LNG lifecycle dynamic modeling: From process design verification to support operations

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Houston, 20th March 2018

inprocess
simulation
knowledge
profit

Agenda

OTS Lifecycle dynamic modeling approach

- ✓ Motivation
- ✓ Targets and schedule
- ✓ Benefits
- ✓ Phases
  1. Process Design & Control Validation
  2. Integration and Control narrative verification
  3. Procedures Verification & Early Senior CRO´s Training
  4. ICSS Database Checkout
  5. Operator Training System
  6. OTS Support operations
- ✓ Conclusions

Source: https://www.spe.org/en/print-article/?art=218

Motivation for Lifecycle Dynamic Modeling: Challenges

Code is massive in modern ICSS, Can we test it in advance?

Is the design suitable for all potential transients?

How will the vendor packages (UCPs) interact with the ICSS?

Source: https://eng.hec.co.kr/

Will the Safety System perform well?

Are equipment protected?

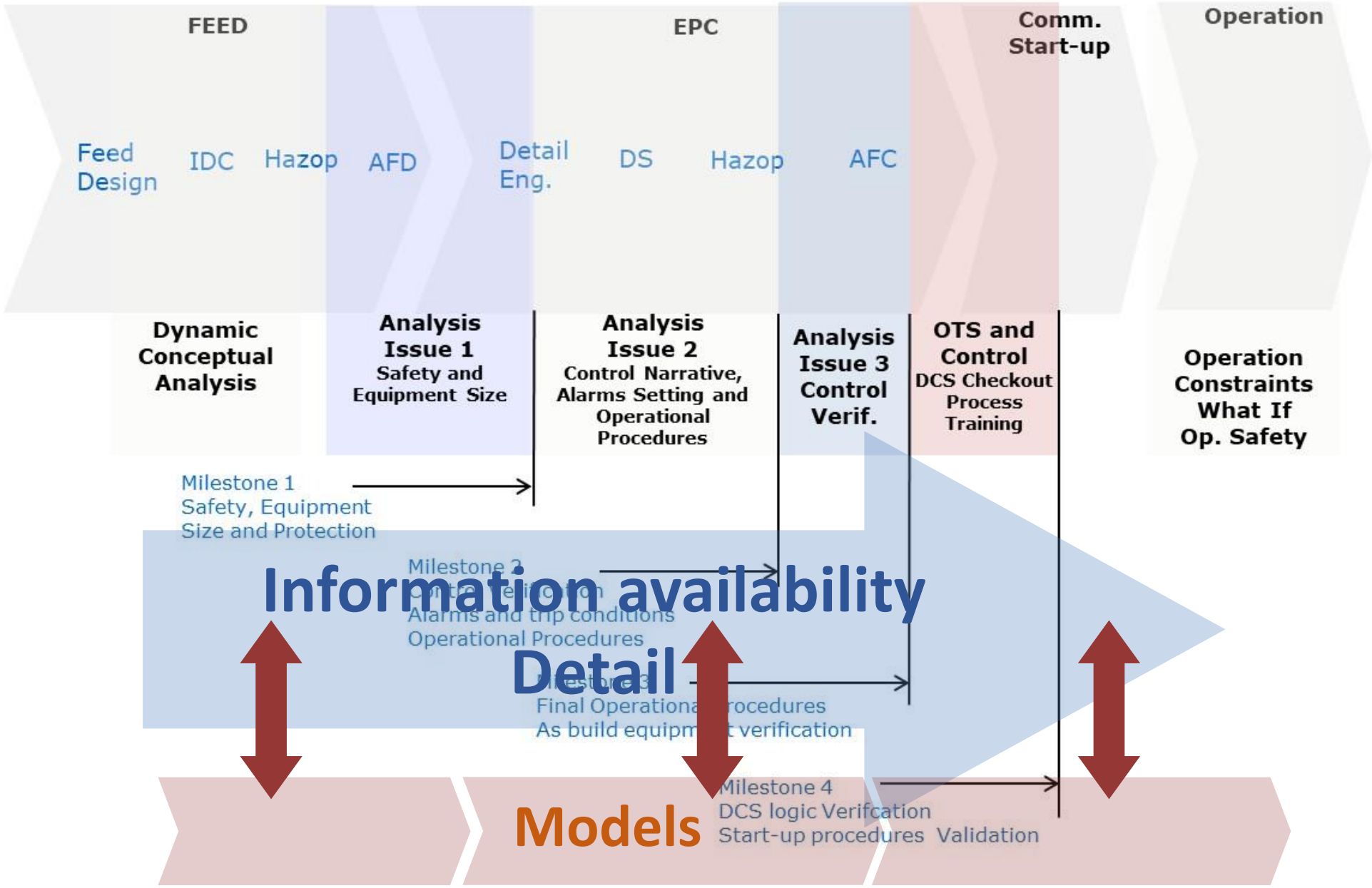
How to fully test the Operating Procedures?

Can we improve the plant's availability?

How to effectively train Operators?

Can we reduce start-up delays?

Engineering Projects



Lifecycle Dynamic Modeling: Benefits

Each phase of the lifecycle approach addresses specific targets , which are aligned with the needs of the project. The model is developed once and refined in successive refined as more detailed information is available.

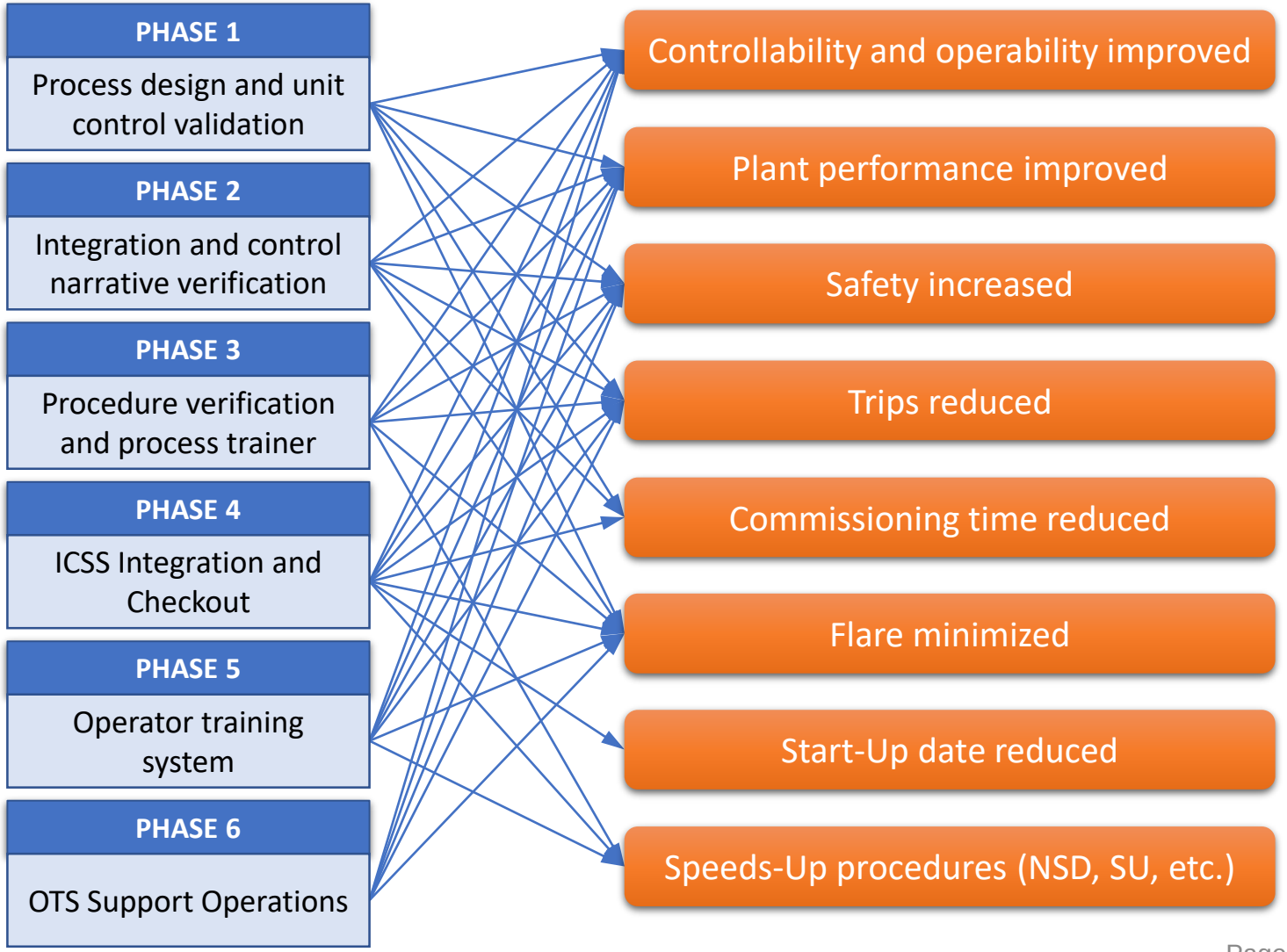
Any early stage finding can be handled easily, to achieve:

- The best solution
- with minimum design modifications
- At minimum costs.

Detects missing equipment or unreachable interlock conditions.
Operators have more ***availability***

Operators: gain confidence and awareness of the plants behavior and interactions

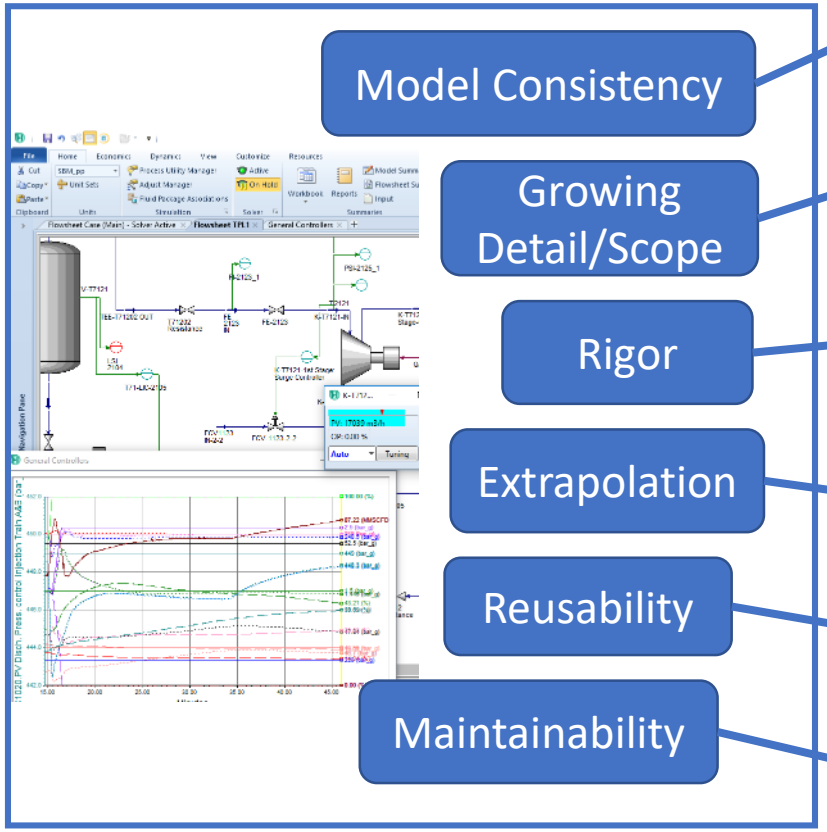
Final product:
Is a valuable tool which can be used for training purposes and as a basis for control logic modifications, optimizations, control tuning, support operations in unforeseen conditions or configurations.



Lifecycle Dynamic Modeling: Why Aspen HYSYS?

What added value does Aspen HYSYS provide to the Lifecycle dynamic modeling?

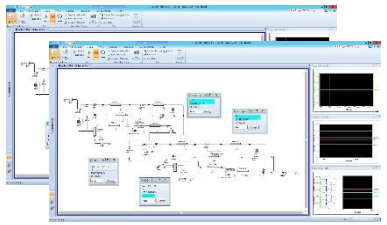
HYSYS LIFECYCLE PILLARS



- **Model Consistency** → Thermo Packages are consistent with the Steady-Sate Design models. Data is introduced once and the model is used along the phases of the lifecycle.
- **Growing Detail/Scope** → Detailed Equipment data is available and refined as the project evolves. Additional process units can be incorporated as needed in the application.
- **Rigor** → CRO´s will expect realistic process responses. This is the key to replicate/verify/ improve operating procedures, pre-tune controllers and define alarms limits.
- **Extrapolation** → Extrapolate process conditions far from nominal. Model will help to determine the settings to maximize production, reduce flaring and improve its controls.
- **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.

HYSYS Lifecycle Dynamic Modeling

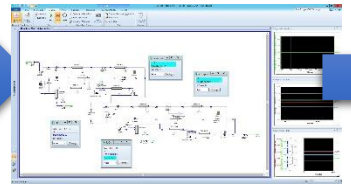
Engineering Study



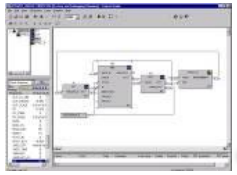
HYSYS Dynamic Model

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

Model
Adjust



Model
Connectivity



ICSS Database
Control Logic

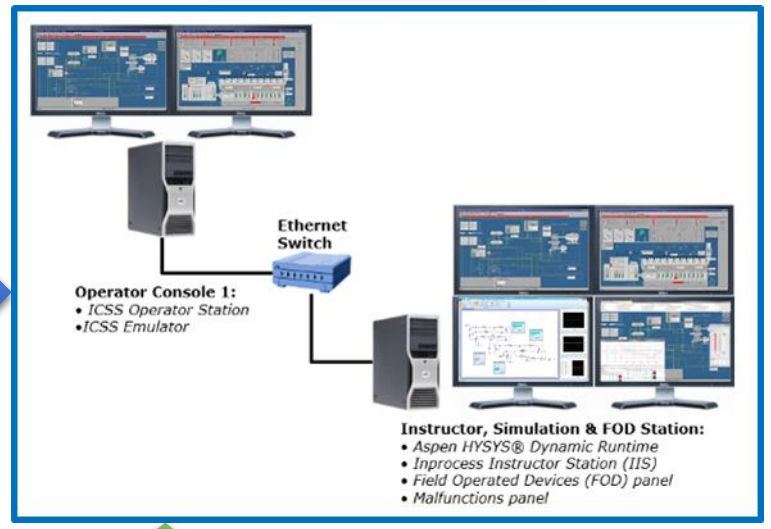
ICSS HMI displays

ICSS Checkout

ICSS HMI Emulated with
Inprocess Instructor Station

Process Trainers

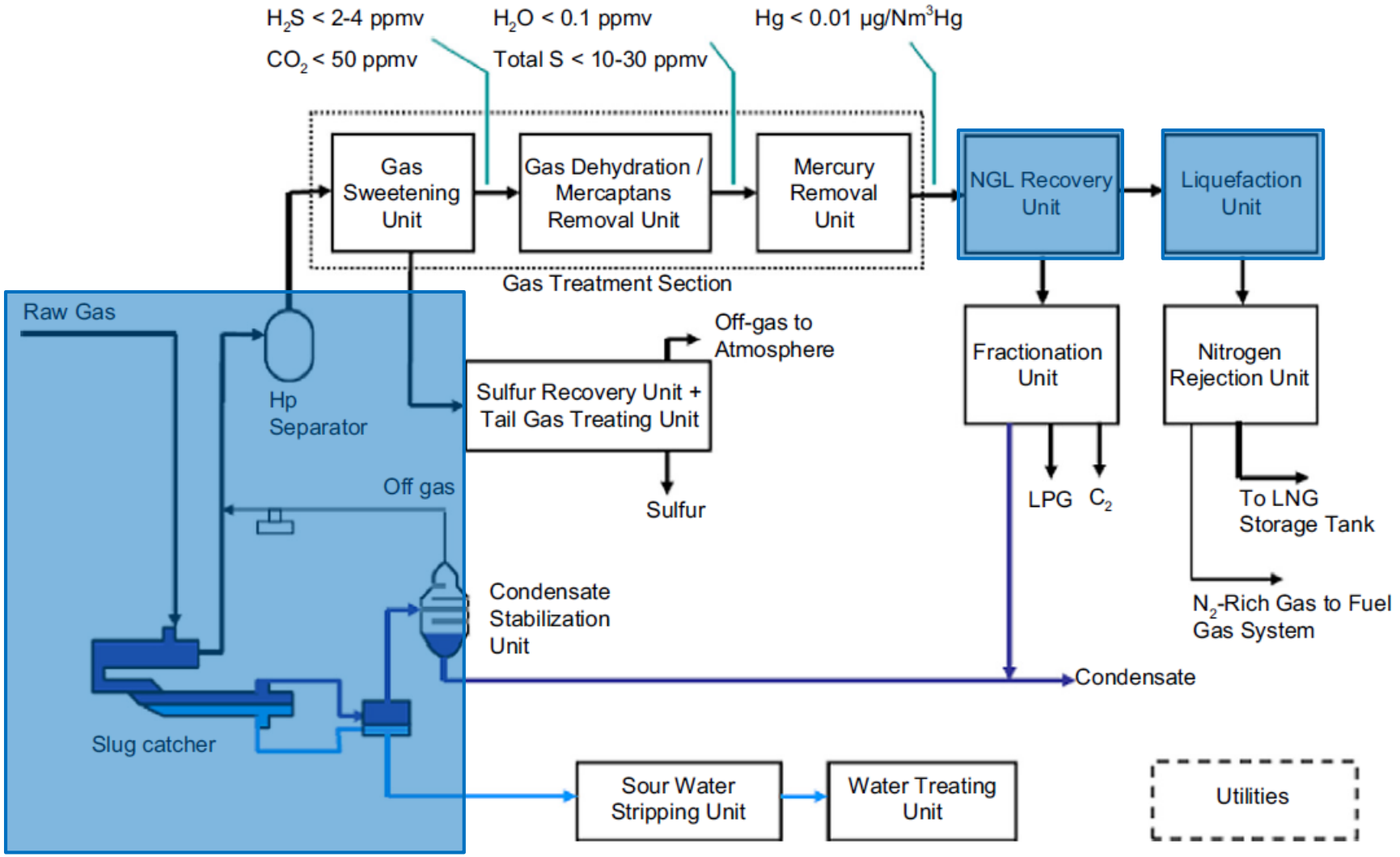
Direct-Connect OTS



Instructor Station,
Training Scenarios,
Additional ICSS Consoles

Phase 1: Process Design & Control Validation, DSS model scope

Any early stage finding can be easily handled, to achieve the best solution with minimum modifications and at minimum costs



DSS → 

Blue boxes indicate the areas included in the scope of the Dynamic Simulation Study

BOG COMPRESSORS

HEATING MEDIUM

Source: Handbook of Liquefied Natural Gas

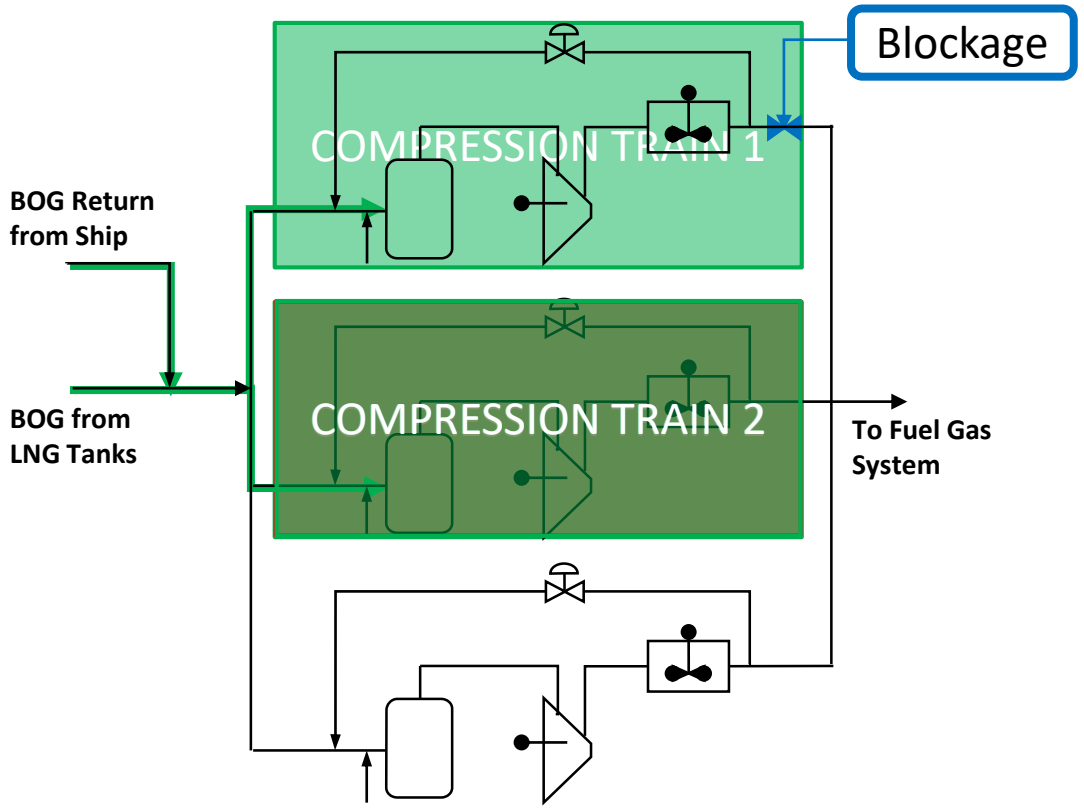
Case 1 : LNG BOG compressors→ Purpose & Scenarios

Purpose: Model the Excess BOG compressor system and associated equipment in order to validate the effectiveness of the compressor control system and operating procedures.

Focus: Detect possible system instabilities, ineffective surge protection, assess the antisurge valve sizing and validate the operating procedures (ESD, NSD, SU, holding -> loading)

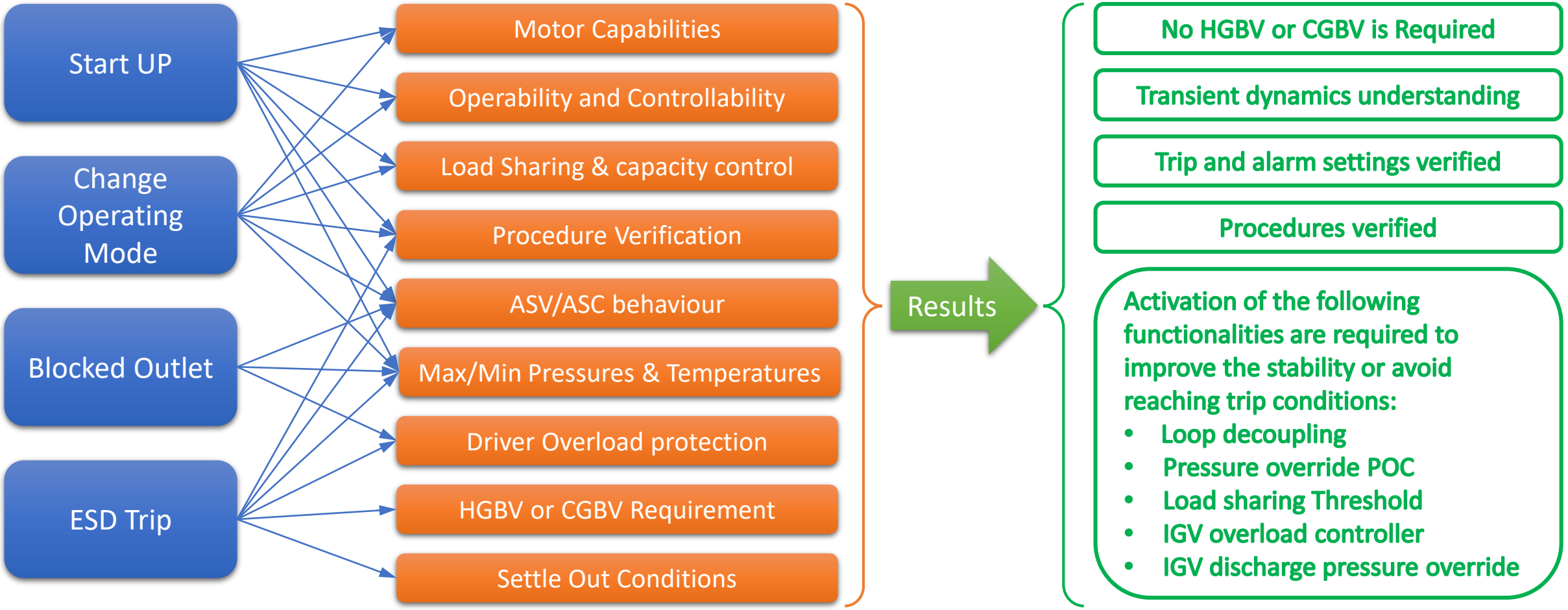
Scenarios:

1. Emergency shutdown scenario (ESD)
2. Start-Up (SU)
3. Trip of one compressor during parallel operation
4. Blocked Outlet Scenario (BO)
5. Change operating mode
   - Holding (1 -> 2) to Loading to Holding (2 -> 1)



Case 1 : LNG BOG compressors→ Results & Benefits

Benefits: Control system instabilities detected, control logic optimized, procedures validated, Safety increased and Commissioning time reduced



Case 2 : LNG Steam network analysis → Purpose & Scenarios

Overview :

A company is expanding its existing LNG facility (i.e. ORF, 1 LNG train, Utilities, ICSS, etc.) to increase the production. Current facility faces difficulties to avoid domino trips during upsets in the steam network while operating in island mode.

Purpose:

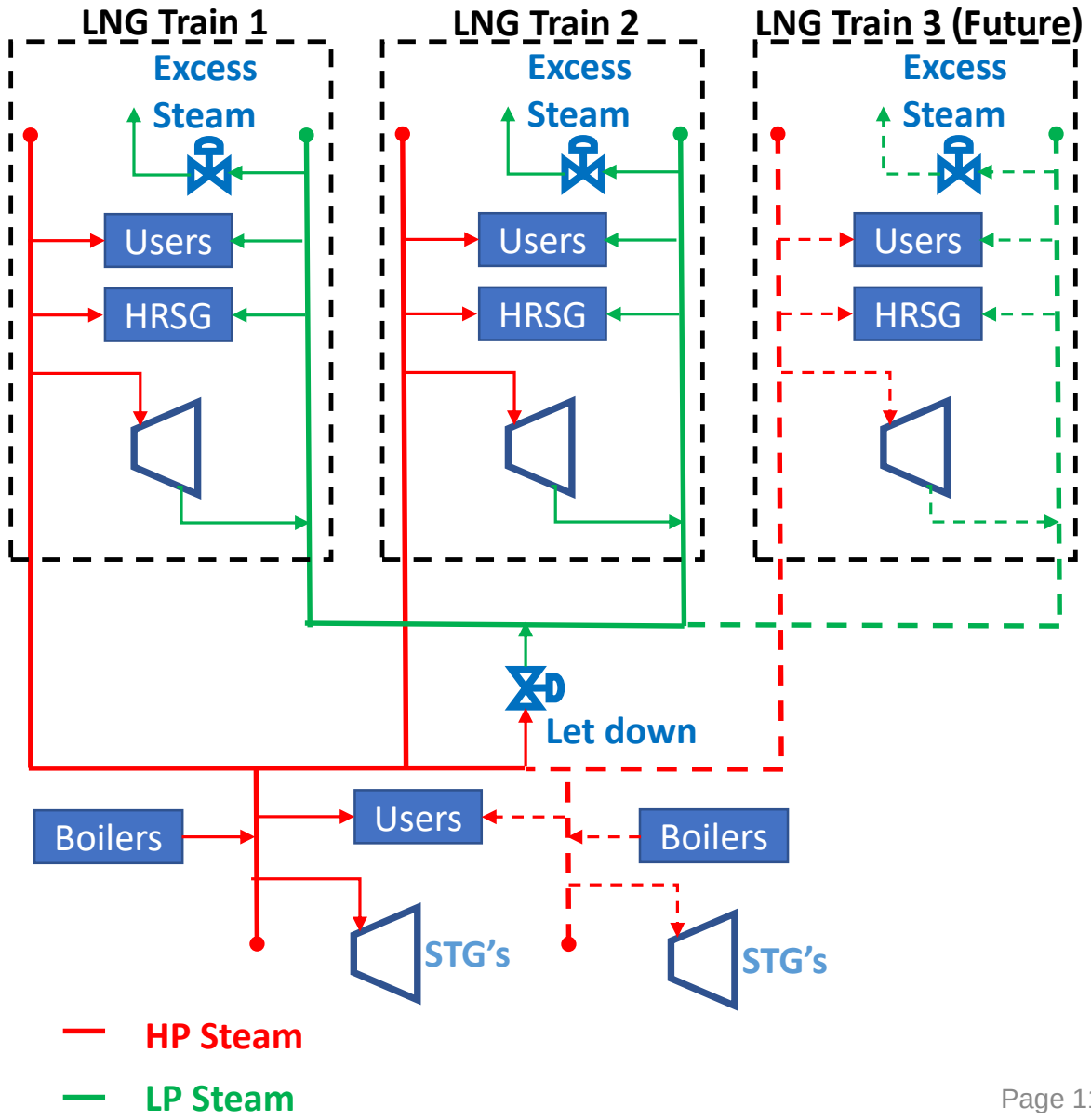
Develop an integrated simulation of HP and LP Steam Network of the existing and new facilities, including main equipment like Boilers, HRSGs, Steam Turbine Helpers and Steam Turbine Generators.

Focus

Evaluate the stability, controllability and operability of the steam network in order to ensure safe operation and the protection of the equipment during upset scenarios

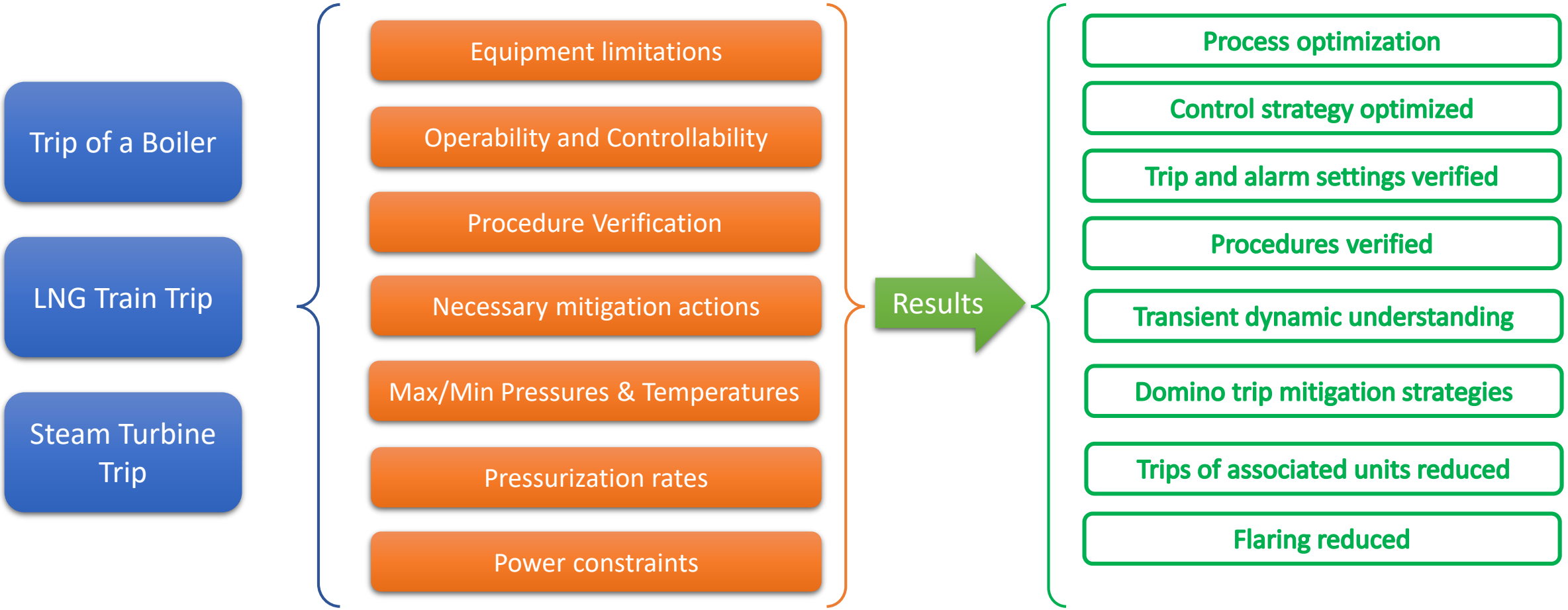
Scenarios:

1. Trip of a Boiler
2. Trip of an LNG Train
3. Trip of a Steam Turbine Generator

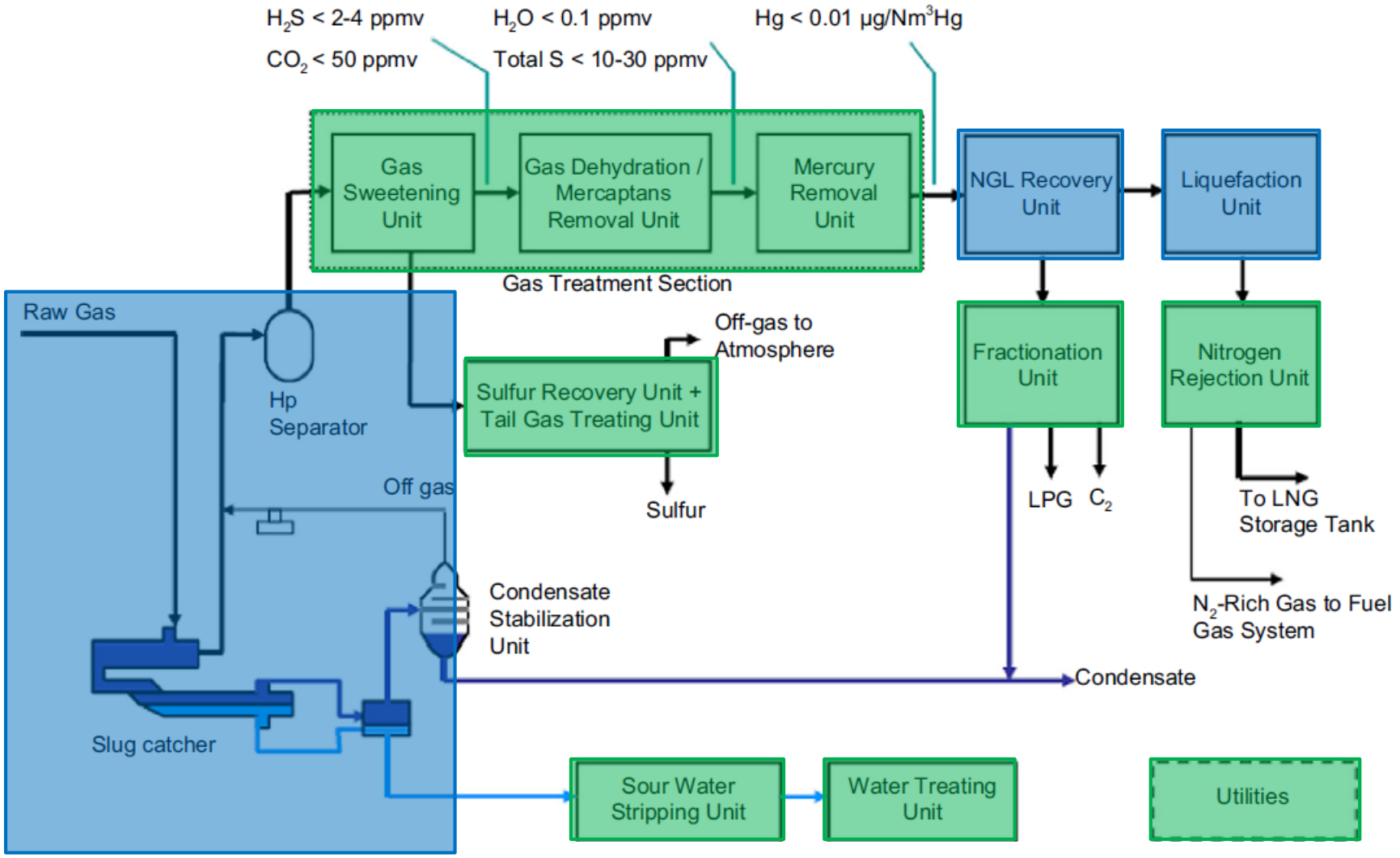


Case 2 : LNG Steam Network analysis→ Results & Benefits

Benefits: Process and control strategy optimized to improve the stability of the steam and power network. Flaring reduced, safety increased.



Phase 2: Integration and Control narrative



Source: Handbook of Liquefied Natural Gas

DSS →

Blue boxes indicate the areas included in the scope of the Dynamic Simulation Study

Training → +

Green boxes indicate the areas added to the HYSYS Dynamic model for training

BOG COMPRESSORS

HEATING MEDIUM

COOLING MEDIUM

MEG

FLARE

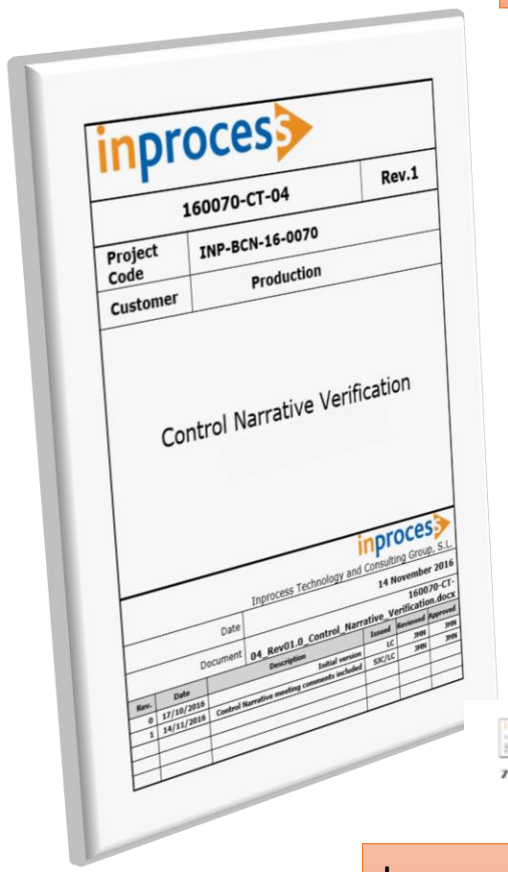
FG SYSTEM

Phase 2: Control Narrative Verification

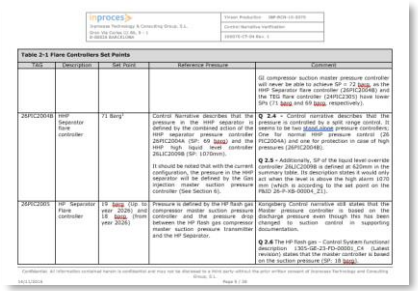
The HYSYS Dynamic model from the DSS was expanded with new units, the latest control logic implemented and the UCP sequences from the compressor packages.

The model was used to verify the Control Narrative Specifications:

- Control interactions with UCP
- Normal operation
- During non-design conditions
- During specific procedures
- Understanding the limits of the system
- Alarm & Trip limits
- Controller pre-setting
- Verify equipment protection

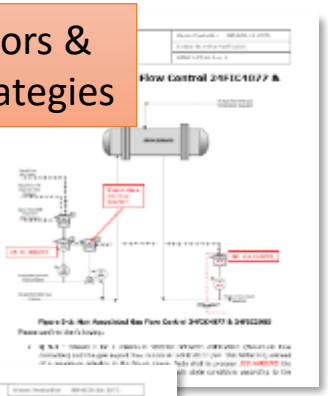


Flare Controller Set Points

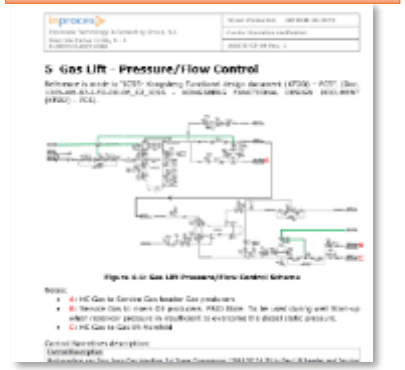


Instrument Ranges & Trip Settings

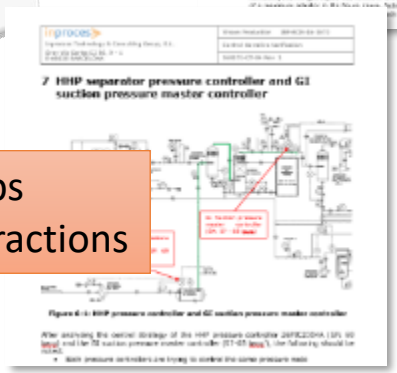
Selectors & SP strategies



Calculations & Override Controllers



Loops Interactions



Phase 3A: Procedures Verification

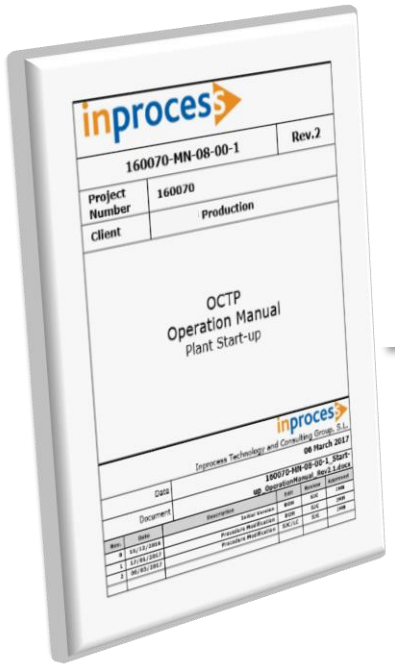
Early verification of Operating Procedures with timing and transitions conditions

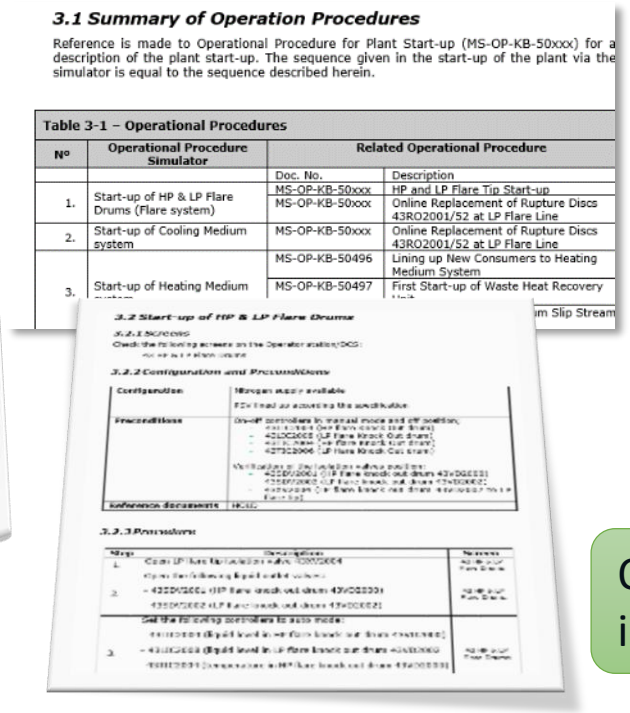
Scope:

- 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	MS-OP-KB-50496	Lining up New Consumers to Heating Medium System
		MS-OP-KB-50497	First Start-up of Waste Heat Recovery

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

Phase 3B: Process Trainer - Early CRO´s Training

Using the *Inprocess Instructor Station* software with the Aspen HYSYS as simulation engine, an HMI layer is added on top of the HYSYS model using the same displays of the ICSS control room.

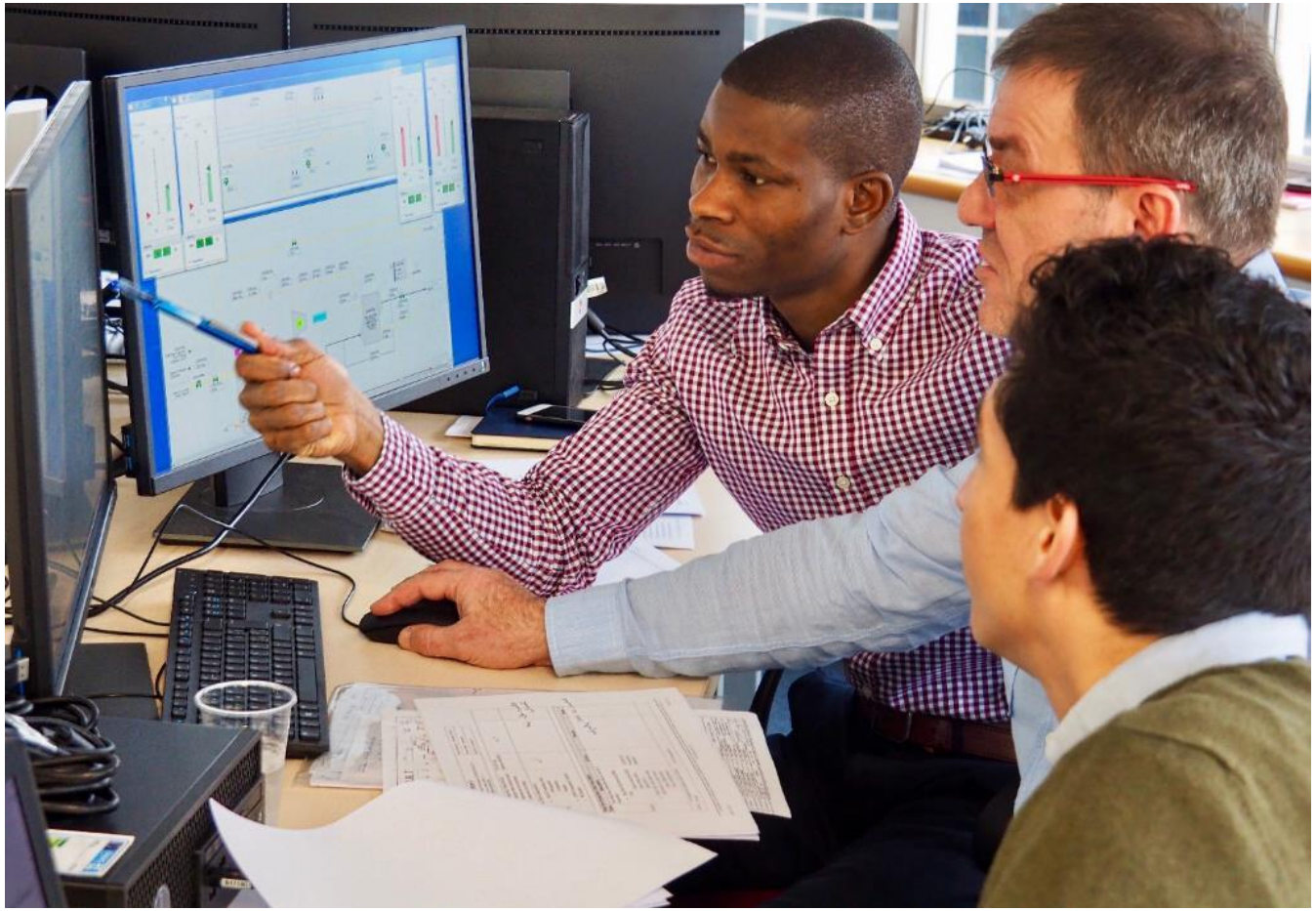
Early CRO´s and Supervisor Training

Knowledge Transfer

- Control Interactions and Issues
- Limits of the system

Training Scope

- ICSS displays familiarization and operability verification
- Start-up / Shutdown Procedures
- Trip scenarios
- Disturbances and Malfunctions



Phase 4: ICSS Database Checkout

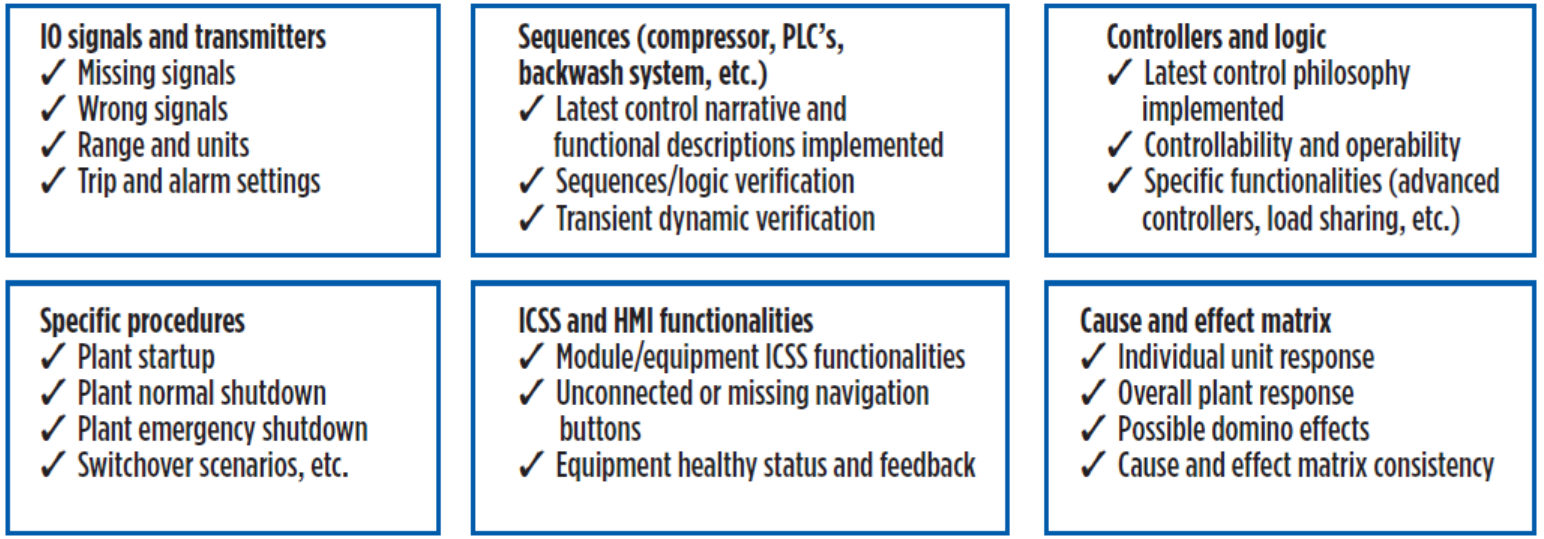
Modern ICSS databases contain massive code lines to keep the system protected and in control. Nevertheless, this process requires exhaustive verification to ensure that the system has been properly implemented.

Validating the ICSS with a process emulation model stimulates the control system with realistic process signals and control interactions. Therefore, it becomes the virtual commissioning phase of the ICSS.

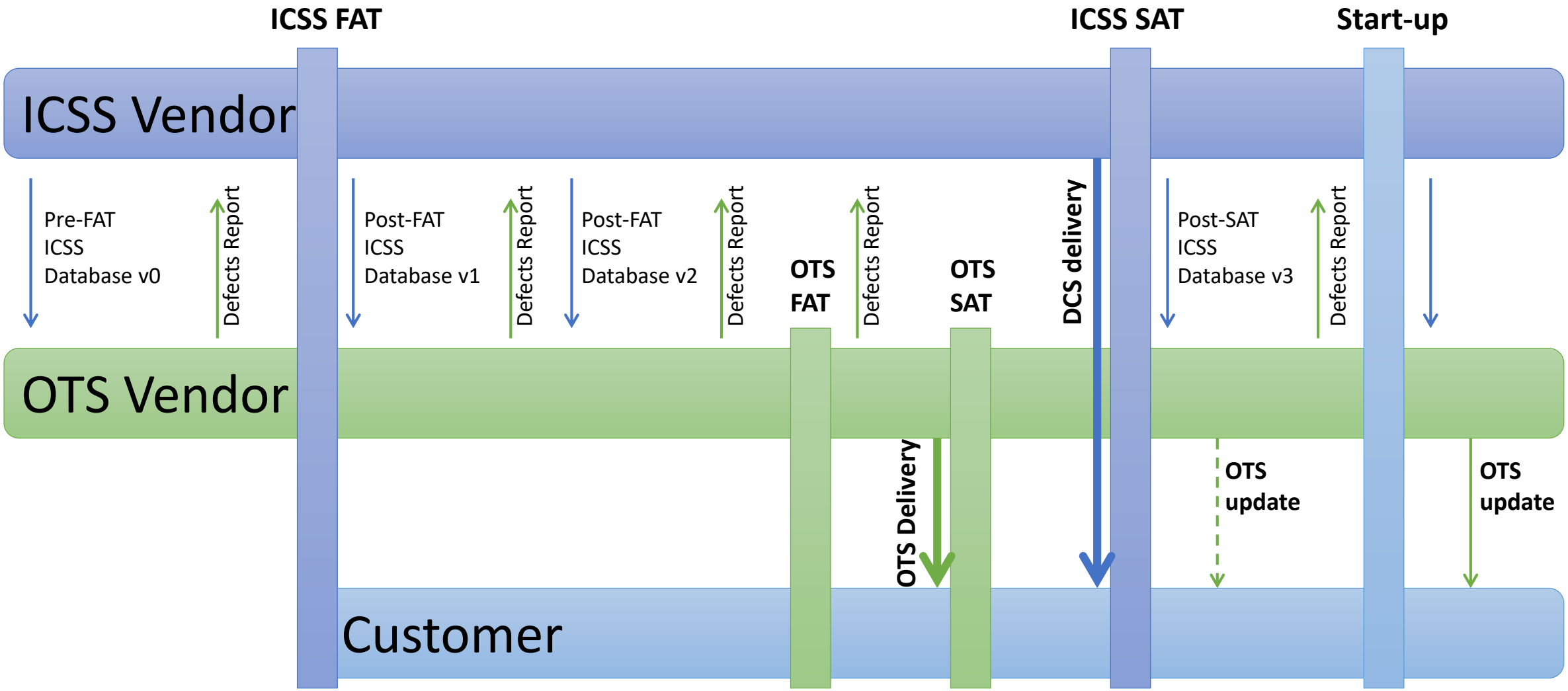
Performing the ICSS checkout with the dynamic model allows:

- A more robust and consistent check-out that reduces the commissioning time significantly.
- An Improvement of the operability and controllability.
- A Reduction of false trip occurrences.

Fig. 5. Main ICSS testing and verifications.

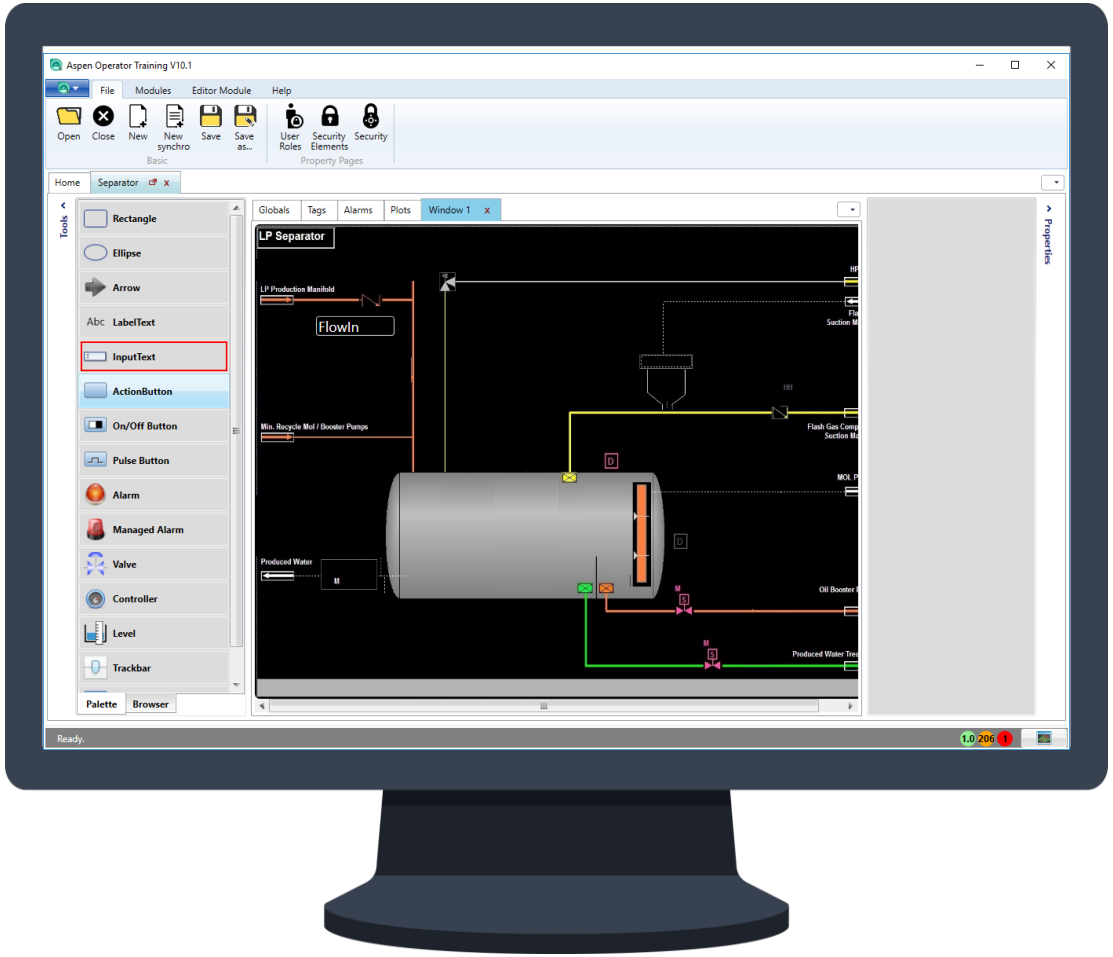


Phase 4: ICSS Database Checkout



Aspen Operator Training

- **Backbone of OTS Solution**
- **Best Combination-** Choose the optimal hardware, software and services combination, tailored to your needs with a DCS-agnostic OTS.
- **Train Earlier-** Eliminate delays and bring your investment online faster leveraging the Aspen HYSYS dynamic lifecycle.
- **Longevity-** Continue to confidently prevent safety incidents after startup with dynamic simulation that is easily maintained and accurately predicts plant behavior.



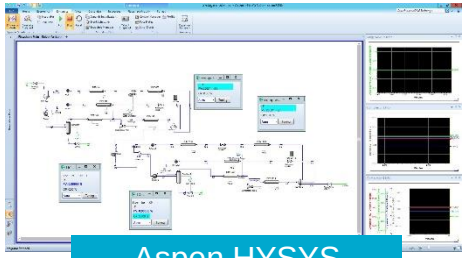
OTS Deployment

Process Plant

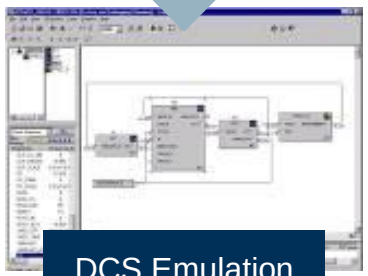
Control System

Interface

Direct-Connect



Aspen HYSYS Dynamics

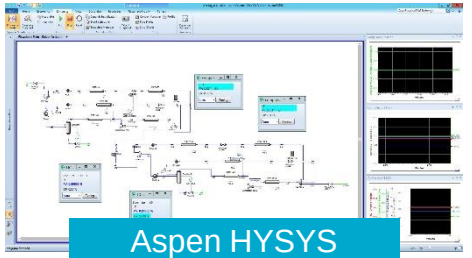


DCS Emulation

Panel Operator

Instructor Station & Field Devices

Fully Emulated



Aspen HYSYS Dynamics

Emulated Controls

Emulated Panel Operator

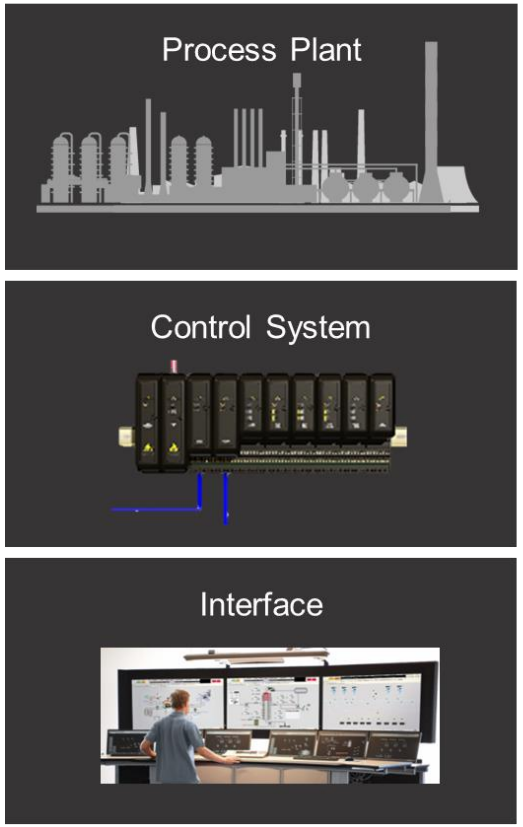
Instructor Station & Field Devices

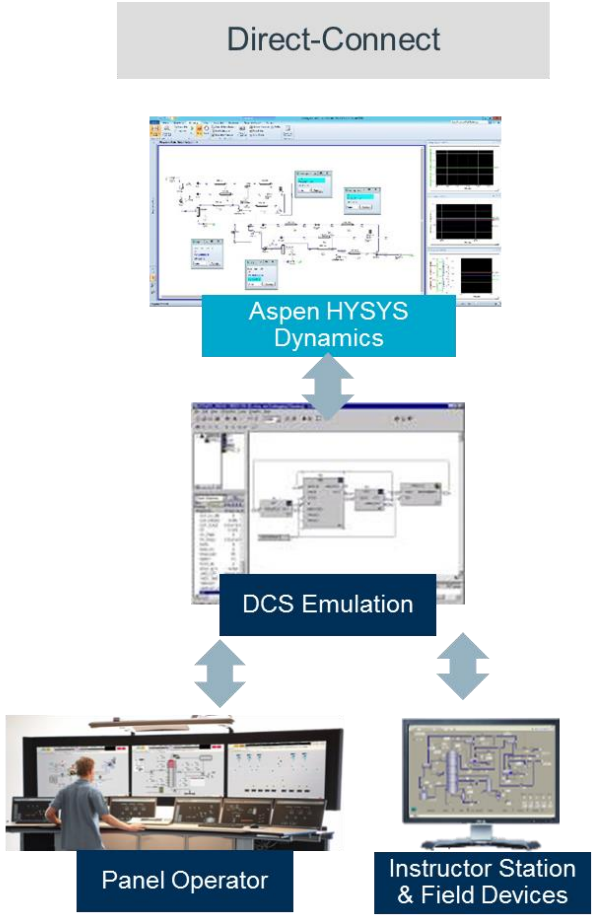
Phase 6: OTS Support Operations

Following the lifecycle dynamic modeling approach provides increased added value to the project itself. As it is based on a highly reliable first principle model linked with the actual ICSS.

A direct connect OTS based on a first principle model allows:

- The evaluation of the operability of the plant under non design conditions (e.g. Start Up operations).
- The determination of potential limitations in process or utility areas.
- The evaluation of potential plant optimizations (i.e. Debottlenecking studies).
- The evaluation of alternative operating modes.
- Analysis of alternative control strategies.

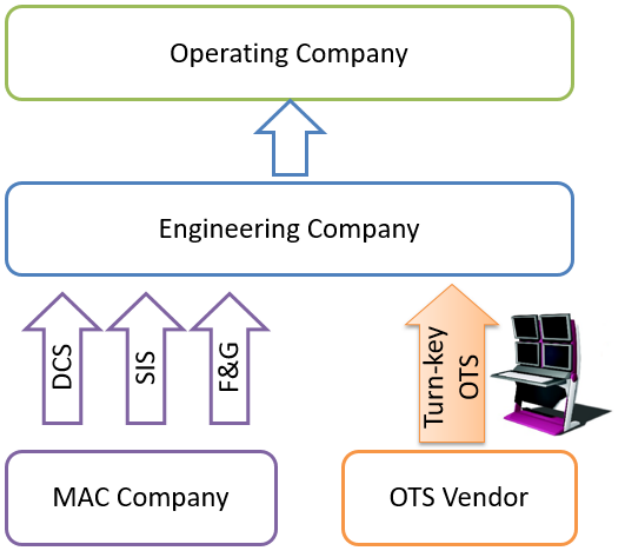




Dynamic model Lifecycle approach

In order to fully exploit the HYSYS Dynamic modeling lifecycle, the OTS should be developed by a supplier (Inprocess) who is independent from the ICSS supplier.

FIVE REASONS TO DECOUPLE OTS FROM THE REST OF ASSET AUTOMATION ACTIVITIES



1. Fast tracking projects. By building an early OTS based on dynamic models, you are freed up from waiting until every detail and revision of the plant DCS is complete.

2. Safer operations. By basing the OTS on dynamic process models, more rigorous and comprehensive safety scenarios can be considered, and impacts can be modeled and assessed.

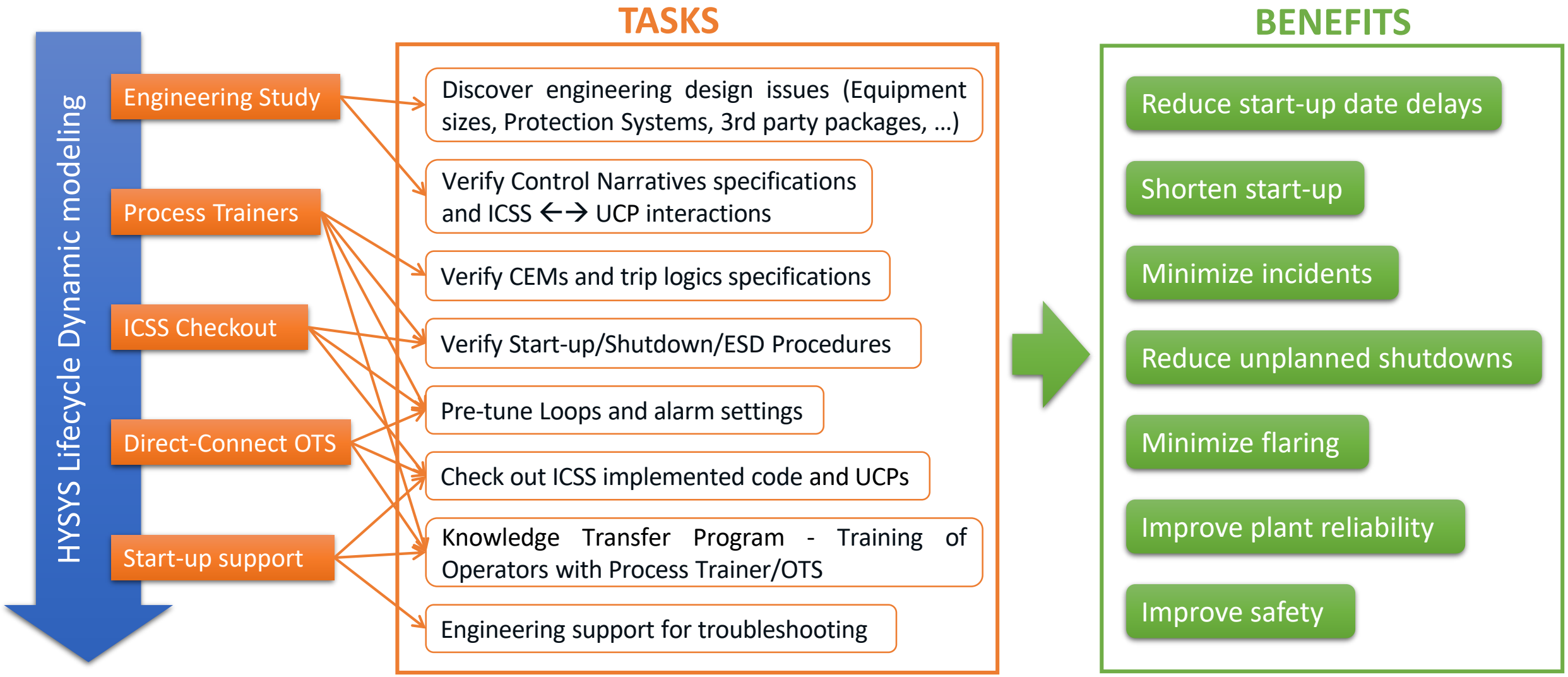
3. Operator training as an area of excellence. By entrusting the development of OTS to dynamic modeling experts, you are involving teams passionate about the topic. You are selecting for excellence rather than just tacking on a must-have to a contractor focused elsewhere.

4. Optimizing for cost & responsiveness. By decoupling the OTS, the owner is encouraging competition, and more likely to get the most responsive and best price / performance solution.

5. Agility. A dynamic modeling team, not dependent on DCS design and delivery, can be extremely responsive to changes in operating objectives, staffing plans, regulations, etc.

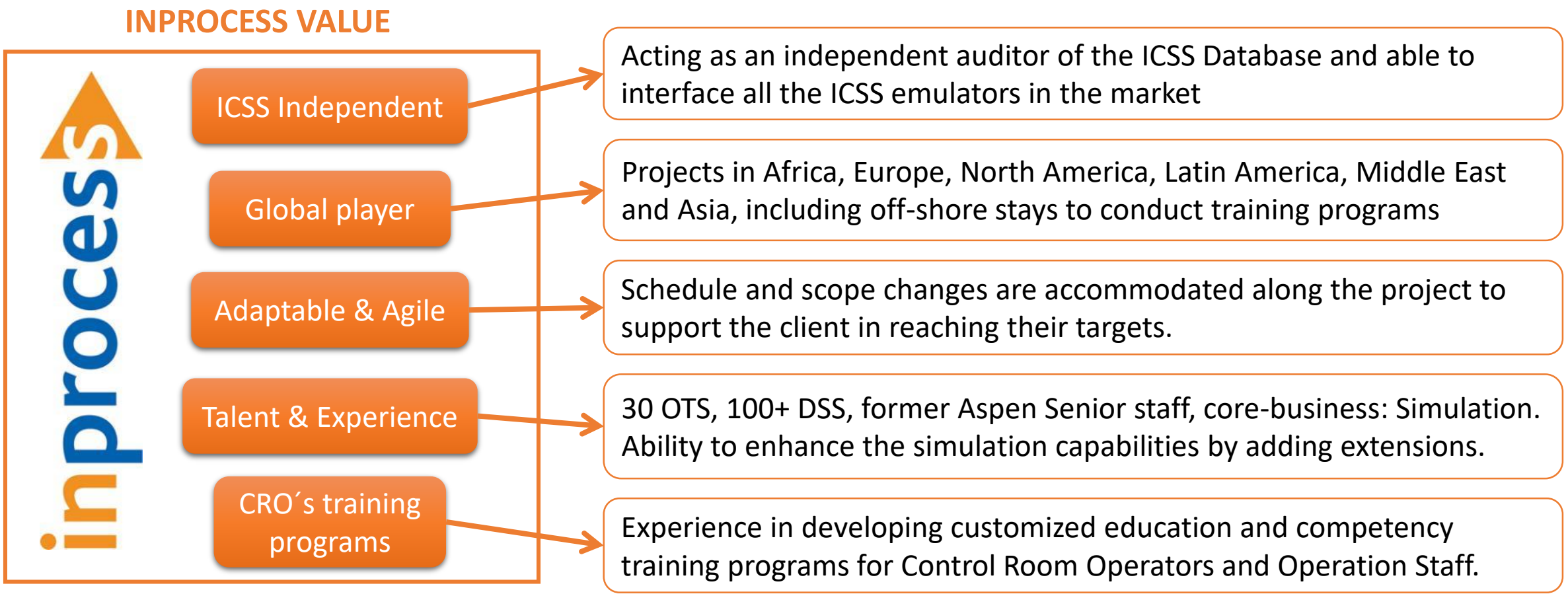
Extract from Ron Beck blog: https://www.linkedin.com/pulse/dynamic-model-essential-accompanyist-project-conductor-ron-beck/

Conclusions



Lifecycle Dynamic Modeling: Why Inprocess?

What added value does Inprocess provide to the Lifecycle dynamic modeling?

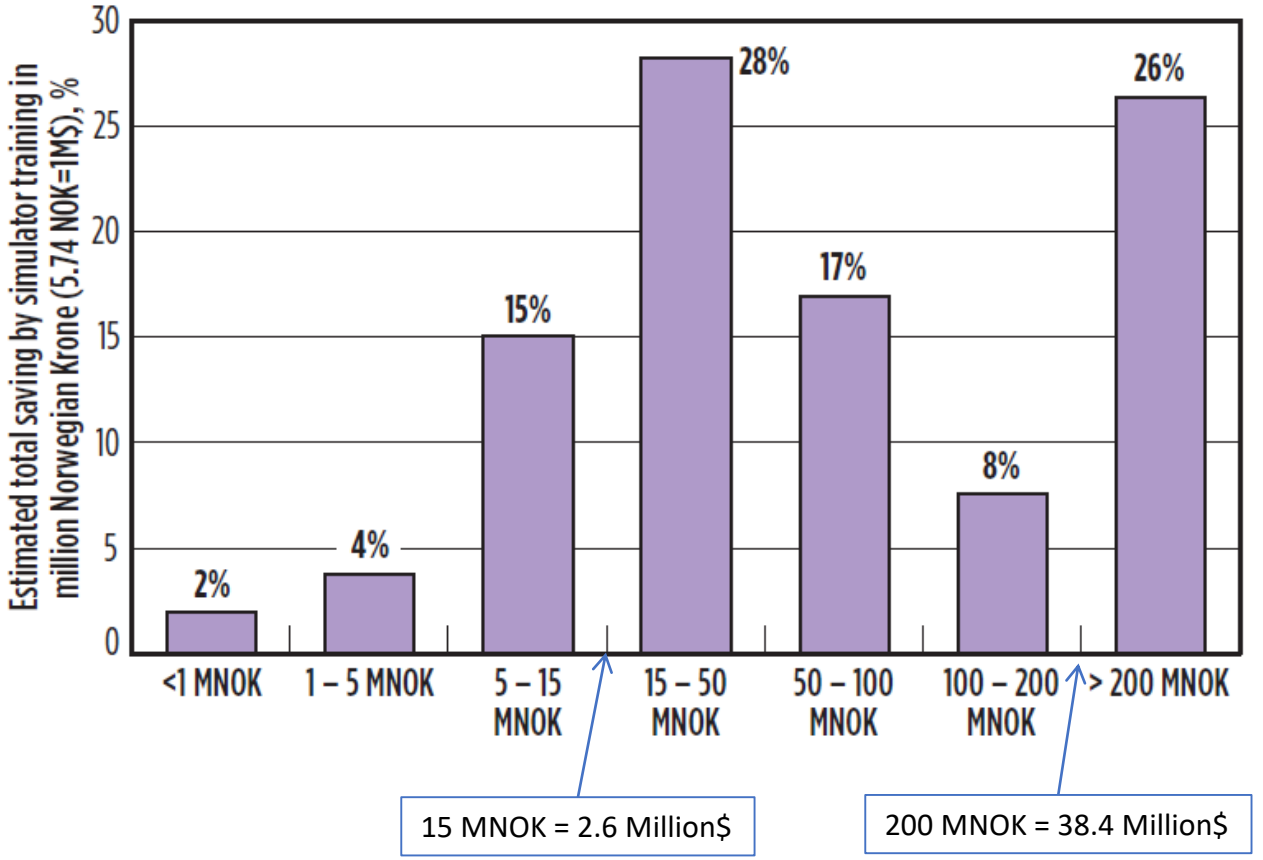


Check out how to request and exploit a Lifecycle OTS!

OTS Value Survey

- Increased Safety
- Minimize incidents (28% due to human error)
- Shortening start-up: around 10-20 days
- Reducing unplanned shutdowns by 2-3 per year
- Speeding-up planned shutdowns/start-ups by 2-3 days per year
- Increased production by 1-2%
- Flaring episodes minimized

15.3 million$ average estimated savings due to OTS



Source: http://hdl.handle.net/10642/1544

Q & A

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inprocess

simulation
knowledge
profit