Project Executive Summary with Status Report
(status as of *November 2000*)

Project Title:	Enhanced State Estimation by Advanced Substation Monitoring
Research/Application Need:	Modern substations are equipped with advanced metering and control equipment along with the associated computer systems. This new capability is not fully utilized by the existing protection and control functions. On the other hand, the state estimator, one of the most critical security functions at the control centers, makes use of measurements taken at the substations. Pre-processing of these measurements at the substations prior to their tele-metering to the control centers can enhance the quality of the state estimator by allowing easy detection and elimination of topology errors, tracking of measurement errors and their variance, as well as monitoring of phase imbalances which are typically ignored in current practice.
Research Stem	Transmission and Distribution Technology
Academic Team Members:	Ali Abur and Mladen Kezunovic
Student Team Members:	Sasa Jakovljevic and Shan Zhong
Industry Team Members:	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P, TXU Electric
Research/Application Area:	Power System State Estimators, Substation Integrated Control and Protection Systems, Topology Error Identification and Detection, Monitoring Unbalanced Power System Operation
Start and End Dates:	September 2000- August 2002
Budget:	$38,000 per year

Project Description: This project is concerned with the integration of new types of analog and digital (contact status) measurements which are made available at the substations via the new generation of digital relays and other IEDs, into various state estimation functions in the energy management systems. The state estimation functions that would benefit from such an integration include topology error detection and identification, tuning of weights associated with various types of substation measurements as well as accounting for unbalances among phase measurements. Some of the measurements that exist at the substation level are never utilized by the state estimator since the overall system model does not include detailed representation of substation configurations. This project will integrate these redundant measurements at the substation level into the state estimator and will improve its topology error identification, error rejection and statistical robustness features.

Potential Benefits: State estimator provides and maintains a reliable data base for almost all steady state security functions that are run regularly at the control center during the daily operation. Therefore, the accuracy of its results are quite important for the system operator. In particular, those companies that experience significant load unbalances, frequent topology or analog errors, divergent or numerically non-robust state estimators with tuning problems can use this project's results to their benefit. The companies pursuing substation automation will be able to demonstrate how the new measurement infrastructure may be utilized for improvements in state estimators.

Deliverables: Prototype program for demonstration of project results and a final report describing the methods and algorithms developed.

Technical Approach: Detailed substation models will have to be developed. These models will incorporate measurements that are normally hidden or aggregated in conventional state estimators. Preprocessing of various internal substation measurements and contact information will lead to a corrected substation configuration at each scan of the measurements. An equivalent system model to correspond to the positive sequence component of the unbalanced system conditions will be developed. This will replace the existing single phase model used based on the balanced operation assumption. Time series techniques will be used to derive a tracking estimator for the error variances of the measuring instruments.

Work Plan:

Task	Description and Completion Date
1	Topology error detection and identification (Aug. 2001)
2	Monitoring of Unbalanced Flows (Dec. 2001)
3	Tuning of Measurement Weights (Aug. 2002)
4	Study of Supporting Substation Communication and Processing Architecture (Aug. 2002)

Related Work: Measurement calibration and tuning has been studied by Mike Adibi and Lamine Mili. Effects of line parameter variations on state estimators was investigated by Kevin Clements within the context of parameter estimation. Topology error detection and identification, system modeling at substation level with zero impedance branch representations were studied by Wu, Clements, Irwing, Sterling, and Monticelli in varying levels of detail.

How This Work Differs From Related Work: Most of the work so far concentrated on the available measurements at the control center in order to detect and identify anomalies related to either measurements themselves or the system topology. Proposed work is a first attempt to combine those measurements that are available but not currently used at the substations, with the existing RTU based information. It aims to improve the reliability of the existing state estimators by taking advantage of this increased redundancy.

Status: Project has started in September 2000. Two graduate students have been hired and have been working on the project tasks since then. No results have been reported yet.