# ABB Information & Energy Management

## systems support Mexico's growing demand for electric power

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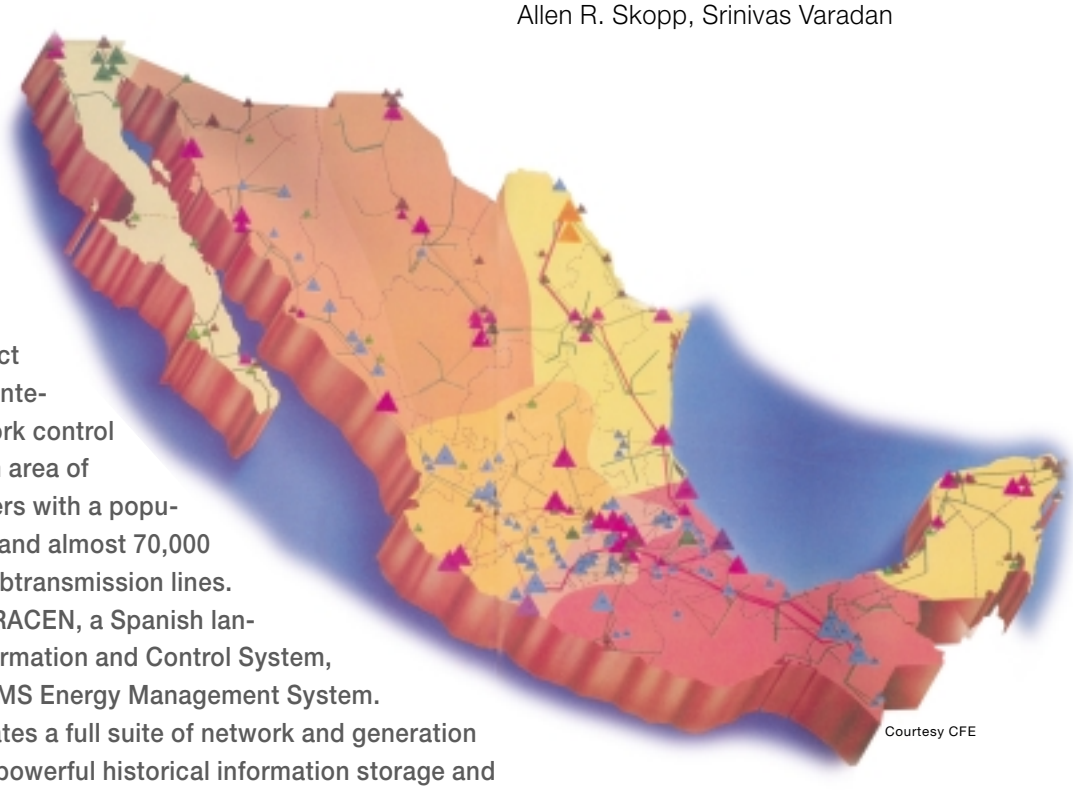
**ABB Network Management, a unit of ABB Automation, was selected by Mexico's national and capital-district electric utilities to implement a massive information and energy management system for control and administration of the country's electrical network. The ABB project has resulted in the largest totally integrated, multi-tiered electric network control system in the world – spanning an area of nearly two million square kilometers with a population of some 100 million people and almost 70,000 kilometers of transmission and subtransmission lines. The massive project is called SITRACEN, a Spanish language acronym for Real Time Information and Control System, and is based on ABB's Ranger® EMS Energy Management System. The hierarchical system incorporates a full suite of network and generation control applications, as well as a powerful historical information storage and retrieval system. The ABB project provides compatible nationwide networking, database, display management and server technologies, and all system elements are interconnected via a private network based on the ATM international protocol and the standard ICCP Inter Control Center Protocol.**



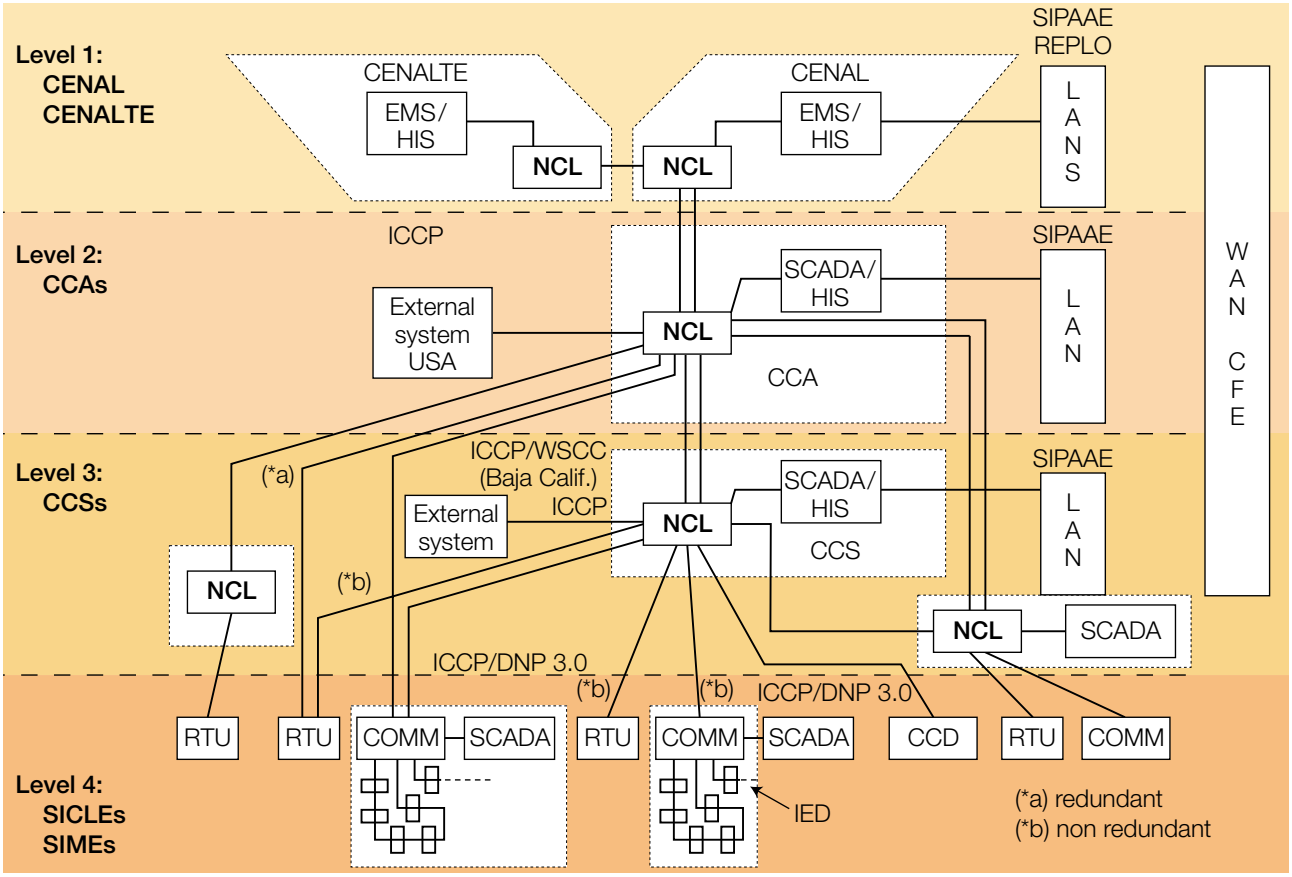
Courtesy CFE

In order to better manage the rapidly growing demand for energy, Mexico's Comisión Federal de Electricidad (CFE), elected to modernize the control systems for its entire electrical network. The project was implemented with Luz y Fuerza del Centro (LyFC), Mexico City's utility district. Due to the country's large size, the many areas into which it is organized, and multiple voltage levels, ABB and its customers chose to implement a multi-tiered control scheme.

The ABB system functions as a wholly integrated component of the nation's overall enterprise systems, and provides a real-time information source for electrical operations across the massive network. The hierarchical organization of the system is shown in 1.

*Level 1* consists of the National Control Center (CENAL) and the Alternate National Control Center (CENALTE), which supports identical functionality. The primary purpose of the remotely located CENALTE system is to serve as emergency backup. At other times, the alternate system functions as a training center for CFE personnel.

*Level 2* consists of eight Area Control Centers, including that of the Mexico City system, distributed throughout the nation. As a point of interest, one of the area




**1** ***General configuration of the SITRACEN project***

EMS *Energy Management System* HIS *Historical Information System* IED *Intelligent Electronic Device*

centers serves Baja, California and is located south of the US/Mexico border in Mexicali. Although part of the SITRACEN communication and information network, this area center is electrically isolated from the rest of the system. The CFE utility area is part of the WSCC (Western States Coordinating Council), which includes western Canada, the western United States and western Mexico.

*Level 3* consists of various Sub-area Control Centers. These are essentially SCADA systems working in association with their respective Area Control Center.

*Level 4* includes the following elements, all of which are connected to either area or sub-area centers via their respective Local Concentrator Nodes:

- Local Substation Control Systems for substation automation
- Integrated Energy Measurement Systems for data concentration
- Distribution control centers for distribution automation
- Remote terminal units

The SITRACEN system also interfaces with Mexico's existing 'System of Information for Administration, Analysis and Studies' and with the utility's Operations Planning Network. Each of these systems benefits from receipt of real-time information from the primary SITRACEN system.

The integrated real-time information and control system links master stations at various hierarchical levels through the data acquisition/communication servers comprising SITRACEN's wide area network. Local area networks at each level were designed to 'open systems' concepts to facilitate future upgrading of functionality and equipment.

*Table 1* shows the functionality available to energy control centers at each level in the hierarchy. Data from the SITRACEN system is available to CFE's other existing networks, as are the results from the State Estimator and the Historical Information System. Equally significant, the new EMS system is capable of interfacing with existing remote terminal units, which use a variety of legacy communication protocols.

## Secure, hierarchical database management

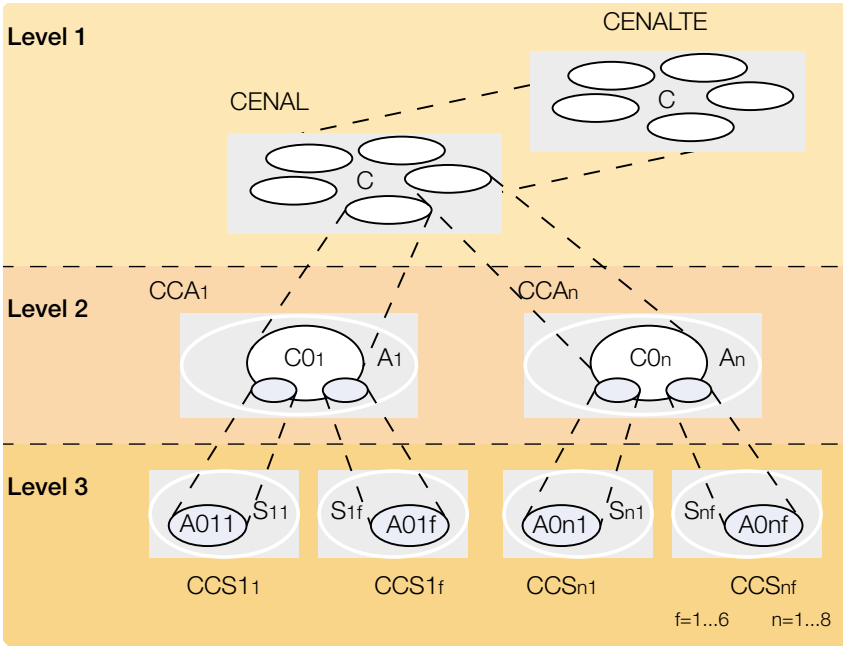
The SITRACEN Database Management System was the most challenging element of the project.

This component was especially critical due to the hierarchical nature of the operation, the size of the database, and the requirements posed by one-time data entry. Integrity and consistency of data across different levels of the hierarchy was also critical. Since the national, area and sub-area centers form a distributed and hierarchical control structure, the following sub-groups of data were defined:

- Data that pertain to a single hierarchical level
- Data that are shared by two or more levels

In order for the hierarchical database scheme to work successfully, the data at each level are organized into groups based on functionality, as shown in 2. At the lowest level, data are grouped into two sets: one for local use and another for observation and use by level 2 above. At level 2 itself, data are grouped into three sets: The first is for local use; the second is shared with the subordinate level, and the third is for observation and use by the system's top level. At level 1, the highest in the hierarchy, data is organized into two sets: the national center's own data and shared data from level 2.

The update and maintenance of data intended exclusively for local use is the responsibility of that level's database administrator. For changes to common tables at level 3, which are essentially in the form of 'insert' or 'modify' operations, an audit trail is maintained and sent to level 2 whenever there is a switch-over to the new, stable database. When level 2 receives the alarm message, the database administrator there may review, accept




2 *Hierarchical database organization*

**Table 1**
**SITRACEN: Functionality available to each energy control center at each level in the hierarchy**

| Main functions | CENAL & CENALTE | CCA | CCS |
|---|---|---|---|
| SCADA | X | X | X |
| AGC | X | X | |
| Network analysis in study mode and real time | X | X | Access by console |
| Pre-dispatch and post-dispatch applications | X | | |
| HIS | X | X | X |
| Data engineering system | X | X | X |
| Training simulator | X | X | |
| Communications subsystem with other levels of hierarchical control by NCL | X | X | X |
| Communication with CFE networks (SIPAEE, office LANs, etc) | X | X | X |
| Communication with external companies | Future function | X | X |

## Glossary

| | |
|---|---|
| ACE | *Area Control Error* |
| AGC | *Automatic Generation Control* |
| CCA | *Area Control Center* |
| CCD | *Distribution Control Center* |
| CCS | *Sub-area Control Center* |
| CENAL | *National Control Center* |
| CENALTE | *Alternate National Control Center* |
| CFE | *Comisión Federal de Electricidad (Mexican National Utility Company)* |
| CHT | *Hydro-Thermal Coordination* |
| DBA | *Database Administrator* |
| DBMS | *Database Management System* |
| ED | *Economic Dispatch* |
| EMS | *Energy Management System* |
| EPF | *Economic Participation Factor* |
| ESA | *Energy Accounting and Scheduling* |
| HC | *Hydro Coordination* |
| HIS | *Historical Information System* |
| ICCP | *Inter Control Center Protocol* |
| IDB | *Integrated Database* |
| IED | *Intelligent Electronic Device* |
| LAN | *Local Area Network* |
| LyFC | *Luz y Fuerza del Centro (Mexico City District Utility)* |
| NCL | *Local Concentrator Node* |
| OPF | *Optimal Power Flow* |
| PO | *Optimal Basepoint* |
| REPLO | *Operations Planning Network* |
| RS | *Resource Scheduling* |
| RTDB | *Real-time Database* |
| RTU | *Remote Terminal Unit* |
| SE | *State Estimator* |
| SICLE | *Local Substation Control System* |
| SIME | *Integrated Energy Measurement System* |
| SIPAAE | *System of Information for Administration, Analysis and Studies* |
| SITRACEN | *System of Information in Real Time for the Administration and Control of Energy* |
| SSP | *System Status Processor* |
| WAN | *Wide Area Network* |
| WSCC | *Western States Coordinating Council* |

or reject any changes as he deems appropriate for his level. Any modifications to the level 2 database in turn become part of the audit trail visible to level 1. The level 1 administrator, as well, may review, accept or reject lower-level changes passed to his database. The transfer of data records is automatically initiated via the Inter Control Center Protocol. When the level 1 administrator has completed and activated the desired changes to his database, this is confirmed by an alarm message sent back to all level 2 administrators.

At the customer's request, there is no communication between different entities at the same level (ie, CCS1 and CCS2 do not communicate directly with each other). It is the responsibility of the next-higher level, CCA in this case, to pass on the information from these entities whenever requested to do so. For maintenance purposes, the following additional capabilities are available:

- Total update of the database, performed in real time
- Incremental update, initiated where only selected changes are made in the real-time database

Additionally, it is possible for an operator to initiate on-line changes to the real-time database, such as changes to the operative limits. When the database is updated at more than one level, and one or more communications channels are not connected (communication interruption), the Database Manager marks updates for those points as pending. Once communications are re-established, the updates are automatically distributed. The database management system has the integrity, security and backup measures needed to ensure the specified system availability.

### Powerful historical information management

The Ranger® Historical Information System (HIS), featuring state-of-the-art compression and time-

based storage technology, is backed up for maximum security and seamlessly integrated with the SCADA/EMS system. The historical system allows information to be archived, at scan rate, for virtually every point in the system. This facilitates post-mortem analysis by storing all relevant information, including millisecond data. The reviewer can then more easily determine the correct trigger event after the fact, rather than try to pre-determine which areas must be set up for post-mortem analyses and then speculate on the correct trigger for each anticipated event.

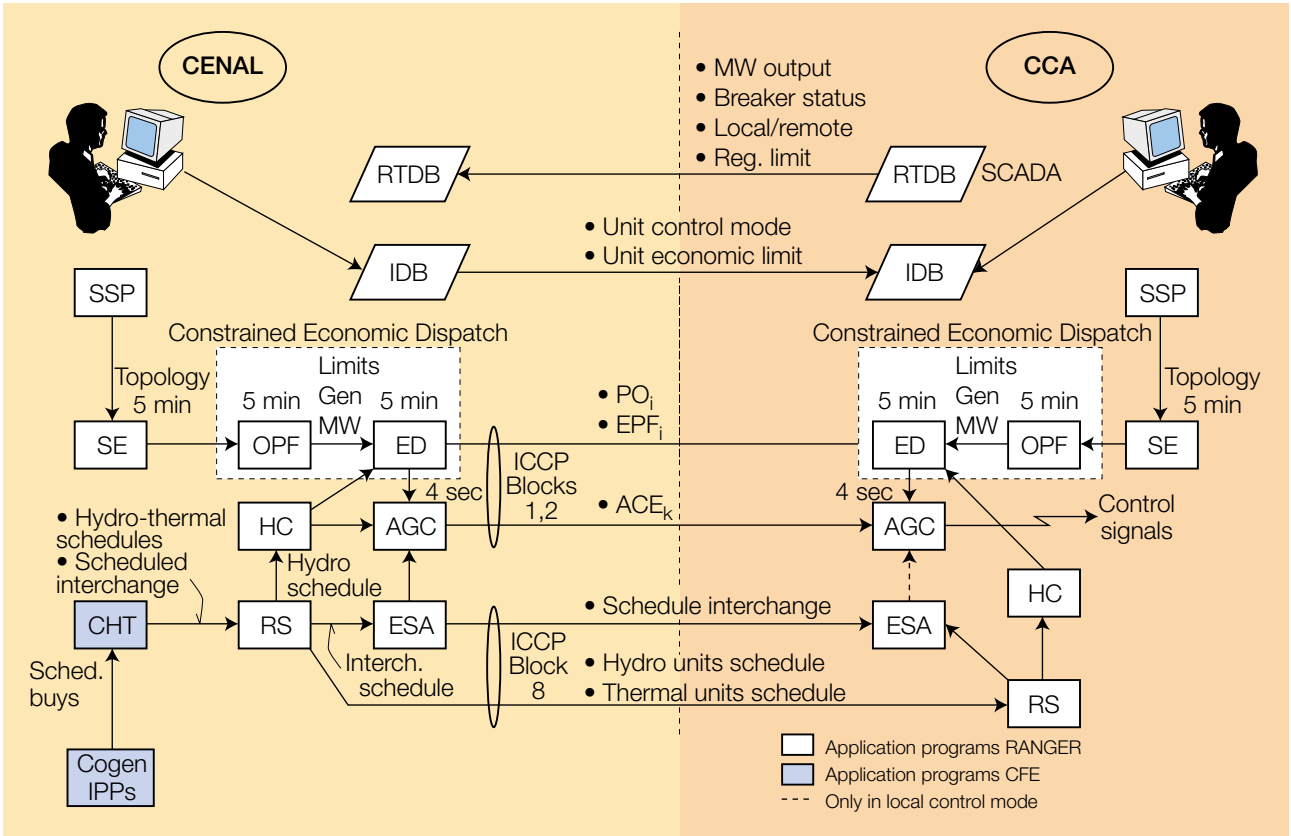
SITRACEN system data may be archived for a period of 10–15 years, without loss of resolution and without additional memory. The following data types are stored:

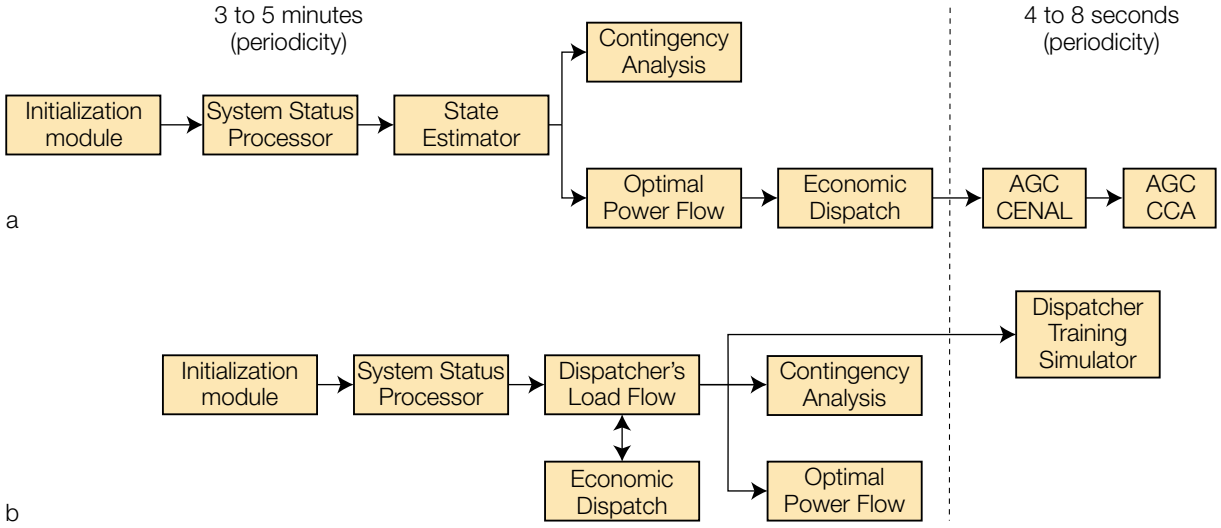
- Status and corresponding quality flags for each status point in the real-time database
- Sequence of Events state changes with sub-second timing information
- Engineering unit value and corresponding quality flags for each analog point in the real-time database
- Accumulator point's value and corresponding quality flags for each accumulator point in the database
- Engineering unit value changes for calculated data designated for maintenance by application programs

The Ranger historian data is set up in a client/server configuration, where it may be easily accessed (via SQL or ODBC) by various user-friendly, third-party applications for trending, user-defined reports prepared in Microsoft Word or PowerPoint, and spreadsheet-type applications such as Microsoft Excel for presentation or further analyses. Historical data are also available to CFE's established utility systems for corporate and executive functions. Further, the data may be used for executing energy management applications such as a Study Mode State Estimator and Dispatcher Training Simulator.

The ABB system also includes a library of specific application programming interfaces that allow hardware from multiple vendors to interconnect seamlessly with the historian server and clients. These interfaces position the Ranger system as an integral part of the utility's strategic enterprise management network.

**3** *Hierarchical AGC and Constrained Economic Dispatch scheme at CENAL and CCA*





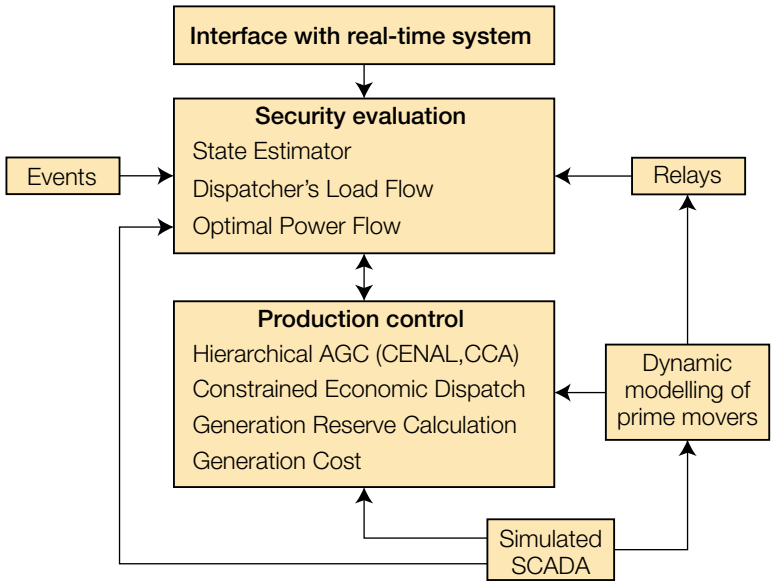

**4** *Real-time sequence of periodic applications* (a), *study mode applications* (b)

## Multiple applications; Single data entry

The applications programs developed and supplied by ABB Network Management are intended to satisfy functional needs in the areas of Energy Management and Control, Network Analysis, and Dispatcher Training Simulation.

While these applications fully support the hierarchical operation of the CFE system, all application source data are in a common database, and any data shared by multiple applications are entered only once. The ABB applications are designed to meet the needs of both the operators who supervise and control the power system, and the engineers/analysts who plan daily operations. For the latter, study cases based on real-time data can be initialized and state estimation performed using historical data from the ABB system.

**5** *Dispatcher Training Simulator schematic*




The various SITRACEN advanced application functions belong to one of the following types:

- Database for applications
- Production control functions
- Security assessment functions
- Functions to improve operations

Each of these advanced applications supports several individual functions, as shown in *Table 2*. These functions are requested for levels 1 and 2 only, and many run in either real-time, study mode, or both.

While the network security applications provide an interface to other CFE systems, the production planning system can use the output from an existing CFE application for Hydro-Thermal Coordination as its input. This requirement, coupled with the fact that

the Automatic Generation Control scheme is hierarchical, makes production planning more complex than it would be in a non-hierarchical system.

The hierarchical scheme is designed such that, in 'pool' mode, the Area Control Error is sent to the area center which, in turn, issues commands to its local units to minimize the error. These corrections are performed according to the results of the Constrained Economic Dispatch, Hydro-Thermal Coordination and Resource Scheduling functions at the national control center. In the event of a communication breakdown, local Automatic Generation Control changes to 'constant frequency' mode and controls the error within that area, using the results of its own Constrained Economic Dispatch functionality as shown in 3.

These network security applications are complemented by the usual suite of applications, including State Estimator, Dispatcher's Load Flow, Contingency Analysis and Optimal Power Flow. 4 shows the standard real-time and study mode sequence supplied by ABB for the SITRACEN system.

The Dispatcher Training System is illustrated in 5. This is available at both national and area levels, and simulates the hierarchical operation of the CFE power system based on operator-defined events.

**Table 2**
**Individual functions supported by advanced applications**

| Category | Functions |
|---|---|
| Database for applications | System Status Processor,<br>State Estimator |
| Production control functions | Hierarchical AGC,<br>Constrained Economic Dispatch,<br>Resource Scheduling,<br>Energy Accounting and Scheduling |
| Security assessment functions | Dispatcher's Load Flow,<br>Contingency Analysis,<br>Stability Margin Analysis |
| Functions to improve operations | Optimal Power Flow,<br>Resource Scheduling,<br>Neural Network Load Forecasting,<br>Dispatcher Training Simulator,<br>EMS Fault Calculation |

## Support for growth and system migration

As noted, the SITRACEN system is the largest totally integrated, multi-tiered electrical network control system in the world, and one of the largest implementations worldwide of the ICCP standard protocol. All ABB deliveries have been completed on schedule, and all installed systems functioned without incident during the year 2000 rollover.

The SITRACEN system is designed both to support expected growth in Mexico's energy demand and to facilitate migration of hardware and software to the evolving state of the art. The flexibility and open nature of the Ranger system design assures Comisión Federal de Electricidad and Luz y Fuerza del Centro that their systems will accommodate future requirements, both planned and unforeseen.

As much of the world moves toward deregulation of electric power, tools such as ABB's Ranger EMS and Historian systems will offer utilities the ability to precisely document production, marketing and delivery of energy via shared, multi-company power networks. End users will enjoy a greater choice of suppliers, while ABB provides to its customers the technology necessary for efficient, competitive operation. ■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