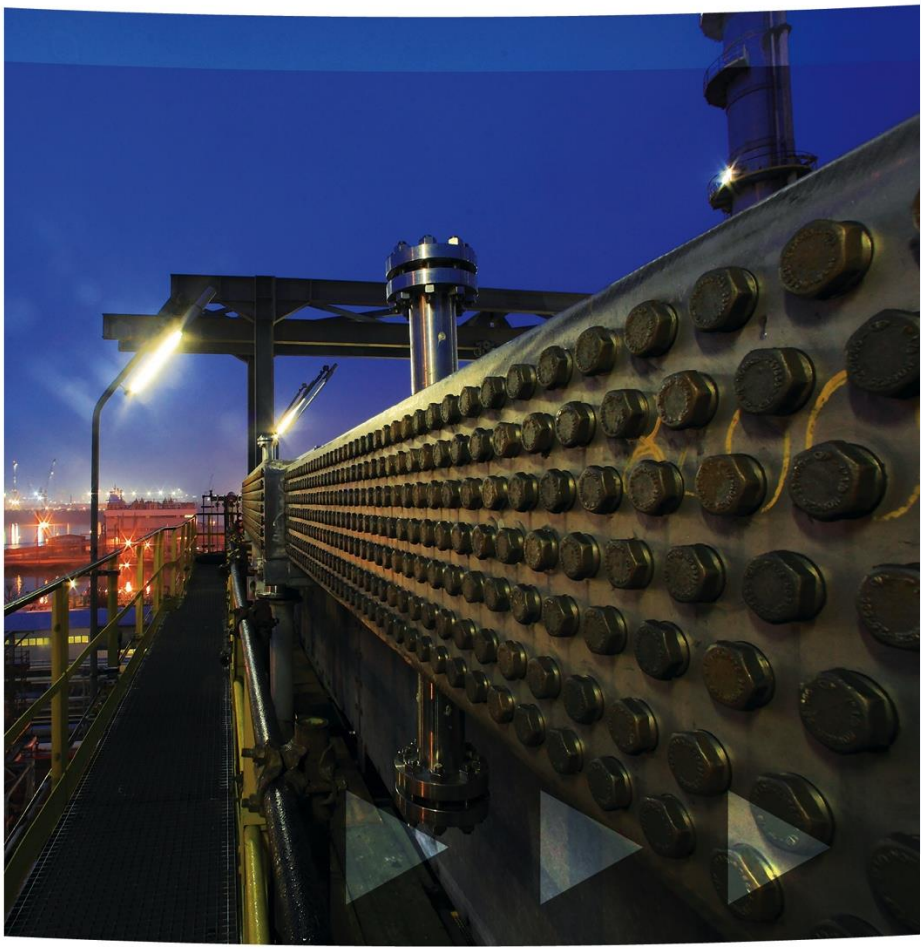
HYDROCARBON PROCESSING®

IRPC 2015

1–3 June 2015 | Jumeirah at Etihad Towers | Abu Dhabi, UAE



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Operator Training Simulator for a new Cumene & Phenol plant

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Outline

- Piloting a process plant
- Project background
- Why OTS investment
- The OTS
- OTS value

Piloting a process plant

If your process plant were the Saturn V,
your panel operators will be the astronauts

Now, think about the training hours of an astronaut

Process plant vs. Saturn V

	Ethylene plant	**Saturn V**
Throughput	800 kty ~ 90 t/h of Naphta	1st Stage burns 14200 t/h (Kerosene) with 32200 t/h Liquid Oxygen
Working time	~ 50 years	4 hours, 20 min
Instruments	~ 5000 AI/DI	Stage-1 about 900 instruments, Stages 2&3 ¿?
Cost	~ 1.5 Billion$	Per launch: $494 million in 1964–73 dollars (~$3 billion today)
PID loops	~ 800 loops in ICSS	~ 20 faceplates in Command Module
Training time before launch	3-9 months	Two years for Apollo missions (they are test pilots before)
OTS cost	0.8 – 1.2 Million$	All simulators > 50 million$

OTS is a multiplier of every hour invested in training

Source: https://www.hq.nasa.gov/alsj/NASATND7112.pdf

Project background

CEPSA Chemical Shanghai ("CCS") is building the new Cumene and Phenol plants in the Shanghai Chemical Industry Park (SCIP), with a capacity to produce:
250kMt of phenol and
150kMt of acetone

CCS is using OTS to reinforce the training for all the operation staff, with plenty of scenarios, to improve the economical operation of the plant, such as normal operations, start-up and shutdown, equipment malfunction and emergency conditions.

Inprocess Technology and Consulting Group ("Inprocess") has rich modeling and project experiences for OTS (Operator Training System).

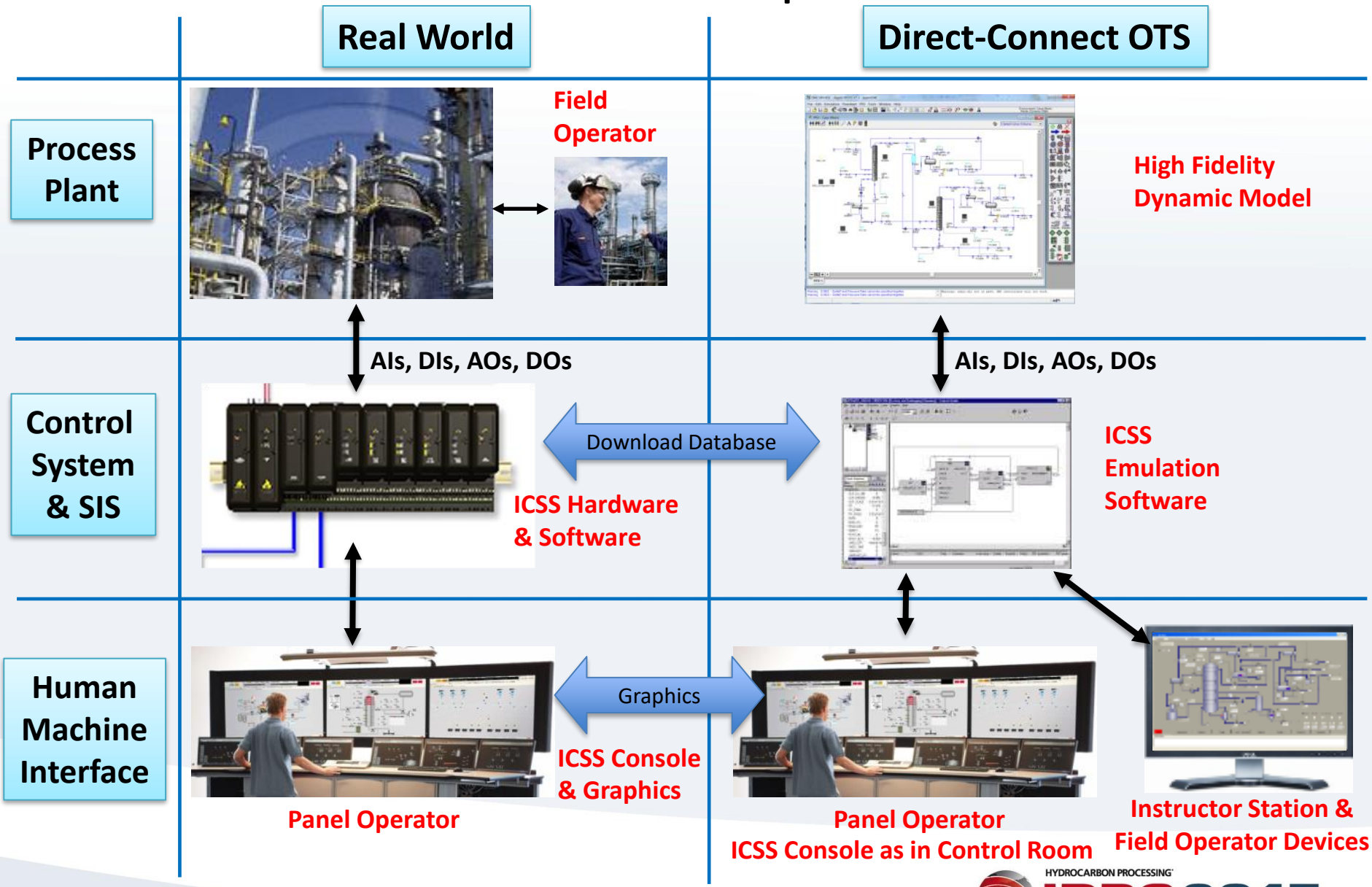
www.youtube.com/watch?v=NJxIXR3ZAKs

Why OTS investment

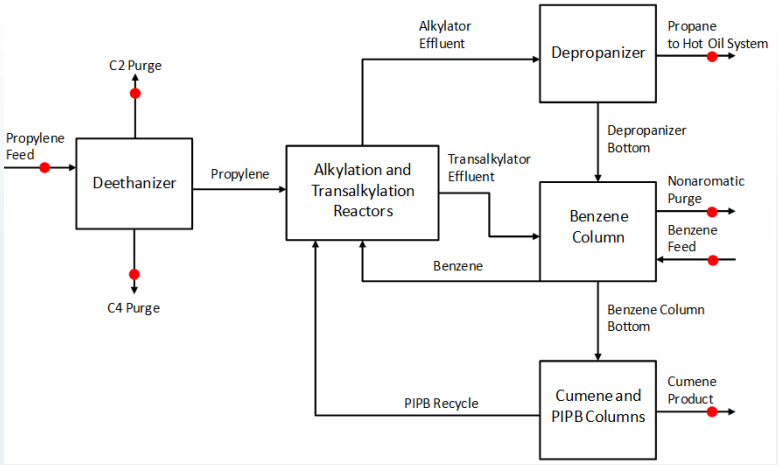
The OTS overall objectives were:

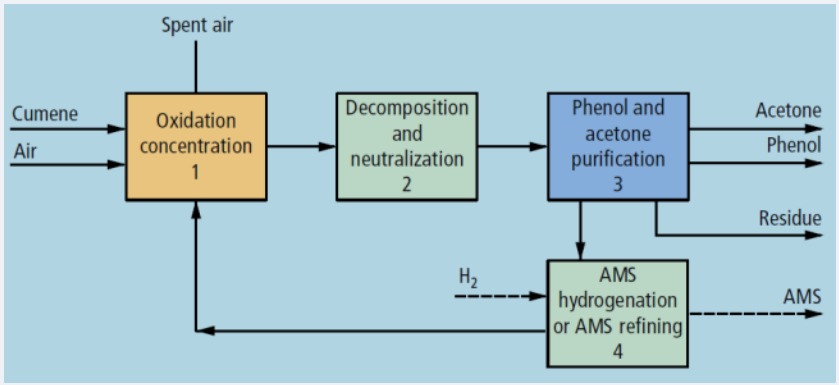
- Train the Chinese operation staff on the process and the DeltaV system in Shanghai.
- Train the support Spanish operation staff on the DeltaV system in Huelva (Spain).
- Reduce the risk of major operational incidents
- Reduce start-up time
- Increase plant on-stream time and performance
- Verify Process Control System (PCS) operation
- Verify Safety Instrumented System (SIS) operation
- Avoid equipment damages
- Provide a test-bed system for engineering analysis

The OTS: Concept



The OTS: Model Scope





Simulation Scope Cumene

- Equipments: 60
- Isolation valves: 20
- Control valves: 91
- Relief valves: 20
- PID loops: 90
- I/O Count: 1000

Component List-Cumene	
H2O	Benzene
Methane	Toluene
Ethylene	E-Benzene
Ethane	Cumene
Propene	n-Pbenzene
Propane	AMS
Cyclopropane	i-BBenzene
Propadiene	m-Cymene
M-Acetylene	p-Cymene
1-Butene	1-E-4-iP-BZ*
i-Butene	13-iP-BZ
i-Butane	n-Hexyl-BZ
13-Butadiene	135-iP-BZ*
n-Hexene	DiPhenylC3

Simulation Scope Phenol

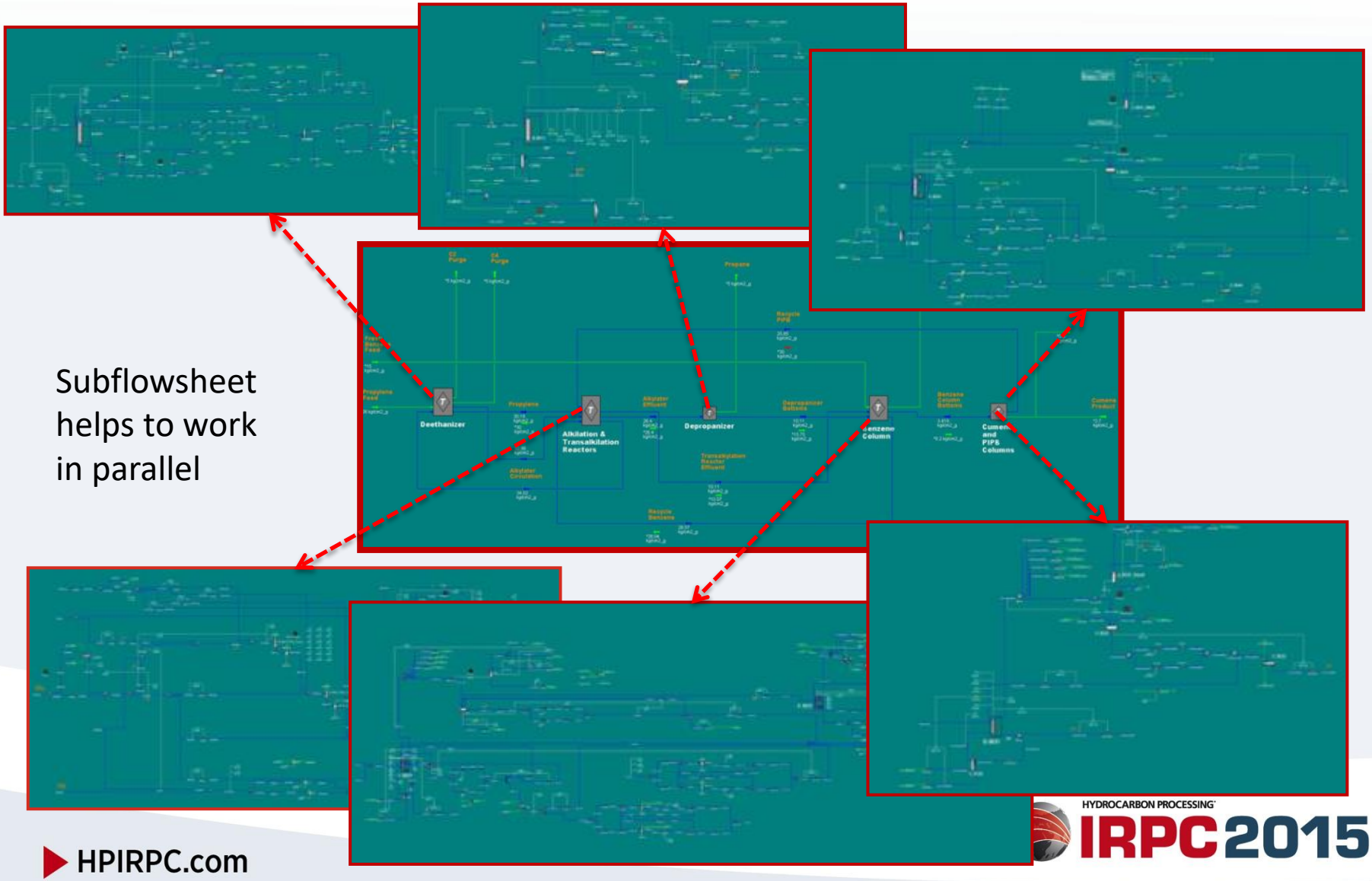
- Equipments: 132
- Isolation valves: 62
- Control valves: 210
- Relief valves: 41
- PID loops: 204
- I/O Count: 2000

Component List-Phenol	
H2O	diAcetone-ol
Hydrogen	BZoicAcid
Nitrogen	o-Cresol
Oxygen	m-Cresol
Methane	p-Cresol
CO	M-PH-Ketone
Formaldehyde	2MBenzoFuran
FormicAcid	AMS
Methanol	Cumene
Oxalic_Acid	DMPHCarbinol
AceticAcid	CumHyPeroxid
Propanal	o-Cymene
Acetone	m-Cymene
Acetol	p-Cymene
Benzene	pCumylPhenol
Phenol	DCumPeroxide
Mesityloxide	H2SO4*
3Mcycpentene	

Challenge

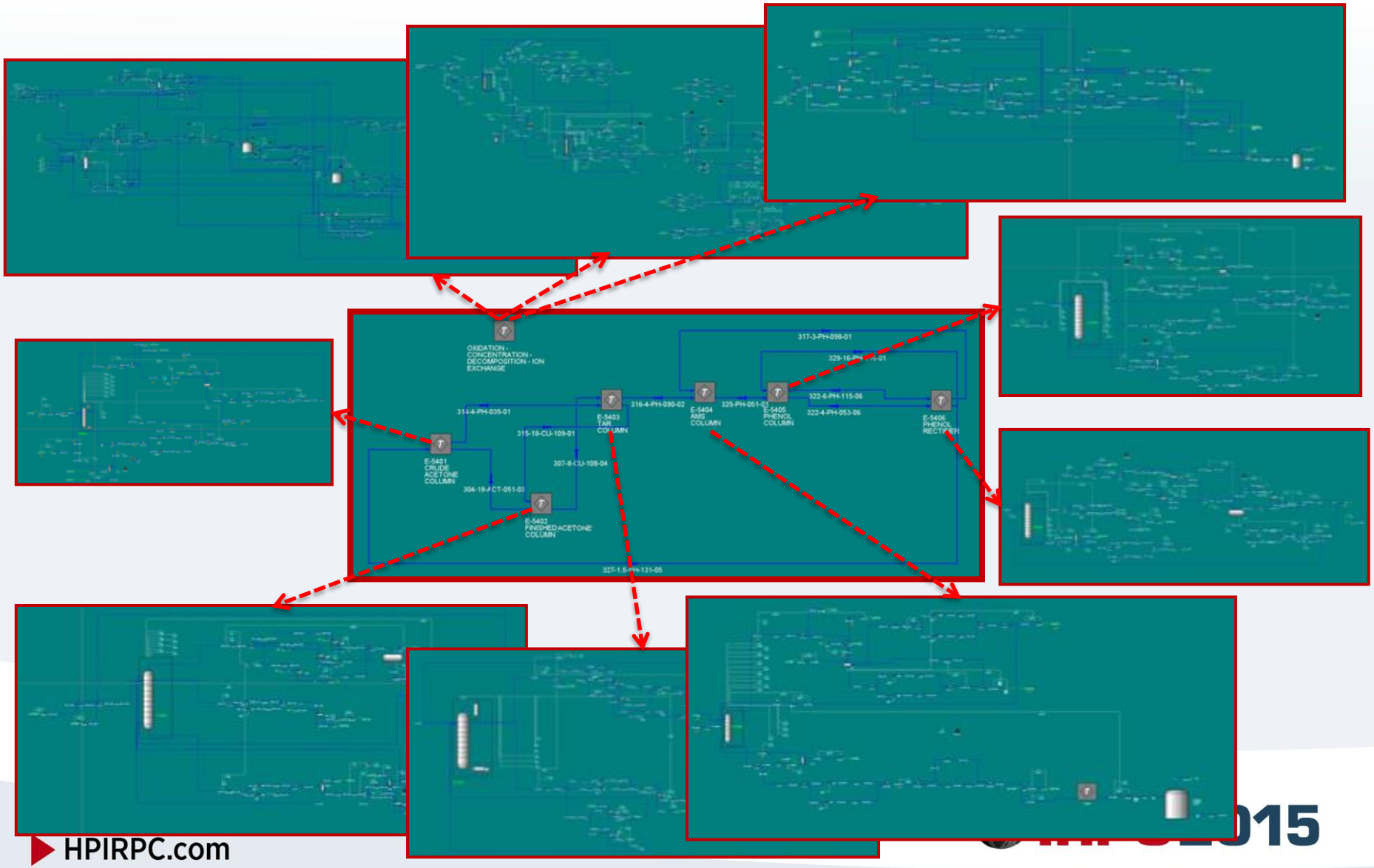
Multiple chemical reactions, many separation units (18 distillation columns) and large recycles

Cumene HYSYS Dynamics model



Subflowsheet helps to work in parallel

Phenol HYSYS Dynamics model



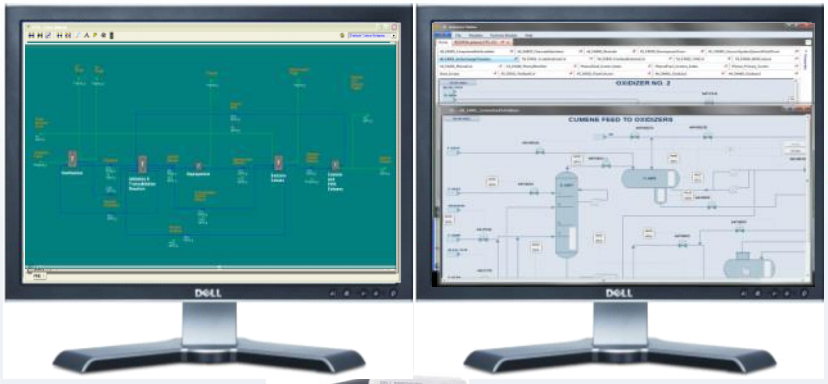
The OTS: modeling highlights

Reactor Dynamics
The HYSYS CSTR reactor was used with rigorous kinetics. Reactors parameters and kinetics constants were adjusted to obtain accurate dynamics.

Hydraulics Effects in Reactor Dynamics
Compressors push air to the bottom of the Oxidizers and the liquid mass is in suspension, but HYSYS CSTR is an ideal homogenous reactor. These dynamics were modelled, therefore when compressor trips the Oxidizers levels are affected.

Calorimeters DeltaT
They are the sensors of the reaction. They were calibrated with the same dynamics that the existing Huelva (Spain) plant was providing.

The OTS: Architecture



Ethernet

OPC Protocol

DCS Operator Workstation

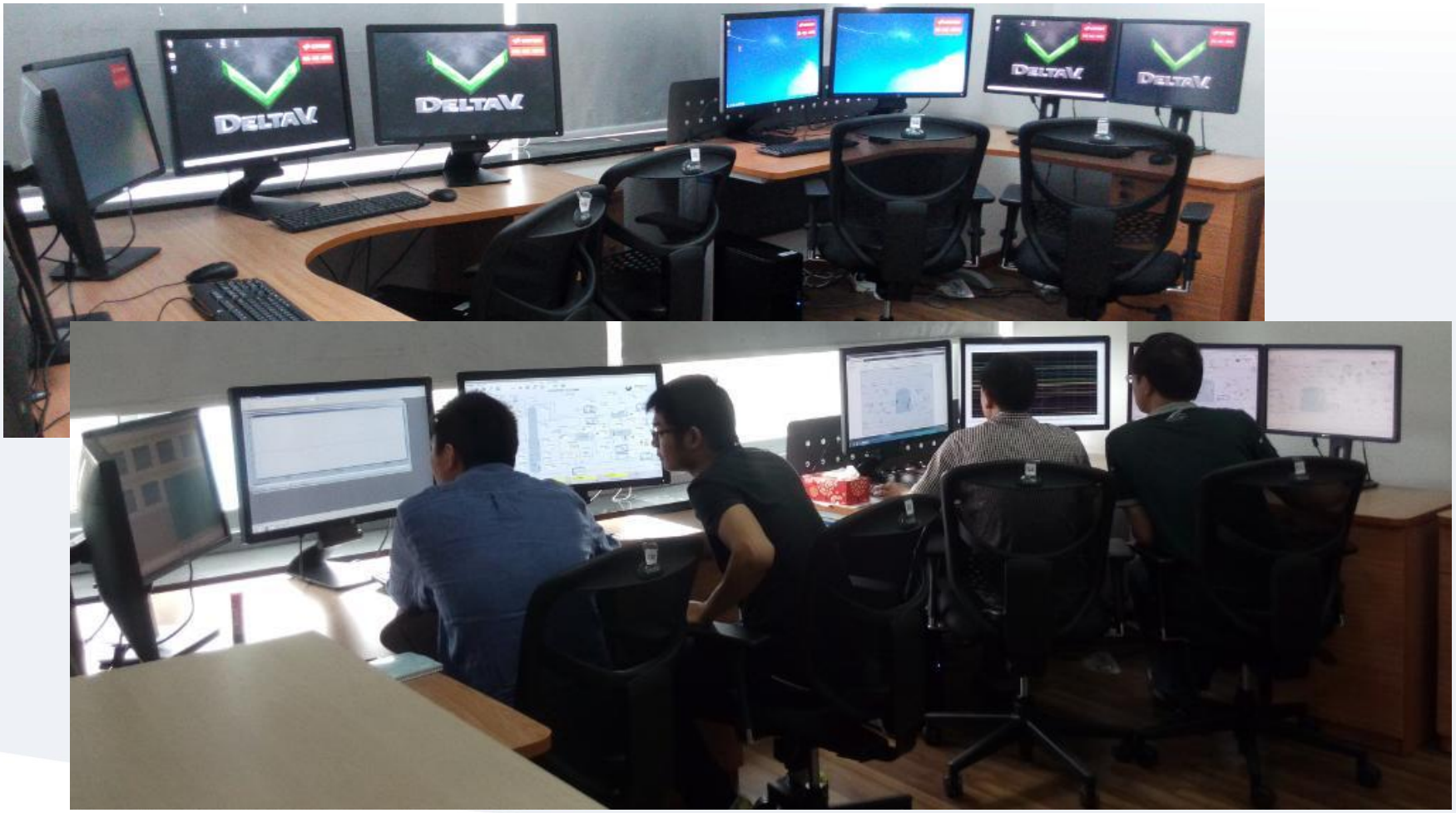
- Plant Control System Emulator DeltaV Simulate Pro
- Operator HMI, DCS DeltaV

Instructor Workstation

- Plant Dynamic Model (HYSYS Dynamic model)
- Inprocess Instructor Station
  - HMI for Field Operated Devices
  - Simulation Management
  - Communication

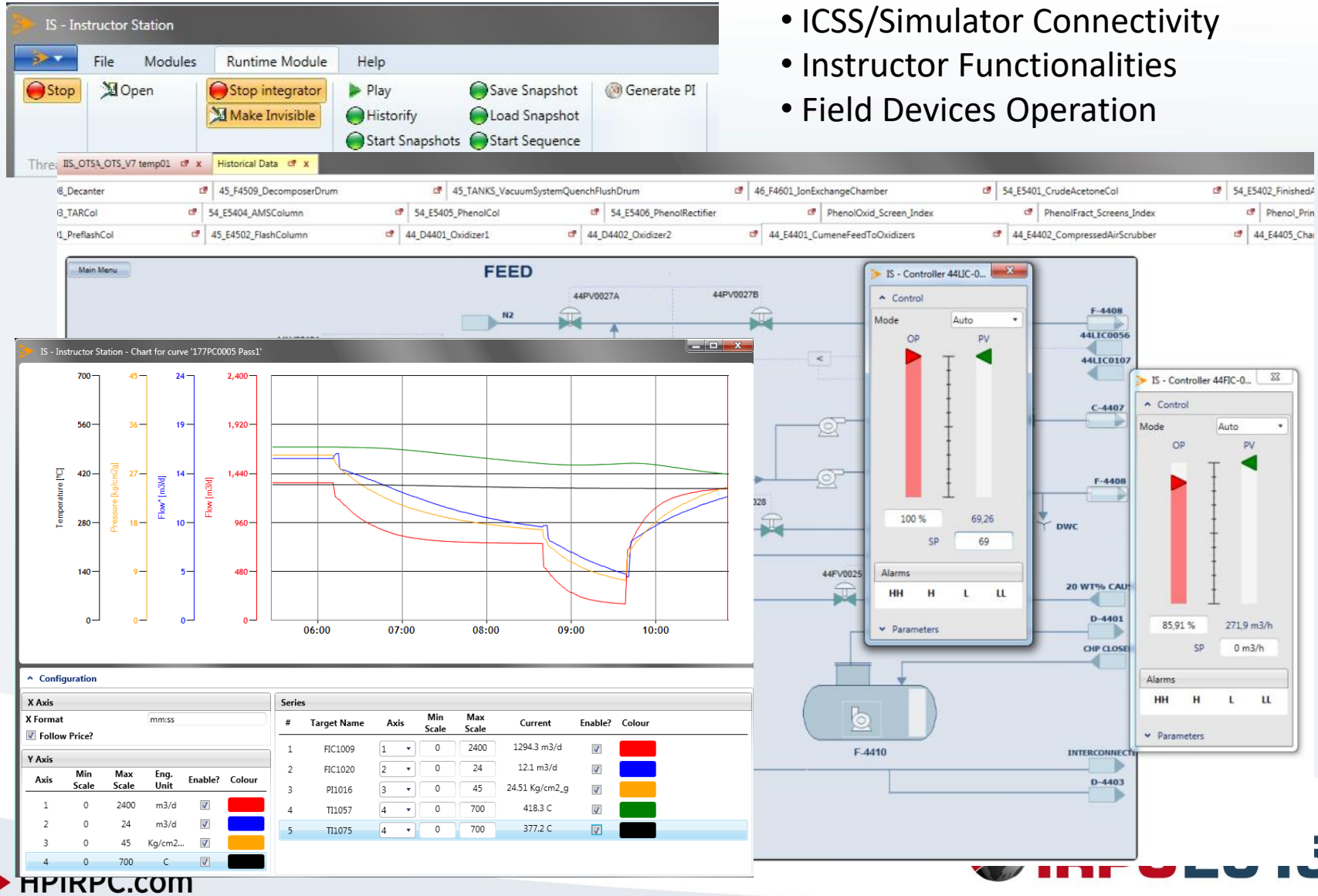
An OTS replica was installed in Huelva complex (Spain)

The OTS: DeltaV Operate



The OTS: Instructor Station

- ICSS/Simulator Connectivity
- Instructor Functionalities
- Field Devices Operation



The OTS: Scenarios

50 scenarios were developed:

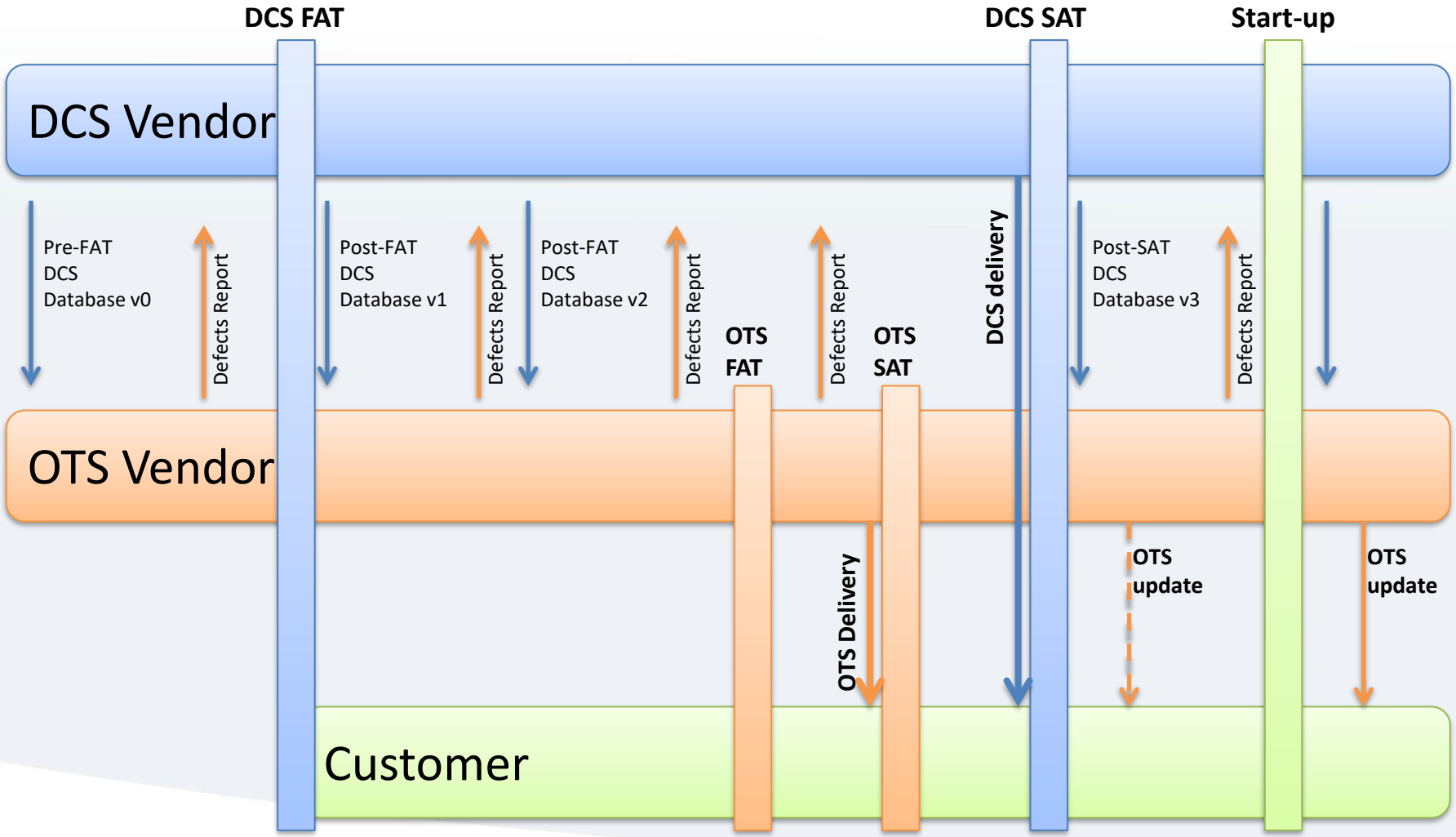
- Operational scenarios:
  - change utilities conditions
  - change in raw material quality
  - throughput changes

- Procedure scenarios:
  - Start-up
  - Shutdown

- Safety Scenarios:
  - Equipment power loss
  - Instrument air failure
  - Critical utilities loss

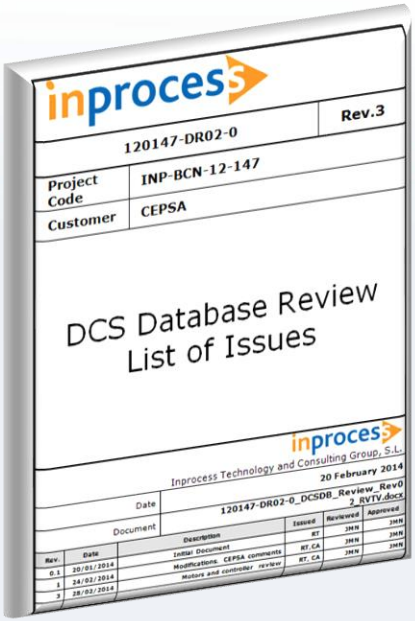
- Equipment failures and malfunctions:
  - Column steam failure
  - Exchangers fouling
  - Instrument failure

OTS value: Debug ICSS code

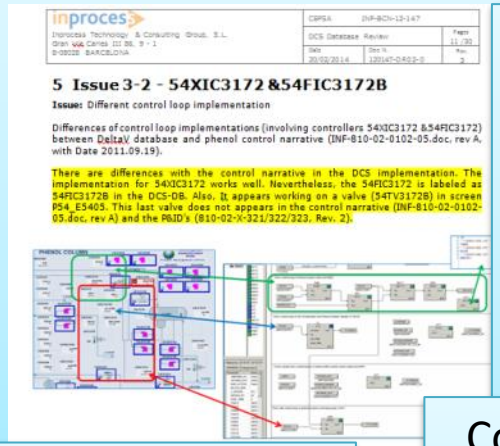


Important: OTS Vendor acts as a truly independent auditor of the ICSS functionality

Examples ICSS database review



Loop implementation



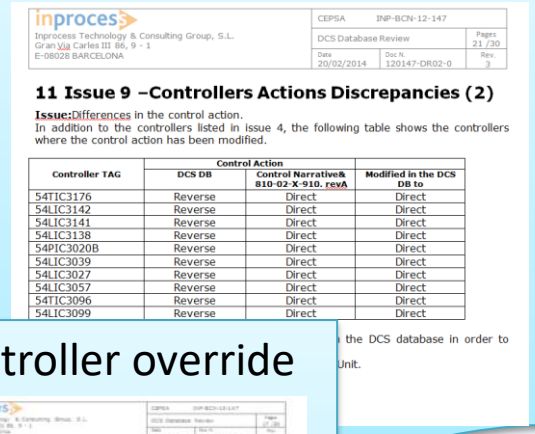
5 Issue 3-2 - 54XIC3172 &54FIC3172B

Issue: Different control loop implementation

Differences of control loop implementations (involving controllers 54XIC3172 &54FIC3172) between DeltaV database and phenol control narrative (INF-810-02-0102-05.doc, rev A, with Date 2011.09.19).

There are differences with the control narrative in the DCS implementation. The implementation for 54XIC3172 works well. Nevertheless, the 54FIC3172 is labeled as 54FIC3172B in the DCS-DB. Also, it appears working on a valve (54TV3172B) in screen P54_E5405. This last valve does not appears in the control narrative (INF-810-02-0102-05.doc, rev A) and the P&ID's (810-02-X-321/322/323, Rev. 2).

Controller Actions



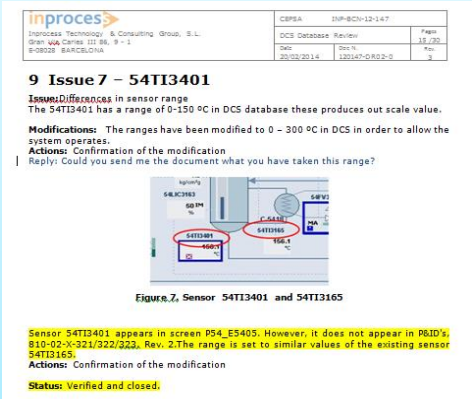
11 Issue 9 –Controllers Actions Discrepancies (2)

Issue: Differences in the control action.
In addition to the controllers listed in issue 4, the following table shows the controllers where the control action has been modified.

Controller TAG	Control Action		
	DCS DB	Control Narrative& 810-02-X-910. revA	Modified in the DCS DB to
54TIC3176	Reverse	Direct	Direct
54LIC3142	Reverse	Direct	Direct
54LIC3141	Reverse	Direct	Direct
54LIC3138	Reverse	Direct	Direct
54PIC3020B	Reverse	Direct	Direct
54LIC3039	Reverse	Direct	Direct
54LIC3027	Reverse	Direct	Direct
54LIC3057	Reverse	Direct	Direct
54TIC3096	Reverse	Direct	Direct
54LIC3099	Reverse	Direct	Direct

the DCS database in order to
Unit.

Sensor Ranges



9 Issue 7 – 54TI3401

Issue: Differences in sensor range
The 54TI3401 has a range of 0-150 ºC in DCS database these produces out scale value.

Modifications: The ranges have been modified to 0 – 300 ºC in DCS in order to allow the system operates.
Actions: Confirmation of the modification
Reply: Could you send me the document what you have taken this range?

Figure 7, Sensor 54TI3401 and 54TI3165

Sensor 54TI3401 appears in screen P54_E5405. However, it does not appear in P&ID's, 810-02-X-321/322/323, Rev. 2.The range is set to similar values of the existing sensor 54TI3165.
Actions: Confirmation of the modification

Status: Verified and closed.

Controller override

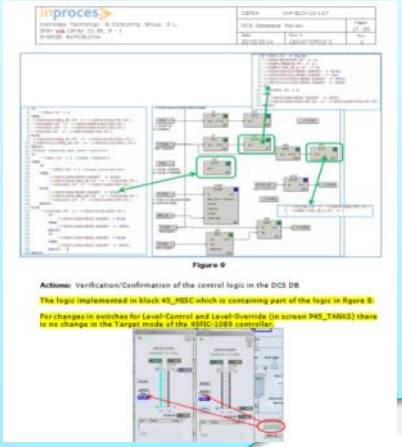


Figure 9

Actions: Verification/Confirmation of the control logic in the DCS DB

The logic implemented in block 43_MISC which is containing part of the logic in figure 8.

For changes in switches for Level-Control and Level-Override (in screen P45_TANK3) there is no change in the Target mode of the 43PIC-1089 controller.

OTS value: Operator Training

- 46 operators has been trained: 1998 hours in total, training table sample

			Tue	Wed	Thu	Fri	Mon	
			10-Jun	11-Jun	12-Jun	13-Jun	16-Jun	17-Ju
1	Han Chunxing	韩春星	0800-1000					0800
2	Zhao Xu	赵旭	0800-1000					0800
3	Zhan Meng	展猛	1000-1200					1000
4	Zhao Feng	赵峰	1000-1200					1000
5	Wu Weiwei	吴伟伟	1230-1430					1230
6	Wang Yan	王焱	1230-1430					1230
7	Lu Jian	陆坚	1430-1630					1430
8	Wang Haiyang	王海阳	1430-1630					1430
9	Yang Chaolong	杨超龙		0800-1000				
10	Yang Yiyong	杨奕勇		0800-1000				
11	Bao Jianghong	鲍江鸿		1000-1200				
12	Bai Xusheng	白旭升		1000-1200				
13	Chen Xinhui	陈新辉		1230-1430				
14	Fei Ping	费平		1230-1430				
15	Chen Huiwen	陈会文		1430-1630				
16	Kang Weitang	康为唐		1430-1630				
17	Wang Changping	汪长平			0800-1000			
18	Zhang Hailong	张海龙			0800-1000			
19	Wang Chengcheng	王诚诚			1000-1200			
20	Zhou Runqi	周润琪			1000-1200			
21	Yang Yi'hao	杨亦豪			1230-1430			
22	Xu Zhong'hao	徐忠豪			1230-1430			
23	Shen Si'tao	沈思涛			1430-1630			
24	Bao Yue	包越			1430-1630			
25	Wang Mei'ling	王美玲				0800-1000		
26	Yang Qiang'qiang	杨强强				0800-1000		
27	Luo Hai'ping	骆海平				1000-1200		
28	Zhang Jia'qi	张嘉琪				1000-1200		
29	Zhang Ling	张玲				1230-1430		
30	Yao Chao'yi	姚超亿				1230-1430		
31	Ye Qin'mei	叶琴梅				1430-1630		
32	Liu Er'long	刘二龙				1430-1630		
33	Yao Ye'zhou	姚叶舟					0800-1000	
34	Chu Yuan	楚渊					0800-1000	
35	Jin Yi'hui	金怡辉					1000-1200	
36	Mo Zi'jie	莫子杰					1000-1200	
37	Zhou Zi'yun	周子蕴					1230-1430	
38	Wu Qiao'wei	吴桥伟					1230-1430	
39	Tang Zi'li	唐自立					1430-1630	
40	Yu Chun	余淳					1430-1630	

1. GET FAMILIAR:

With the process
With the procedures
With HMI navigation and controls

2. IMPROVE:

Operation and safety procedures
Uniform skills levels in all operators
Rational thinking
Time to react

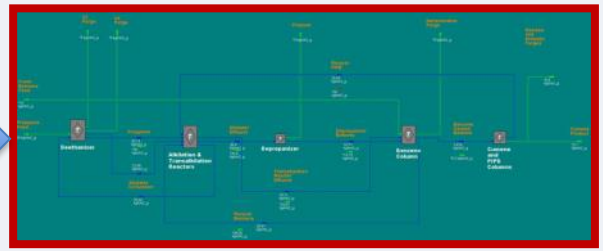
3. RESULTS:

Increased Safety
Reduce Start-up time
Off-spec reduction

OTS value: Operating range

In the Shanghai petrochemical area, there were several alternative providers of feed propylene, each with different grades and other distributions of Lights and Heavies components.

OTHER FEEDS



CEPSA Operations requested to investigate the process operating constraints (valve saturation, duty limits, impurities accumulations) with different streams compositions of propylene feed.

The model proved that, making certain SetPoint adjust, other propylene grades were able to be handled by the plant.

OTS ownership

There is one important aspect when Operating Companies decide to invest in OTS:

The OTS itself does not do the training and knowledge transfer

The Operating Company needs to design the operator competency program making use of the OTS as an integral tool of the training programs.

Like NASA does with astronauts

Like Airlines do with pilots

Like Mercedes does with Hamilton

Inprocess helps to design and complement those training programs with the use of the OTS. Resources and workflows need to be defined and **budgeted**.

HYSYS as OTS engine

Using HYSYS Dynamics as OTS simulation engine has some advantages:

1.- It is a known software inside CEPSA and most of the engineers are familiar with it

2.- It can increase the rigor as needed, depending on training objectives

3.- It is flexible enough to develop custom items (spreadsheet, UserVar, Extensions)

4.- It is powerful enough to handle >5000 I/O tags/sec in realtime in one PC.

5.- Models can be taken from the OTS to run other operations/eng. studies

6.- It is easy to maintain for typical changes (new instrument, new valves, loop changes, etc)

Conclusions

- OTS improves the ICSS testing and debugging
- OTS could reduce the major operational incidents
- OTS is a good platform to evaluate operation skills of operators and to uniforms the operators skills
- OTS is a suitable tool to validate raw material planning decisions
- HYSYS-based OTS secures reusability of the process model
- OTS was executed within time and budget; OTS team was adaptive to the EPC and ICSS schedules.
- This was the first high fidelity HYSYS OTS in CEPSA; as a result CEPSA is considering OTS for new and existing plants. CEPSA is executing the 3rd training simulator with Inprocess.

Q&A, contact

Thank you

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