Beyond Optimize 2021

Operator training simulator benefits for a Steam Cracker

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ORLEN Unipetrol

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Agenda

- ✓ Company presentation
- ✓ OTS
  - ❖ Motivation
  - ❖ OTS Sections
  - ❖ Flowchart
- ✓ Steam Cracker Overview
- ✓ Challenges
  - ✓ Unit Component determination
  - ✓ Unit definition – customizations
  - ✓ Complex reactors
  - ✓ Highly interacted system
- ✓ OTS added value
  - ✓ Virtual sensors
  - ✓ Procedure improvement
- ✓ OTS Benefits

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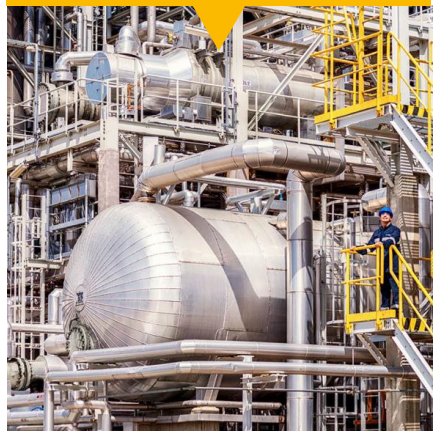
ORLEN Unipetrol Group at a glance

The largest refinery and petrochemical company in the Czech Republic



The only crude oil refining company in the Czech Republic

Manufacturer and distributor of fuels, oils, lubricants, plastics, fertilisers and other products

Operator of the largest Czech network of filling stations

Member of international ORLEN group since 2005

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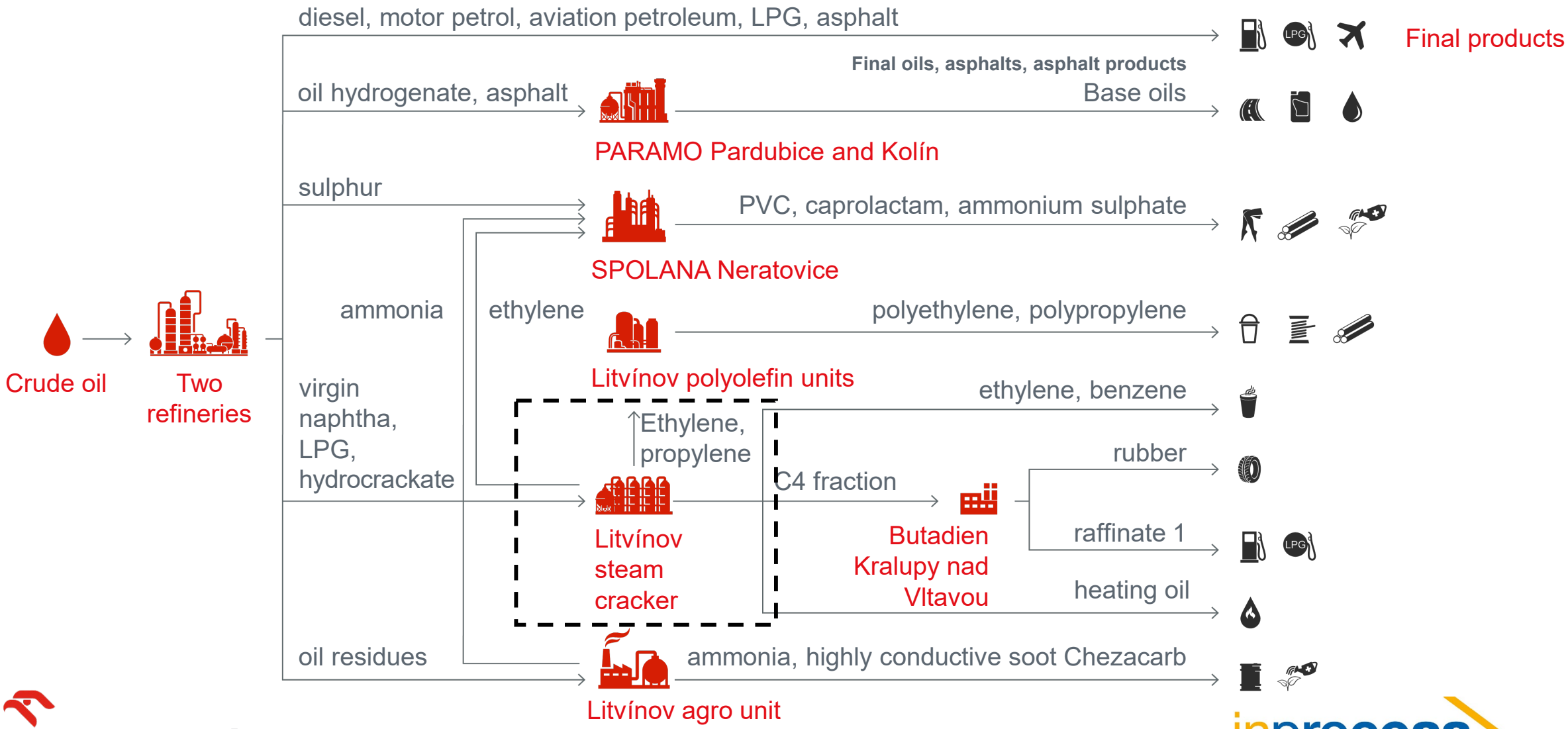
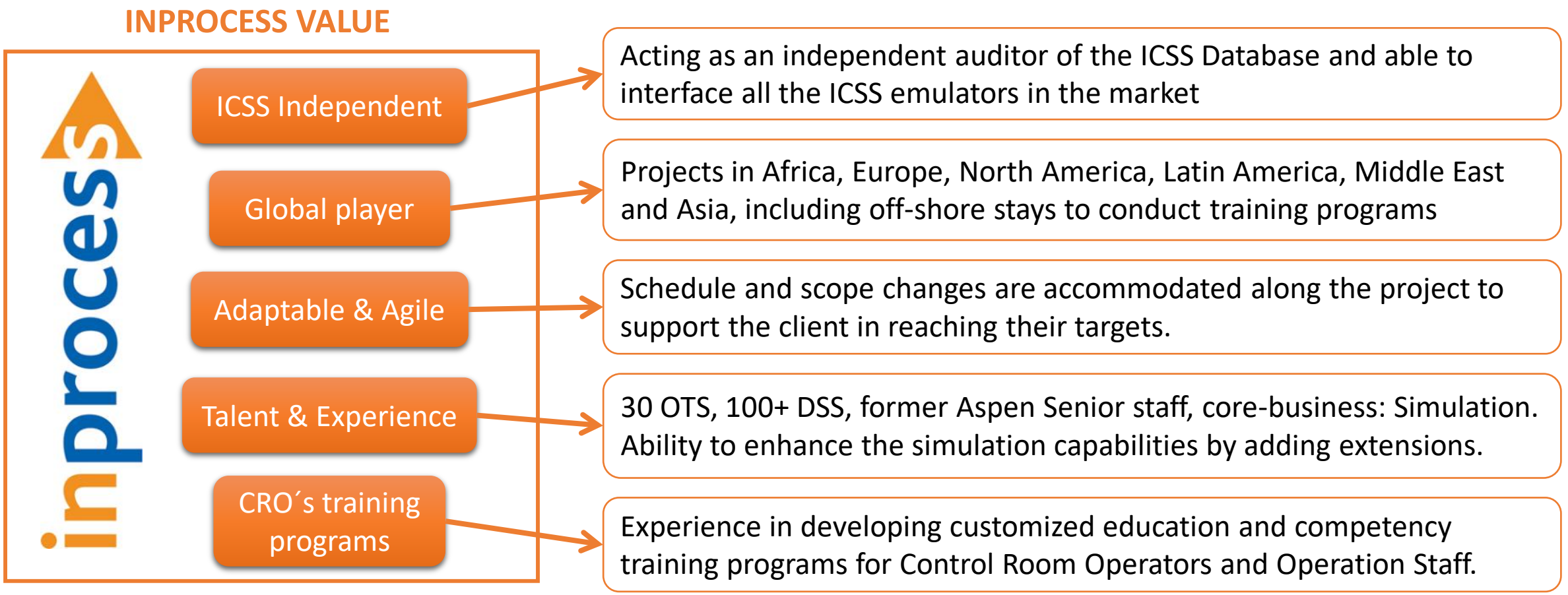
Oil refining process



Why Inprocess?

What added value does Inprocess provide to an Operator training simulator?



*DSS- Dynamic Simulation Studies
*ICSS – Integrated Control and Safety System
*OTS – Operator Training Simulator

Steam Cracker OTS : Motivation

How to reduce unforeseen shutdowns?

Can we shorten the start-up time?

How to increase the plant safety?

How to improve the controllability?

How to effectively train experienced Operators?

How to improve the Operating Procedures?

How to retain the knowledge from experienced operators

How to effectively train new Operators?

Can we reduce the general downtime ?

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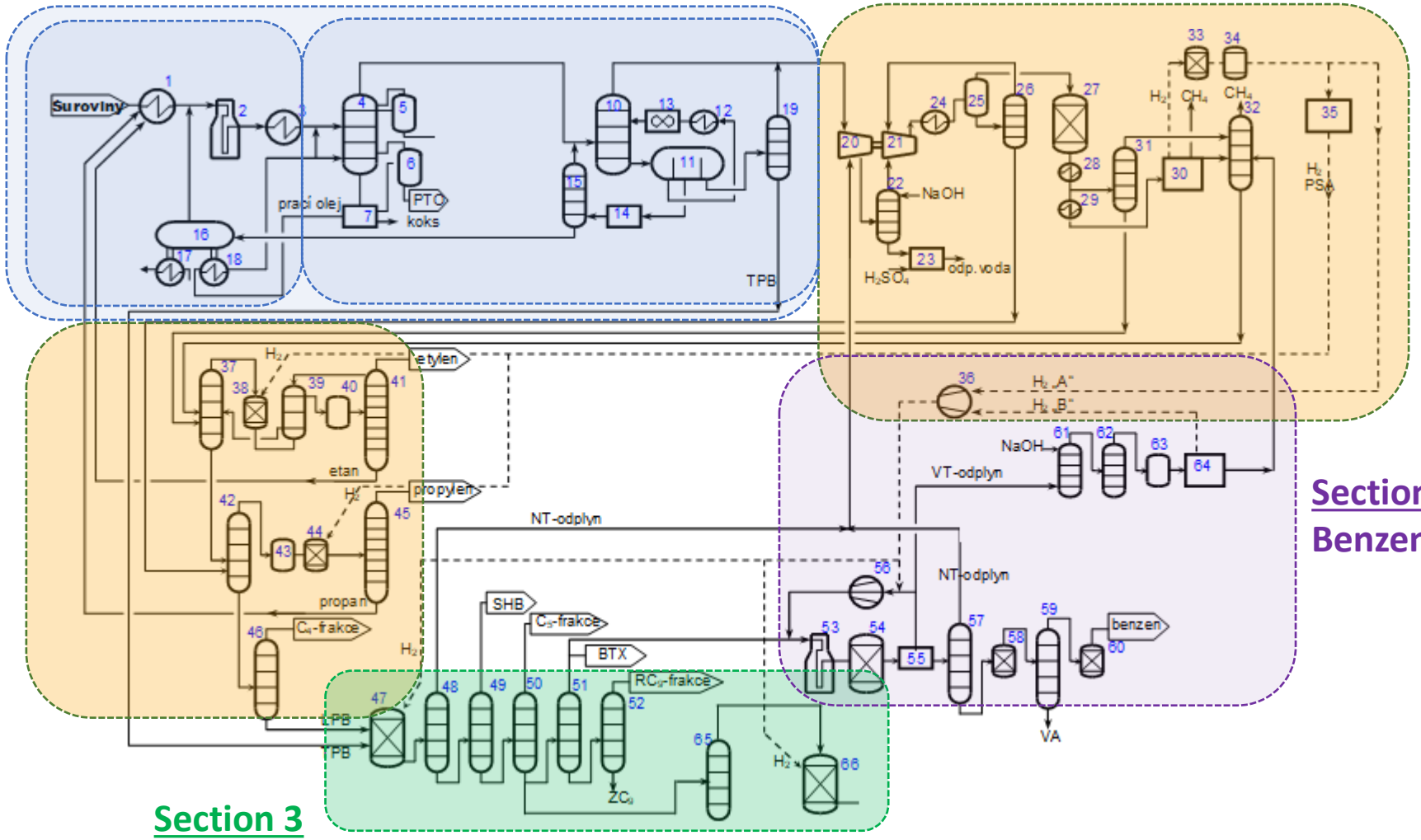
Steam Cracker - OTS Sections

Section 1:
Furnaces and Hot Section



Section 2:
Charge gas compressor, Ethylene and Propylene Cooling, Cold Section and Separation Line

Section 4:
Benzene production - Pyrotol

Section 3
Hydrogenation of Pyrolysis Gasoline

Steam Cracker Pyrolysis Furnaces

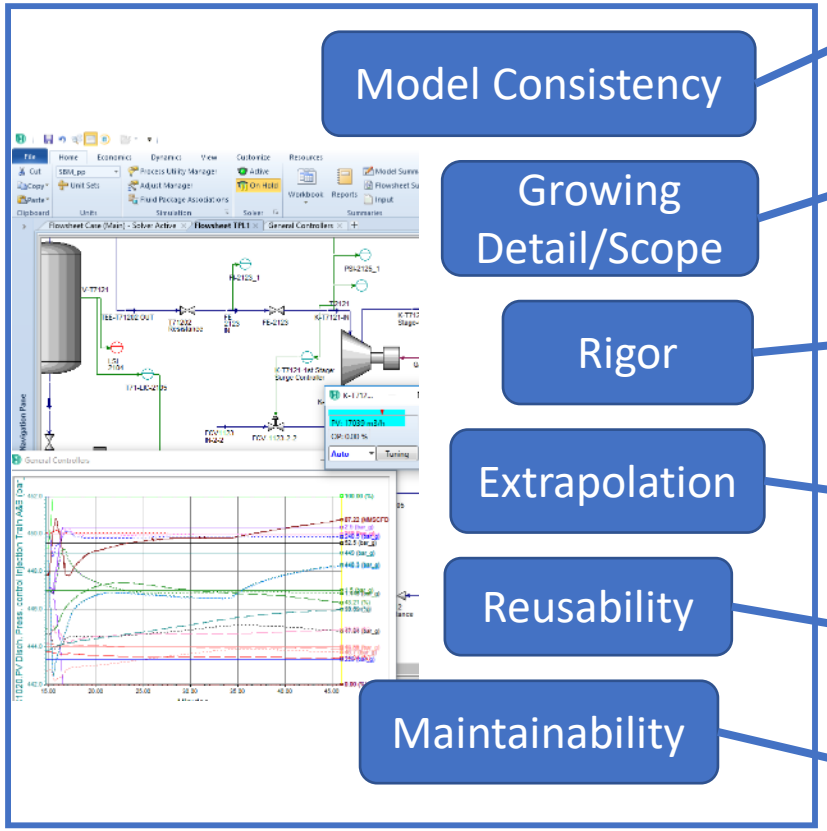
- Key part of the whole process
- Multiple Feedstocks available: Primary Naphtha, HCVD, LPG, AGO, Recycle Ethane and propane
- Highly endothermic process.
- Hydrocarbons are mixed with steam and heated in the furnaces to 800~ºC for 0.1 to 0.5s. Low residence times favors the highly value desired products (Ethylene and Propylene)
- Feedstock is cracked to a very high range of HC (from H2 to heavy pyrolysis heating oil)
- Product outlet temperature needs to be decreased fast (TLE + Quench Oil) to avoid secondary reactions.
- Lower pressures favors the formation of desired products.
- Steam lowers the HC partial pressure, which reduces the formation of secondary product. It also reduces the fouling by reacting with the coke deposited.
- Product temperature cooling produces in TLEs highpressure superheated steam used in the turbines which drive the compressors (charge gas, ethylene and propylene cooling).
- Product mixture, varies with the feedstock and the cracking conditions.

*TLE – Transfer line Exchangers

Why Aspen HYSYS?

What added value does Aspen HYSYS provide to the Operator Training Simulator?

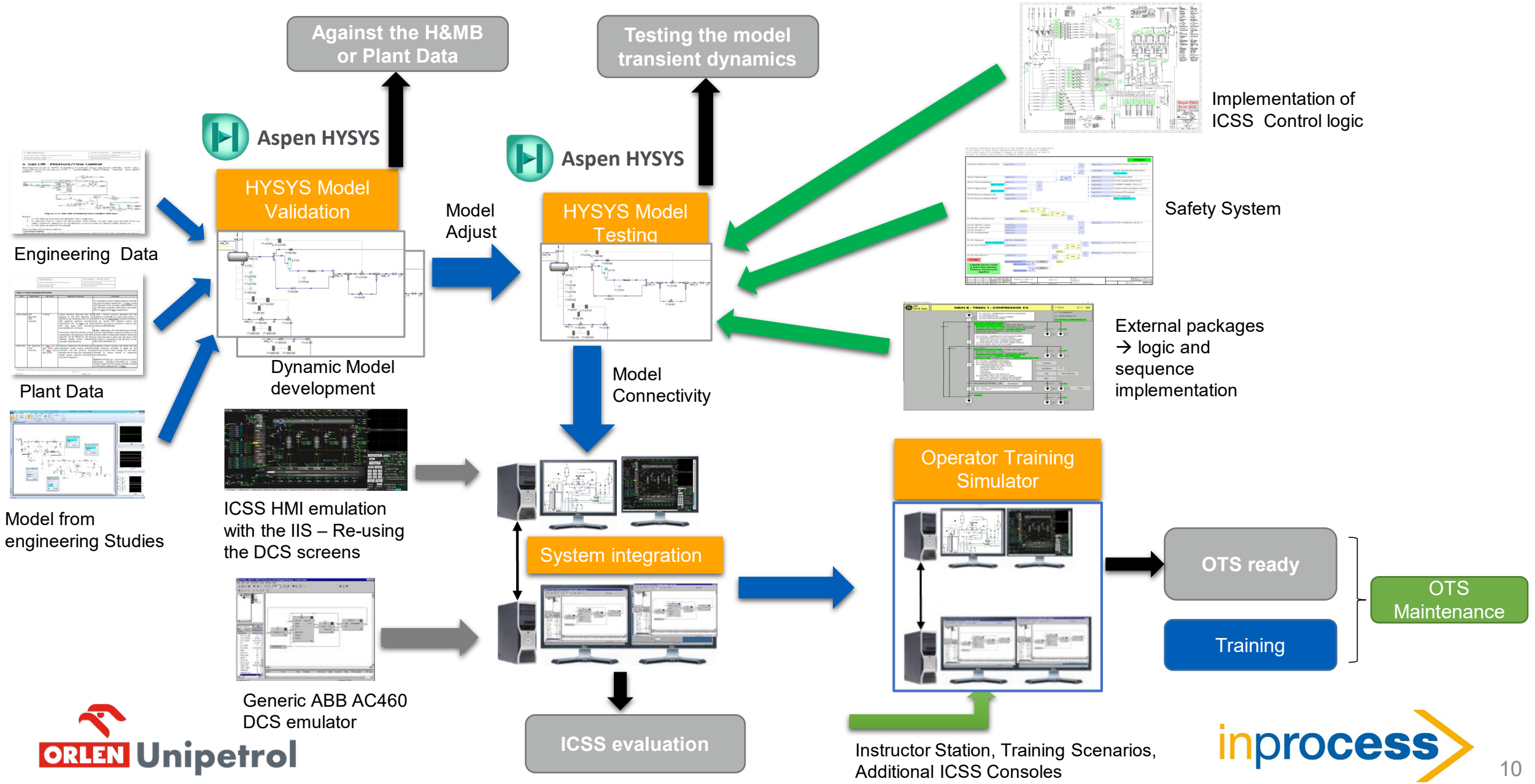
HYSYS LIFECYCLE PILLARS



- **Model Consistency** → Thermo Packages are consistent with the Steady-Sate Design models. Previous available dynamic models from the client can be re-used.
- **Growing Detail/Scope** → Additional process units or additional equipment details can be incorporated as needed in the application.
- **Rigor** → CRO´s* expect a realistic process responses. This is the key to replicate/verify/ improve operating procedures, train in normal and abnormal conditions.
- **Extrapolation** → Extrapolate process conditions far from nominal. Model must replicate a wide range of operating conditions (from cold start-up to maximum production)
- **Reusability** → The dynamic model can be re-used with minor modifications for other purposes
- **Maintainability** → Model update workflow is defined to keep the model alive and synchronized with the process, control and procedure changes.

*CRO- Control room operator

Operator Training Simulator - flowchart



Challenges – Unit Component determination

The plant is fully operational. Hence, the known plant data available is:

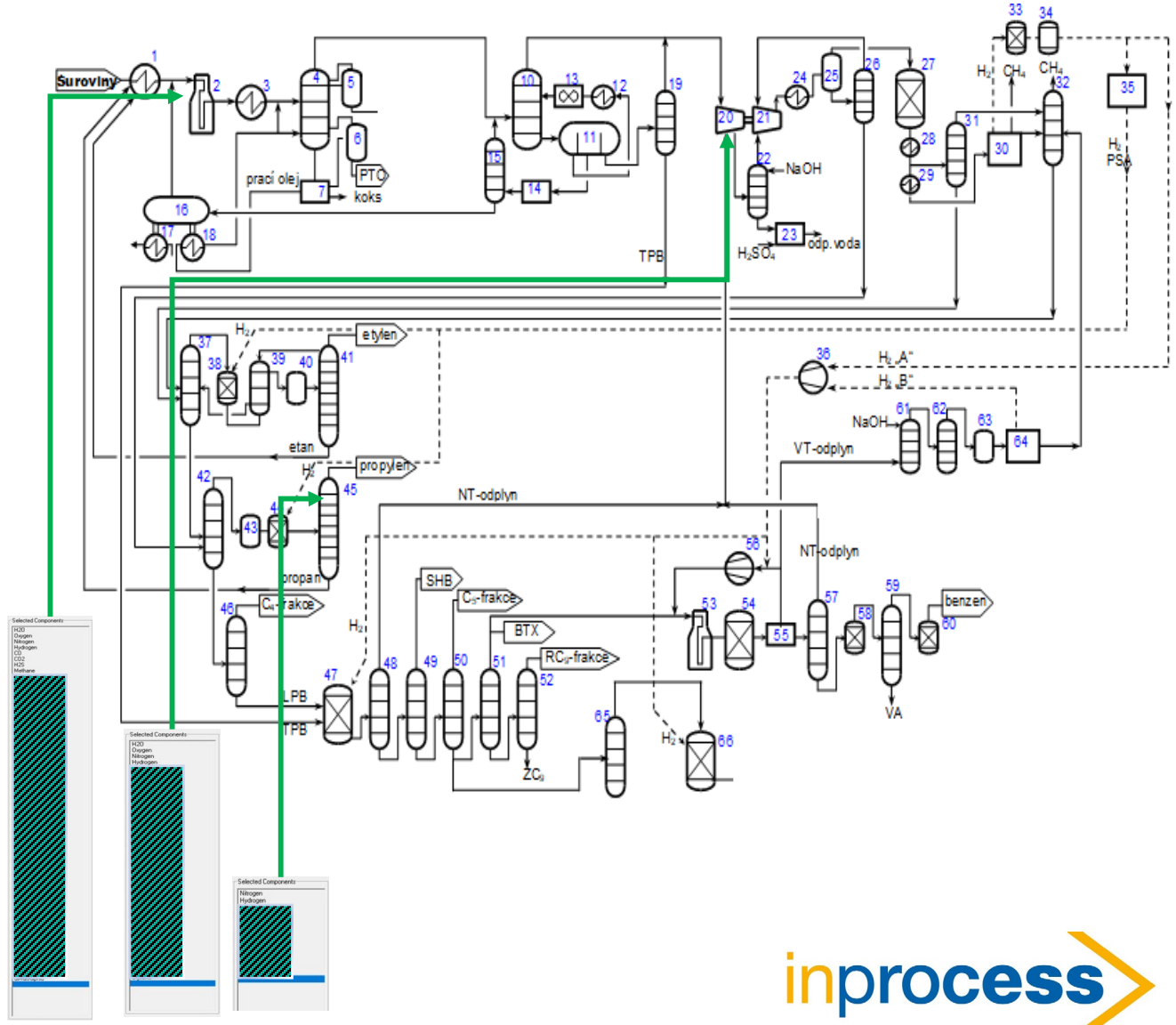
- Steam cracker feedstocks (5 types)
- Data from the transmitters Pressure, temperature & flow transmitters
- Online data (Composition)
- Local samples
- Product quality

Nevertheless, composition within certain units is not clearly defined. Therefore, the actions performed were:

- Overall mass balance
- Component balance

Taking into consideration the main reactions taking place in the whole process

Specific component sets have been selected for each OTS sections



Challenges – Unit definition - customizations

In order to achieve a high accuracy of the simulator the OTS was divided in several sections to be able to simulate in real time (computer speed constraint in HYSYS dynamic simulation).

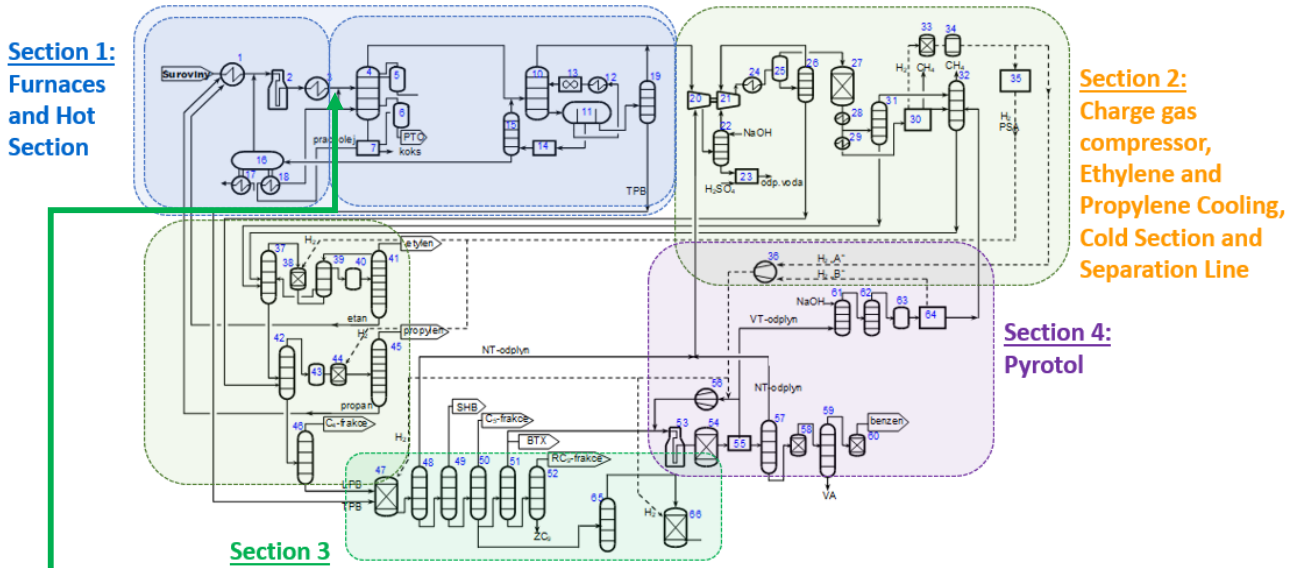
Dividing the unit into specific sections of interest allows us to:

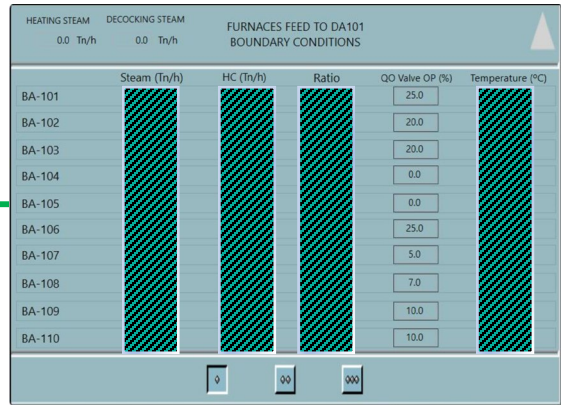
- Avoid interactions or trips from parallel training sessions
- Perform a deep and specific training of our unit of interest.

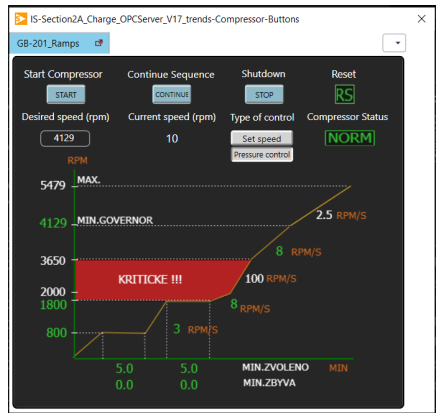
Nevertheless, the individual unit boundary conditions (upstream and downstream) need to be carefully defined to reproduce the normal transient dynamics.

Additionally, custom faceplates were developed to emulate the plant transient conditions during specific events.

Custom faceplates were also developed to perform specific external PLC sequences







Challenges – Complex Reactors

The approach followed to emulate complex reactors:

1. Evaluation of the steady state conditions at several operative points based on real plant data.

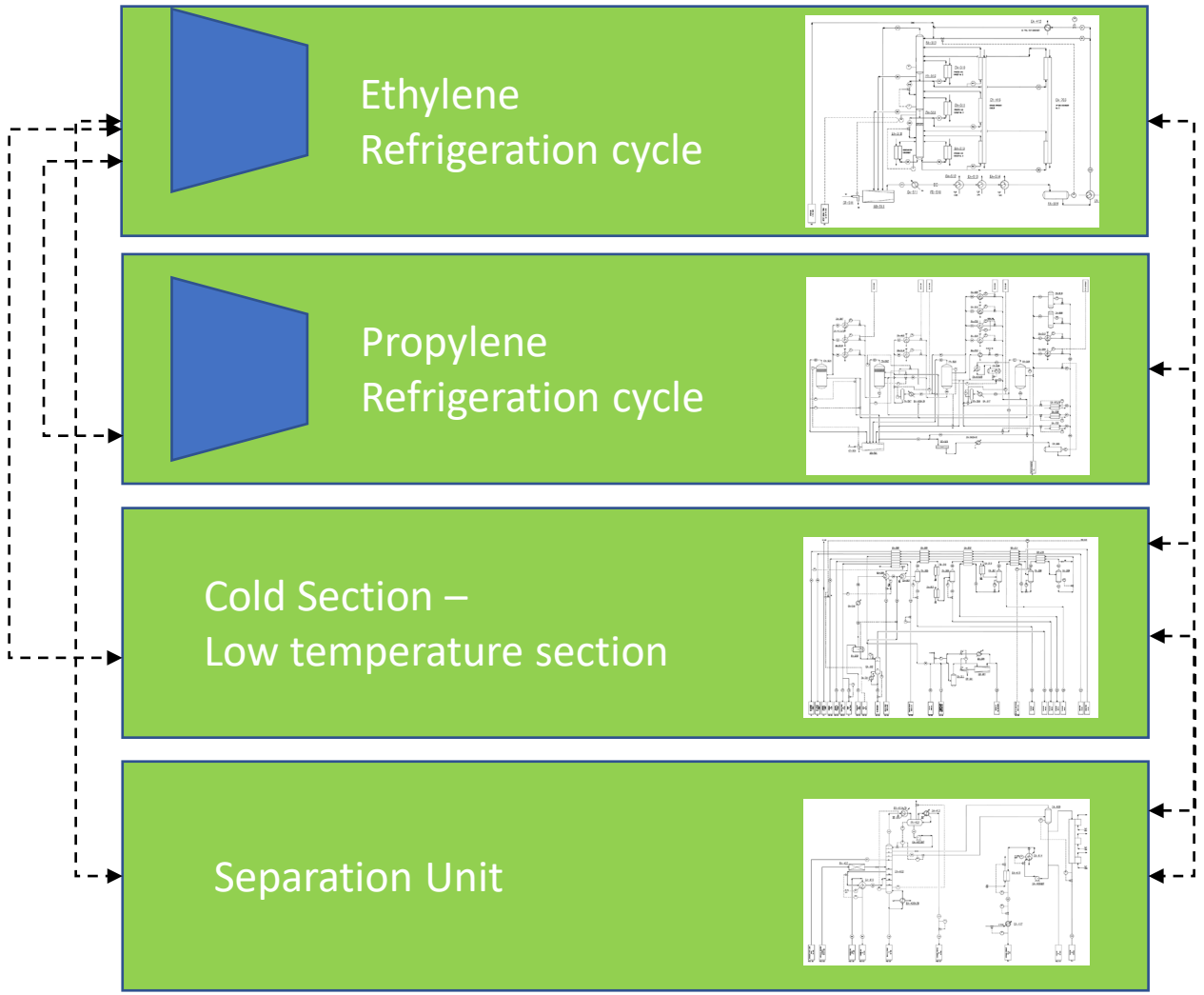
2. Define how these compositions or parameters will shift with variations of the operating conditions (load, Temperature, catalyst, etc.)

3. Adjust the capacity (volumes or hold-ups and transfer area) to represent the real velocity of change of the process variables. Therefore, we are defining the dynamics of the process unit.

Challenges – highly interacted system

The inclusion of this unit implies the

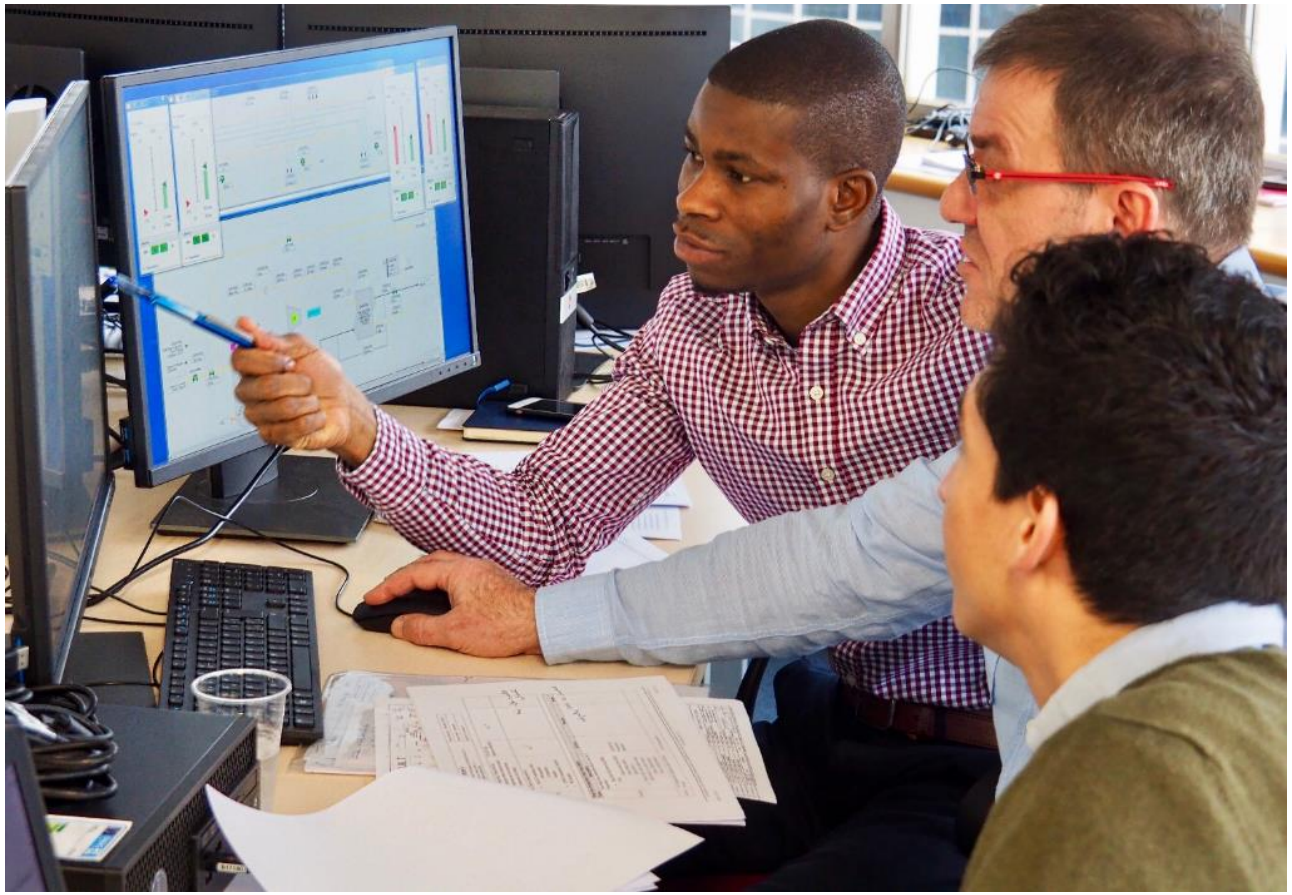
- The system consists of two refrigeration cycles (Ethylene and Propylene compressors), which are highly interconnected with the low temperature section and the separation unit (distillation columns).
- This leads to the necessity to fully integrate these units to capture the:
  - Overall plant dynamics
  - Heat transfer and constraints
  - The correct composition distribution
  - The proper control response and system interaction
- In order to achieve this, the dynamic model was validated against a consistent set of data, plant data at steady conditions during normal production.



Training objectives

Improve the operator competence (new and experienced operators) by performing extensive virtual training without risk for the process units.

- ✓ Improve the overall process understanding
- ✓ Improve the operator awareness and response while facing abnormal scenarios.
- ✓ Control interactions
- ✓ Unit limitations
- ✓ Train on
  - ➢ Normal operating conditions
  - ➢ Abnormal conditions
  - ➢ Trips and disturbances
  - ➢ Malfunctions
- ✓ Perform common and uncommon operating procedures
  - ➢ Plant Start-Up
  - ➢ Plant shutdown
  - ➢ Change over
  - ➢ Load variations



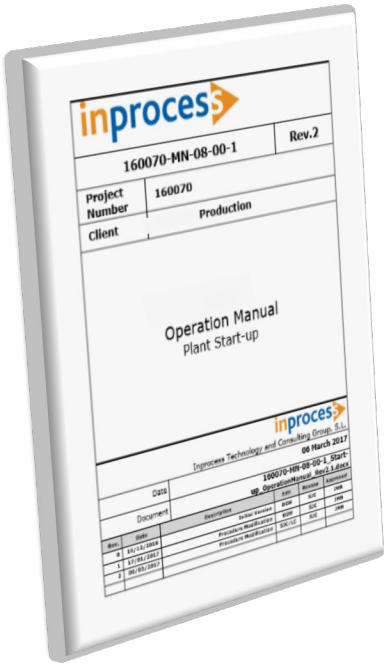
OTS added value – Procedure improvement

Scope:

- Individual Units
- Overall Start-up process

Combining Expertise's:

Mix of experienced Engineers / Operators know-how with realistic response of Process Trainer



3.1 Summary of Operation Procedures

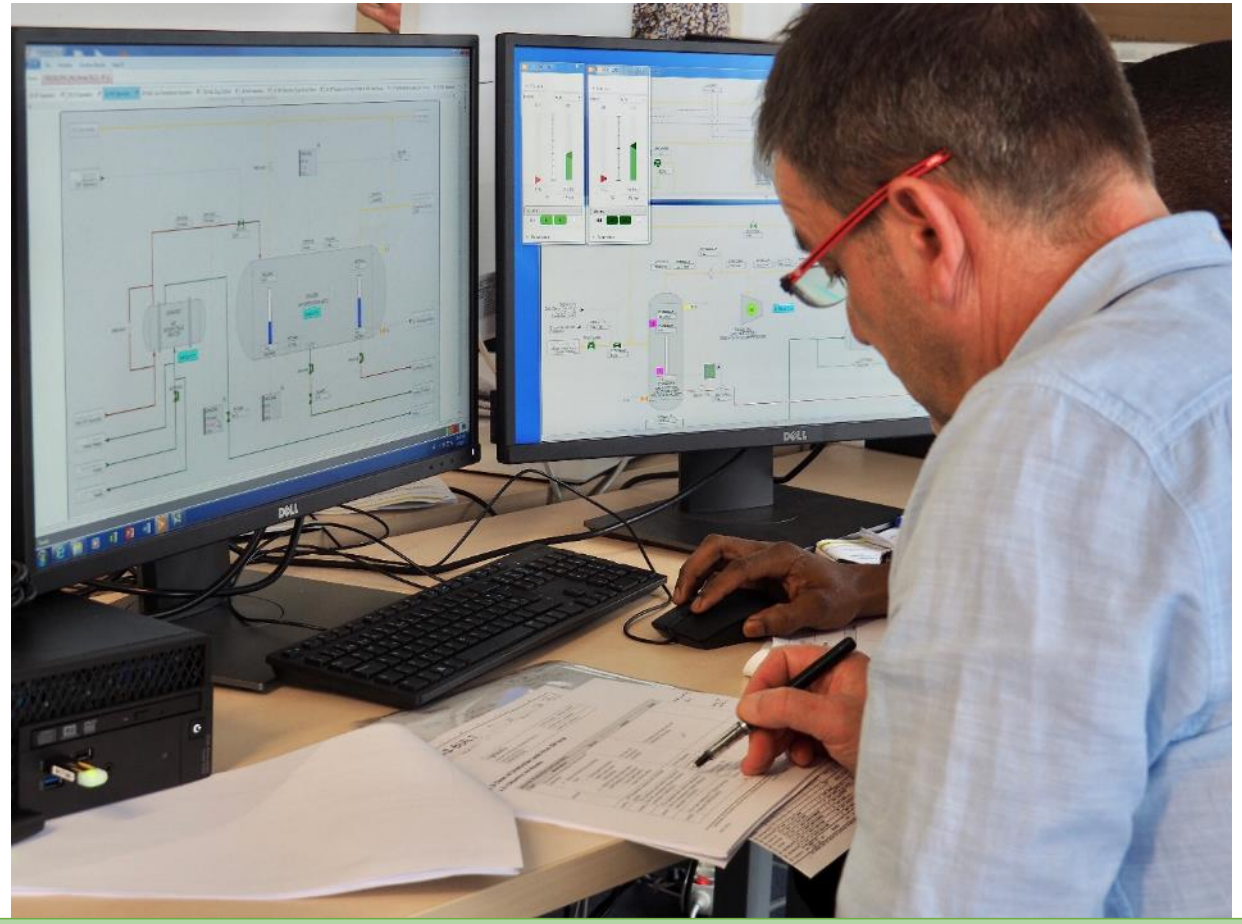
Reference is made to Operational Procedure for Plant Start-up (MS-OP-KB-50xxx) for a description of the plant start-up. The sequence given in the start-up of the plant via the simulator is equal to the sequence described herein.

Table 3-1 – Operational Procedures

N°	Operational Procedure Simulator	Related Operational Procedure	
		Doc. No.	Description
1.	Start-up of HP & LP Flare Drums (Flare system)	MS-OP-KB-50xxx	HP and LP Flare Tip Start-up
		MS-OP-KB-50xxx	Online Replacement of Rupture Discs 43RO2001/52 at LP Flare Line
2.	Start-up of Cooling Medium system	MS-OP-KB-50xxx	Online Replacement of Rupture Discs 43RO2001/52 at LP Flare Line
3.	Start-up of Heating Medium system	MS-OP-KB-50496	Lining up New Consumers to Heating Medium System
		MS-OP-KB-50497	First Start-up of Waste Heat Recovery Unit
		MS-OP-KB-50495	Cleaning of Heating Medium Slip Stream Filter

Operating procedures with

- Unipetrol's best practices
- Expected Transient dynamics
- Timings and interlocks
- Relevant unit information



Operating Procedures are drafted and validated in a close interaction between experienced operators and simulation experts

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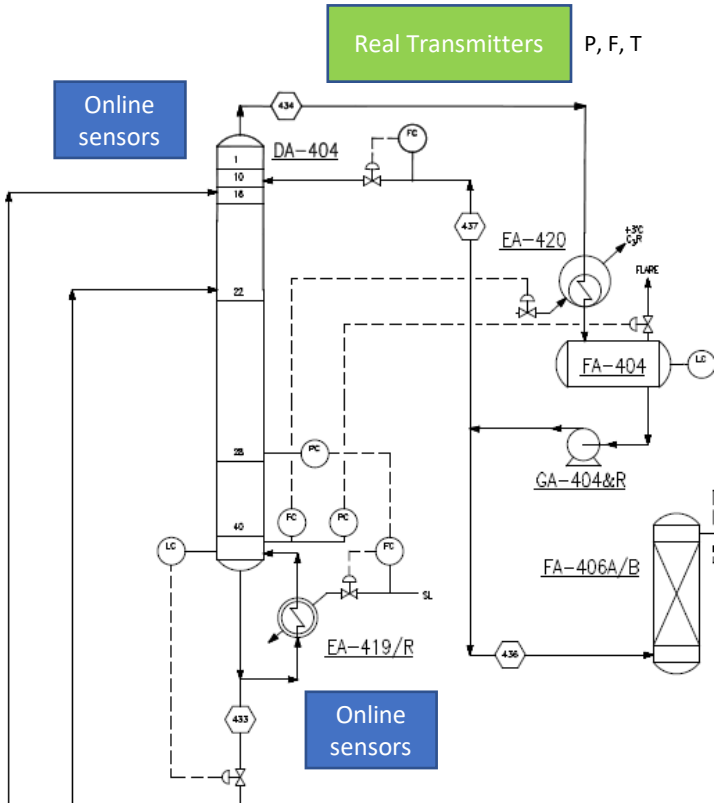
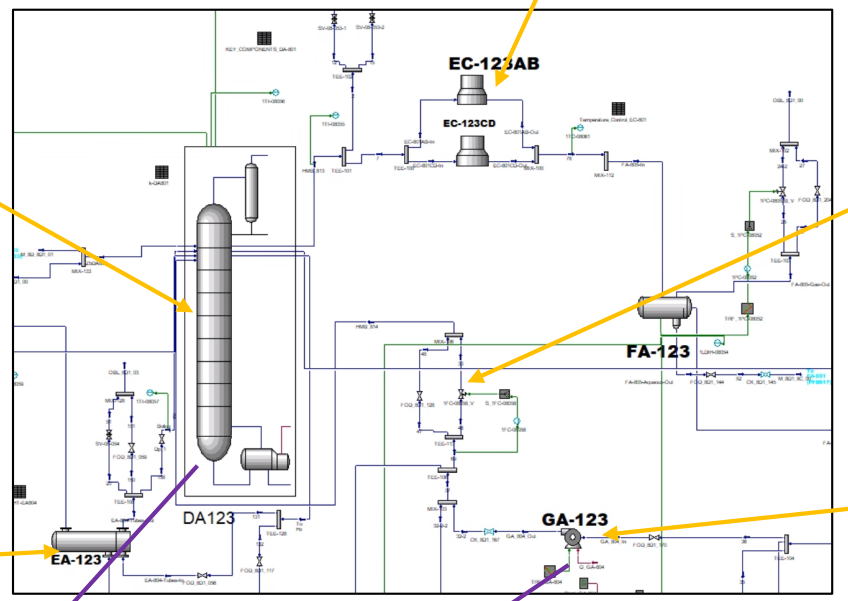
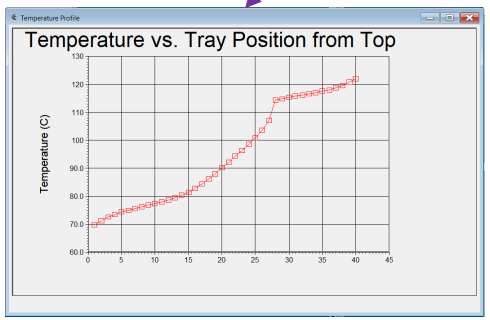
OTS added value – Virtual sensors – Process Data

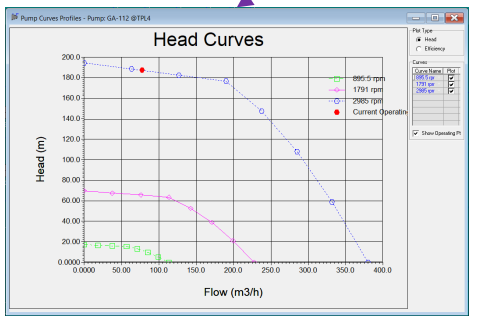
Real Plant



OTS model







Plant Data

- Online sensors
- Transmitters
- Local samples

Model Data available

All process layout and stream conditions.
More information to understand overall process and transient conditions

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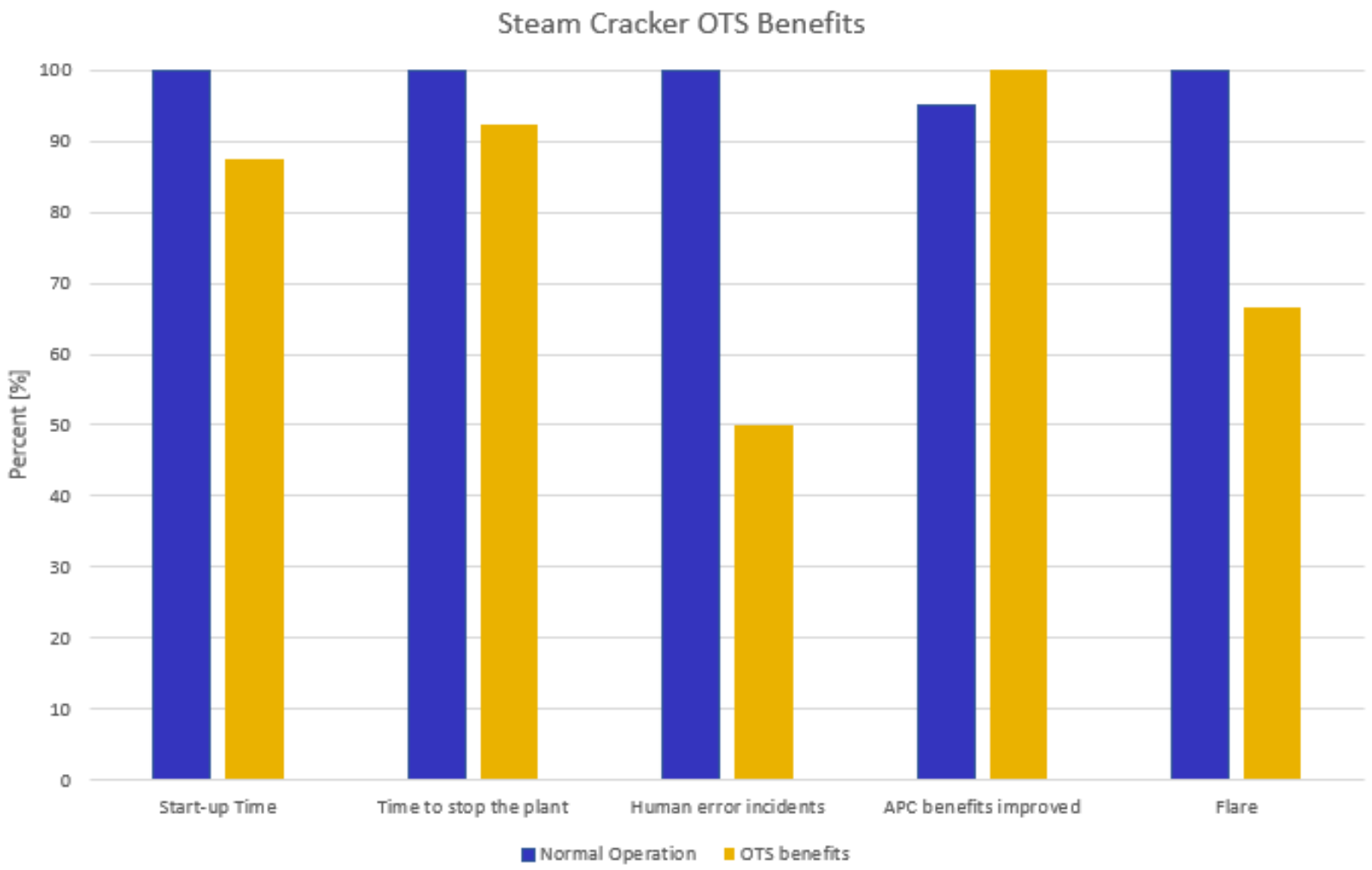
Steam Cracker - OTS Benefits - Brownfield



Estimated Savings are ~2,6 MM$/Year