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Digital Twin: Three Birds, One Stone

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Three Birds, One Stone: Using Digital Twin

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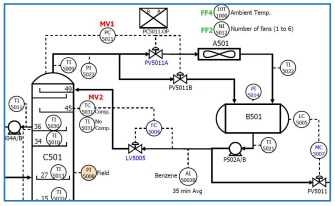
Agenda

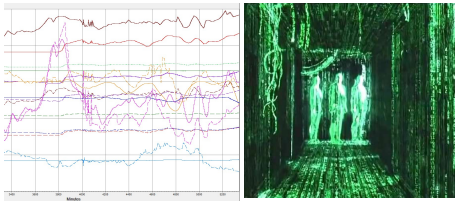
- The DCS migration challenge
- The stone and the three birds:
  - DESIGN the process control
  - VERIFY the DCS code
  - TRAIN the operators
- Benefits and future applications

Four things I do when I begin a modelling project



1.- Ask for a good PFD. Otherwise I draw my own PFD, exactly as I like it.

2.- Visit the real plant. To touch, smell and feel the real stuff.



3.- Ask 1-year at 1-min sample historical data and study them until I see the “matrix” bits.

4.- Talk with operation staff and ask them many Whys.

My favourite answer:
“we do this because we have been doing this for 20 years”

The DCS migration challenge

Half of the control system of the plant (raw materials preparation, etc) was based on TDC3000 and the other half (Batch reactors, mixing, drying, etc) on DeltaV.

It was decided to migrate the TDC3000 part to DeltaV and undertake a number of improvements.

DeltaV migration scope

- 2 raw-material purification units
- 5 hydrocarbons purification units
- 6 flash units
- 2 raw-material2 purification units

GOALS

- Improve process control layouts
- Automatize start-up/operation/shutdown of distillation units (Safety and uniform operation)
- Reduce operator workload and alarms
- Shorten DCS migration shutdown time

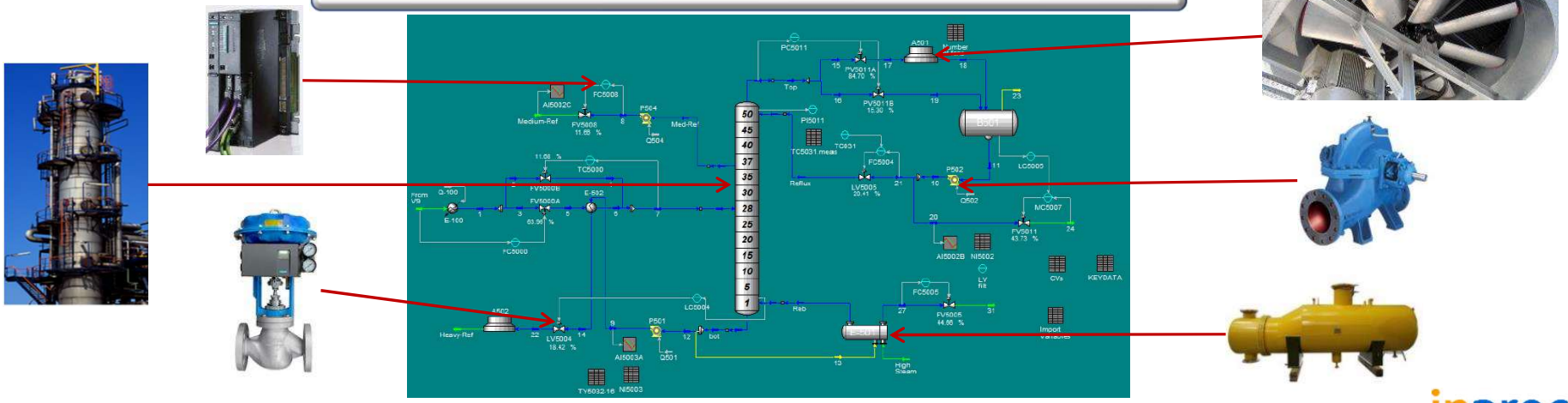
Digital Twins in the process industries

What is a Digital Twin?

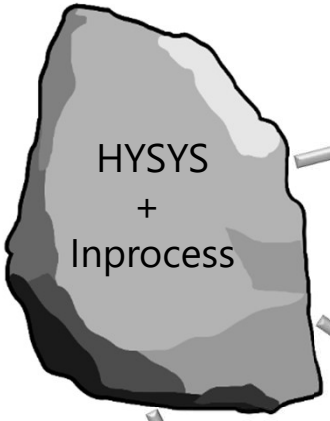
It is the digital version of your running asset. It contains:

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

All this information is consolidated in a HYSYS Dynamic Process Model



The stone and the three birds



CONTROL DESIGN

- Model units against planta data, the improved control schemes were tested.
- Automatic column sequences were tested.
- Total of 34 Engineering scenarios were studied, used for the new Control Narrative specification.

VERIFY CODE

- The same HYSYS Dynamic models were link to DeltaV Simulate
- DCS FAT was conducted, with HYSYS acting as the plant.
- Extensive DCS checkout report containing 124 issues.

TRAIN OPERATORS

- Detailed training manual, including all operation procedures.
- Inprocess instructors gave 4x6 days of onsite training to operators before plant start-up using the HYSYS-based OTS
- Operator feedback was collected to fine-tune sequences

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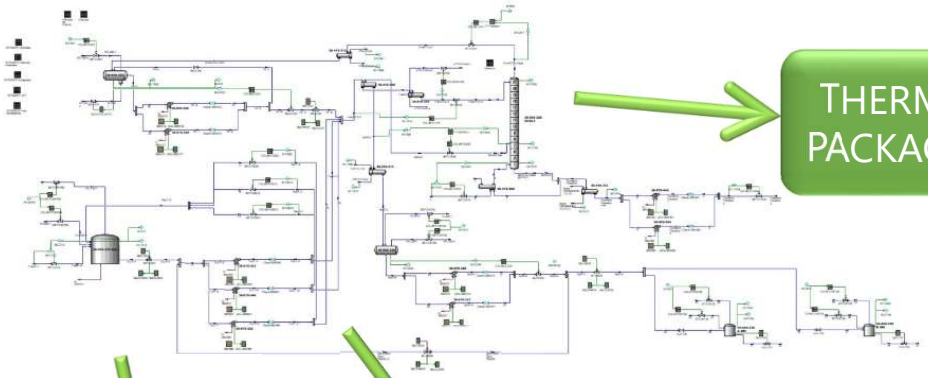
The stone: Why HYSYS?



THERMO PACKAGES

- Customer AspenPlus models were reproduced in HYSYS with Aspen Properties
- Azeotropic distillation and other exotic key species were handled in the property package
- HYSYS native packages improved real-time factor

MODELS REUSABILITY

- Plant engineers were directly able to use developed models
- The dynamic models of the engineering studies were fully reused to configure the DCS-checkout and OTS, with very few changes
- The master models are in the OTS linked to DeltaV, independent models can be quickly generated by switching to HYSYS controllers

REALISTIC TRAINING

- Operators relied on the dynamic responses generated by the HYSYS-based OTS
- New automatic sequences were taught to all operators.
- A key senior operator spent four months testing sequences and their parameters

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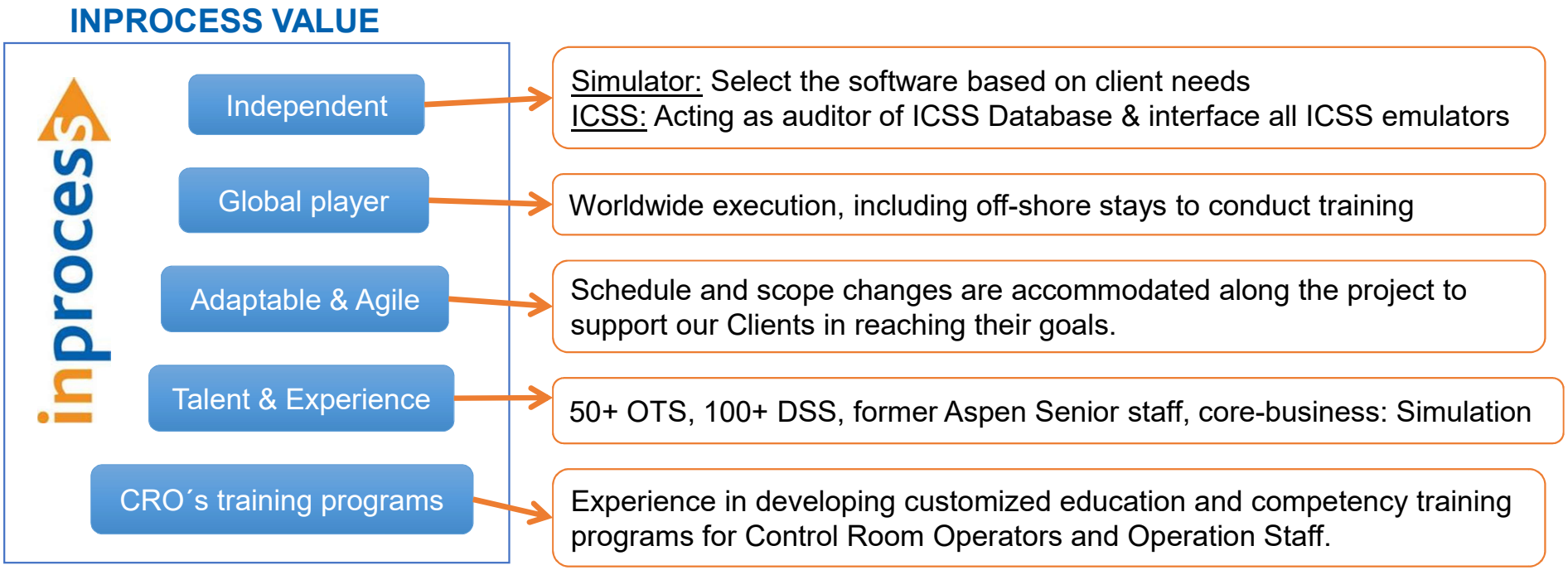
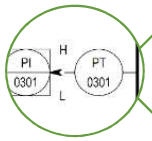
The stone: Why Inprocess?

Customers chose Inprocess as the company to fully exploit Dynamic Modelling for their project.



DESIGN the process control: Key findings



Plant instrumentation check. Consistent values?

- Through the Steady State and Dynamic model all the instruments were check, finding those who were indicating values that were not consistent with the heat and material balances.

Confirmed suspicions.

- Through the model, engineers could confirm most of the suspicions that they had regarding uncertain compositions or unknown problems causes , which are very difficult to do without a detailed model (key components concentration, reaction in columns, accumulation timing, nitrogen carry-over or leaks, etc).

Pumps might not meet the design specifications.

- For long time, engineers could not explain erratic behavior of the certain pumps. Thanks to the model some tests could be done in order to clarify the problem.

Reduce energy consumption during recycling mode by reducing load.

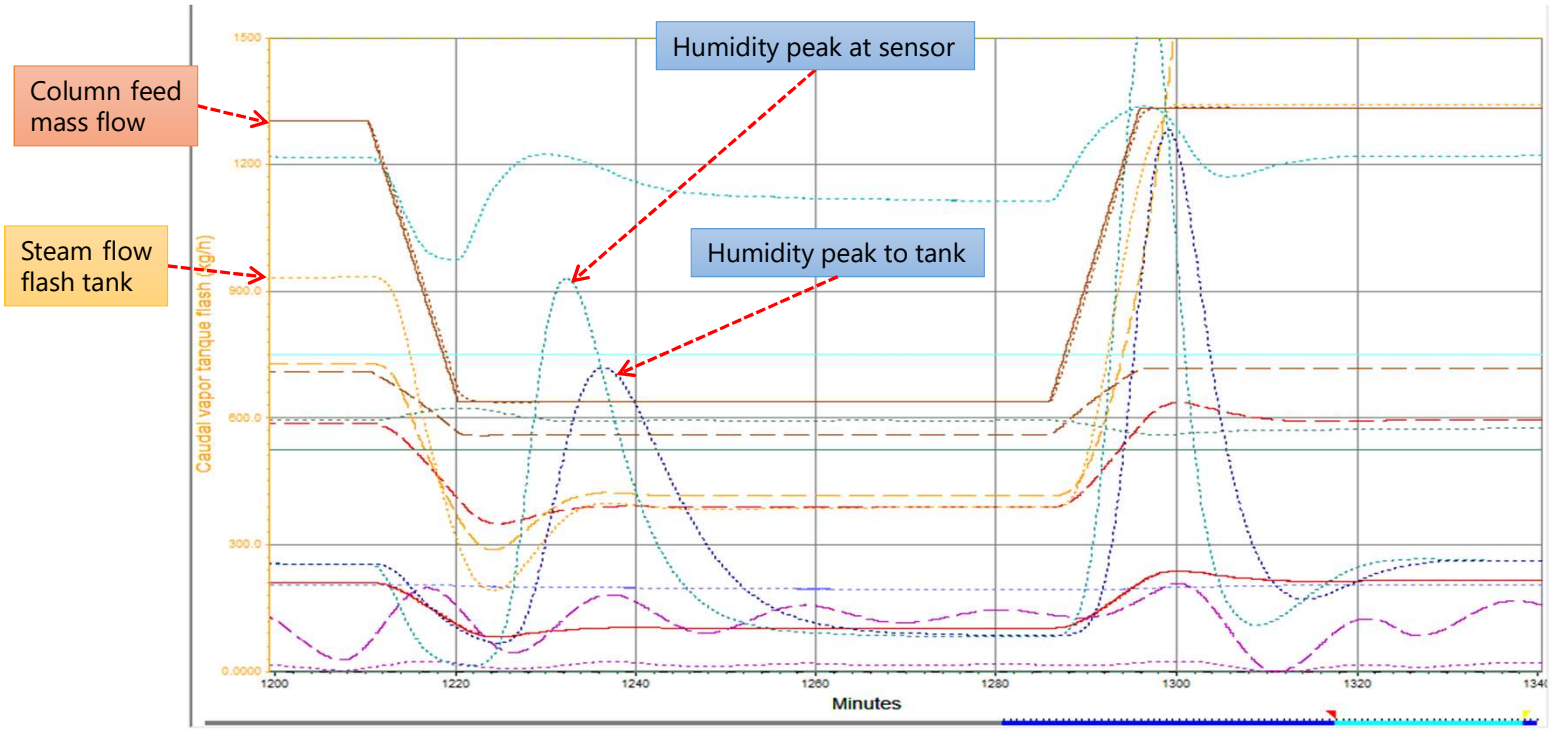
- The model allowed to test different column loads and ramps during recycling mode that turned into more efficient ways of operating the column reducing the steam consumption.

New control strategies.

- Through the model, new control strategies were raised allowing to propose better ways to control the production and the purified raw material inventory.

DESIGN the process control: load changes

Column feed mass flow was reduced with certain ramps during recycling mode to minimize the amount of steam used in the column reboiler and Flash tank. The water content was stabilized in less than 30 minutes. In this way, the column in recycle mode was able to reduce its steam consumption by 40%.

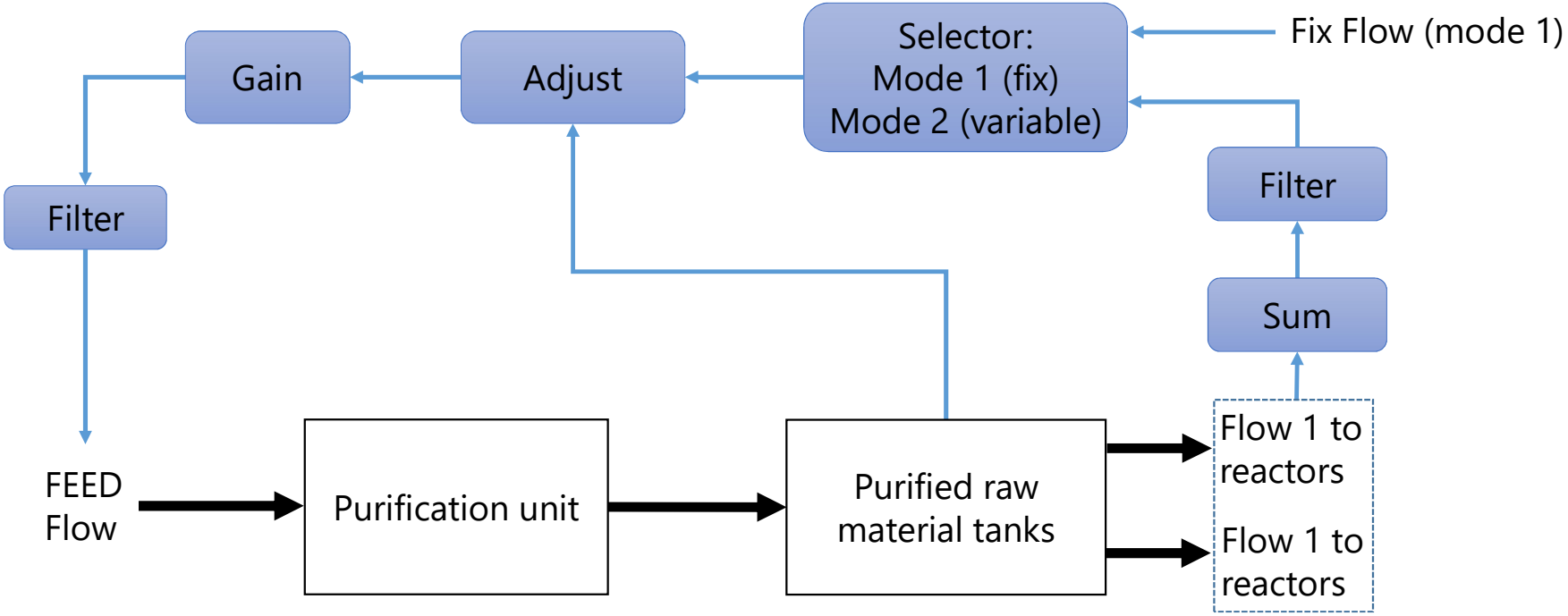


But there was something better than this??

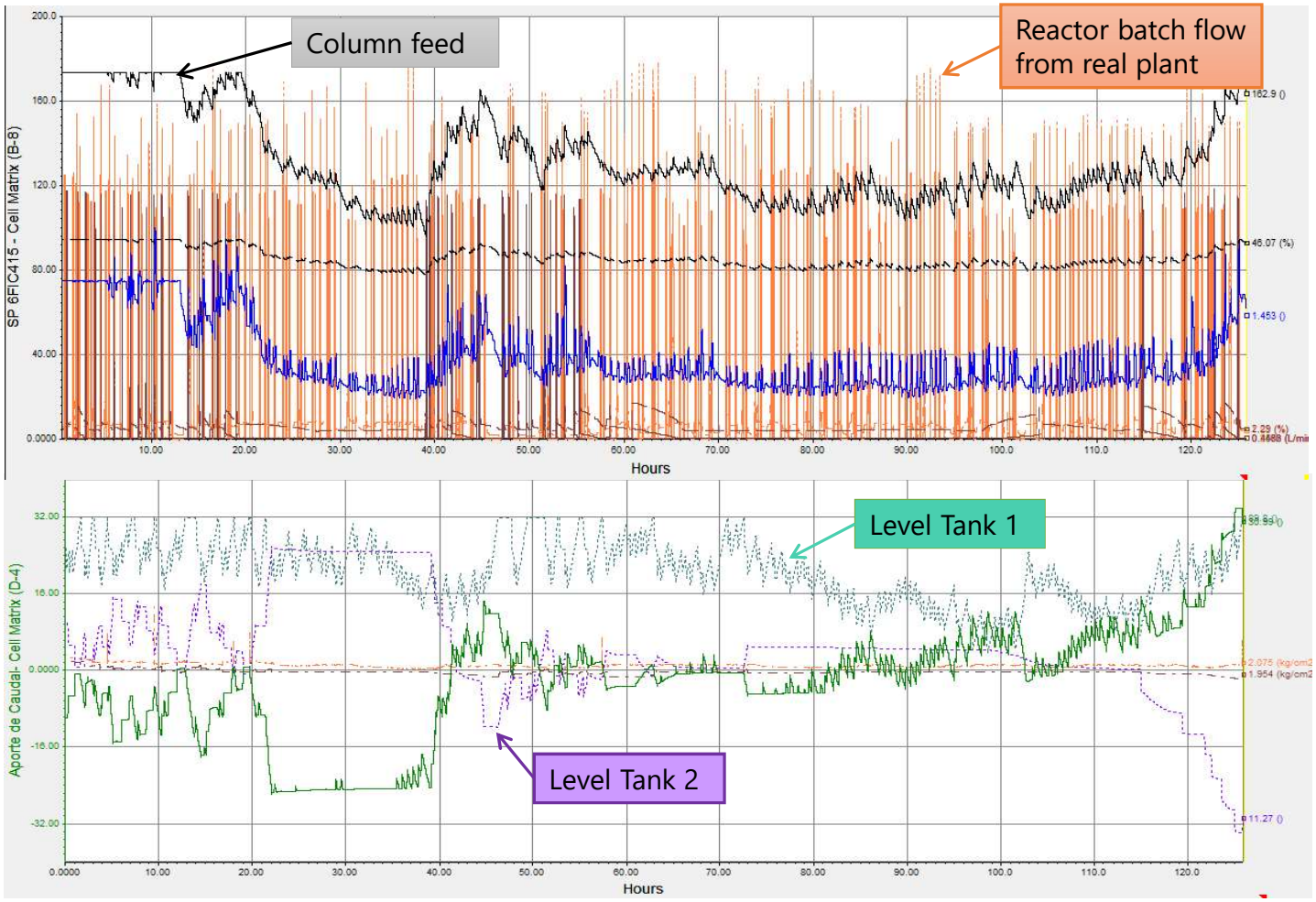
Try to avoid recycle mode!!

DESIGN the process control: Inventory Control

A new inventory control scheme was designed to align the column load (continuous process) to the consumption of the reactors (batch process), avoiding the recycle mode



DESIGN the process control: 5-day test Inventory Control



The new control scheme was tested using historical plant data.

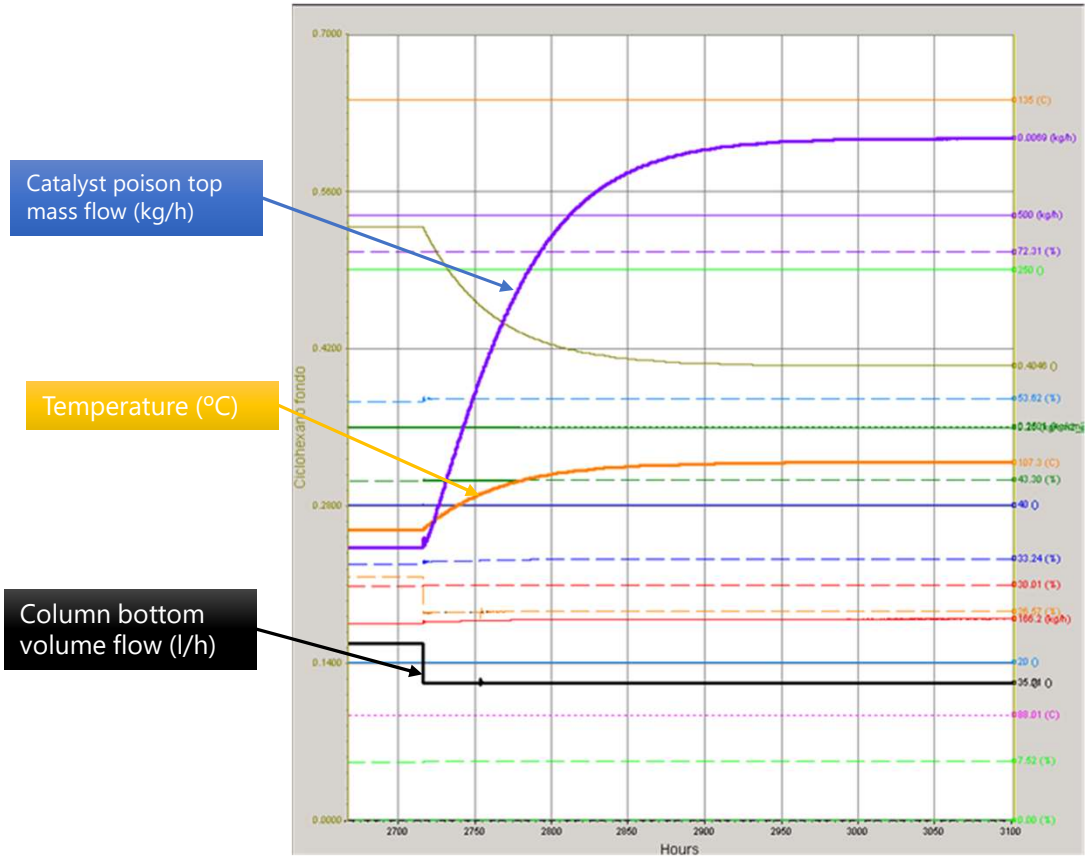
A simple VB macro feeds data from excel into the dynamic model.

The control scheme was tuned and demonstrated that the feed to the raw material purification unit can be regulated to avoid entering in recycle mode and maintain specification.

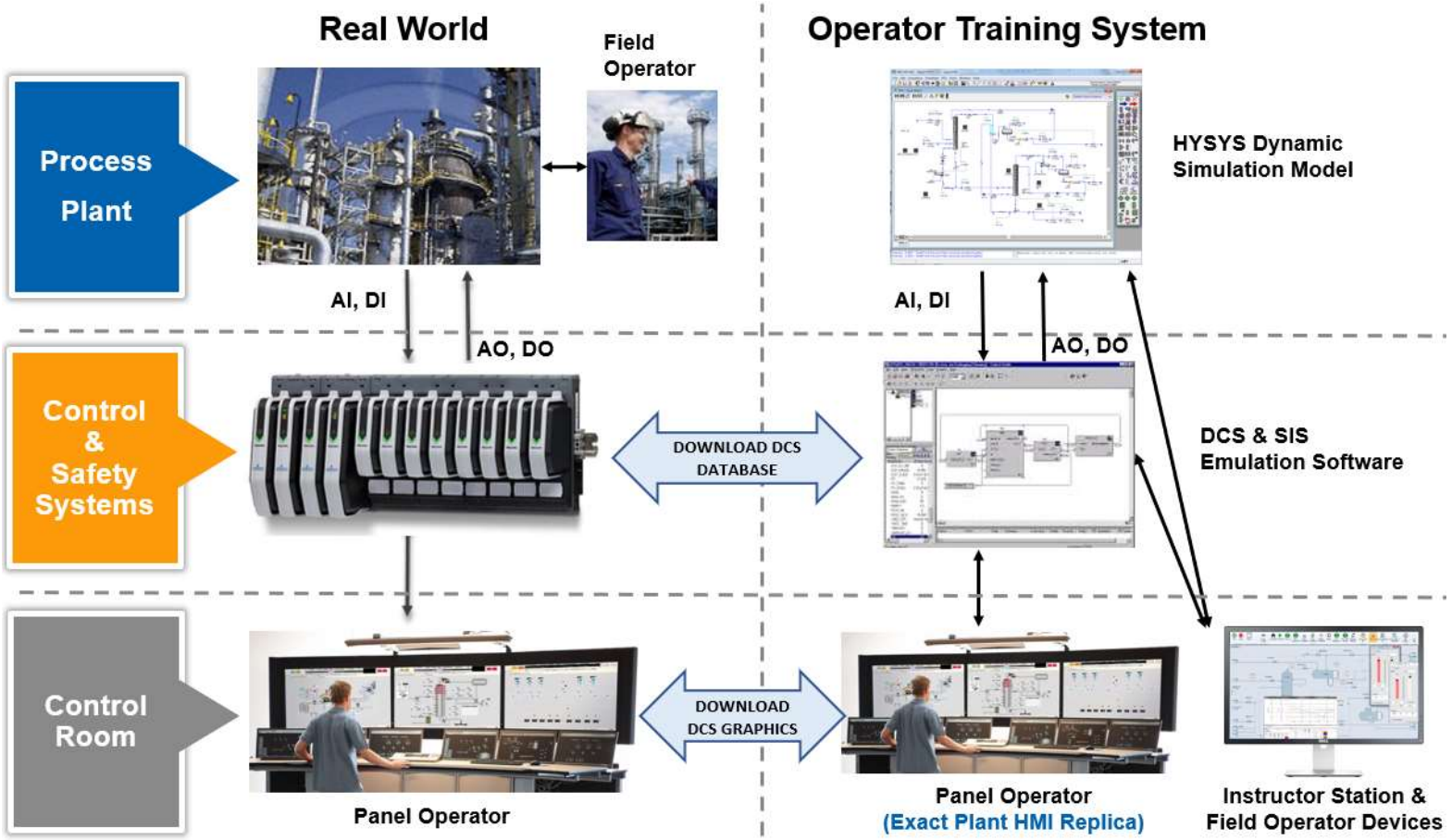
DESIGN the process control: Reactive distillation

A catalyst poison problem appeared in one of the distillation columns. The reason was the high temperature reached at the bottom of the column with the high molecular weight compounds.

Dynamic simulation with reactions on the trays was able to predict successfully the formation of the catalyst poison and its rate in function of other variables such as bottom stream volume flow or bottom temperature

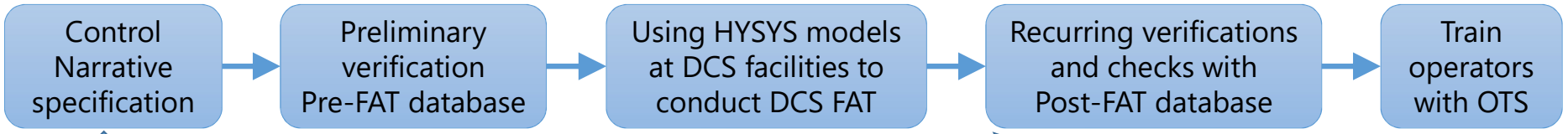


OTS scheme


Real World
Field Operator
Operator Training System
Process Plant
HYSYS Dynamic Simulation Model
AI, DI
AO, DO
AI, DI
AO, DO
Control & Safety Systems
DOWNLOAD DCS DATABASE
DCS & SIS Emulation Software
Control Room
DOWNLOAD DCS GRAPHICS
Panel Operator
Panel Operator (Exact Plant HMI Replica)
Instructor Station & Field Operator Devices

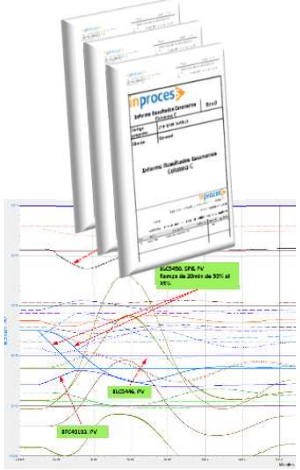
VERIFY the DCS code: Workflow

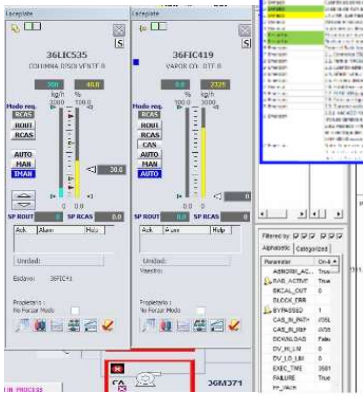
DCS project was split in 4 areas, each with phased parallel schedules. Each schedule comprised:

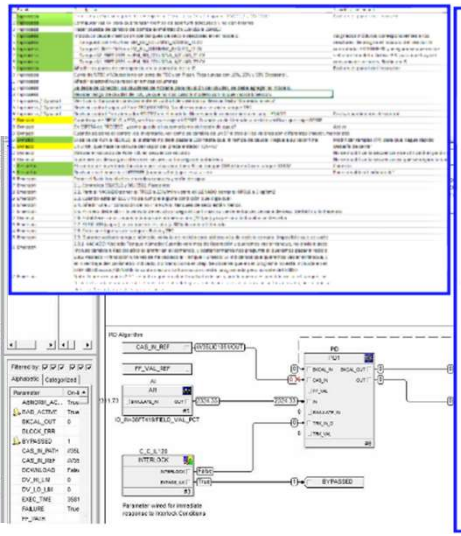


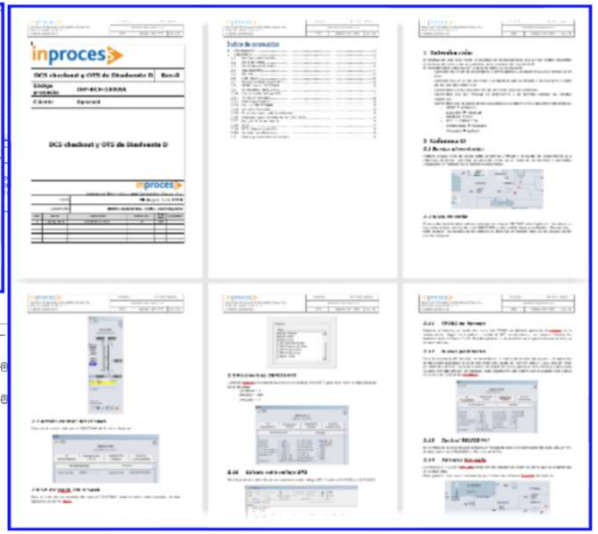
DSS reports

Live punch-list + DCS checkout reports

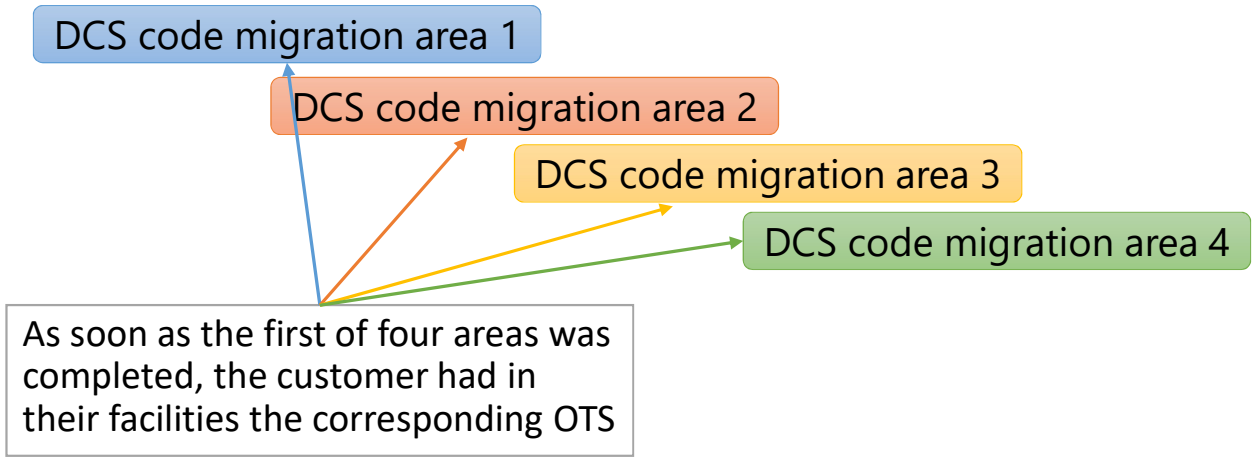






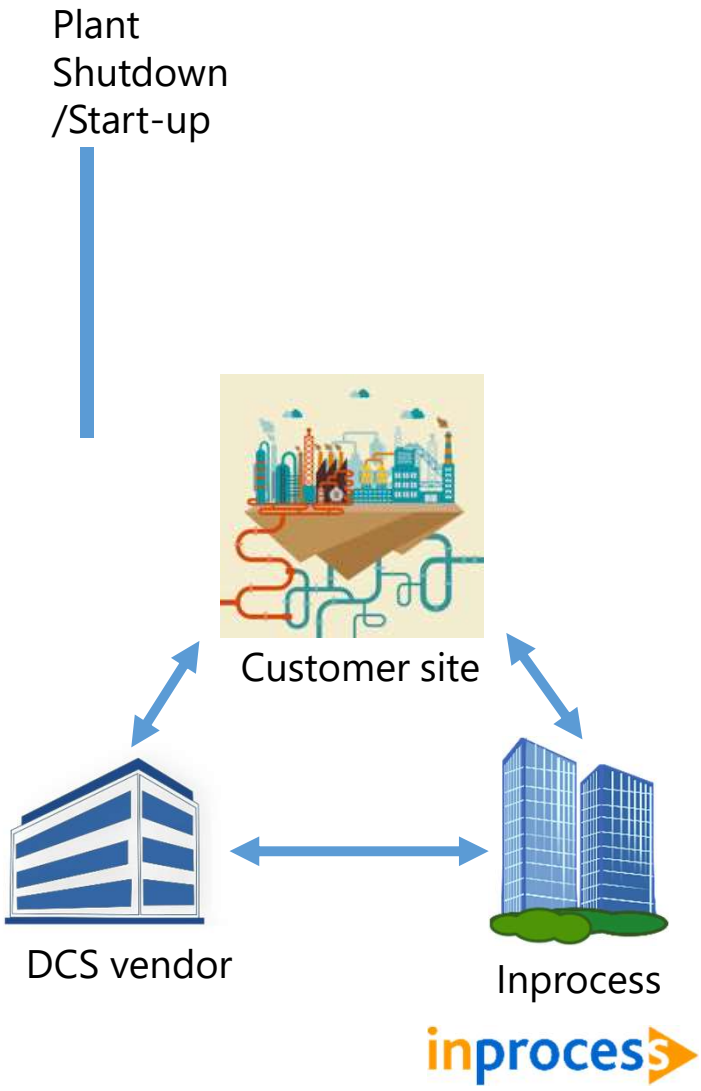


VERIFY the DCS code: Early use of OTS



Enabling the customer to independently:

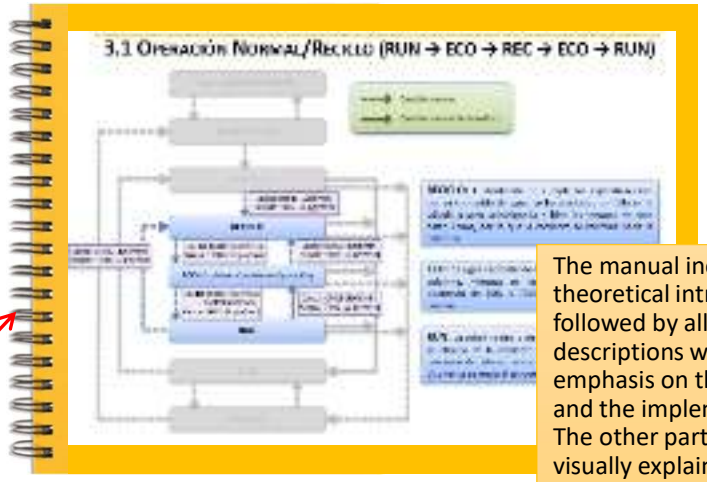
- Test Post-FAT modifications
- Detect errors in the Control Narratives given to DCS vendor and develop the modifications
- Get practice with the new controllers and sequences.
- Develop and tune the plant operating procedures



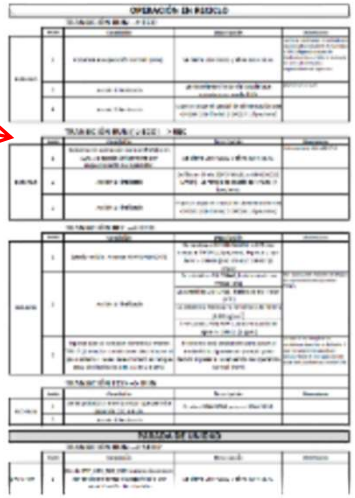
TRAIN the operators

Inprocess delivered several weeks of training and awareness to all plant operators and shift supervisors:

- Theoretical explanation of changes
- Hands-on practicing on actual DeltaV Operate screens with HYSYS models
- Exam
- All aided with
  - Visual training manual and procedures.
  - Automatic sequences sketches
  - Parameter glossaries cards

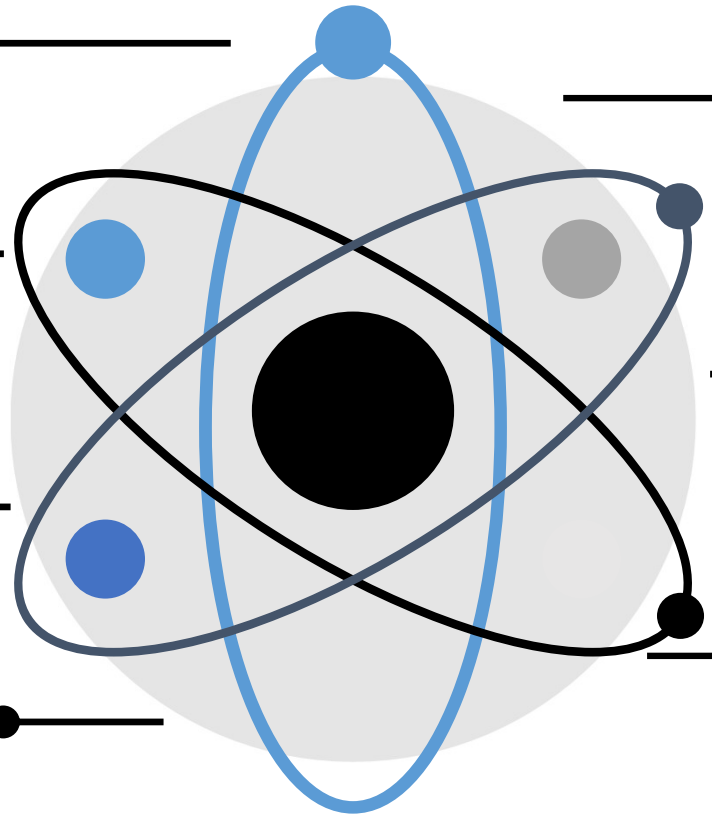


The manual includes theoretical introduction followed by all process descriptions with a special emphasis on the controllers and the implemented changes. The other part of the manual visually explains the start-up, shut down and operating sequences step by step.



Due the knowledge gained along the project (process, control changes, new sequences, DeltaV operation, etc) the Customer requested to the Inprocess engineers to join their team during 10-day start-up period in the control room

Benefits



Safety
Aditives

Additives concentration control for multiple injection streams

Safety
ALARMS

Reduction of alarms associated to the operation by modelling the conditions

Operation
OPERATION STATES

Required ramps to change plant conditions without impacting quality

Savings
REDUCE RECYCLE TIME

New inventory control reduce the time the columns are in recycle mode

Operation
OPERATION STATES

Improved operation with the use of OPERATION STATES and automatic transitions.

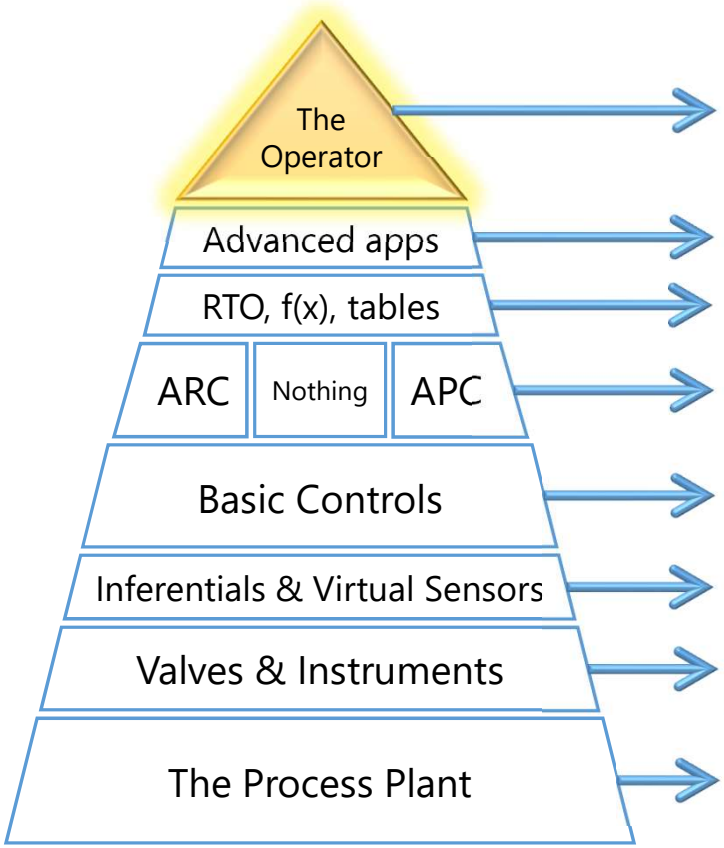
Training
OTS FOR OPERATORS

DeltaV Direct-Connect OTS replicating same control room consoles and using same DCS code

Savings
COMMISSIONING TIME REDUCTION

The time taken for Start-up after DCS-migration has been reduced thanks to the use of simulation

The Automation Pyramid with the HYSYS Digital Twin



- Train operator on Start-up, Shutdown, Emergency & trip scenarios.
- Knowledge repository of plant incidents & best operation practices

- Equipment anomaly detection. Monitoring and look-ahead apps.

- SS models for RTO. Obtain simple optimization f(x) or lookup tables

- Develop & Test ARC. Deep Gain analysis and seed models for APC.

- Improve basic control layout (this is the most important layer!)
- Checkout new DCS code. Checkout automatic sequences.

- Develop rigorous inferentials. Train AI data driven models.

- Discover faulty instruments. Automatic fault detection application.

- Better understanding of plant behaviour (SteadyState & Dynamics)
- Reproduce and study any plant operation issue
- Develop and tune Operating Procedures. HAZOP assistant.

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Q&A

THANK YOU!
And visit us
at Barcelona!

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