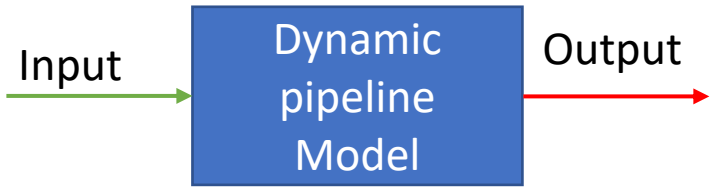
Holistic Dynamic Model Overview

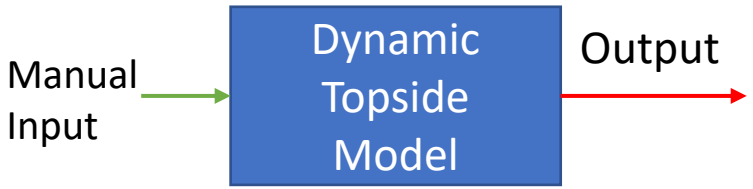




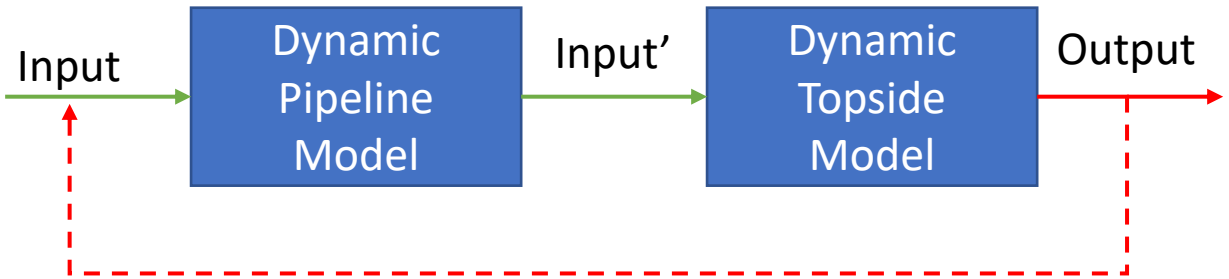
Scenarios WITH / WITHOUT model integration

Models not integrated





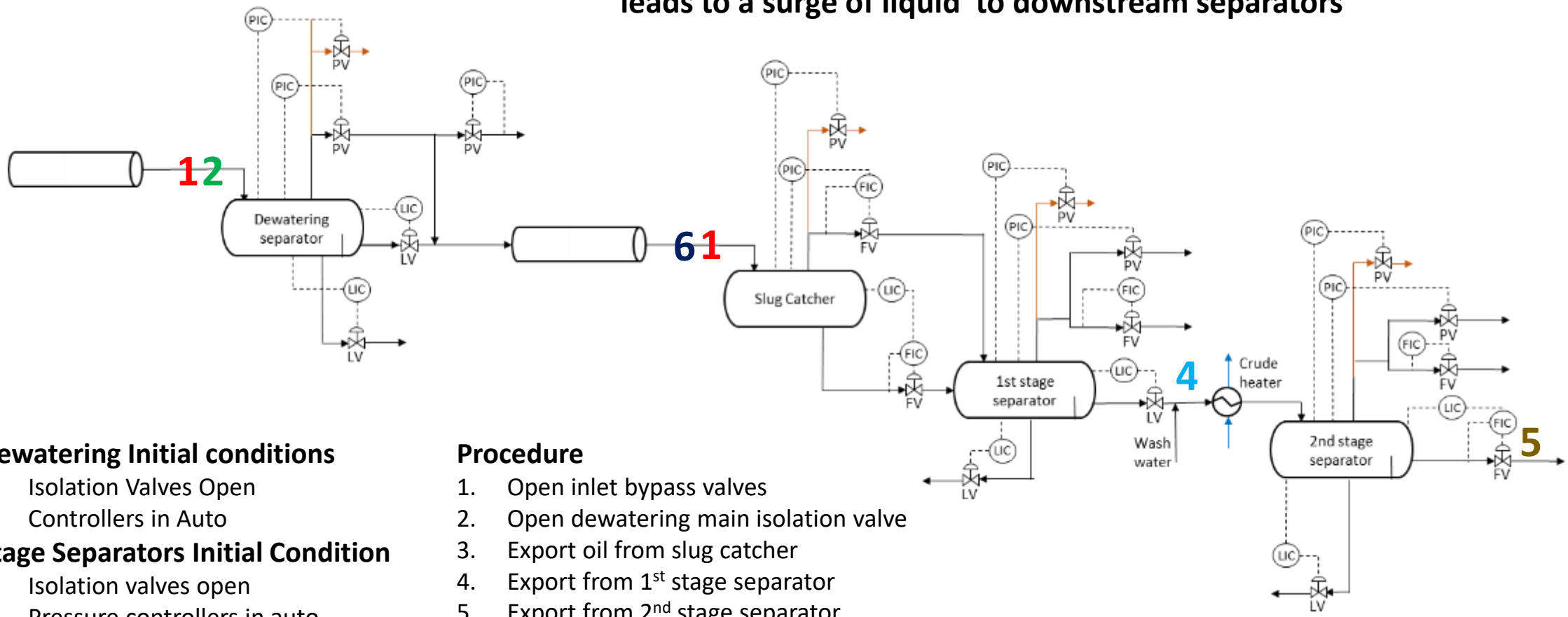
Integrated Models



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

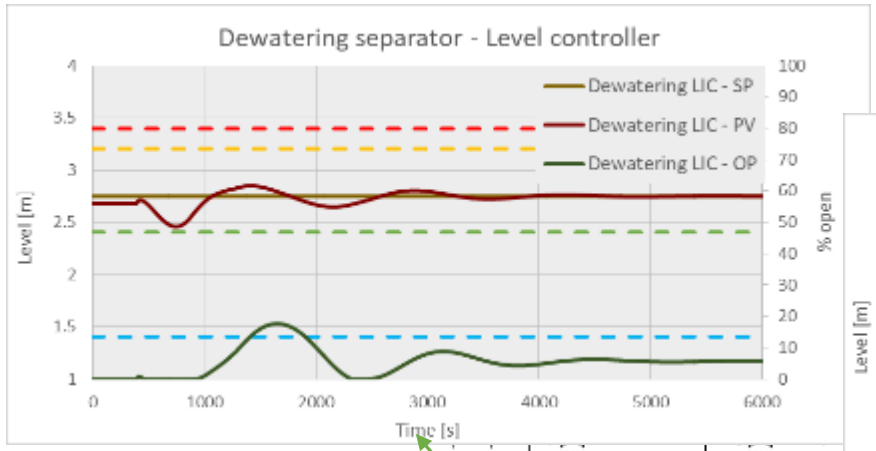
Procedure

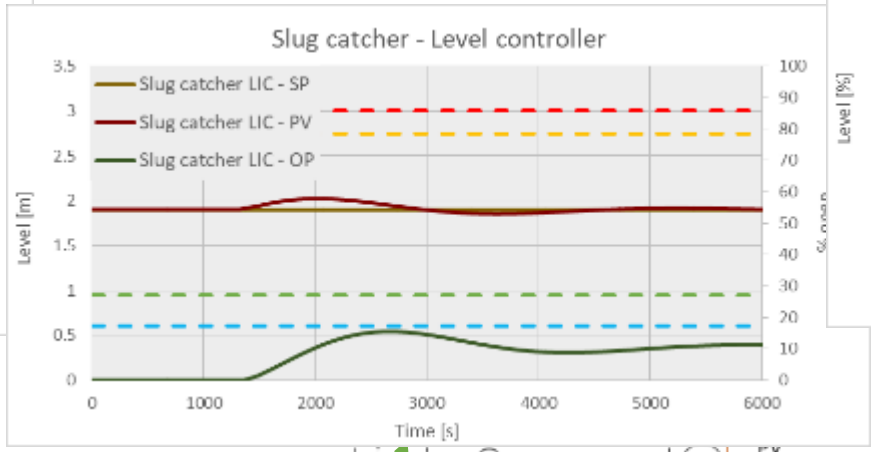
1. Open inlet bypass valves
2. Open dewatering main isolation valve
3. Export oil from slug catcher
4. Export from 1st stage separator
5. Export from 2nd stage separator
6. Open full feed

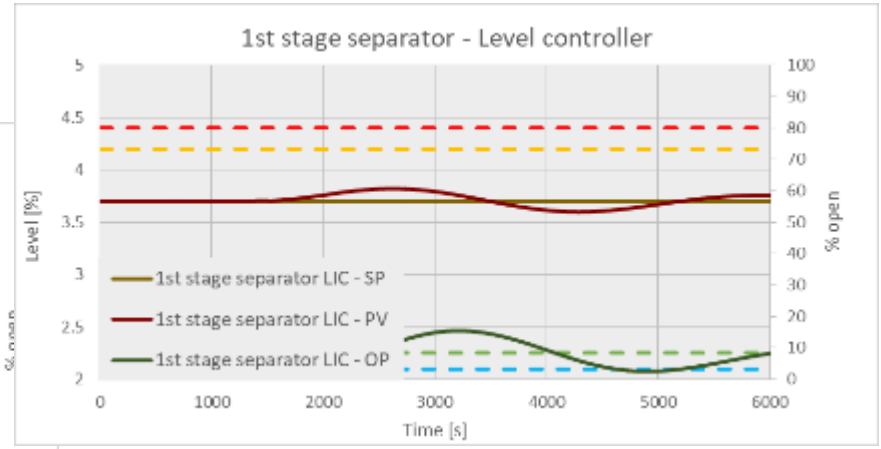
*ESD- Emergency shut down

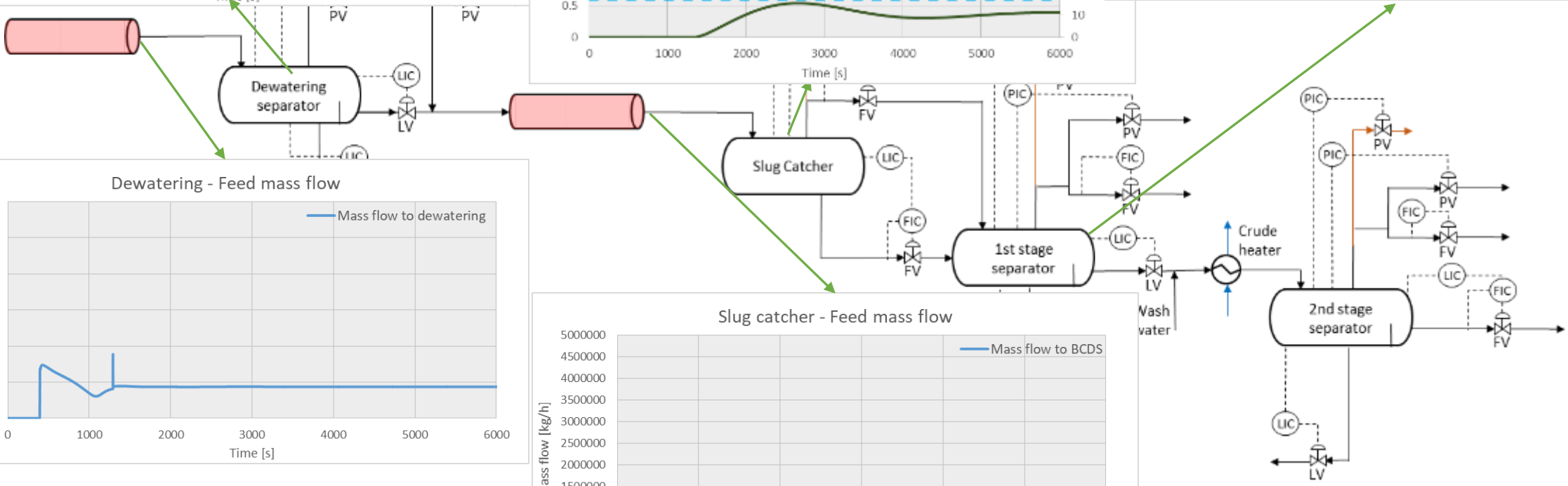
From: "Transient Behavior of Pipelines Through Holistic Dynamic Models"; K. Jain et.al.

Start-up After ESD – Results (independent models)



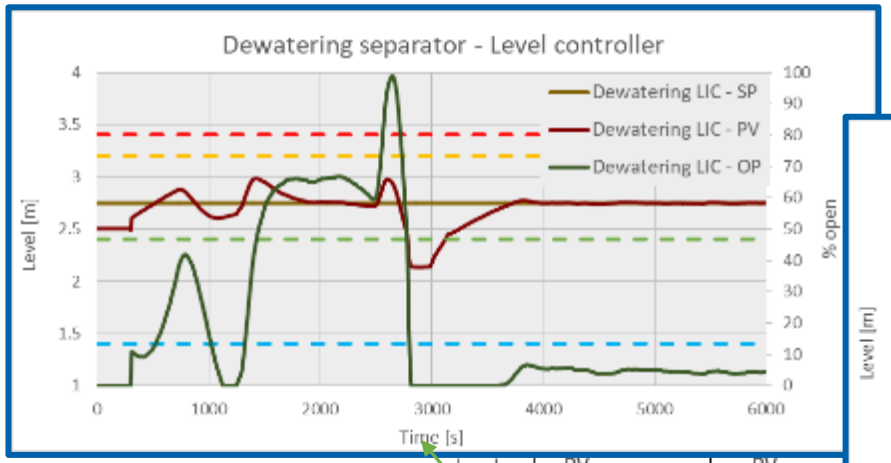


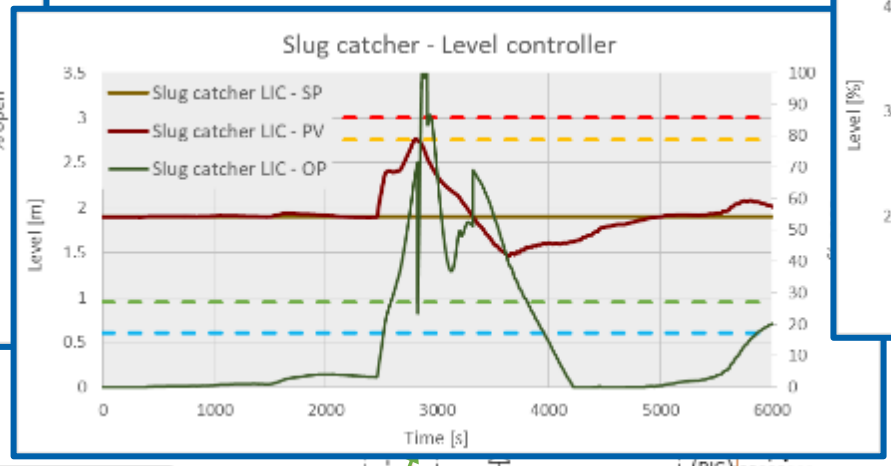


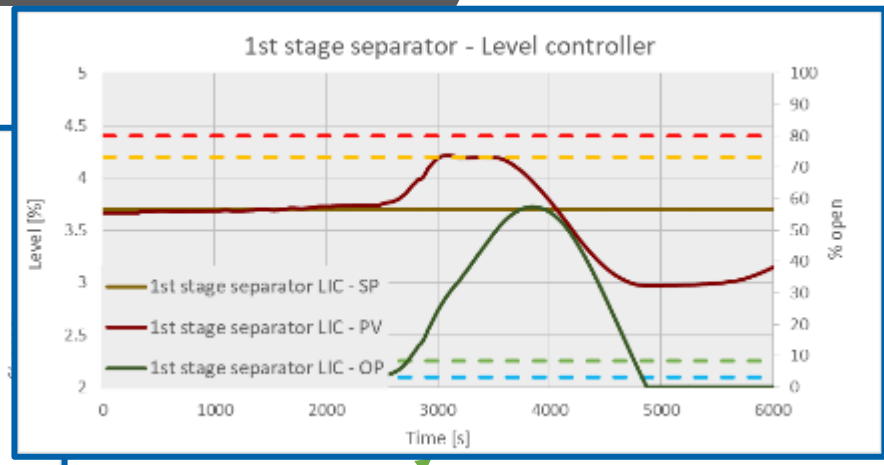


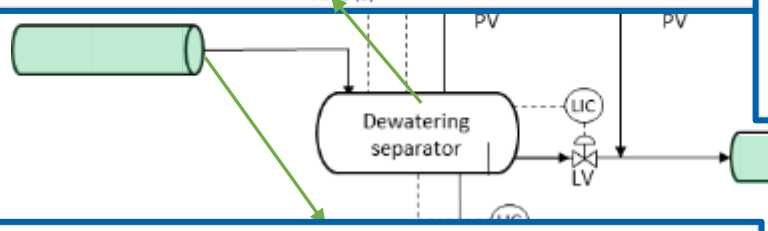
From: "Transient Behavior of Pipelines Through Holistic Dynamic Models"; K. Jain et.al.

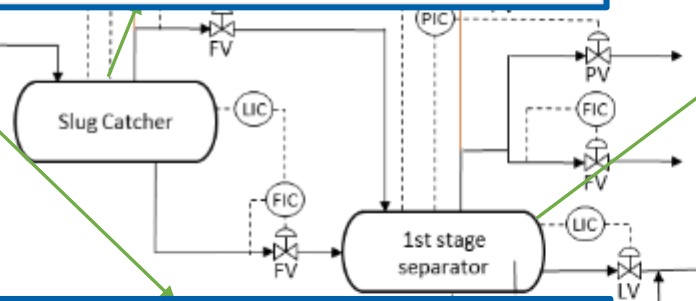
Start-up After ESD – Results (integrated models)

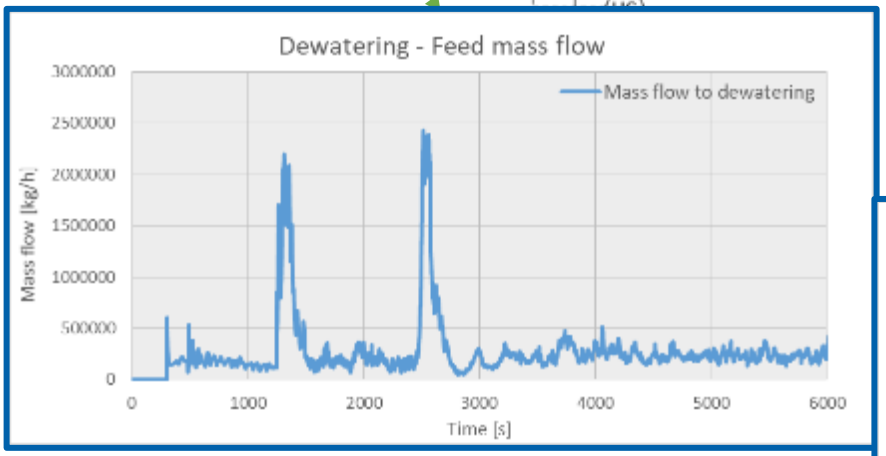


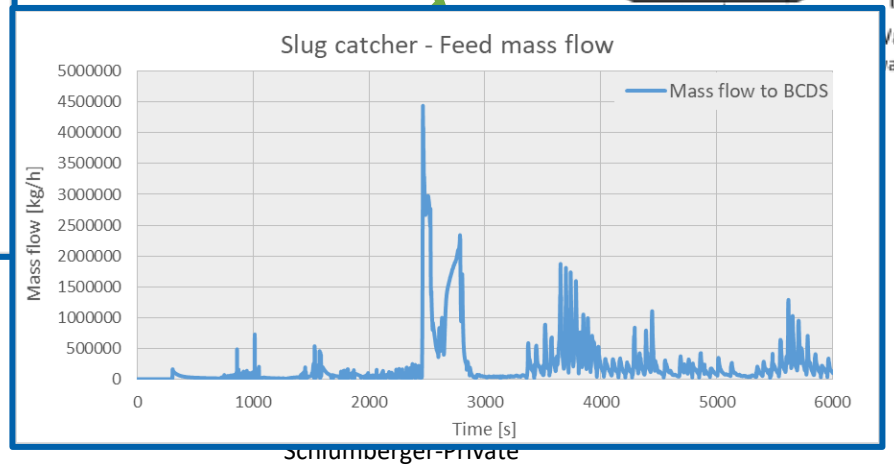


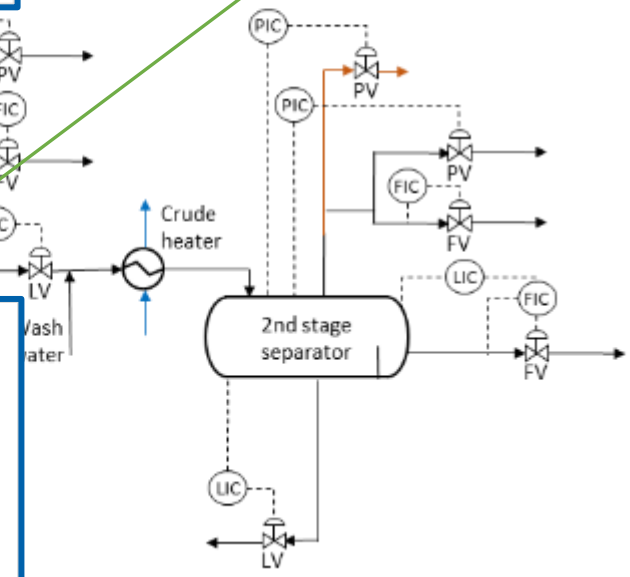












From: "Transient Behavior of Pipelines Through Holistic Dynamic Models"; K. Jain et.al.

Start-up After ESD – Conclusions

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.

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

Agenda

- **Inprocess at a glance**
- **Process Digital Twin**
- **Multi Purpose Dynamic Simulator (MPDS)**
- **Case Study**
  - Project Overview
  - Operation Scenarios Results
  - Conclusions
- **Benefits of MPDS**

Why Owner Operators engage with Inprocess for MPDS?

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

Your takeaways

Originally appeared in World Oil® NOVEMBER 2017 issue, pgs 33-38. Posted with permission.

SPECIAL FOCUS: ADVANCES IN PRODUCTION

FPSO lifecycle modeling adds benefits to development offshore West Africa

In a recent FPSO development project offshore West Africa, a lifecycle modeling approach project, ending in a direct-connect Operator Training System with Aspen HYSYS Dynamics, was used for process

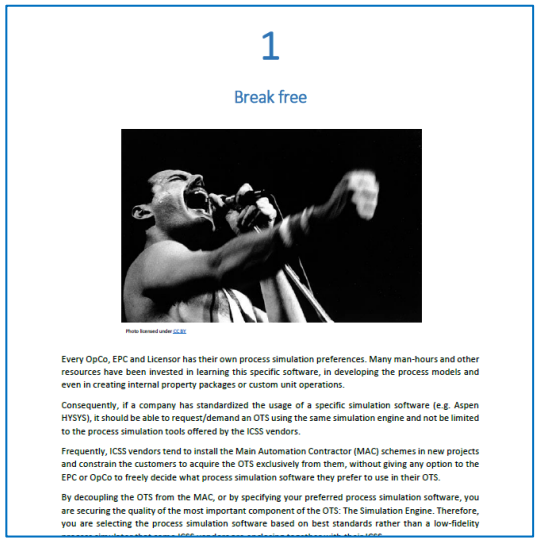
Yinson Production Pte Ltd (Yinson) recently converted a double-hull, very large crude carrier (VLCC) oil tanker to a Floating Production Storage and Offloading (FPSO) vessel for its development project offshore West Africa. In this project, the dynamic models from the engineering phase have been re-used for process design

- Is the primary protection designed properly for the planned operational conditions?
- Will the safety system perform well?
- How will the vendor packages control system interface with the integrated control & safety system (ICSS)?

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

Visit our webpage, or Google

FPSO lifecycle modelling



1

Break free

Every OpCo, EPC and Licensor has their own process simulation preferences. Many man-hours and other resources have been invested in learning this specific software, in developing the process models and even in creating internal property packages or custom unit operations.

Consequently, if a company has standardized the usage of a specific simulation software (e.g. Aspen HYSYS), it should be able to request/demand an OTS using the same simulation engine and not be limited to the process simulation tools offered by the ICSS vendors.

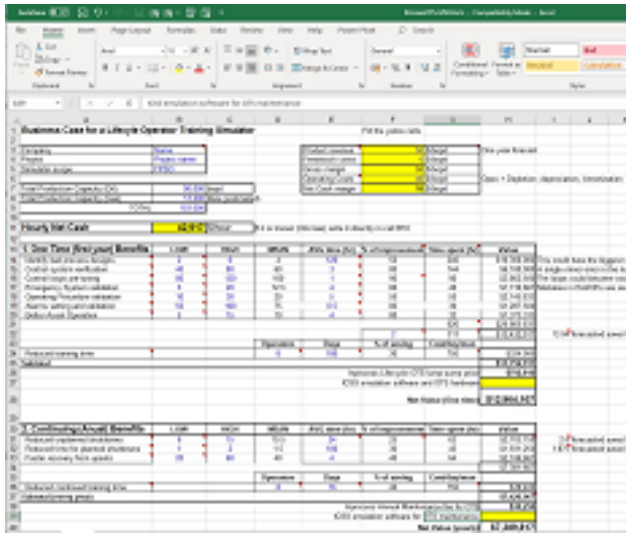
Frequently, ICSS vendors tend to install the Main Automation Contractor (MAC) schemes in new projects and constrain the customers to acquire the OTS exclusively from them, without giving any option to the EPC or OpCo to freely decide what process simulation software they prefer to use in their OTS.

By decoupling the OTS from the MAC, or by specifying your preferred process simulation software, you are securing the quality of the most important component of the OTS: The Simulation Engine. Therefore, you are selecting the process simulation software based on best standards rather than a low-fidelity

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

Oriol Millan

Michael Brodkorb

www.inprocessgroup.com