Replacing I/O System in Angra2 simulator

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Background
Background

At present, Brazil has two nuclear units in operation and a new unit is under construction

- Angra I – Westinghouse PWR, two loops, 640 Mwe.  
  In operation since 1985
- Angra II – Siemens KWU PWR, four loops, 1350 MWe.  
  In operation since 2001
- Angra III – Areva PWR, four loops, 1405 Mwe.  
  Under construction
Background

Simulators located in Training Center in Mambucaba, ETN property

Angra1 simulator
- Delivered by Tecnatom in 2013
- I/O System → Tesis+
- TEAM suite environment

Angra2 simulator
- Interface Thomson-CSF developed in the 80's
- Models updated by L3-Mapps in 2010
Background

Current I/O interface obsolete
- Developed in the beginning of 80’s
- Controller replaced in 2010 by L3-Maaps
- No enough spares

Very complex wiring distribution
- Broaden the HW scope of the simulator becomes hard
- It is very difficult to maintain

Additional Scope
- Some instruments are partially simulated
- Instruments like TSE, AKA and Synchro are real and hard to maintain
- TV and Sound circuits, Electrical distribution, Power supply, …
International bidding

- Published: 19th February 2018
- Documents presentation: 2nd April 2018
- Prices presentation: 10th May 2018

International competitors

- Questions and answers distributed to all competitors
- Envelopes opened in public session
- Anyone could claim

We were the winner!

- Officially transmitted: 21st May 2018
- A waiting period of 5 days for possible claims
The challenges
The Challenges

- **Additionally** to Complete rewiring and I/O replacement, we had to replace also the electrical distribution, the cameras and microphones
- **No test platform available** to communicate with the models
- **Time for manufacturing** the interface and instruments was shorter than other cases
- Very **few information** about some instruments to replicate, (e.g., timer tester)
- Only **8 weeks** of simulator **availability**
- Very limited **budget**
The Challenges

Eight weeks available for: disassembly, complete rewiring, I/O replacement, electrical distribution replacement, microphones, cameras, RPS instruments assembly, FAT, SAT and simulator RFT.

**Phase I: Specification**
- **Deadline 0**: Contract award
- **Deadline 1**: Kick-off meeting
- **Deadline 2**: Preliminary review design

**Phase II: Component & information store**
**Phase III: HW & SW development & FAT Tests**
- **Deadline 3**: Completion of procurement services
- **Deadline 4**: FDR accepted
- **Deadline 5**: Completion of FAT

**Phase IV: Installation at site**
- **Deadline 6**: 03/05/2019: ready to be shipped
- **Deadline 7**: 05/10/2019: completion at site

**Phase V: Tests & training**
- **Deadline 8**: 06/07/2019: completion of SAT
- **Deadline 9**: 06/17/2019: simulator RFT

**Phase VI: Documentation delivery**
The strategy
The strategy

The team
- Solid
- With experience
- In permanent communication with the customer
- Motivated

The Schedule:
- Task planning reflecting the activities, tools, staff, work shift, detailed description, estimated time, …
- Shared and compliant with the customer
- In permanent revision
- Nothing is left to chance

The preliminary:
- Reviewing over and over again the input data
- Developing a visual map of the distribution to help the mounting
- Preparing the wiring in advance

The assembly:
- Trained local staff
- Agile techniques
- Working together customers-contractor-subcontractor
- Overlap assembly & tests
- Confidence
- Two shifts
The strategy: the schedule

A general Schedule for the whole project

A very detailed Schedule for the 8-weeks-installation

An even more detailed daily Schedule task by task and team by team
### The strategy: the preliminary

#### DO138 CWA06

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<thead>
<tr>
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<th>119</th>
<th>117</th>
<th>115</th>
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A specific drawing generated from the Database, linking pins of terminal blocks and pins of instruments, very useful for the technicians.

<table>
<thead>
<tr>
<th>Actividad AC-03</th>
<th>CABLEADO INTERNO PANELES</th>
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<tbody>
<tr>
<td><strong>Actividad Precedente:</strong> AC-02</td>
<td><strong>Actividad Sucesora:</strong> AC-04 / AC-05</td>
</tr>
<tr>
<td><strong>Tarea:</strong> AC-03-T1</td>
<td><strong>Descripción:</strong> Montaje de relés</td>
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<td>Montar y equipar los carriles DIN para los relés. Esta actividad se irá haciendo en paralelo con el cableado de señales en el turno de la mañana. Los planos de distribución indicarán el número de relés a montar en cada panel.</td>
</tr>
<tr>
<td><strong>Herramientas/Materiales:</strong> Generales cableado, carriles DIN y relés.</td>
<td></td>
</tr>
<tr>
<td><strong>Documentación de referencia:</strong> Planos distribución, wiring lists, esquemas eléctricos</td>
<td></td>
</tr>
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<td><strong>Personal Necesario:</strong> VER PLANNING EXCEL</td>
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| **Tarea:** AC-03-T2 | **Descripción:** Cableado Pin tarjeta a Pin instrumento de las tarjetas. Independientemente de que se hayan cableado las tarjetas intermedias antes de montar o se haga sobre el carril DIN habrá que cerrar el circuito llevando el segundo extremo de la manguera al instrumento. Existirá una wiring list suministrada por Tecnatom que dirá de que pin de la tarjeta a que pin de cada instrumento va cada hilo de cada manguera. En algunas

A detailed description of each task with the predecessor, the successor, the needed tools, the reference doc and the staff.
The strategy: the assembly

SCRUM methodologies used to plan and follow-up every activity during disassembly and assembly.

KANBAN board installed and reviewed every shift change.
Features

- Distributed I/O system based on TCP/IP network protocol
- Runs under Windows 7 and higher - 64 bits
- Supports the processing of up to 64,000 signals
- Updating time less than 50 ms
- Extensive auto diagnosis in real time
- Remote control and supervision of the instrumentation power supply
- Allows for on-line interaction with any signal
- Customized test on user demand
Features

- Very simple system layout
- Only one protocol (Ethernet)
- Protection and detection of hardware faults with real-time information
- Jumper-free system
- Editing and compilation utilities to make easy the changes in hardware configuration and maintenance
- Monitoring and remote control of power supply modules
- Possibility of displaying and modifying signals from the card frontal
Architecture

Very simple system layout: Ethernet connection, commercial switches, each Tesis+ component with its own IP address
## References

<table>
<thead>
<tr>
<th>Year</th>
<th>Simulator</th>
<th>Signals #</th>
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<tbody>
<tr>
<td>2012</td>
<td>Atucha 2 (Argentina)</td>
<td>20,000</td>
</tr>
<tr>
<td>2013</td>
<td>Trillo (Spain)</td>
<td>29,000</td>
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<td>2013</td>
<td>Angra 1 (Brazil)</td>
<td>13,000</td>
</tr>
<tr>
<td>2013</td>
<td>José Cabrera (Spain)</td>
<td>300</td>
</tr>
<tr>
<td>2013</td>
<td>Almaraz (Spain)</td>
<td>11,200</td>
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<td>2018</td>
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<td>2019</td>
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Conclusions
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<th>Now</th>
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<td><img src="image1.png" alt="Before Image" /></td>
<td><img src="image2.png" alt="Now Image" /></td>
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*Tesis+ Angra2*
## Conclusions

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![Before Image](image1)

![Now Image](image2)
Conclusions

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<tr>
<td><img src="image1" alt="Before CWM3" /></td>
<td><img src="image2" alt="Now CWM3" /></td>
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<tr>
<td><img src="image3" alt="Before wires" /></td>
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<td><img src="image4" alt="Now Image 2" /></td>
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<td><img src="image6" alt="Now Image 3" /></td>
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Conclusions

Planning and re-planning in the earlier phases become an investment for the installation phase

Training local staff, it is a good option to reduce costs and risks

Experienced team minimizes the time and the setbacks during the critical phases

Involving the customer in all the phases builds confidence and trust

Strict follow-up of the tasks progress to trigger contingency actions
Tesis+ Angra2

Conclusions

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Before Now
Tesis+ Angra2

Conclusions
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Pablo Rey: prey@tecnatom.es