CHEMISTRY THAT MATTERS™

Enhancing Operator Readiness with Aspen HYSYS®-Based OTS at SABIC

ASPEN OPTIMIZE 2026 HOUSTON

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Agenda

- Olefins 4 plant
- Why an OTS?
- Project requirements
- Project set-up and phases
- Summary

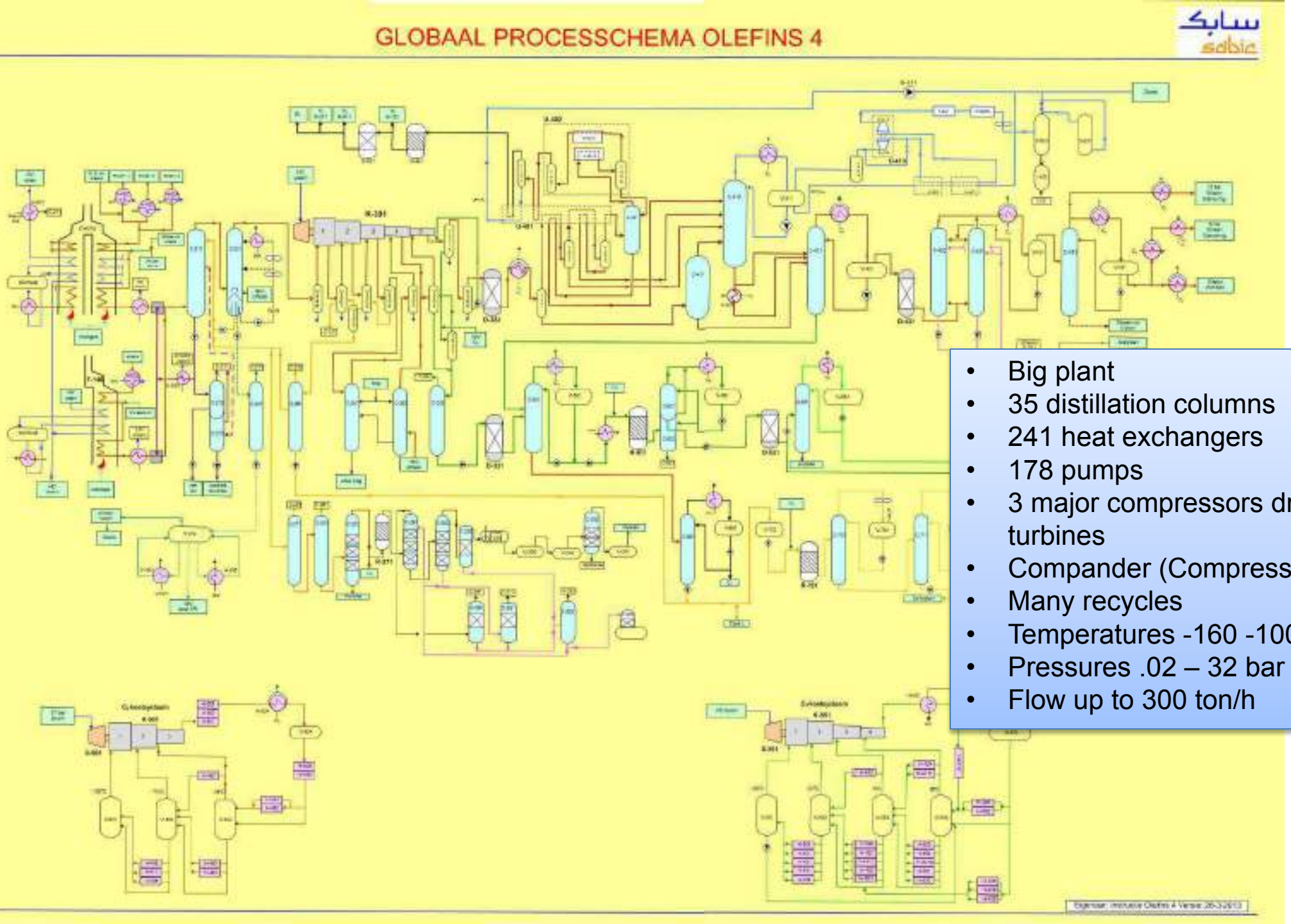
Olefins 4

- Steam cracker, started up in 1979. Geleen (Netherlands)
- Initial capacity 450 KTA ethylene, current 675 KTA
- Chemelot site dependent on Olefins 4 as the only cracker on site after closing Olefins 3 in 2024

  reliability crucial
- Operation team: 5 shifts with 15 operators

Control Room Olefins 4

GLOBAAL PROCESSCHEMA OLEFINS 4



- Big plant
- 35 distillation columns
- 241 heat exchangers
- 178 pumps
- 3 major compressors driven by steam turbines
- Compander (Compressor-Expander)
- Many recycles
- Temperatures -160 -1000 deg C
- Pressures .02 – 32 bar
- Flow up to 300 ton/h

Why an OTS at Olefins4?

- Many experienced operators at Sabic Olefins 4 will retire soon.
- In the past learning on the job: many disturbances and upsets
- Today: very smooth operation also thanks to APC (Aspen DMCplus)
- New operators don’t get the opportunity to hands-on learning on the job.
- However, they need to have the capabilities to handle disturbances and upsets adequately.
- Problem similar to pilots in airplanes
- **Solution**: training with OTS
- Also for start-up training after Turnaround every 6 years

Operators are the pilots of the process industry

Cockpit Flight Simulator Boeing 737-800

Operators are the pilots of the process industry

Bringing two worlds together

Automation Paradox

- The more efficient the automated system the more crucial the human contribution of the operators
- Humans are less involved, but their involvement becomes more critical.

Automation in chemical plants:

- automatic control
- advanced process control (APC)
- automatic sequence/batch control
- optimizer

Example: Air France flight 447 Airbus A330

Example of Automation Paradox
Air France flight 447 – Airbus A330

- Airbus A330 highly automated
- During flight AF447 inconsistencies between the airspeed measurements (likely resulting from ice crystals obstructing the aircraft's pitot tubes) caused the autopilot to disconnect
- The crew reacted incorrectly caused the aircraft to enter an aerodynamic stall from which it did not recover
- Plane lost including all 228 passengers and crew on board

Outcome of analysis

Pilots operated more as system supervisors than as pilots: **training as pilots needed**

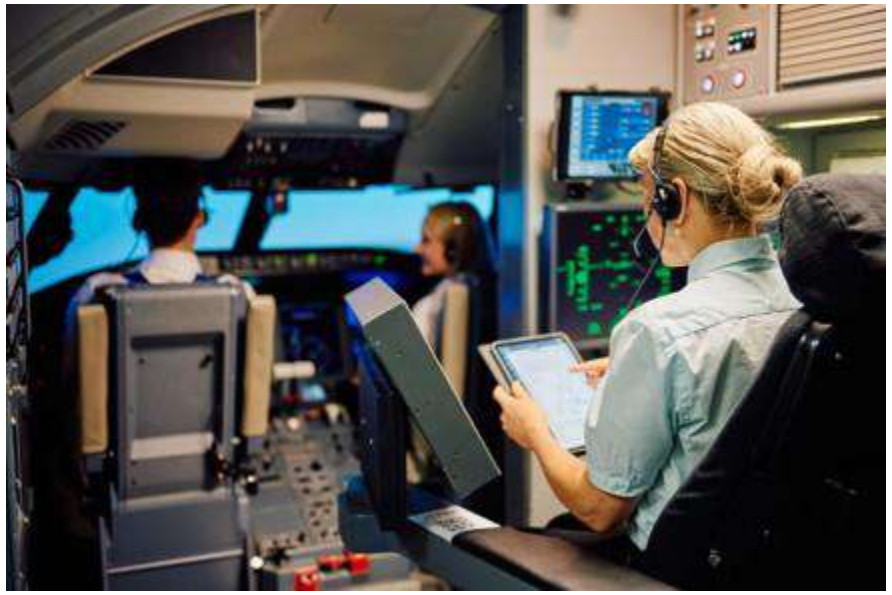
See: Air France Crash Probe Raises Pilot Training Questions | WIRED

ICAO: the eight core competencies of flight crew

1. Application of procedures
2. Communication
3. Flight path management - automation
4. Flight path management - manual control
5. Leadership and teamwork
6. Problem solving and decision making
7. Situation awareness
8. Workload management

Sounds familiar?

Why doesn’t our industry have an ICAO?



- Global regulator → International Civil Aviation Organization
- Standard competencies (CRM, decision-making)
- Simulators used for certification
- Same philosophy worldwide

- No global authority
- Training is company-specific
- Simulators (if any) used for training only
- Each plant/DCS = different “universe”

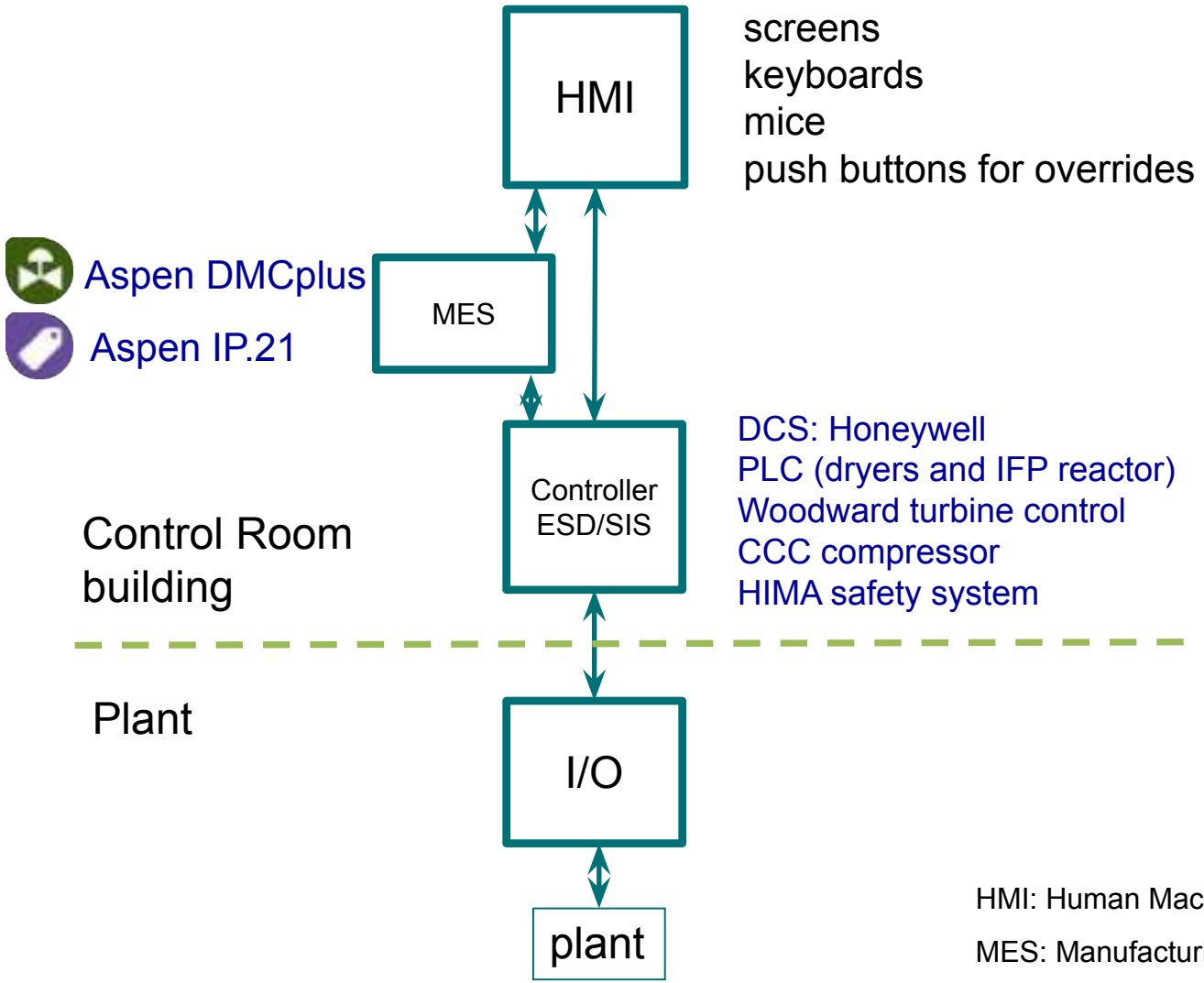
The aviation industry didn’t become safe by standardizing machines alone, it became safe by standardizing human performance.

Use OTS not just to train operators, but to certify their performance

OTS Requirements

- HiFi model
- Normal operations
- Start-up (cold and warm) of plant or plant sections
- Shut down of plant or plant sections
- Total reflux operations
- SIS overrides
- Instrument and Equipment failures
- Scenarios
- Creating snap shots/initial conditions

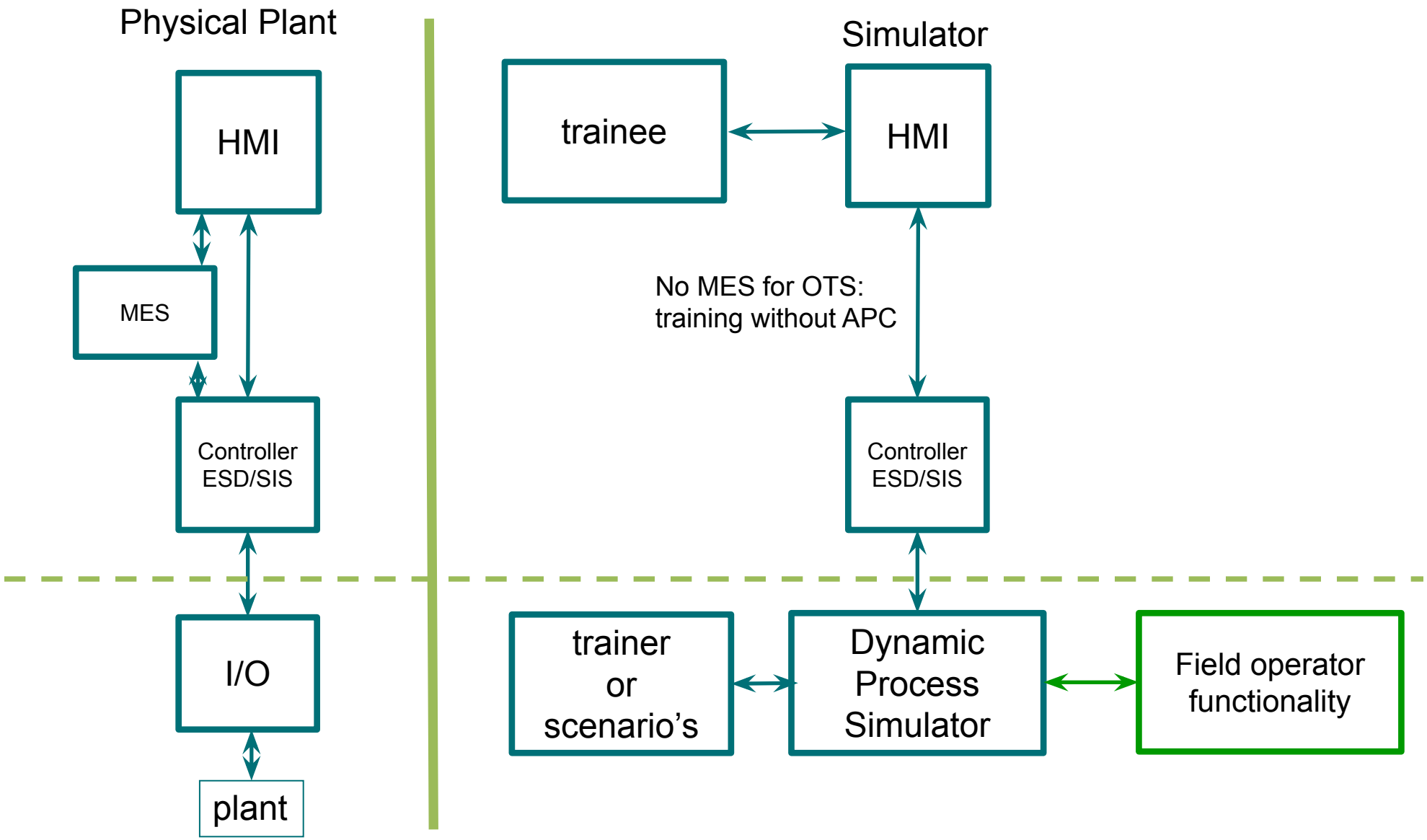
Control Architecture Olefins 4



HMI: Human Machine Interface

MES: Manufacturing Execution System

Plant versus OTS



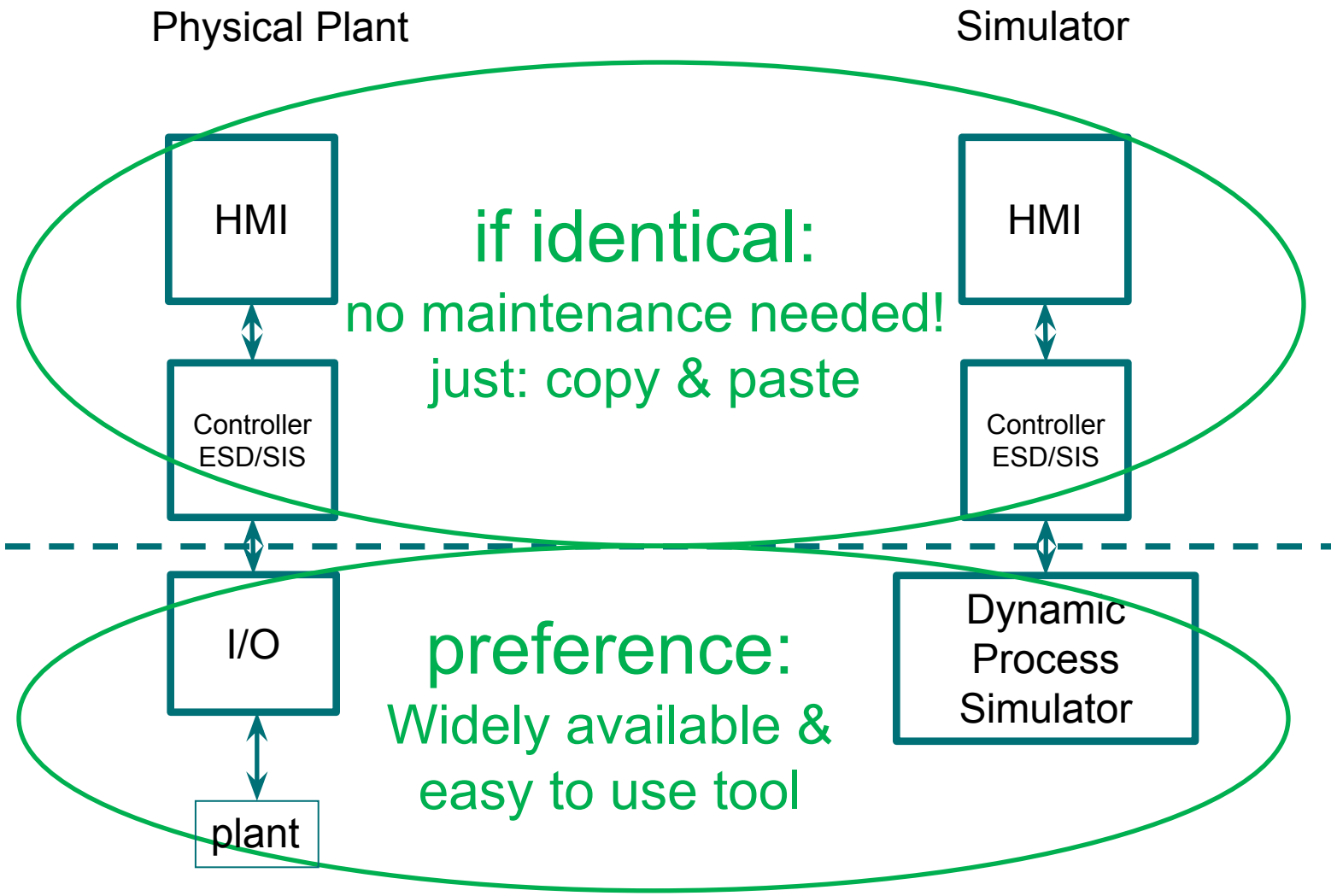
Challenge: using OTS on a permanent basis

Many OTS in the industry are not used after some time:

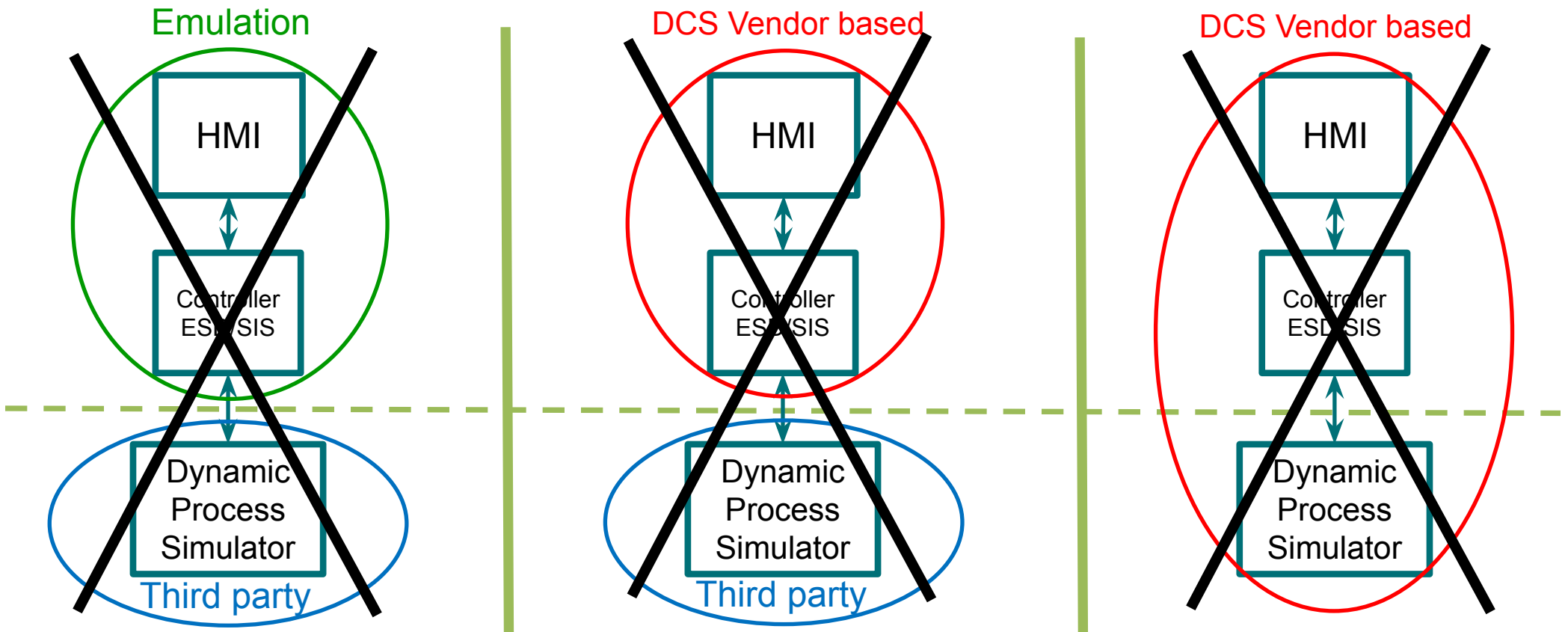
Industry average:
around 70% get obsolete

- Mismatch between plant and OTS along time:
  - Changes in plant DCS graphics, control etc not updated in OTS
  - Plant modifications not implemented in OTS
- Training program not challenging
- Not a part in the official certification of process operators

OTS architecture: regarding maintenance



Initial Thinking: Possible OTS architectures



- Differences DCS plant vs. OTS very likely
- Maintainability poor (no copy paste)
- On the long run more expensive
- No Testing of new DCS soft releases
- Test controller changes more effort needed

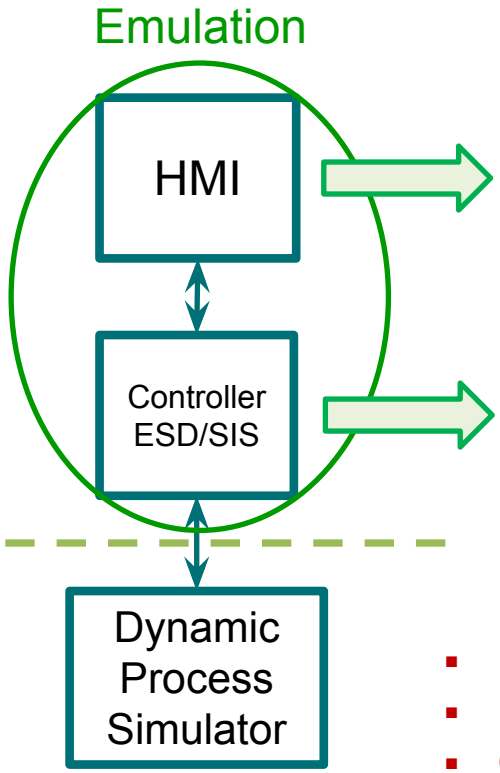
- Maintenance: just copy/paste

- Maintenance: just copy/paste
- Initially preferred option (single vendor)

During bidding procedure and negotiation these options appeared not to be feasible

Inprocess Emulation

Luckily Inprocess came with an approach that reduced the disadvantages of emulation significantly

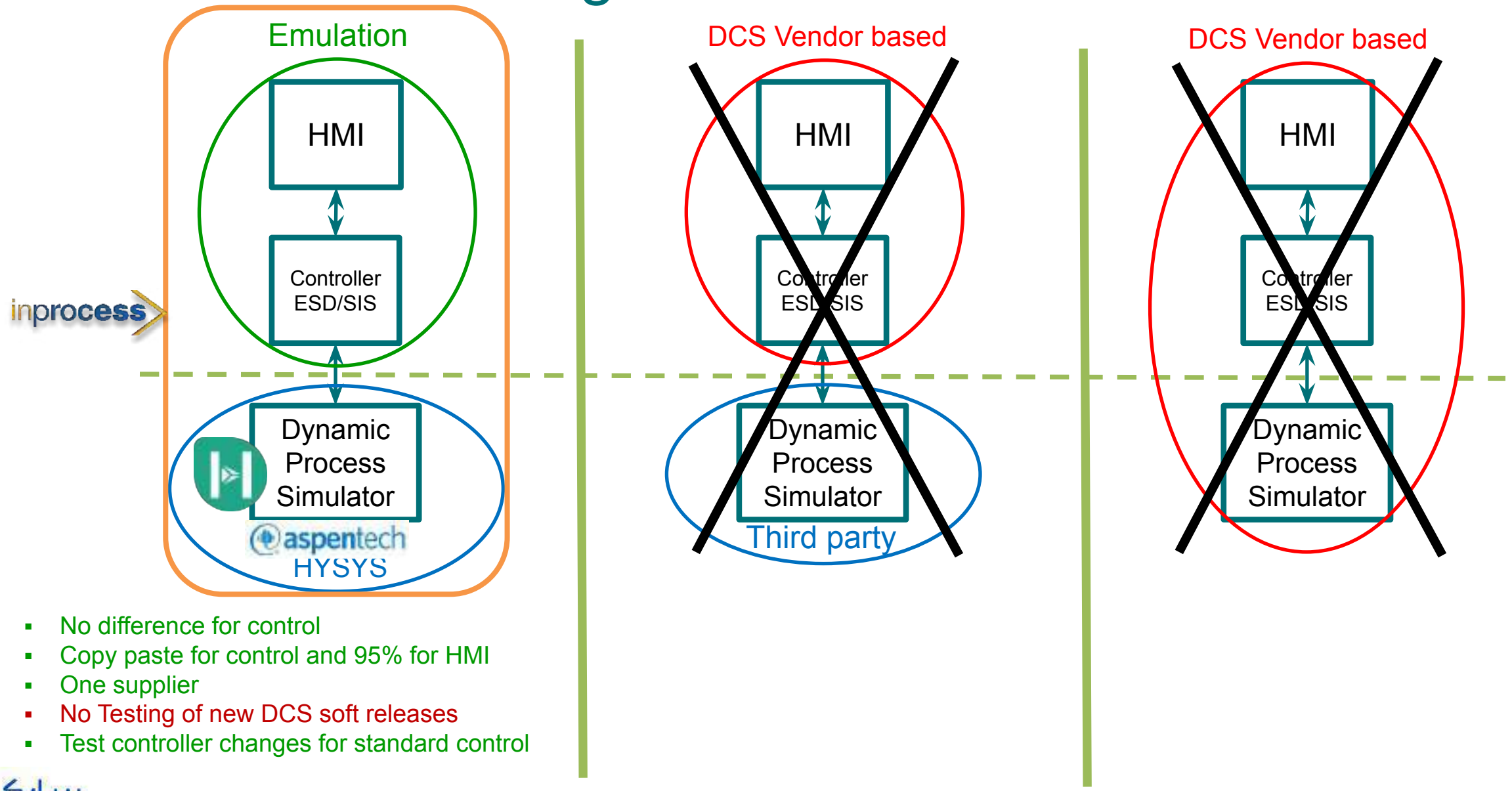


DCS html bases graphics exactly the same as in control room
- Only minor differences in trend plots

Full DCS controller blocks functionality via emulation
- EB configuration files from plant to OTS

- Differences DCS plant vs. OTS very likely No difference for control
- Maintainability poor (no copy paste) Copy paste for control and 95% for HMI
- On the long run more expensive Cheaper: no DCS link software, one supplier
- No Testing of new DCS soft releases
- Test controller changes more effort needed Not for standard control

Final Thinking: Possible OTS architectures



- No difference for control
- Copy paste for control and 95% for HMI
- One supplier
- No Testing of new DCS soft releases
- Test controller changes for standard control

Challenge using OTS on a permanent basis

Many OTS in the industry are not used after some time

- Mismatch between plant and OTS
  - Changes in plant DCS graphics, control etc not updated in OTS
  - Plant modifications not implemented in OTS

→
- SABIC *OTS plant manager* responsible for use and maintenance
- Part of MOC procedure both for plant and DCS
- Maintenance contract for process model: by Inprocess as supplier
- Maintenance for DCS mostly by copy/paste

- Training program not challenging

→
- Unexpected events that need to be identified and solved.
- Based on serious plant disturbances

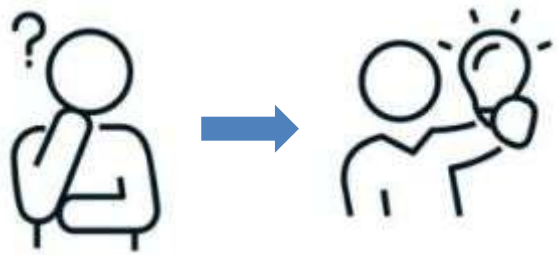
- Not a part in the official certification of process operators

→
- Training of new operators
- Like airline pilots also experienced operators need to show their competence on a simulator regularly basis
- Official assessment on OTS

Olefins 4 started with an OTS pilot project

- Investment full cracker > 1M€
  - Takes time to put it on budget plan
- Justification difficult
  - Impact of an OTS for management not clear
- We started with a pilot
  - Small part of the plant, but challenging enough for training
  - Less money involved: could be done within existing budgets
  - After successful pilot : management was convinced to put full fledged OTS on investment plan
  - Also: learning working together as customer and vendor

A 20-year experience operator during the FAT commented that the model was wrong in behaviour. After discussion with modelling engineer he concluded that the model was right and he had a 20-yr long misconception of what was really happening in the plant.



OTS project

- Kick-off
  - Detailed scope per section: what is in what not
  - Colouring P&ID's
- Modelling
  - Steady state review
  - MAT (Model Acceptance Test): HYSYS model only
    (appeared to be difficult for operators, later also MAT on DCS screens)
  - FAT incl. DCS
  - Tuning & SAT incl. DCS

Project teams at SABIC

Crucial to have an experienced operator full time available for testing.

project definition and contractor selection

- Steering committee
  - Manufacturing director
  - Plant manager
  - Manager Technology
  - Manager Process Control
  - Buyer
  - Project Manager
- Working group
  - Production manager
  - Process engineer
  - Process Control engineer
  - ICT specialist
  - Trainer
  - Project Manager

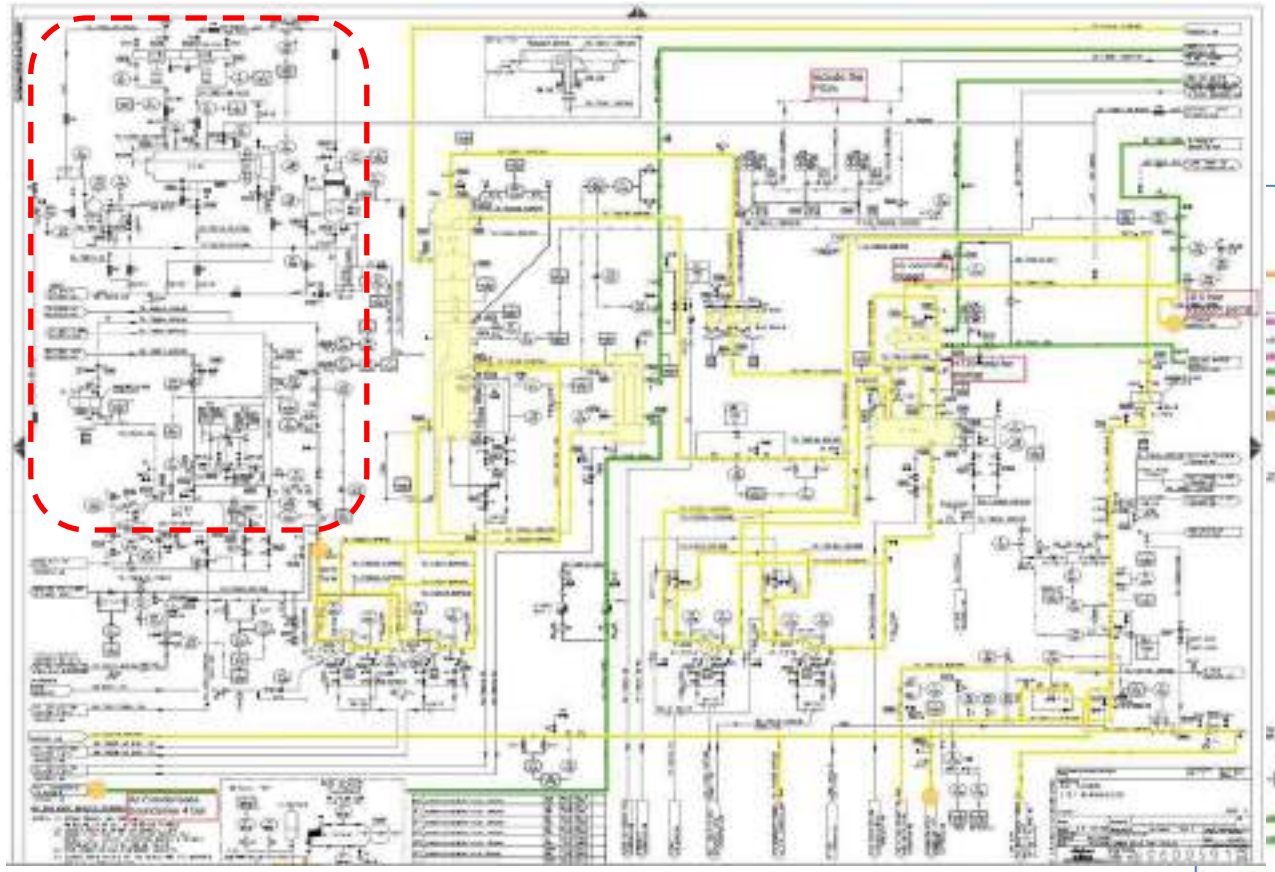
during project phase

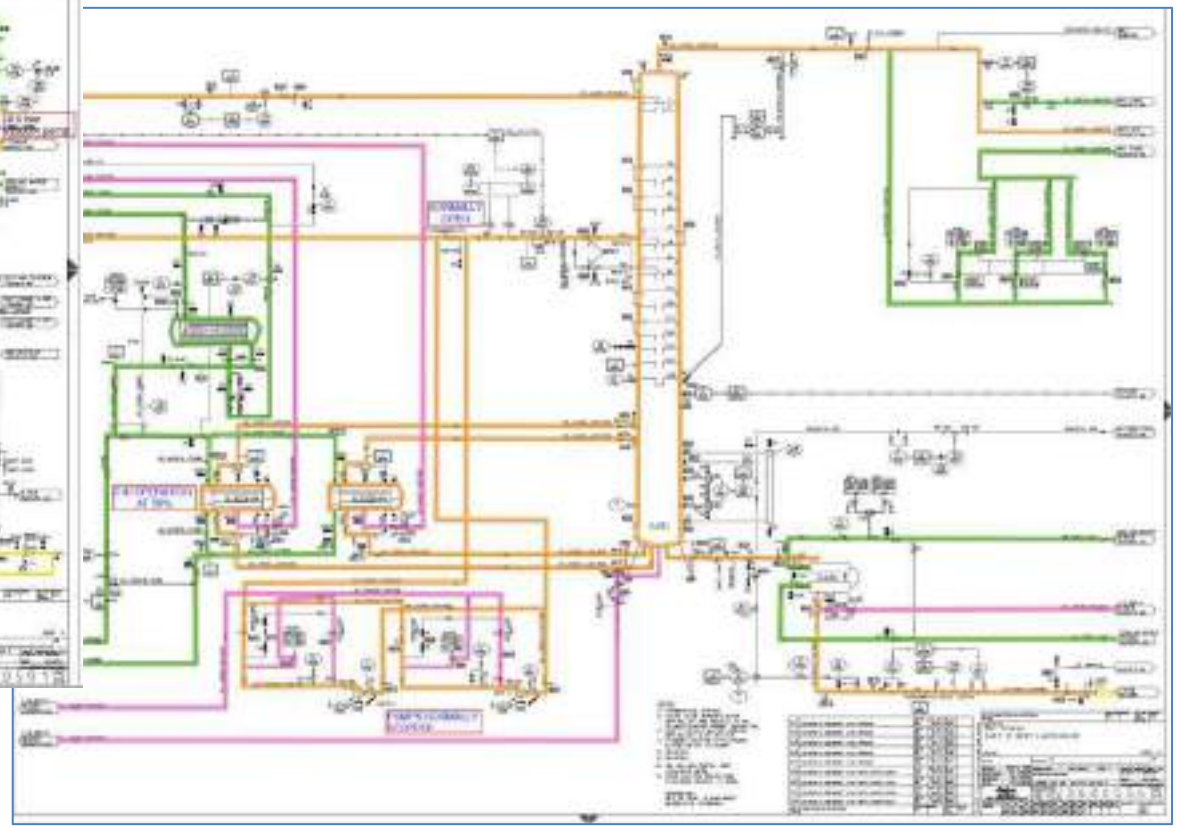
- Trainer (full time)
  - Very experienced senior operator > 20 years
  - Liaison between SABIC and Inprocess
  - Testing and tuning the dynamic model
- DCS engineer (on demand)
  - Providing DCS EB files and HMI html files
- Production Team (part time)
  - 2 operators per shift
  - Trained to using the OTS, also as trainer
  - Part of FAT team (2 operators)
  - Creating buy in
- Project Manager (part time)

OTS project

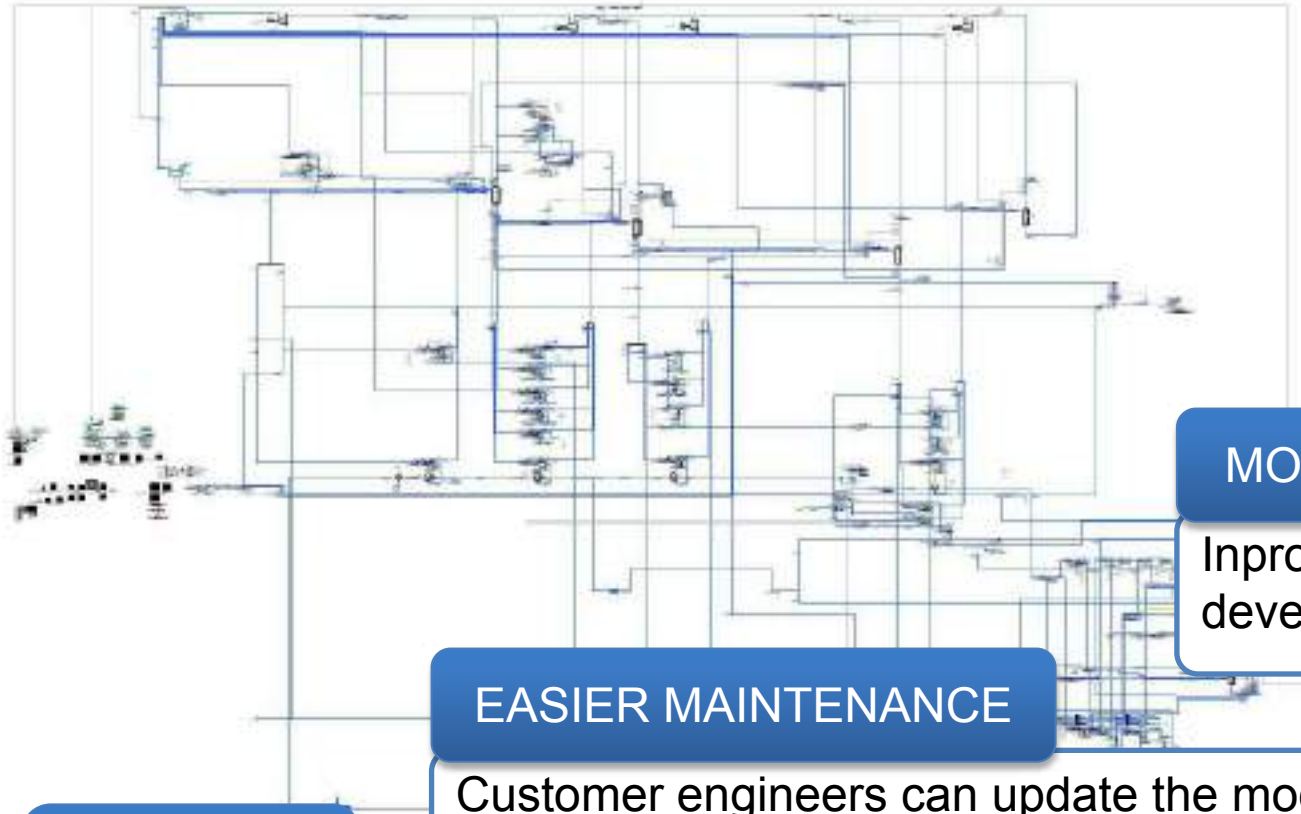
P&IDs was coloured to define process model scope and boundaries

Out of process model





Using HYSYS for OTS



THERMO PACKAGES

HYSYS property packages reproduce accurately VLE of components in Olefins plant with good real-time factor for large models

MODELS REUSABILITY

Inprocess and customer engineers can use developed models to conduct engineering studies

EASIER MAINTENANCE

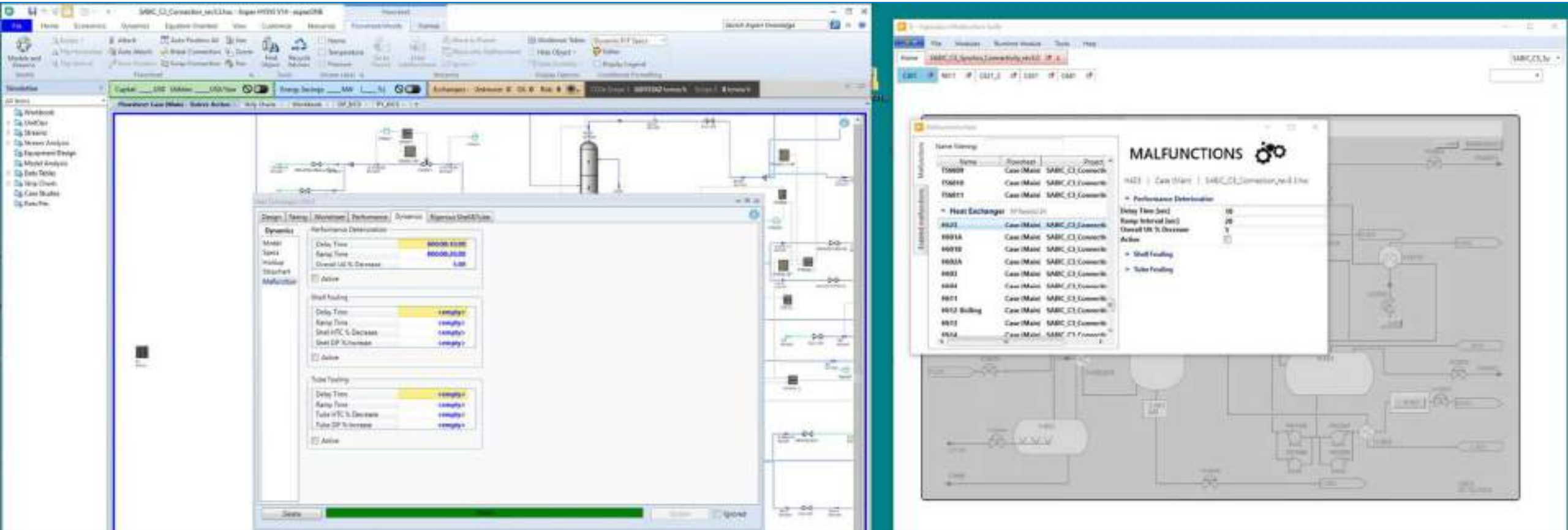
Customer engineers can update the model for small changes and be complemented by Inprocess as required

REALISTIC TRAINING

- Model based on first-principle allows extrapolation in whole operation envelope
- Operators buy-in, high-fidelity dynamic responses

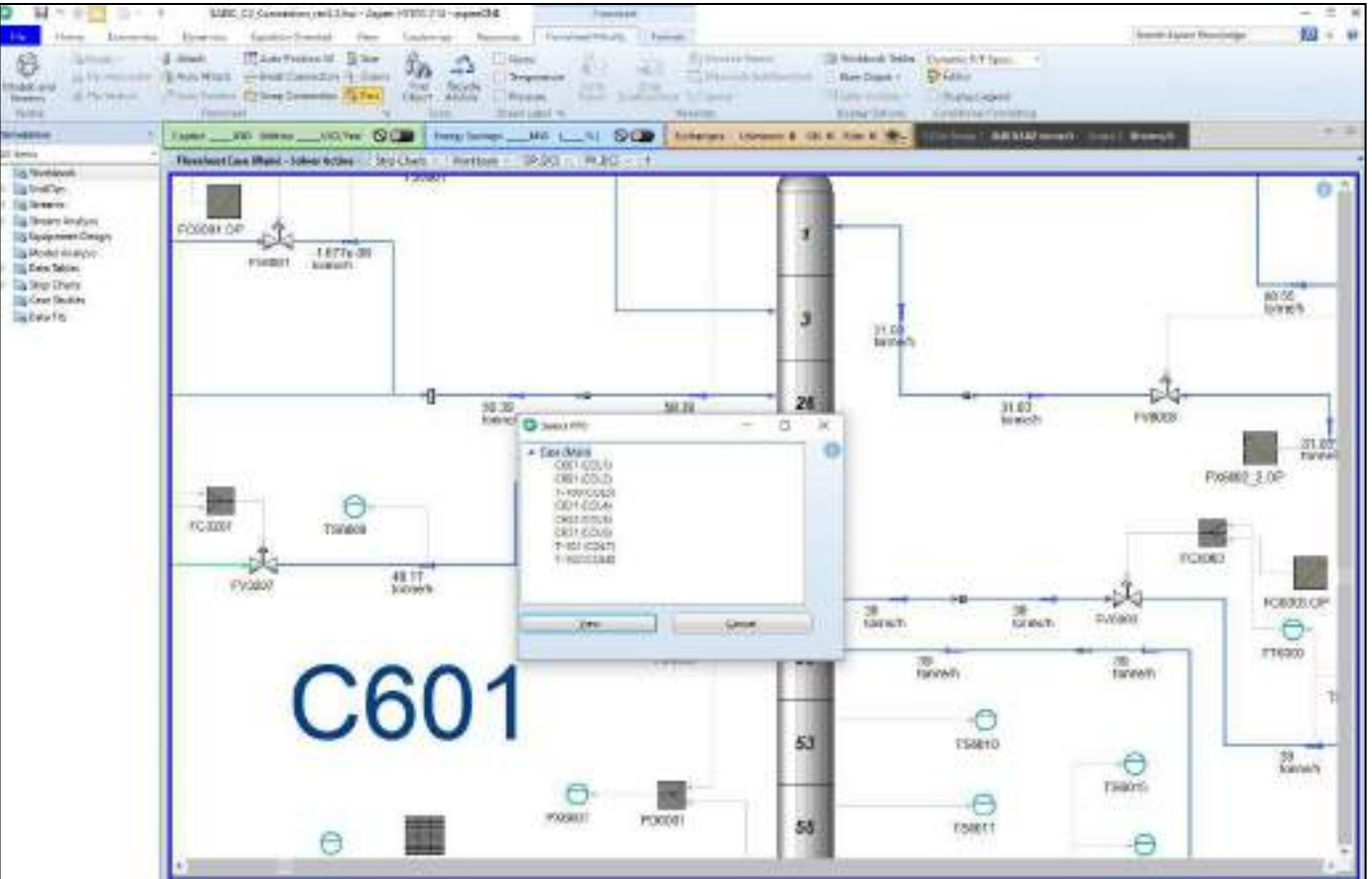
Using HYSYS for OTS

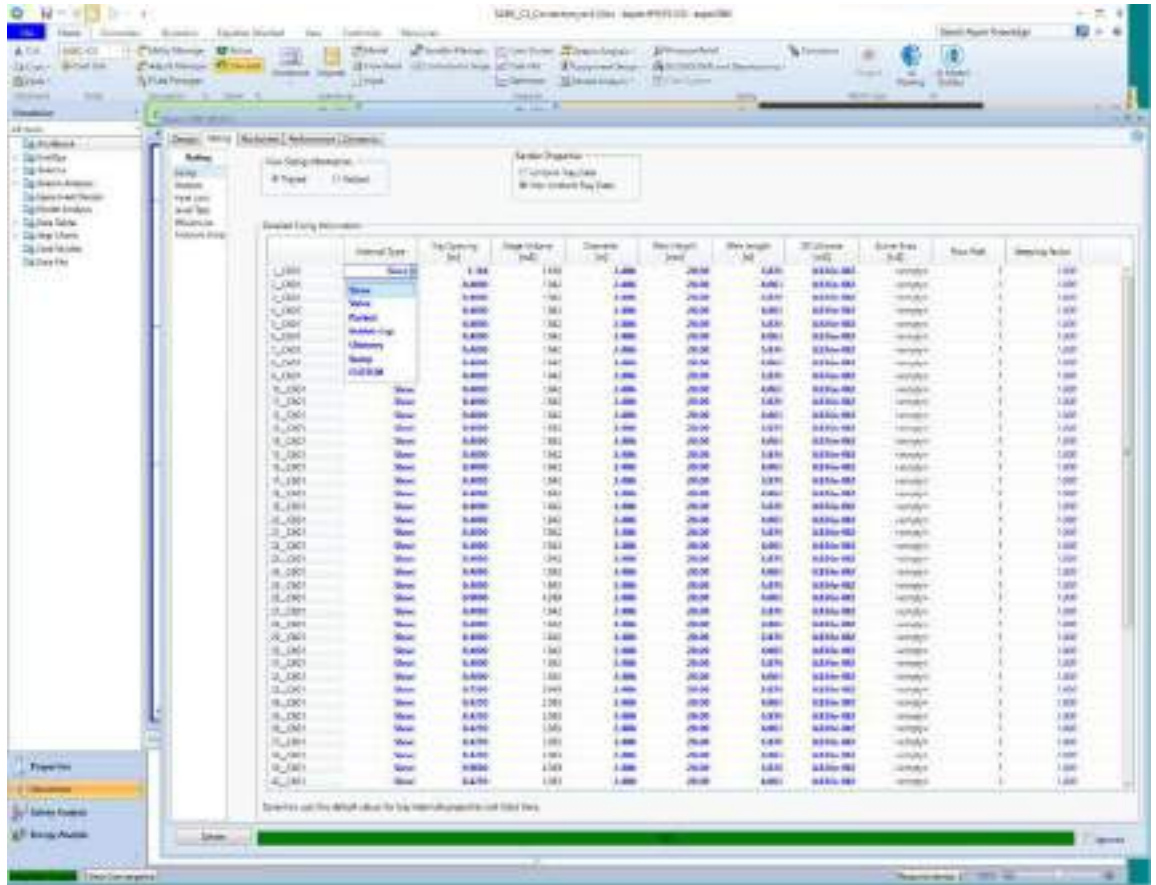
The availability of default malfunctions is especially useful, as it allows direct connection to them without having to define them from scratch, significantly simplifying system configuration.
The most recent versions (v14) have expanded their capabilities with the addition of new equipment, such as compressors and air coolers, improving the scope of the simulation.



Using HYSYS for OTS

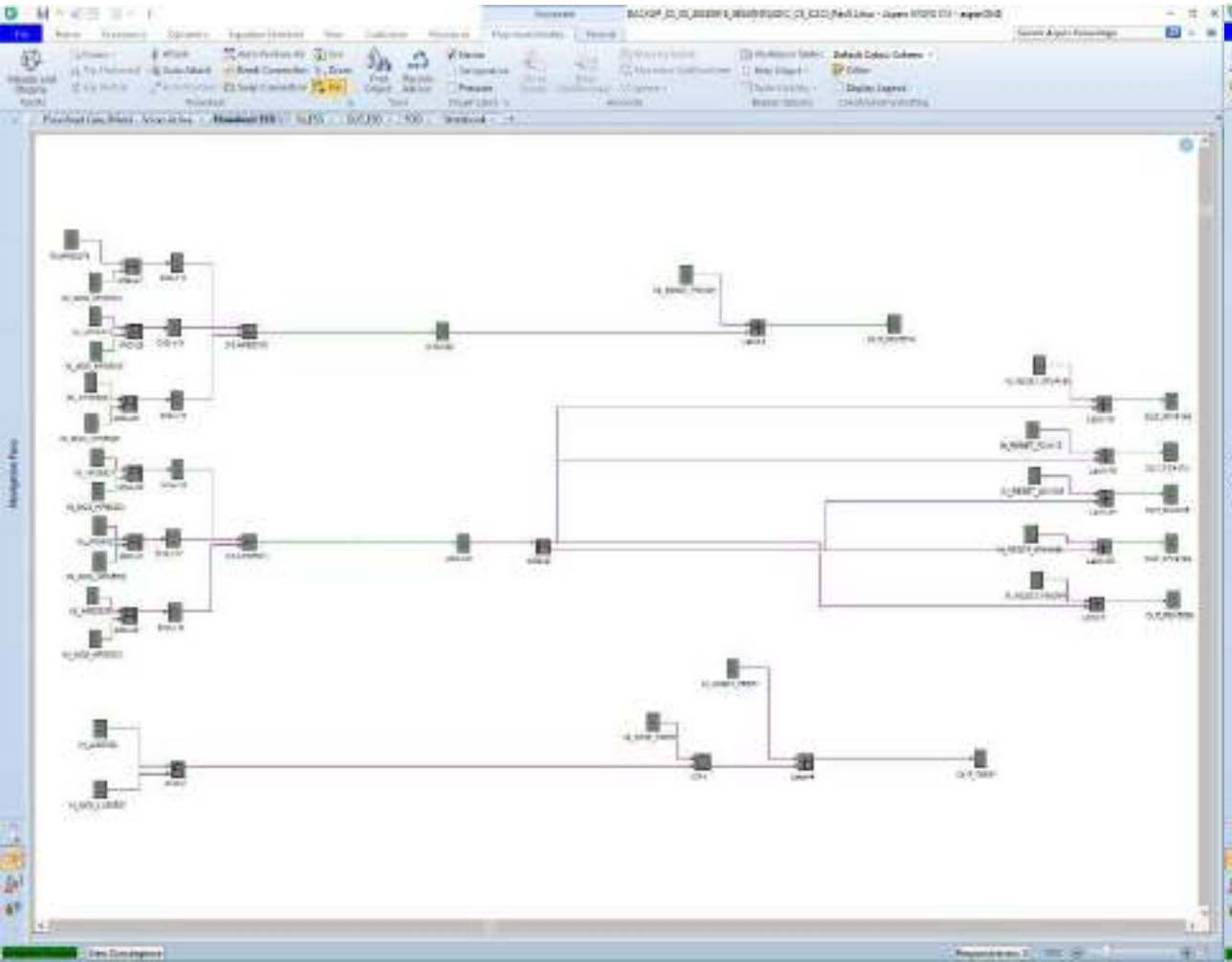
The model has a large number of columns, which allow the simulator to represent the internal mechanisms of this equipment with a high level of detail. As a potential improvement, it would be beneficial to incorporate column-specific malfunctions, such as plate fouling, among others.

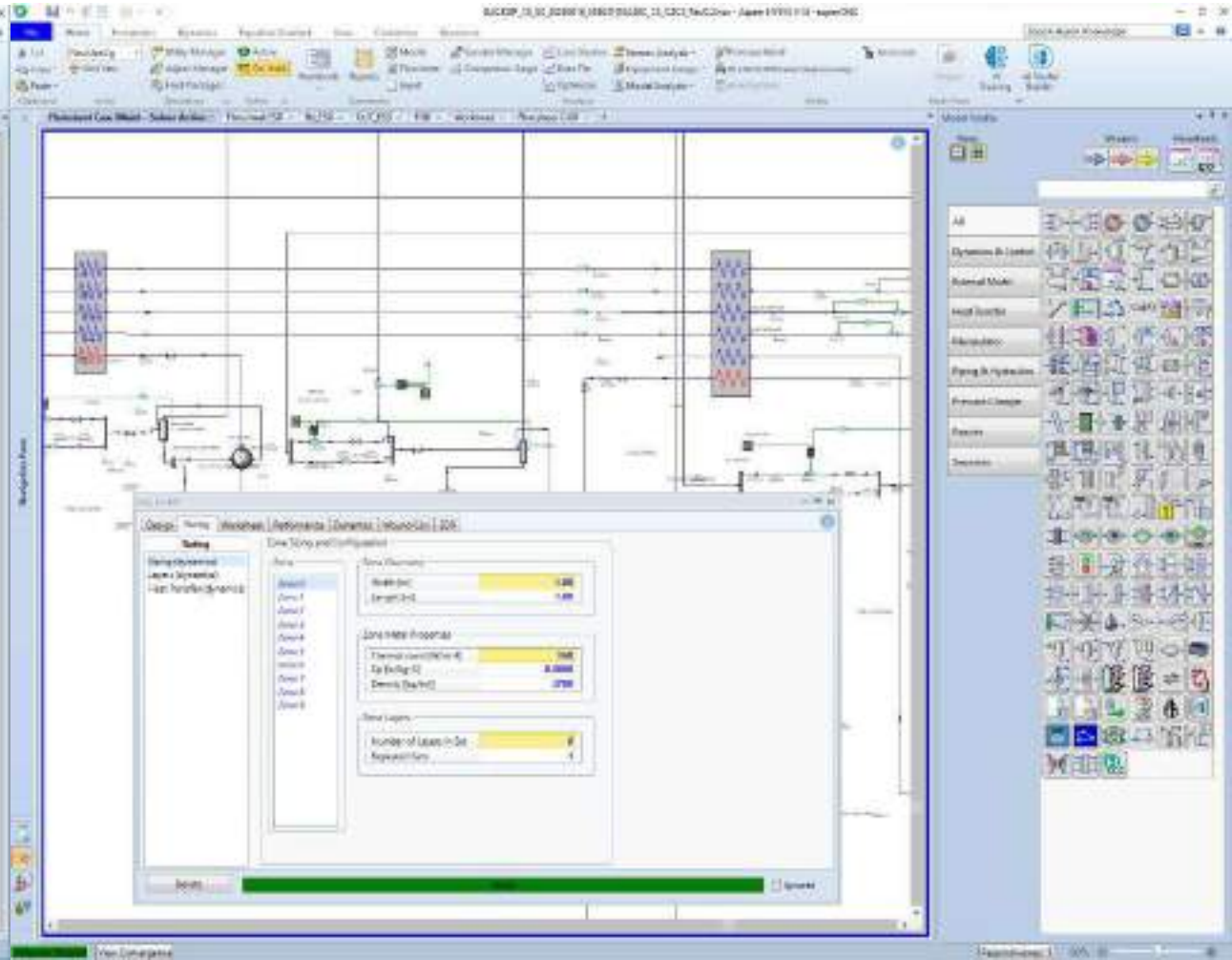




Using HYSYS for OTS

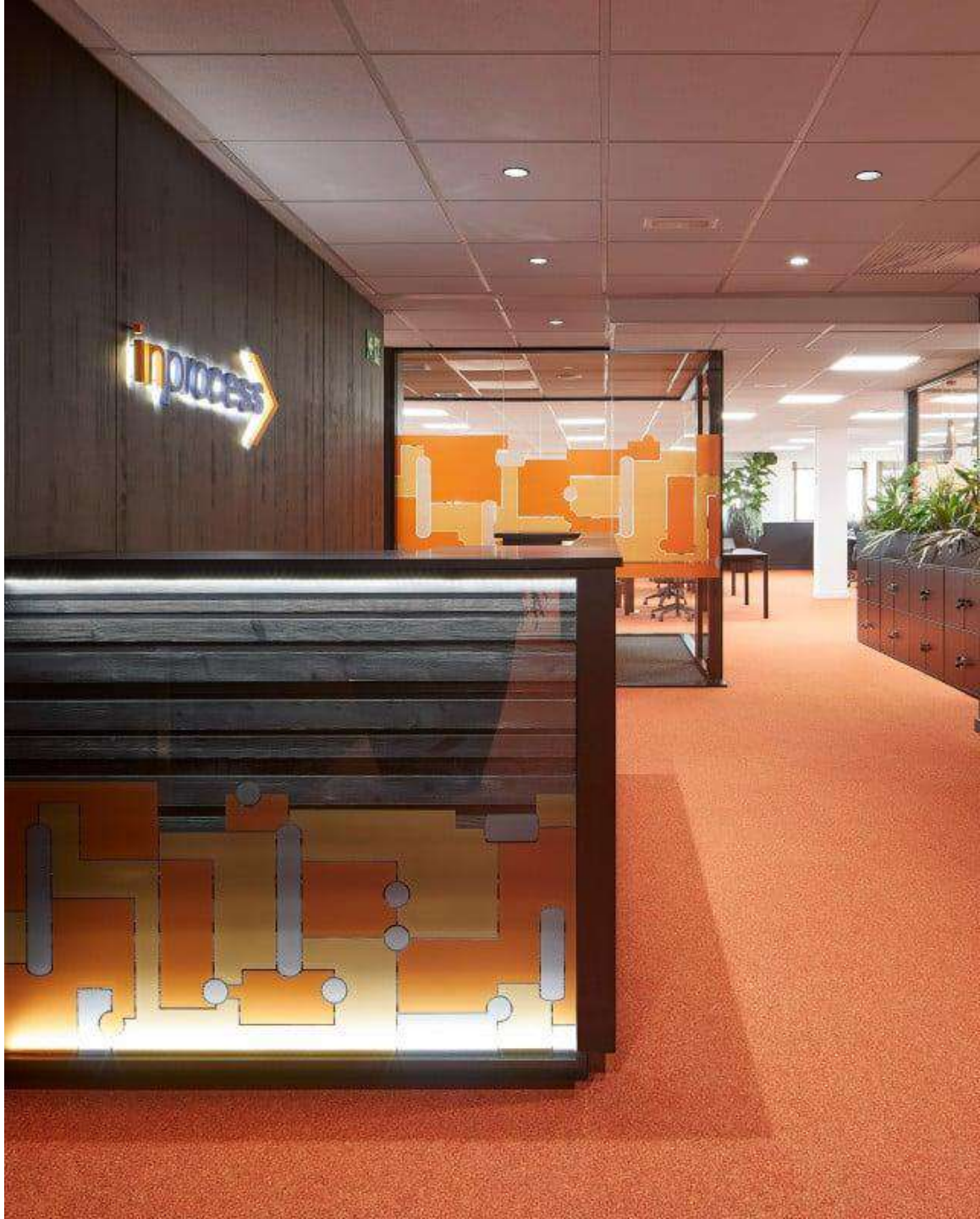
HYSYS allows the creation of custom objects and external connections to them, facilitating the development and updating of complex logic systems, including ESD logic gates and cause-and-effect matrices.





OTS FAT

- FAT at Inprocess HQ in Barcelona
  - Advantage for SABIC
    - Fly time ~ 2 hours
    - Easier to go for pre-FAT's and FAT's
- With 2 or 3 experienced control room operators
  - Involvement of operators also creates buy-in and commitment
- About 1 week per section



OTS Tuning

- Crucial to have experienced operators available
- Resource: 50% of time of an experienced operator for tuning
- Why tuning?
  - In a detailed model assumptions are needed for:
    - Tray efficiency
    - Heat losses
    - Pressure drops over pipe lines
    - …..
  - Testing scenario's and upsets

OTS Tuning

- Project operator works on DCS screens as he is used to, resulting in a punch list

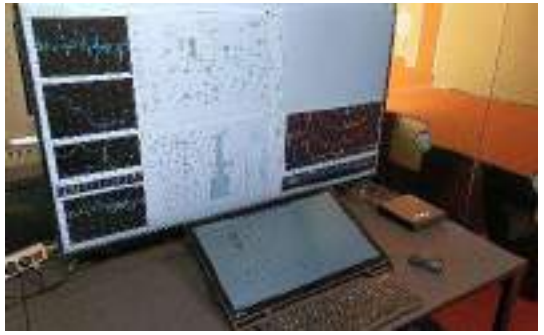
Online interaction

SABIC operator □□ Inprocess engineer was very efficient

- Inprocess has a replica of the OTS where they can develop/update the OTS and deploy updates remotely

OTS at SABIC

Replica at Inprocess



updates

Control Room Olefins 4

Olefins 4 sections

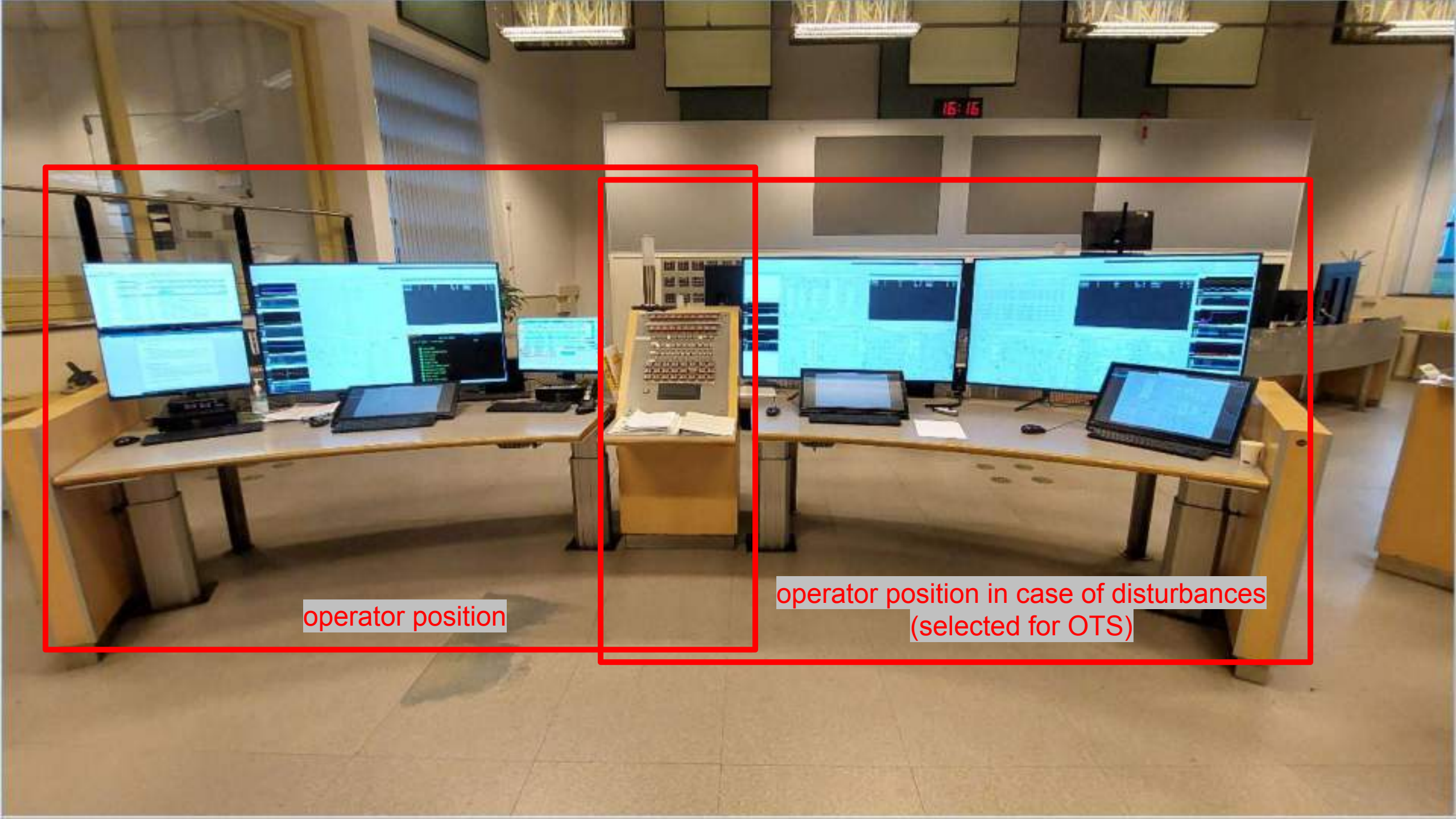
Split-up 3 parts

Mid section
- Cracked gas compresor
- Ethylene refrigerant compressor
- Propylene refrigerant compressor

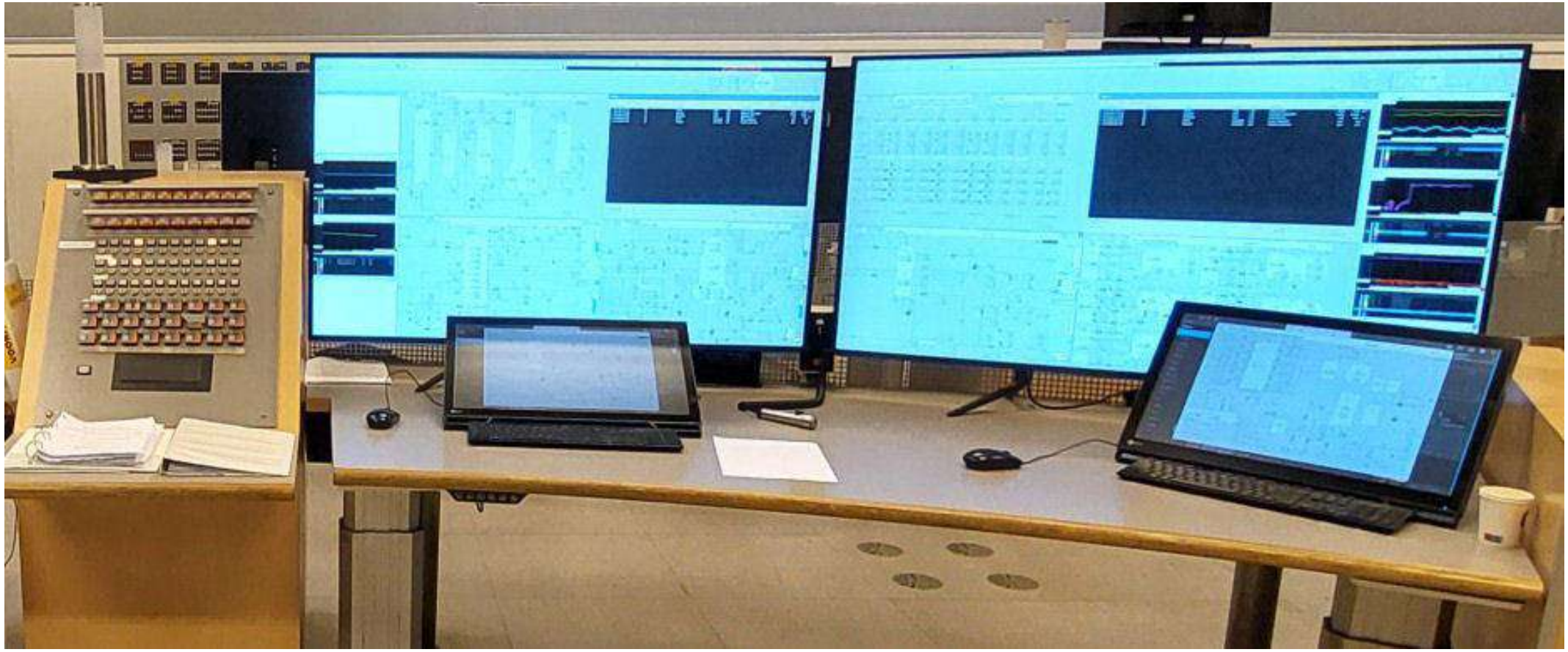
Front end
- 12 furnaces/reactors
- Hot separation

Back end
- Deep cooling incl. dryers
- C2 section
- C3 section
- IFP section (gasoline)

- To run the full cracker at normal condition 1 control operators per section needed
- In case of upsets/start-up 2 operators per section
- To train the full cracker: 6 operators needed
- Size of the shifts don’t allow to train more than 2 operators at the same time
- Therefore: OTS full cracker split up in parts
- Advantage: training can also be not too complex


operator position
operator position in case of disturbances
(selected for OTS)

Control room operator console



OTS operator console

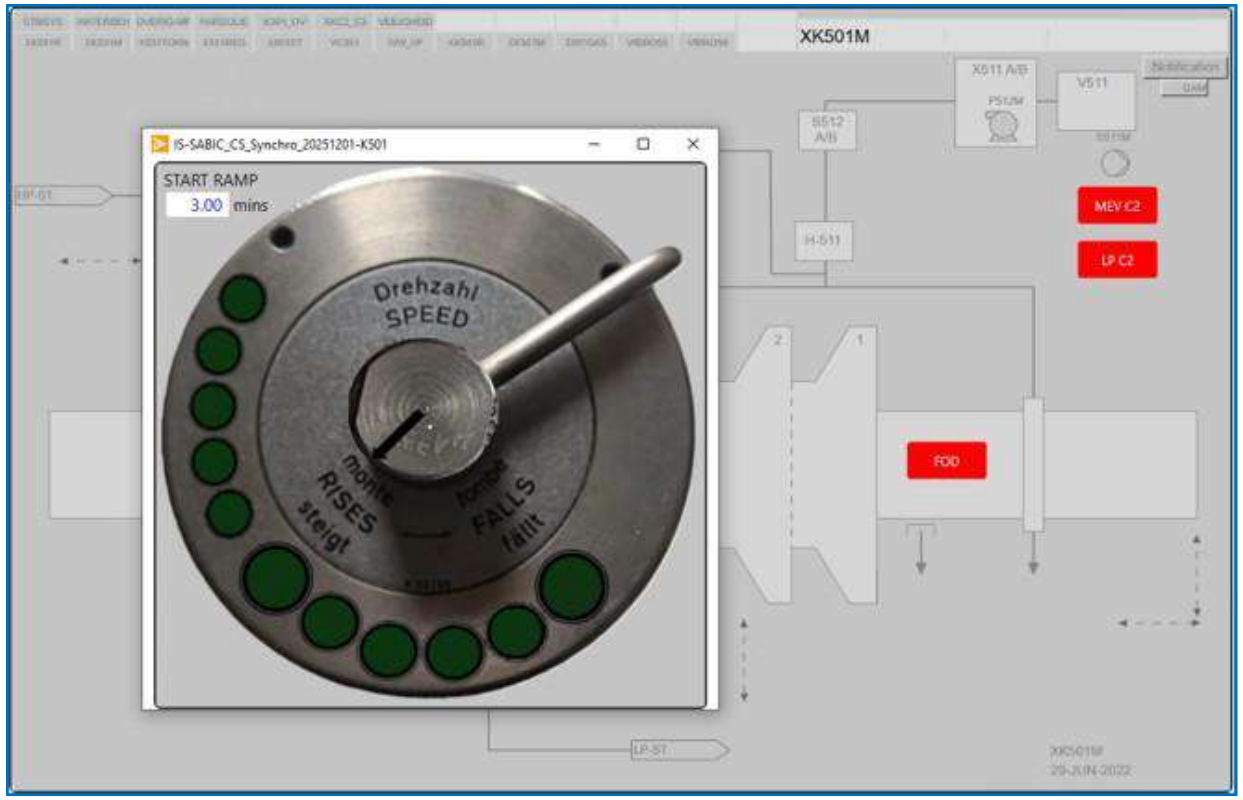
Override switches touch screen

Same hardware than control room

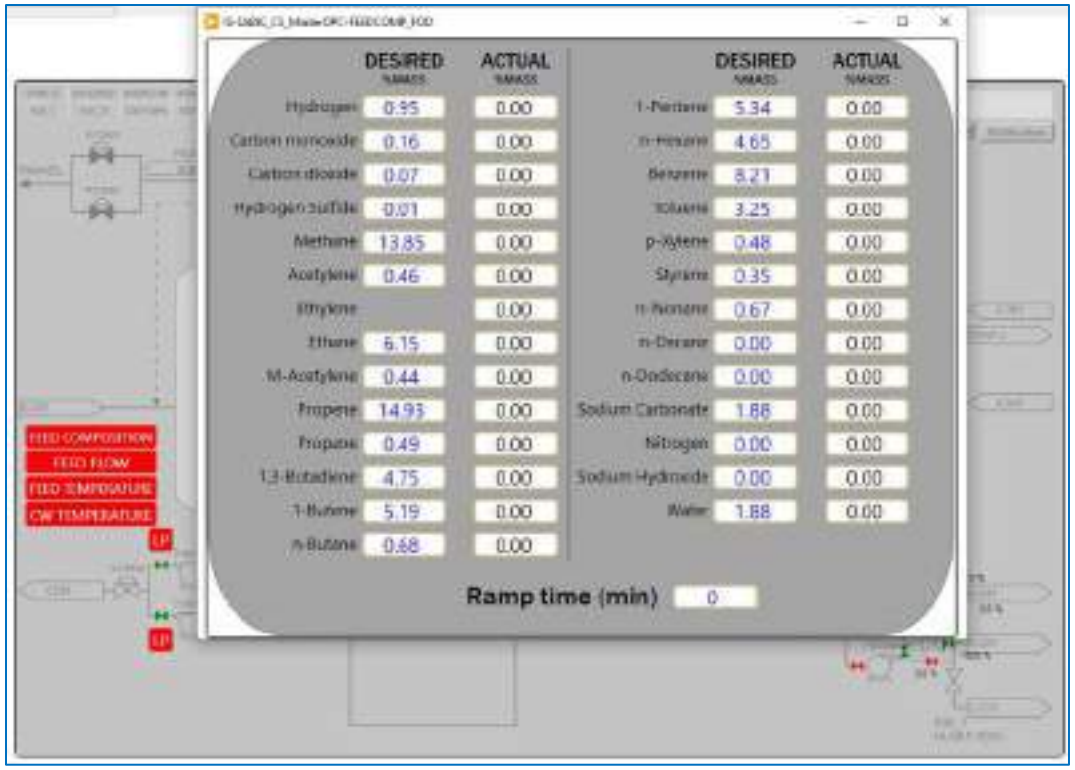
OTS Instructor console

OTS instructor console: Inputs & Field Devices

Field device to set speed of Steam Turbine of C2 compressor



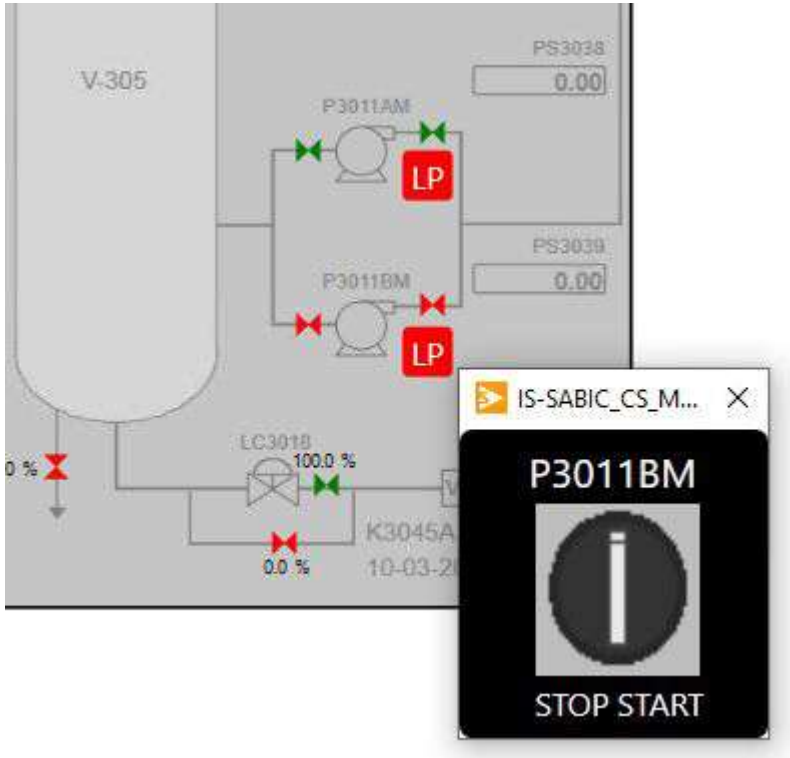
Instructor input to modify feed stream



OTS instructor console: Inputs & Field Devices

Replica of Key Override in Control Room

Field device to start pump or local valve



OTS in action!

C2-section and compressor section completed

Operators of compressor section are trained for start-up of the plant after Turn Around in May 2026

Examination of control room operators for C2-section also on OTS

Project completed by end 2026

Expected value from OTS

Item	Feedback from SABIC OTS Instructor
Turnaround start-up time reduction	During shut down and start up, the APC is off, and the younger generation operators have little experience in shut down, start up with DCS control. The OTS allows to train these procedures resulting in **time gain and better controlled shut down and start up**.
Plant trips / incidents /off-spec reduction	Because of APC, operators are less experienced in controlling the process themselves via DCS. With OTS operators can be trained to recognize deviations, to understand them and to handle these situations via DCS control without APC and **therewith avoid plant trip or major upsets**.
Faster recovery after plant trip	OTS enables training possibilities to understand coherence between the plant sections. This enables **better communication and cooperation** between the control room operators of the different plant sections.
Flaring reduction	Better controlled shut down, start up and handling of upsets will result in less flaring. The OTS already proved its value in the Feb-2026 shut down. We stopped the plant in a controlled way without issues and **without using the stack flare** which is important for the relation with stakeholders and the surrounding cities
Training time reduction	With the OTS, the operators can test and see reactions of the process instead of just discussing it at the control panel. **Seeing/doing it yourself helps to remember and learn**.
Intangibles: Safety, Operator stress and motivation	A better trained/prepared **operator will experience less stress** because he will know how to handle upsets and understand deviations. They will be able to make decisions regarding incidents/upsets faster and more well-founded. OTS training also will therefore help to give the right assignments to the field operators. Operators overall get more self-assured.

Normal Ethylene production 650 KTA
Normal Propylene production 450 KTA

→ Saving 8 hours from the Turnaround or from a trip is about **1.5 Million Euro**

Summary

- Starting with a pilot for speed, justification and learning working together
- Emulation for control the same, HMI almost the same as using a 1:1 DCS copy
- Intensive model tuning sessions crucial
- Create buy in by forming an operator OTS-team
- Appoint an OTS plant manager for keeping OTS up to date (MOC) and used
- Inprocess fully dedicated to simulation and SABIC experienced an excellent collaboration


•THANK YOU