Application

The key to the successful operation of a sophisticated Energy Management System (EMS) has long been recognized as the effective matching of powerful computer functions with a knowledgeable human staff.

Training of personnel has therefore become an increasingly important consideration in the implementation and continued operation of control centers.

The SPIDER Operator Training Simulator (OTS) is composed of three major elements:
- Instruction Module, used to define the training exercises and monitor the training session
- Power System Simulator, which provides a real-time dynamic model of the physical power system
- Control Center Module which provides normal EMS and SCADA functions for the trainee.

Benefits

SPIDER OTS offers the EPRI OTS embedded as basis of its design. The EPRI OTS has proven to be a useful model for dispatcher training.

- For experienced dispatchers the OTS is used for training emergency situations, system restoration etc.
- The OTS increases the understanding of the power system
- The OTS trains the novice as well as experienced dispatcher how to use SCADA and EMS functions in a safe and realistic environment
- New control center functionality and new operational strategies can first be tested in the OTS
Functions

General Functions
- The control center functionality is the same as in the real system. The pictures and Human Machine Interface (HMI) dialogue are identical.
- Realistic Simulation of power system and data acquisition is performed.
- Predefined training scenarios based on power flow solutions.
- Events may be scheduled prior to or during the simulation e.g.:
  - circuit breaker trip/close
  - change in output of unit
  - RTU communication failure.
- Periodic and on-demand snapshots of the state of the simulation, for evaluation or later restart at that point.
- Ability to create a 'library' of training exercises.
- Multi-island networks are handled.
- Powerful full-graphic scenario building from one-line diagram pictures.
- Load curve selection.
- In supervised mode the instructor controls the flow of the simulation.
- In unsupervised mode the trainee can stop, take a snapshot of the state of the simulation and backtrack to ensure a full understanding of the results of his actions.
- Ability to use a snapshot from the run-time system for initiation of the simulation.

The OTS power flow differs from a conventional power flow. Regulation involving tie-flows, LTCs and phase shifters follows naturally from the explicit dynamic modelling of these controls.

Human Machine Interface (HMI)
The trainee uses the same full-graphic pictures and the same dialogue as the dispatcher in the run-time system.

The instructor uses a dedicated set of displays to control the OTS session. In addition the instructor has access to the same pictures as the trainee.

Several trainees may work simultaneously in the OTS system provided that a sufficient number of dispatcher consoles are available. Each trainee may have a different authority.

Data Engineering (DE)
The OTS uses the same Data Engineering as the rest of the SPIDER system. The OTS environment is a modified version of the run-time system where all connections to the real process have been removed.

Data used both by OTS and other applications needs only be specified once, e.g. the topology data of the Network Analysis functions is also used by the OTS function.

Methods
The mathematical model used to represent the long-term dynamics of a power system is the second-order differential equation known as the swing equation. One such equation is required for each electrical island. All generators within an island have a common acceleration and each generator’s accelerating power is proportional to its inertia.

Dynamic models for fossil-fired units, hydro units and combustion turbines are available. Similar units may share the same models. Load Tap Changers (LTCs) and phase shifters are also modelled.

The trapezoidal integration method is selected to solve the frequency dynamics equations because of its numerical stability.

A full system power flow is solved at pre-specified intervals (a multiple of the integration time step). The fast decoupled load flow algorithm is used.

Hardware Requirements
In the normal configuration the OTS uses one of the application servers in the system. Any application server may be used by OTS and any dispatcher console may be assigned to the OTS server. Nominally one console for the trainee and one for the instructor is needed. These consoles need not be permanently assigned to the OTS and could be used for other tasks when OTS is not active.

![Typical hardware configuration](image-url)