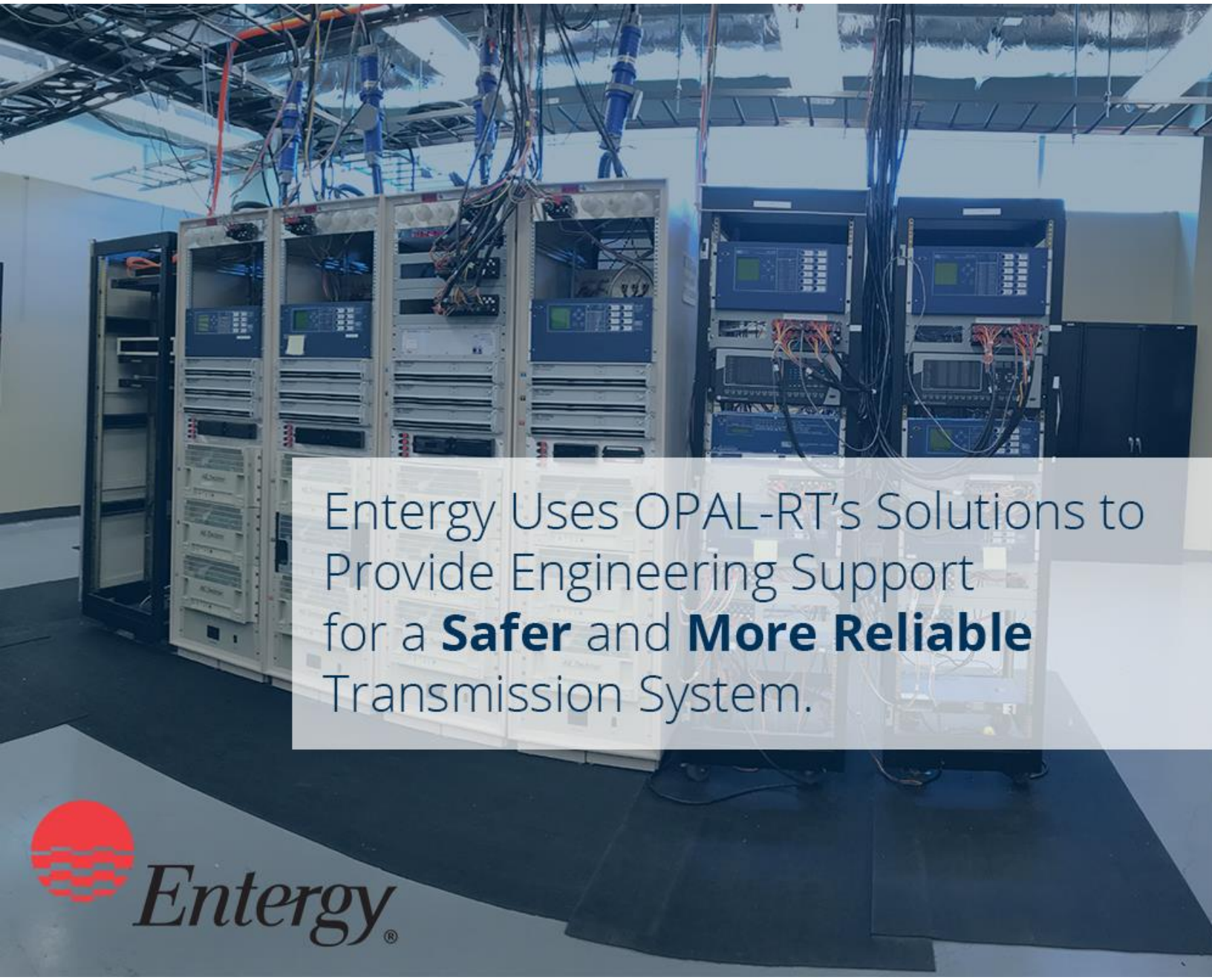
OPAL-RT TECHNOLOGIES

Success Story



Entergy Uses OPAL-RT's Solutions to Provide Engineering Support for a **Safer** and **More Reliable** Transmission System.

Entergy®

Entergy Corporation is an integrated energy company engaged primarily in electric power production and retail distribution operations. Entergy owns and operates power plants with approximately 30,000 megawatts of electric generating capacity, including nearly 9,000 megawatts of nuclear power.

Entergy delivers electricity to 2.9 million utility customers (residential, commercial and industrial energy users) in Arkansas, Louisiana, Mississippi and Texas. Entergy has annual revenues of approximately $10.8 billion and nearly 13,000 employees.

1. Challenge

Entergy continuously aims to deliver safer and more reliable power to their customers. Consequently, they have always been pioneers and long-time users of Hardware-in-the-Loop (HIL) real-time simulation. They purchased their first Silicon Graphics International Corp. (SGI) supercomputer and HYPERSIM® license back in 2003.

The appearance of revolutionary trends in the power generation and distribution industry (microgrids and smart grids) resulted in significantly more complex control systems and grid infrastructures. While this evolution holds the promise of greater reliability and stability, new challenges have emerged for engineers developing modern controllers and implementing them in the field.

Accordingly, Entergy has the objective to deploy various new technologies on their systems and to target new applications. They wanted to use their simulator for the testing of new Intelligent Electric Devices (IEDs) and new applications of them as well as their Static Var Compensators (SVCs). To meet their objectives within project timeframes and budgets, advanced yet flexible testing tools were required.

For those reasons, Entergy decided to upgrade its hardware platform to an OPAL-RT 32-core OP5031 simulator in order to model and simulate in real-time its transmission networks and controls more efficiently and accurately. In collaboration with OPAL-RT, Entergy's improved simulation lab enabled

researchers to engage in innovative research projects and to provide the highest level of engineering development and support for their transmission system. For the same network model, the OP5031 allowed to **test and obtain results 50% faster** than the preceding SGI.

2.Solution

The Delivered Simulation System

Entergy's new lab now includes OPAL-RT's 32-core OP5031 simulator, three customized OP5640 simulator platforms to manage I/O connectivity, I/O boards to connect up to 384 I/O channels simultaneously (96 digital inputs, 96 digital outputs, 64 analog inputs and 128 analog outputs), voltage and current amplifiers and six OP8320 voltage dividers for maximum computing and connectivity capabilities.

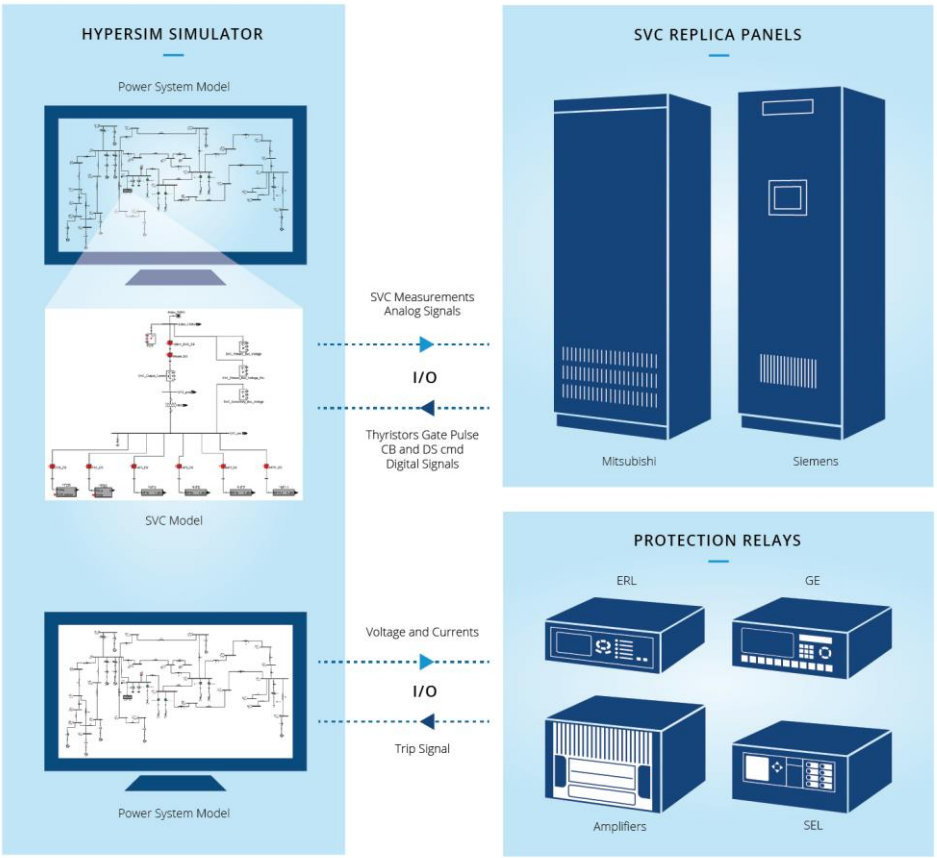


***Figure 1**: Entergy's Closed-Loop Simulation Architecture*

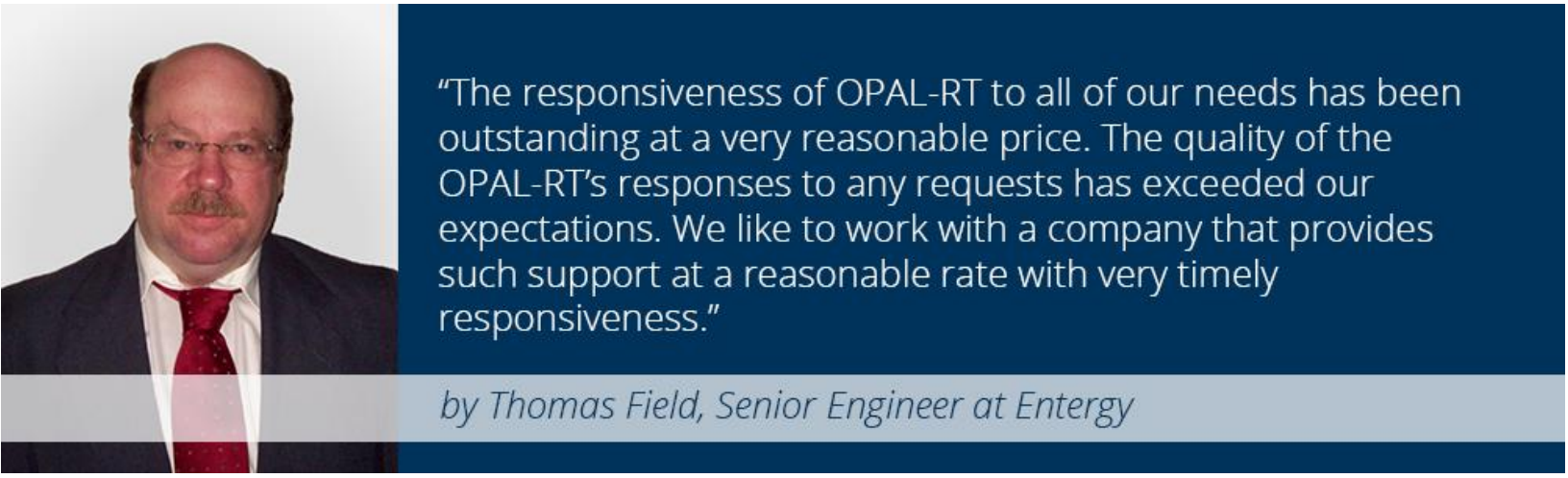
Entergy's HYPERSIM models include the transmission system, two modelisations of the SVC controls in real-time and capacitor banks as well as I/O and communication management. The overall model runs at a time step of 40 us on 9 HYPERSIM cores. Although one HYPERSIM core could generally compute up to 100 buses, the high number of switches in each SVC's control requires more computational power. This increase in computational power between the new simulator and the previous SGI simulator led to a **50% efficiency gain**.

Test All Control's Communication Layers

OPAL-RT not only provides the standard I/Os that are needed in the industry, but that are also specifically designed for power controls. A C37.118 driver was integrated in Entergy's platform to enable the communication between the simulation platform and devices under test using IEEE's Standard for Synchrophasor Measurements for Power Systems.

Controls and Protection Systems Under Test

The OP5031 simulator was used to modify settings/relay requirements for series compensated lines and independent pole operation of relays. It has also been used to develop Digital Fault Recorder (DFR) acceptance test requirements and to perform them. In addition, the real-time simulator was operated to better understand the behavior of the actual Static Var Compensator (SVC) controls which was not possible with the manufacturer's model in PSS/E.



3. Commissioning and Training

Customized Training and Expert Services

OPAL-RT's team of experts visited Entergy's lab a first time to complete the commissioning of their Siemens SVC controller. They tested all I/Os, validated the model and performed multiple operational tests of the SVC, such as:

- Start/Stop sequence
- Protection stop
- Step response
- Voltage ramp response
- Degraded mode operation
- Inductive/capacitive step
- 1LG and 3LG faults

They returned to Entergy's facility to commission their Mitsubishi SVC, test its I/Os, validate the complete model and execute functional tests with both SVCs in operation. They also delivered a customized 5-day training program including:

- Review of simulation basis including how to quickly and efficiently set up their new real-time simulator
- How to properly select and use mathematical solvers for their specific simulation application including their SVC test model
- Advanced lesson on the processes behind simulating complex systems
- Extensive hands-on workshops

"The training was all performed on-site and was very well prepared and comprehensive. The instructors were professional and helpful. OPAL-RT has accommodated many of our requests for unique modeling and assistance. Both the phone and remote computer support have been invaluable in obtaining accurate results."

4. Results

Decisive and Valuable Test Results

Through the HIL tests performed with the OPAL-RT 32-core simulator, Entergy was able to determine that the original relays desired for their short series compensated lines were not sufficient to perform the protection needed. They concluded that the settings of the relays initially selected for the series compensated lines had to be modified to operate properly. In addition, Entergy's researchers learned that changes to the settings initially proposed were required for the IPO operation of their EHV lines. Finally, by comparing the results obtained using the actual SVC with the PSS/E, they also uncovered that their PSS/E model did not respond the same way that the actual SVC control boards did. With their new OPAL-RT simulator, Entergy is now equipped with a tool that provides the same results as the replica.

All those tangible results are valuable to Entergy's R&D operations and their early detection allowed the prevention of substantial costs and development delays. The results are applied to controls and power system operations for improved reliability.

Flexible Technology for the Best Return on Investment (ROI)

In addition to being much faster than its SGI predecessor, the OPAL-RT 32-core simulator is compatible with the latest version of HYPERSIM simulation system. Entergy was able to use their HYPERSIM licenses, which their staff had become proficient in using throughout the years, on their new simulator. This strategy allowed significant time and cost-savings as the purchase of additional licenses was not required and a steep learning curve was avoided.

OPAL-RT's unique hardware integrates parallel, distributed computing with commercial, off-the-shelf technologies, and offers an unmatched combination of performance, openness and affordability. In addition to adapting and building on Entergy's original system architecture, OPAL-RT's flexible and reasonably priced hardware combined with the use of their HYPERSIM licenses provided Entergy with a powerful solution with **low initial investment and high returning value**.

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GETTING STARTED

Each engineering and research project has unique objectives and challenges. We want to hear about yours. Contact us at +1 514 935-2323 or http://www.opal-rt.com/contact-sales-team/ to discuss your R&D project and how we can help.

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OPAL-RT.COM

OPAL-RT is the world leader in the development of PC/FPGA-based real-time simulator, Hardware-In-the-Loop (HIL) testing equipment and Rapid Control Prototyping (RCP) systems to design, test and optimize control and protection systems used in power grids, power electronics, motor drives, automotive industry, trains, aircraft and various industries, as well as R&D centers and universities.

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