Alarm System for Structural Monitoring of the ITAIPU Dam Employing the tools of the PI System

Presented by Airton Bordin Junior
Agenda

• About us
• Business Challenge
• PI System in ITAIPU
• The Solution
• PI System Tools
• Next Steps
• Results
• Conclusion
About us
ITAIPU Binacional

- Largest generator of electric energy in the world
- Installed capacity 14,000 MWs – 20 generator units of 700 MW each
- 2013 Record: 98,630,035 megawatts-hour
ITAIPU Binacional

75.2% of the Paraguayan consumption

16.8% of the Brazilian consumption
PTI – ITAIPU Technological Park

- Since 2003
- 420 direct jobs
- Innovator space that congregates projects and programmes addressing
  - Social insertion
  - Jobs and income creation
  - Distribution of knowledge
  - Transfer of technology
- Incubated firms
- 3 universities
PTI - ITAIPU Technological Park

Total Area: 75,54 hectares | Constructed Area: 49,521 m²
ITAIPU/PTI and OSIsoft

• ITAIPU utilizes PI System since 2002
• Specification and acquisition of EA – 2015 to 2019
R&D CEASB
CEASB

- Centre of Advanced Studies on Dam Safety
- Programme of the ITAIPU Technological Park
- Develops research and development projects in the area of dam safety
- 9 research areas
- Database: projects utilising PI System
  - 6 graduation fellowships
  - 2 volunteers
Áreas de pesquisa

- Virtual environments
- Numerical Simulation
- Register of Dam
- 3D
- Concrete
- Geotechnology
- Instrumentation
- Increased reality

Database
Business Challenge
Business Challenge

- Monitor a dam 8km long, 185m high with 2,700 instruments in real time;
- Identify possible abnormal behaviour of the structure;
- Automatically correlate between the instrumentation;
Business Challenge

- Identify possible faults in the structure;
- Alert those responsible for the dam at the exact moment an event occurs;
- Assist those responsible in reaching a decision.
ITAIPU power plant civil structure

1 – Reservoir
2 – Diversion Channel
3 – Downstream
Q – Right Earthfill Dam
A – Spillway
D – Left Lateral Dam
E – Right Wing Dam
F – Main Dam
H – Diversion Structure
I – Left Connecting Dam
K – Rockfill Dam
L – Left Earthfill Dam
U – Power House
PI System on ITAIPU
PI System on ITAIPU

- 70000 tags that store data related to diverse aspects of the dam
- 7000 tags that store instrumentation data of the civil structure of the ITAIPU power plant
- There are 19 types of instruments that monitor the civil structure
Itaipu Instrumentation
<table>
<thead>
<tr>
<th>INSTRUMENTS TYPE</th>
<th>FOUNDATION</th>
<th>CONCRECT</th>
<th>GEODETIC</th>
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<tbody>
<tr>
<td>PIELÔMETRO</td>
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<td>EXTENSÔMETRO DE HASTE</td>
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<tr>
<td>TRIORTOGONAL</td>
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<td>DEFORMÔMETRO</td>
<td>MEDIDOR DE JUNTA ELÉTRICO</td>
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<td>PÊNDULO</td>
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<td>PARES DE PINOS</td>
<td>TERMÔMETRO</td>
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<td>DRENOS</td>
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<td>ALVOS</td>
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<tr>
<td>MARCOS</td>
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<td>TOTAL DE INSTRUMENTOS</td>
<td>661 136 22 51 9 879 4346</td>
<td>261 58 66 16 645 63 6 99 139 399 949 20 141 2792</td>
<td></td>
</tr>
</tbody>
</table>
Instruments

- Some dam blocks are called key-blocks
- Key-blocks are totally instrumented
- Defined by ITAIPU Binational Engineers according the block technical characteristics
  - High
  - Position
  - Type of foundation
Key block
The solution: Alarm System for Structural Monitoring of the ITAIPU Dam Employing the tools of the PI System
The solution

• Analyses the data from the readings;
• Executes processing of the information;
• Applies the Fault Tree technique;
• Generates an alert on the structural situation.
Architecture of the solution

Alarm

Orange
Green
Yellow
Red
The Solution

- OSIsoft products in use
  - PI Server 2012
  - PI System Management Tools
  - PI Asset Framework
  - PI Advanced Computing Engine
  - PI Notifications
  - PI SDK (PI AF SDK)
  - PI Performance Equation
PI Asset Framework (PI AF)
PI Asset Framework

• Implementation of the analyses of the instrument readings is done in the PI Asset Framework, using the fault tree method

• Fault tree
  – 60’s, Bell Laboratories, created to evaluate the safety performance of a launch control method
  – Systematic analysis of possible faults and consequences
  – Corrective or preventive methods
Fault Tree– PI AF

• Due to its hierarchical characteristic, we utilize the PI AF to represent the fault tree structure of the blocks
• It presents the present situation of the dam structure
• Levels of alarm conform to the degree of emergency
• Alarms defined by colours
Fault Tree – Basic Example

Risk of foundation displacement

AND

Disturbing increase in foundation strain

OR

Extensometer 1

Extensometer 2

AND

Disturbing increase in vertical strain

AND

Piezometer 1

Piezometer X

Piezometer 2

Piezometer Y
Fault Tree – PI AF
Notification – Alarm Level
PI Notifications
PI Notifications

• Define the FT elements that are to be analysed by the Notification (target)
• Define the conditions of conformity with the alarm type attribute (conditions)
• Configure those responsible who will receive the alert messages (subscriptions)
• Analysis of the target element executed every 30 minutes
Message
Message

• The specialist user receives an email with information on the alarm to assist in taking a decision

• He also receives a link to access the module of visualization of the system for further information on the fault
  – Complete route of the fault
  – Historical graph of the tags related to the fault
  – Localization of the instrument in the dam
Informações sobre a falha:

**Nome:** D-38: Risco de Escorregamento da Fundação - Alarme Amarelo;
**Horário:** 15/08/2014 10:44:55 Hora oficial do Brasil (GMT-03:00:00);

**Nível de Alarme:** 2 (Limite Histórico)

Para mais informações, acesse o link:
P&D System

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**alarm_map.png**
~4 KB  Exibir  Baixar

**block.png**
~132 KB  Exibir  Baixar

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Email message example
WEB GUI – Javascript + PI AF SDK
Details of the alarm
Responsive design - Mobile
Demo
Next steps
Next steps

• Oracle Database Integration (manual readings)

• Statistical analysis using PI ACE
Results
Results

• System executes the structural monitoring of the ITAIPU Binational dam
• Automatic alerts are sent to the specialists responsible for the auscultation area
• Response time to verify a possible problem is immediate
• The system permits detailed analysis of the anomaly and assists the specialist in reaching a decision
• Guarantees greater safety and more efficient monitoring of instrumentation of civil structure of the dam
Conclusion
Alarm System for Structural Monitoring of the ITAIPU Dam
Employing the tools of the PI System

“The implementation turned our system more proactive instead of reactive”

Business Challenge

- Monitoring the ITAIPU dam
- Generation of alarms
- Sending messages to those responsible

Solution

Results and Benefits

- Assists structural monitoring of the dam
- Facilitates reaching decisions
- Automatic alerts to those responsible
- Greater safety…
Credits

• ITAIPU Technological Park Staff
• ITAIPU Binational Staff
• Students
• Volunteers
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Questions

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State your name & company
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