Fukushima Daini Case Study
2F-2 Simulator Replace Project
Yasuji Saito
- In charge of 2F-2 Simulator Replace Project
- Working with TEPSCO for over 5 years
- Background is in Digital Signal Processing Software
Tokyo Electric Power Services Co., Ltd. (TEPSCO)

- Established in December 1960
- Affiliated with Tokyo Electric Power Company Incorporated (TEPCO)
Introduction of My Division

Nuclear Power Systems Department is developing...

- Plant Process Computer (PPC)
- Control System & Remote Monitoring System
- Simulator for Operator Training
Agenda

1. Background
2. Resource Control
3. 2F-2 Features
4. Lessons Learned
1. Background

2. Resource Control

3. 2F-2 Features

4. Lessons and Learned
Training Background

TEPCO’s nuclear power plants have been inactive since Japan earthquake in 2011

- During this inactive term:
  - Experienced operators retired
  - The number of operators with NO experience has increased

TEPCO has inherit operating skills and maintain technical abilities
- Fukushima Daiichi was damaged by the earthquake is under decommissioning work
- Fukushima Daini will be decommissioned

In order to improve abilities, TEPCO planned to change Fukushima Daini to the Training Center for ALL TEPCO’s operators
State of Fukushima Daiichi

Tsunami in 2011 damaged to many Facilities.
- Diesel generator
- AC and DC power supply system

- Units 1~4 exploded by H2 mixed with O2.
- Units 5,6 placed more higher than 1~4 units.
  These units reached cold shutdown using own Deisel generator.
State of Fukushima Daiichi Unit 1

Unit 1

Before 3.11

After 3.11

Now
State of Fukushima Daiichi Unit 2

Unit 2

Before 3.11

After 3.11

Now
State of Fukushima Daiichi Unit 3

Before 3.11

Unit 3

After 3.11

Now
State of Fukushima Daiichi Unit 4

Unit 4

Before 3.11

After 3.11

Now
Plant Condition in 3.11 Earthquake

• Fukushima Daini had been Station Black Out. (AC and DC system survived)
• Loss of ressure removal in units 1, 2, and 4.
• Building 9km temporary power cable
• from outside of site.
• Recovery of ECCS. All unit was settled in cold shutdown.
• And now Fukushima Daini will be decommissioned
The State of The Old Simulator

- 2F-2 simulator has been running everyday.

- Workstations were obsolete. (Old simulator was built at 2000.)

- 2F-2 simulator could not accept the request for the diversification of training.
# The Scope of 2F-2 Replace Project

<table>
<thead>
<tr>
<th></th>
<th>OLD Simulator</th>
<th>NEW GSE Simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware</strong></td>
<td><strong>Workstation</strong> (x14)</td>
<td><strong>Workstation</strong> (Server x3, Client x14)</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td><strong>Vertical Soft Panel</strong></td>
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<tr>
<td></td>
<td>-</td>
<td><strong>Workstation</strong> (Soft Panel Server, Client x2)</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td><strong>Soft Panel</strong> (x4)</td>
</tr>
<tr>
<td><strong>Software Platform</strong></td>
<td><strong>Supervisor Module</strong></td>
<td><strong>SimExec</strong></td>
</tr>
<tr>
<td></td>
<td><strong>SMABRE, NETFLO</strong></td>
<td><strong>REMARK, RELAP5-HD, Jtopmeret, Jelectric</strong></td>
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<tr>
<td></td>
<td><strong>Malfunction</strong></td>
<td><strong>Malfunction</strong></td>
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<tr>
<td></td>
<td><strong>MAAP3</strong></td>
<td><strong>MAAP5</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Euro sim instructor system</strong></td>
<td><strong>JStation</strong></td>
</tr>
<tr>
<td></td>
<td><strong>DataViews</strong></td>
<td><strong>JDesinger</strong></td>
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<tr>
<td></td>
<td><strong>ASK+AutoCAD</strong></td>
<td><strong>JASK+Jdesigner</strong></td>
</tr>
<tr>
<td><strong>Simulation Range</strong></td>
<td><strong>EuroSim I/O system</strong></td>
<td><strong>GSE I/O system</strong></td>
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<tr>
<td></td>
<td>-</td>
<td><strong>(Additional) Site Panel &amp; Electric Panel</strong></td>
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<td></td>
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<td><strong>New Facilities for SA</strong></td>
</tr>
</tbody>
</table>
“To replace 2F-2 simulator workstations and software while minimizing disruption to the simulator”
<table>
<thead>
<tr>
<th>Activity</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>The term of the project</td>
<td>3Q</td>
<td>4Q</td>
<td></td>
</tr>
<tr>
<td>The Clarification of Simulation Range</td>
<td></td>
<td>3Q</td>
<td>2Q</td>
</tr>
<tr>
<td>Collecting Plant Data</td>
<td>3Q</td>
<td>2Q</td>
<td>4Q</td>
</tr>
<tr>
<td>Software Panel Design for V-panel</td>
<td>1Q</td>
<td>2Q</td>
<td>3Q</td>
</tr>
<tr>
<td>System Design</td>
<td>4Q</td>
<td>1Q</td>
<td>2Q</td>
</tr>
<tr>
<td>Adjustment of MAAP I/F (TEPSYS)</td>
<td>2Q</td>
<td>3Q</td>
<td>4Q</td>
</tr>
<tr>
<td>FAT</td>
<td>3Q</td>
<td>4Q</td>
<td>1Q</td>
</tr>
<tr>
<td>Setting for SAT</td>
<td></td>
<td></td>
<td>1Q</td>
</tr>
<tr>
<td>SAT</td>
<td></td>
<td></td>
<td>2Q</td>
</tr>
<tr>
<td>Test with TEPCO</td>
<td></td>
<td></td>
<td>3Q</td>
</tr>
</tbody>
</table>

The duration of Disruption to Simulator
<table>
<thead>
<tr>
<th>Company</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEPSCO</td>
<td>Instructor: Determination of simulation range, Test &amp; Tuning</td>
</tr>
<tr>
<td></td>
<td>System: Arrangement of Requirement(Specification), Debug, Software Panel Design</td>
</tr>
<tr>
<td>GNESC</td>
<td>System Design, Debug, Hardware Delivery</td>
</tr>
<tr>
<td>GSE</td>
<td>Simulator Program and Model Design, Test &amp; Tuning, Debug</td>
</tr>
<tr>
<td>TEPSYS</td>
<td>Adjustment of MAAP I/F</td>
</tr>
</tbody>
</table>
1. Background

2. Resource Control

3. 2F-2 Features

4. Lessons and Learned
## Hardware Resource

<table>
<thead>
<tr>
<th>Category</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator Sever (Development)</td>
<td><img src="image1" alt="Simulator Sever (Development)" /></td>
</tr>
<tr>
<td>Simulator Sever (Deliverables)</td>
<td><img src="image2" alt="Simulator Sever (Deliverables)" /></td>
</tr>
<tr>
<td>Soft Panel</td>
<td><img src="image3" alt="Soft Panel" /></td>
</tr>
<tr>
<td>Vertical Soft Panel</td>
<td><img src="image4" alt="Vertical Soft Panel" /></td>
</tr>
<tr>
<td>Hard Panel</td>
<td><img src="image5" alt="Hard Panel" /></td>
</tr>
<tr>
<td>Console</td>
<td><img src="image6" alt="Console" /></td>
</tr>
</tbody>
</table>
Software Panel
Vertical Software Panel
Utilization of Hardware Resource for Training

Basic combination for the training

Training @ FSS

Back up

Basic Training @ V-panel

Developing and Verify Scenario
### Schedule Compression by HW Resource Control

#### Ex.1
- Shorten FAT/SAT from 70 weeks to 29 weeks by HW Resource Control

#### Ex.2
-...

#### Ex.3
-...

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**Engineering for the NEXT**

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Utilization of Hardware Resource in FAT (1)

Example 1. A combination in FAT (* We were NOT able to use Hardware Panel in FAT.)

Test : Shut down / Start up

Debug1

Debug2

Debug3 @ GSE(US)

Software Panel Development @ TEPSCO

Developing and Verify Scenario

Tuning : Shut down / Start up
Utilization of Hardware Resource in FAT (2)

Example 2. A combination in FAT (* We were NOT able to use Hardware Panel in FAT.)

Test : Shut down / Start up

Test &Tuning: Malfunction Validation

Tuning : Shut down / Start up

Developing and Verify Scenario

Debug1

Debug2 @ GSE(US)

TEST : Annunciator @ TEPSCO
Utilization of Hardware Resource in SAT

Example 3. A combination in SAT (* We were able to use Hardware Panel in SAT.)

Snapshot(Final) : Shut down / Start up

TEST : New Regulatory Requirement

Developing and Verify Scenario

Tuning for Final Snapshot

Tuning : NRR

Debug

TEST: Annunciator
It enabled us to ...

- Work without a hardware panel
- Work in parallel
- Work efficiently
Utilization of Human Resource

We built teams for TEST, Tuning and Debugging works in FAT / SAT. Team member were changed everyday depending on the work.
The Point of Team Makeup

- Instructors as members of Development Team
- GNESC and System Engineering Group of TEPSCO as the interface between Instructors and GSE
Benefits of Working with a Team

- Instructor understood the simulator system more deeply
- They could restart training with new simulator immediately
- They can build more complex scenarios
Achievement by The Resource Control

- Shortening FAT/SAT
- Restarting training smoothly
- Getting the skills suppling the complex and real training
2F-2 Features

1. Background
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AST (Automatic Scenario Testing)

Used GSE simulator TOOL to execute and create scenarios

We created 200 scenarios in FAT and SAT
Benefits of Using AST

- GUI based system is easier to edit the scenario and parameters
- The scenarios like flow chart is easier to grasp their progress
Management of Software in Developing Term

- Work each independent tasks on each servers
- Merge each tasks on SVN Master using SVN feature
Management of Software in FAT/SAT

The possibility of Conflicts with the modifications at 2F-Site and GSE (US)
Daily Routine About Software Update

1. GSE in US worked and updated development servers at GSE during daytime in US (Night in Japan)

2. Members in Japan update servers in JAPAN in morning in JAPAN (Evening in US)

3. Members in Japan worked on server in JAPAN during Daytime in JAPAN (Night in US)

4. Members in Japan merged their updates into SVN Master at the evening in JAPAN (Morning in US)
Daily Routine : Step1

(GSE) Work on SVN Master during Daytime at U.S. (Night at JAPAN).
Daily Routine : Step 2

(Members in Japan) Update Servers in Japan at morning in Japan (Evening in U.S.)
(Members in Japan) Work on Servers in JAPAN during Daytime in JAPAN (Night in U.S.).
Daily Routine : Step 4

(Members in Japan) Merge with other updates on SVN Master at the evening in JAPAN (Morning in U.S.).
Daily Routine : Step1 (next cycle)

(GSE) Work on SVN Master during Daytime at U.S. (Night at JAPAN).
Realistic Malfunction with HD sound effect

Update of Sound System
• Replace the old devices
• Add 18” Passive Subwoofer for the sound of earthquake

661mm
507mm
574mm
1750mm
The sound including Resonance frequency shake the room.
Monitoring and recording system made effective the training. We replace sound system and built monitoring system.

Construction

• Sound system
  • Microphone x 8 (omnidirectional mic x 3, pin mic x 5)
  • Speaker x 2 (in instructors room)

• Video recording system
  • Camera x9 (wide angle x 5, Pan-Tilt-Zoom x4)
  • HDD recorder
**Training support by monitoring and recording**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Image</th>
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<tbody>
<tr>
<td>PTZ camera (Pan, Tilt, Zoom)</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Wide angle camera</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Omni directional mic</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Pin mic</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Console (for instructor)</td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td>Console (for Review)</td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Training support by monitoring and recording

Before built
• Instructor had to watch by own eyes or binoculars.
• Instructor was difficult to listen to voice of operator.

After built
Monitoring had became easy by zoom camera controlled joystick.
• Target is switch position, indicator, and Annunciator.
• Display by digital monitor.

Instructor became able to give guidance easy and objective.
• Video recording and reviewing with operator after training.
Training support by monitoring and recording

Example: Display of console for instructor.
Training support by monitoring and recording

Review and effectively feedback by using training video.

Training video is used as teaching materials.
  • Operator can review own motion.
  • Instructor can give guidance objective and verifiable.
2F-2 Simulator

• Upgraded Simulation Program and Model
• Multi Language Platform for instructor station
Lessons and Learned

1. Background

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Current State of 2F-2 Simulator: Soft Panel

- Trainings for some systems / facilities of nuclear power plant
- Development and Verification of new scenario
Current state of 2F-2 Simulator: Remote Support

- VPN Connection for Remote Support
- SVN for Software Management
Lessons Learned

1. Updated the simulator in accordance with the requests for the training
   - Implementation of new simulation ranges and facilities
   - More precisely simulation

2. Realized importance of instructors as members of development team
   - Minimization of the duration of SAT
   - Smooth restart of the training

3. Realized again how useful the software panel system is
   - Training for young operators by soft panels
   - High quality trainings prepared 100% by soft panels
QUESTIONS