The Electric Power Research Institute (EPRI) recently conducted an update to the Technical Basis Report (TBR) for severe accident management, and is conducting a technical evaluation study of the Fukushima Daiichi event. ERIN Engineering and Research, Inc., has been the principal technical contributor to both of these efforts. Each of these projects represents a component of enhancing commercial nuclear power plant safety using lessons learned from Fukushima. The TBR incorporates lessons learned to enhance Severe Accident Management Guidelines (SAMG). The technical evaluation will provide the industry with greater insights and a deeper understanding of the event.

ERIN Engineering was a primary contributor to the effort to update the TBR. It is continuing to be the principal contributor to EPRI’s technical evaluation effort with simulation and modeling support from GSE Systems. The companies are using EPRI’s Modular Accident Analysis Program (MAAP) code to analyze the severe accidents that occurred at Units 1F1, 1F2, and 1F3.

The EPRI Technical Evaluation study is being conducted in phases. The Phase 1 effort, already completed, identified a number of key insights that can strengthen and improve responses to severe accident management. These insights apply to all nuclear technologies and will prove valuable to enhancing current SAMGs. The simulation of the event also demonstrated the capability of the MAAP5 computer code to accurately represent the progression of a severe accident. This study enhances the existing technical basis of the MAAP5 code, supporting its current and future applications in evaluating measures to both prevent and mitigate severe accidents. The MAAP5 code is proving to be an important element in demonstrating the effectiveness of measures to enhance mitigation of beyond design basis accidents.

Building on the success of Phase 1, EPRI is conducting an on-going Phase 2 study to refine the analysis of the Fukushima event using details from the forensic investigation as they become available. Major tasks include evaluation of the progression of core damage to containment failure, as well as the signatures of radiological releases within the reactor building and, at different points, outside the building. The progression is intricate, involving multiple units and potentially different containment leakage points. As a result, the presentation of the scenario in a traditional report...
format could be complicated. To address this issue, GSE Systems is developing a graphical simulation of this multi-unit event that can represent the progression of core damage and containment failure as well as the release of fission products to the environment. The simulation tool also has greater flexibility to interactively perform what-if analyses of multiple unit site events.

DESIGNEP ADVANCED SIMULATION-BASED MODELING AND ANALYTICAL TOOL

GSE has integrated EPRI’s MAAP code* into its advanced simulation-based modeling and analytical tool, DesignEP, and provided features that allow several instances of the MAAP code to be coupled to each other and run interactively. Users are able to easily interact with equipment controls and code models through a modern Human-Machine Interface (HMI). Advanced 3D visualizations coupled directly with simulation models can be added to inform the user of the conditions inside containment and the reactor during severe accident scenarios. The HMI provides users with a clearer insight into the accident progression and plant responses.

One of the key objectives for enhancing simulation and modeling during Phase 2 is the seamless synchronization of multiple instances of the MAAP code and other simulation tasks. For example, core melt scenarios can take place simultaneously in each of the three units; and the simulation will show their composite effects on the evolution of offsite dose. DesignEP’s simulation architecture provides the capability to host multiple reactor units with a MAAP model originally designed for one reactor unit. It not only reduces cost and improves efficiency of simulation; it also enables convenient simulation of systems that may be shared by multiple reactor units.

This is all done while maintaining the original integrity of the EPRI MAAP code.

DesignEP also provides the tools needed to make experimentation and data analysis easier, including:

• Ability to dynamically change, monitor or plot internal variables, and collect data for further analysis,
• Online or offline verification and validation against reference data, and
• Graphically depict and interact with the event.

Along the event progression, users may visually observe the event unfolding in the reactor core, reactor vessel, containment, and reactor building. Users may also display trending dynamics for the scenarios, facilitating...
more in-depth evaluation of the key parameters of interest alongside the visualization. The data trending can be collected, stored, and later analyzed offline for additional insights. DesignEP also has the capability to assist users with automatic testing of a large number of long and complex scenarios. Coupled with automatic collection and analysis of data along with automatic report generation, the performance of complex work flows is greatly simplified.

**SUMMARY**

GSE's DesignEP incorporates the inherent capability of the MAAP code that allows the simulation of various plant systems in different transient phases. The unique client server structure provides DesignEP with the capability to simulate the entire plant site with multiple units/systems in a synchronized parallel fashion, which the original MAAP code cannot handle. The memory handling techniques facilitate easy access to MAAP internal variables during execution, and thus give users the ability for code debugging, tuning, interactive control and simulation. The comprehensive snapshot of the physical memory also enables DesignEP to have better repeatability as well as freedom to reset code execution to any conditions that are stored in IC files. The advanced GUI gives code users the convenience to execute and interactively control analysis cases, facilitating the development of clear insights into the phenomena.

DesignEP will lessen the plant burden to meet new requirements in light of the Fukushima events. It will help reduce cost and time for analysis of site wide plant specific needs, verification and validation of SAMG; and it can also be an excellent training tool, as either a standalone tool or an integral part of a plant specific full-scope simulator.

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**Benefits of DesignEP**

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<tbody>
<tr>
<td>1</td>
<td>Synchronized parallel simulation to the entire plant site with multiple units/systems</td>
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<tr>
<td>2</td>
<td>Multiple executives coordinated and interfaced to represent interactions between units/systems</td>
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<tr>
<td>3</td>
<td>Integrate MAAP into client-server architecture while maintaining the code integrity &amp; fidelity</td>
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<tr>
<td>4</td>
<td>Improved code repeatability through snapshot to comprehensive physical memory</td>
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<tr>
<td>5</td>
<td>Open the “black box” to access code internal variables for display, plot and record without affecting the integrity of the MAAP calculations</td>
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<tr>
<td>6</td>
<td>User's interactive actions are available during entire code execution</td>
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<tr>
<td>7</td>
<td>User friendly GUI to give users easily control &amp; a clear insight to the transient</td>
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<tr>
<td>8</td>
<td>Online V&amp;V to compare current simulation data with reference data</td>
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* EPRI (www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI does not endorse any 3rd party products or services. Interested vendors may contact EPRI for a license to MAAP5.
GSE Systems, Inc.

We are a next-generation simulation, training, and engineering services provider applying a world of experience to help you achieve the performance you imagine. GSE is a world leader in real-time high-fidelity simulation, providing a wide range of simulation, training and engineering solutions to the energy and process industries. Our comprehensive and modular solutions help customers achieve performance excellence in design, training and operations. GSE’s products and services are tailored to meet specific client requirements such as scope, budget and timeline.

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ERIN Engineering and Research, Inc.

ERIN is the premier nuclear safety and reliability consulting firm in the world and the leading provider of PRA consulting services to the nuclear power industry.

ERIN has been at the leading edge of the US nuclear industry response to Fukushima. Our related services include:

- Accident Analysis/Simulation
- Integrated Assessments of Flood Response
- Seismic PRA
- External and Internal Flood PRA
- SAMG and TSG Support

With offices throughout the United States and over 30 years of proven experience, ERIN is known for providing high quality, practical solutions to clients worldwide.

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