SIMULATOR BENEFITS BEYOND TRAINING.
ENGINEERING ACTIVITIES SUPPORT

60 Years providing Solutions to our Clients
Modern Simulators features

✓ Models fully compliant with first principles equations; complex phenomena based on engineering grade “best estimate” codes.
✓ Logic and control models sharing the same components as their equivalent systems at the Plant:
  ✓ L&C Simulation (early stages of design)
  ✓ Emulation or Stimulation of L&C
✓ Simulators can run in real-time or faster than real-time.

Preliminary Conclusion:
Simulators possess a predictive capability that enables to forecast the plant behavior and therefore, they can be used to optimize the design and implementation timeframe of plants modifications.
Modern Simulators features

Graphical, User friendly and real-time connected tools to support the analysis: DCS translators (L&C and HMI)
Modern Simulators features

Graphical, User friendly and real-time connected tools to support the analysis: Excel based on-line debugger
Simulation as an engineering support tool

SAE applied to:

• Assessment of Plant Design Modifications
• Validation and Tuning of new I&C Digital Systems
• Validation of New Operating Support Systems (Computerized Procedures, Alarm Filtering, etc)
• Validation of New Control Rooms (HFE/HSI systems)
• Operating Procedures Validation
• Safety Analysis Support

Different solutions:

• Specific Engineering Simulators/Plant Analyzers
• Use of Training Simulators to support Engineering activities
Project Cost Analysis with and without SAE

- Problem analysis
- Options study
- Plant modification development
- Pretuning
- Installation
- Commissioning
- Start up
- Normal operation

Reduction of mistakes founded during installation, FAT, SAT and commissioning

SAE activities

Training

Training & mistakes reduction
Project overcost without SAE due to project delay

Reference Price → 35 $/MWh
NPP Power → 1.000 MW
1 hour delay → 35.000 $
1 day delay → 840.000 $
Example. A simple HW change of the Reactor Mode Switch

- Grid instabilities cause the Main generator to trip, resulting on a plant trip
- Following the Scram Procedure the reactor operator proceeds to turn the Reactor Mode Switch to Shutdown and to complete the rest of the scram recovery actions
- When looking at the Reactor Mode Switch, the reactor operator is not sure of its position

Who wants to explain that to the regulator???
How could this event be avoided?

• A Design Verification (Nureg 0700) → it will require 1 hour (including documentation of findings)

3.3.2.5-4 Position Indication
Position indication should be provided.

Additional Information: Desirable alternatives are: (1) illuminated indicator lights, (2) a line engraved both on the top of the knob and down the side, or (3) a pointer shape. It should not be possible to confuse the position of the knob in reference to position markers on the panel. To minimize the problem of parallax, pointers on knobs should be mounted close to the settings to which they point.

• Implementation of the Design Modification in the FSS first, no extra cost, just better planning. Either simulator tests or training would have detected the flawed design
Examples
**Angra I. Steam generators replacement**

**OBJECTIVE:**
Determine the best tuning for the SG level control
- Stability under any operational condition
- Avoid Reactor trips

**ACTIVITIES:**
- Development of **new steam generator model**, based on TEAM-TRAC.
- Model Validation against manufacturer design data
- Validation tests were established and stability analysis was performed

**ANALYSIS KEY FACTORS:**
- The **high fidelity of the steam generator model**
- Real time graphic analysis and **interactivity capabilities**.
- Identification of the **most limiting transients**

**STUDY CONCLUSIONS:**
- A stability range of the control parameters was defined
- **Final parameters were proposed and implemented** in the plant.
Angra I. Feed Water Control Replacement

OBJECTIVE:
• Determine whether the new control based on OVATION is accurate and better than the former one

ACTIVITIES:
• Installation on the new control system, with a stimulated solution, 15 months before the plant installation.

ANALYSIS KEY FACTORS:
• Capability to run transients in any range of operation
• Coexistence of both control systems (new and old)

STUDY CONCLUSIONS:
• 21 discrepancies identified, related with configuration, integration and logic
  6 Discrepancies during the installation in the simulator
  10 Discrepancies during the validation
  5 Discrepancies during the advanced operators training
Atucha II. Supporting the plant Start-up

OBJECTIVE:
- Optimize the Plant first Start-up Process

ACTIVITIES:
- In advance execution of plant start-up and test procedures.
- Verification of unexpected behaviors, allowing their analysis and understanding, and eventually defining strategies for their resolution.
- Optimization of control loops to determine the stability point

ANALYSIS KEY FACTORS:
- Simulator available 18 months before plant Start-up
- Simulator capability to on-line adjustment of control loops.
- Capability to execute an unlimited number of scenarios

STUDY CONCLUSIONS:
- The plan virtual start-up in the simulator reduced dramatically the real plant start-up time, avoiding unexpected incidents
OBJECTIVE:
• To identify and analyze the equipment constraints in the BOP systems

ACTIVITIES:
• A new specific simulation tool was developed based on TEAM suite and previous FSS models

ANALYSIS KEY FACTORS:
• Interactive capabilities to modify the components characteristics on-line
• User interface based on EXCEL

STUDY CONCLUSIONS:
• Constraints in heater drain pumps and condensate pump were identified.
• Purchase Specification for the new pumps was established
**Simulated Assisted Engineering with Mark VIe**

**Design modification:**
Replacement of the analog control system by **General Electric MarkVIe** digital
FeedWater Level Control and Feed Pump Turbine Control

**PRIOR IMPLEMENTATION IN THE FULL SCOPE SIMULATOR**

Applying Tecnatom’s methodology:
- Installation of MarkVIe in FSS
- Carrying out of testing program
- Simulation Assisted Engineering activities

**STUDY CONCLUSIONS:**

- Increased **efficiency and safety during commissioning**.
- **Early error detection** and confidence in the new control system
- Licensed **personnel trained** before the plant design modification
- Review and validation of **operating procedures**
- **HFE validation and enhancement** of Human Machine Interface
**Tecnatom’s experience**

- **Atucha II:**
  - Tool to support the plant Start-up (In advance execution of start-up sequence, verification of unexpected behaviors, control loops optimization)
- **Cofrentes NPP:**
  - Replacement of control level valves in plant start up.
  - Steam valves replacement by ejectors.
  - Available operation time to change the ejectors train.
  - Power generation breaker installation.
  - Plant power uprate to 112%.
  - **Level master controller capacity.**
  - Honeywell DCS set up (several phases).
  - P40 system hydraulic analysis.
  - FW/CD system hydraulic analysis.
  - MSRs alternative drain analysis.
  - Turbine control DCS Mark-VI plant installation and validation.
  - Feed Water Mark-VIe control validation.
- **Almaraz NPP:**
  - Steam Generators replacement (TH GV y FW, FW control).
  - Available time to avoid SI after a reactor trip.
  - Turbine change (control valves capacity in loss of performance transients).
  - High level trips analysis caused by unbalanced operation on the 17/07/1999.
  - Turbine DEH Manual closure behavior when 200%/m and 133%/m.
  - New SCDR implementation (24 control loops).
  - New DCS for MSRs drains.
  - New SSGG control level stability analysis, MSRs, tracking activated or not, control loops configuration ...
  - Plant power uprate to 108%.
  - Analysis of the software used to calculate the core power generation.
  - RHR safety valves capacity analysis.
  - Auxiliary Feed Water new control system.
- **Ascó NPP:**
  - New Steam Generators.
  - Control level response in turbopumps speed demand steps avoiding run-out zone.
  - Pressurizer control level optimization.
  - Turbine runbacks efficiency analysis.
  - Low power problems analysis with FW fail to one SG.
- **Vandellós NPP:**
  - Turbine valves capacity to accept a TM program drop.
  - Operation feasibility with one spray valve unavailable.
  - Steam collector depressurization pace through seals and purges.
  - Blackout available time without diesel in starting core melting.
  - EG system capacity analysis with flow reduction.
  - EJ new system start up.
  - EG performance with limited flow.
  - Turbopumps ΔP program changes verification.
- **Trillo NPP:**
  - Analysis of involved logic in YP instrument failures.
  - Analysis of consequences when the YA20T055 transmitter is replaced by other similar from other loop.
  - Protection logic goals surveillance.
  - Neutronic noise impact simulator in protection logics.
  - Teleperm XP installation (Process Computer and Protection logic goals surveillance).
  - Teleperm XP installation (Turbine control).
- **Angra I NPP:**
  - New Steam Generators impact (TH GV y FW, FW control).
  - New ADFWCS implementation at plant.
- **Other:**
  - SAGAs (Simulador Aires Gases central térmica de carbon) (8).
  - Simulation Severe Accidentes in Spent Fuel Pools using MAAP5.
  - Kaxu: Analysis lost of performance in the thermodynamic cycle.
  - Atacama: Optimization of the seals flow control loop.
  - Xina: Optimization of the expansion and overflow tanks control.
SAE Methodology

1. Problem identification
2. Involved models scope analysis (the existing models are valid or……)
3. Test plan design
4. Test plan execution and engineering analysis
5. Uncertainties assessment and conservative measures
Conclusions
SAE Benefits

- Improvement in quality, time and cost
- Early detection and correction of design errors
- Minimizing of uncertainties and confidence building
- Control loops tuning
- Prior training of licensed personnel
- Review and validation of operating procedures
- Latent errors reduction
- HFE improvements

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Conclusions

• Actual simulators have the necessary features and accuracy to use them as predictive tools

• Actual simulators provide adequate tools to support/complement the engineering analysis

• To warrant the simulators’ analysis conclusions, it is necessary to use a well established methodology

• Increased knowledge of the system facilitates an enhanced training and builds confidence in the simulator as a training tool
Conclusions

• Different disciplines are benefited from SAE (Mechanical, I&C, HFE, procedures, training, ...)
• Use of SAE means saving time and money, increasing plant safety and reliability
• Simulator is a big investment. Take advantage of your simulator.
• SAE process is not necessary expensive and sometimes is just a fancy name for a modification project you will be doing in your simulator anyway.
• Involvement of the operation personnel in the project improves the quality of the final product and the plant modification acceptance