Power Systems Engineering Research Center

Brief Summaries of On-Going and Completed Research Projects

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1 Introduction

This document summarizes PSERC's completed and continuing projects. These projects are categorized by research stem: Markets, Systems and T&D Technologies. Section 2 gives summaries of completed projects. Finally, Sections 3-5 contain descriptions of the stem research areas plus project summaries.

Questions on PSERC's research program and projects are welcomed. Questions on the research program should be sent to Vijay Vittal, Director, and to the appropriate Stem Committee leaders:

- Richard Schuler, Chair; Mark Sanford, Vice Chair, Markets Stem
- Jim McCalley, Chair; Mahendra Patel, Vice Chair, Systems Stem
- Jerry Heydt, Chair, Robert Saint, Vice Chair, T&D Technologies Stem

Questions and comments about the substance of PSERC's projects can be directed to the project leaders.

The projects described in the report do not include the work being conducted by PSERC researchers with the Consortium for Electric Reliability Technology Solutions. Information about the CERTS program can be found at http://certs.lbl.gov/.

User Notes

This document contains links within the document as well as links to resources available on the PSERC website. Clicking on any link (indicated by blue characters) will take you to the new location within the document or to the linked Internet site. You will have to be connected to the Internet to take advantage of the links to website resources. The table of contents is also linked to the appropriate section of the report.

Another useful tip is that Adobe Acrobat contains a "back-button" just like a browser. This will allow you to browse from one location in the document to another, and then return.

2 Completed Projects and Projects with Final Reports in Preparation

2.1 Markets Stem

Project Name	**Costing and Pricing of Ancillary Services (M-1)**
Summary	This project investigated methods for establishing justifiable costs for ancillary services. The work focused on the issues of costing reactive power and voltage control. It addressed questions of what it costs to maintain voltage; what it costs an energy provider to use an exciter; what operating costs can be allocated to voltage control; and how these services might affect a third party.
Project Team	Pete Sauer (Illinois - lead), Tom Overbye (Illinois), George Gross (Illinois), Fernando Alvarado (Wisconsin), Shmuel Oren (Berkeley) and James Momoh (Howard)
Industry	TVA, Entergy, Wisconsin Electric, ComEd and WAPA
Start Date and End Date	October 1997 to May 2000
Status	Final report (00-08) available in 2000 Reports Folder.

Project Name	**Market Mechanisms (M-2)**
Summary	This project focuses on market-based mechanisms for planning, scheduling and dispatching generation, transmission services and ancillary services. The project's development, customization and evaluation of market mechanisms incorporates the unique technological aspects of electric power.
Academic Team Members	Shmuel Oren (Lead), Fernando Alvarado, George Gross, Tim Mount, Richard Schuler, Robert Thomas, and Pravin Varaiya
Start Date and End Date	January 1998 to December 2000
Status	Final report (02-42) available in 2002 Reports Folder.

Project Name	**Market Interactions and Market Power (M-3)**
Summary	Given the move toward competitive power markets, this project is examining the incentives under market-based decision-making for market participants to invest in the careful design, operation and maintenance of the overall power system. Market designs will be proposed for ensuring power system enhancement under a wide range of operating condition and market forecast uncertainties.
Academic Team Members	Gerry B. Sheblé (Iowa State University – lead), Daniel Berleant (ISU) and Robert J. Thomas (Cornell)
Industry Team Members	Dale Stevens (MidAmerican)
Start Date and End Date	September 2000 to March 2003
Status	Final report (03-33) available in 2003 Reports Folder.

Project Name	**Market Redesign: Incorporating the Lessons Learned from Actual Experiences for Enhancing Market Design (M-4)**
Summary	This project's objectives are to assess the interactions between the operational and commercial aspects of electricity markets; to study the impacts of the institutional market design on the experiences to date; to identify the key requirements in the reform of the market structure and specification of the appropriate rules of the road; and to propose a set of modifications to improve market design so as to fully harness the benefits of competition in electricity.
Research Stem	Markets
Academic Team Members	Shmuel Oren (Berkeley – lead), Fernando Alvarado (Wisconsin), George Gross (Illinois), and Tim Mount (Cornell)
Start Date and End Date	July 2001 to August 2004
Status	Final report (05-55) available in 2005 Reports Folder.

Project Name	**Design and Development of Bidding Agents for Electric Supply Auctions (M-5)**
Summary	The goals of this work are to develop and demonstrate: a) software agents for electric energy auctions, b) metrics for evaluating and comparing electric energy auctions, and c) guidelines for the design of electric energy auctions
Research Stem	Markets
Academic Team Members	Sarosh Talukdar (Carnegie Mellon – lead), Shmuel Oren (Berkeley), Robert J. Thomas (Cornell) and Tim Mount (Cornell)
Start Date and End Date	July 2001 to August 2004
Status	Final report (05-37) available in 2005 Reports Folder.

Project Name	**Modeling Market Signals for Transmission Adequacy Issues: Valuation of Transmission Facilities and Load Participation Contracts in Restructured Electric Power Systems (M-6)**
Summary	A proposed model to be developed in this project will simulate the competitive and volatile power market environment, together with the physical operating constraints of the system, to provide a realistic tool for asset valuation, especially transmission assets.
Research Stem	Markets
Academic Team Members	Shi-Jie Deng (Georgia Tech-lead) A.P. Meliopoulos (Georgia Tech), Tim Mount (Cornell)
Industry Team Members	GE (Mark Sanford), Duke Energy (Noland Suddeth), ABB (Xiaoming Feng)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (07-02) available in 2007 Reports Folder.

Project Name	**Structuring Electricity Markets for Demand Responsiveness: Experiments on Efficiency and Operational Consequences (M-7)**
Summary	This project uses experimental methods to research such topics as the nature and extent of demand responsiveness (e.g. load shifting, overall load reduction, and lags in customer response), how it interacts with supplier behavior, and the implications for market power (by both sellers and buyers), market efficiency, and system operating stability.
Academic Team Members	Richard E. Schuler (Cornell-lead); Duane Chapman, Timothy Mount, William Schulze, Robert Thomas, Ray Zimmerman (Cornell) Shmuel Oren (Berkeley)
Industry Team Members	GE Power Systems (Mark Sanford); ISO-New England (Peter Wong); NYISO (Kathy Whitaker) and U.S. D.O.E. (Phil Overholt)
Start Date and End Date	June 1, 2002 to August 31, 2004
Status	Final report (04-33) available in 2004 Reports Folder.

Project Name	**Reliability Assessment Incorporating Operational Considerations and Economic Aspects for Large Interconnected Grids (M-8)**
Summary	The increasing frequency of transmission congestion due to the more intensive use of the grid brought about by the entry of many new players and by the proliferation in the number of transactions, has created a critical need for the assessment of the reliability of the bulk system. This project aims to construct models with appropriate level of detail of the operational procedures and economic aspects and use them to develop effective tools for evaluating the reliability and the associated economics of large bulk systems such as those of the RTOs currently in formation.
Academic Team Members	Lead: George Gross (UIUC), gross@uiuc.edu; Sakis Meliopoulos (GaTech), Richard Schuler (Cornell) and Chanan Singh (TAMU)
Industry Team Members	Ali A Chowdhury, MidAmerican Energy Company. Others being contacted.
Start Date and End Date	June 2004 – August 31, 2006
Status	Final report (07-01) available in 2007 Reports Folder.

Project Name	**Market Structures to Reduce Seams and Enhance Investment (M-9)**
Summary	The existing array of different markets used by ISOs in the U.S. will be compared with 1) conceptually ideal market structures, and 2) evidence (statistical over actual operation, experimental using human subjects and computational simulations) in order to devise a set of consistent regulations and market structures that would reduce existing seams (across ISO boundaries) and sluggish investment in G&T facilities. A necessary prerequisite for employing the experimental tool is the development and incorporation of markets for transmission rights into the PowerWeb platform.
Academic Team Members	Lead: Richard E. Schuler (Cornell, res1@cornell.edu, 607-255-7579) Team members: Tim Mount(Cornell, tdm2@cornell.edu) William Schulze (Cornell, wds3@cornell.edu) James Thorp (Cornell, jst6@cornell.edu) Ray Zimmerman (Cornell, rz10@cornell.edu) Shmuel Oren (Berkeley, OREN@ieor.berkeley.edu)
Industry Team Members	Jonathan Mayo, NYISO; Art Altman, EPRI; Mark Sanford, GE; Eugene Litvinov, ISO New England; Jean-Marie Coulondre, RTE
Start Date and End Date	June 1, 2004 – August 31, 2006.
Status	Final report preparation in progress

Project Name	**Uncertain Power Flows and Transmission Planning (M-10)**
Summary	To build a probabilistic or stochastic model of the multiple market trading process to determine the transmission requirements for the regional transmission organization to satisfy a specified level of reliable operation. Once the trading of the multiple markets has been modeled, then the impact on the transmission system over time can be determined for expansion possibilities.
Academic Team Members	Lead: Gerald Sheblé (ISU) – gbsheble@pdx.edu G.T. Heydt (ASU), Peter Sauer (University of Illinois)
Industry Team Members	Jerome Ryckbosch (RTE), John Chatelain (MidAmerican), Pei Zhang (EPRI)
Start Date and End Date	June 1, 2004 to August 31, 2006.
Status	Heydt and Sauer have completed Parts I and II in PSERC report 07-17. It is available for viewing in the PSERC Member Viewing Only folder. Part III (Sheblé) has been drafted. Now awaiting submittal. Sheblé has moved to Portland State University.

Project Name	**Evaluation of Alternative Market Structure and Compensation Schemes for Incenting Transmission Reliability and Adequacy Related Investments (M-11)**
Summary	The transmission inadequacy problem has resulted from the incentive-smearing cost-of-service regulation and incompleteness of market-based investment mechanisms, combined with the imbedded complexity of the system. The issue of providing efficient incentives for transmission investment is to be addressed based on the proposed forward market structures in pool-based systems.
Research Stem	Markets
Academic Team Members	Lead: Shi-Jie Deng (GaTech, deng@isye.gatech.edu, 404-894-6519) Team members: Tim Mount (Cornell, tdm2@cornell.edu) Shmuel Oren (Berkeley, oren@ieor.berkeley.edu)
Industry Team Members	Xiaoming Feng (ABB), Jianzhong Tong (PJM), Mark Sanford (GE Energy), Floyd Galvan (Entergy Corporation), Art Altman (EPRI)
Start Date and End Date	June 2005 – August 31, 2007.
Status	Final report preparation in progress.

Project Name	**Reliability, Electric Power, and Public Vs. Private Goods: A New Look at the Role of Markets (M-12)**
Summary	The economic theory that has been used to support restructuring of the electric power industry has ignored several important technological constraints and public goods that affect the way in which power is delivered. Some of these public goods include voltage, frequency, and reliability of lines. Similarly, engineers, by using security-constrained optimization to incorporate the demand for reliability, have failed to properly define the economic problem. This research attempts to remedy this deficiency through a collaborative effort between economists and engineers to examine the theoretical and empirical properties of a networked power system that provides economically optimal reliability and draw conclusions regarding efficient market design.
Research Stem	Markets (and Systems)
Academic Team Members	Lead: William Schulze (Cornell, wds3@cornell.edu, 607-255-9611) Team members: George Gross (Illinois, gross@uiuc.edu) Daniel Tylavsky (Arizona State University, tylavsky@asu.edu)
Industry Team Members	William Museler, President and CEO, NYISO; Theresa Flaim, Senior V. P. Strategic Planning and Analysis, TVA; Vic Niemeyer, EPRI.
Start and End Dates	June 2005 - August 31, 2007.
Status	Final report preparation in progress

Project Name	**The Electric Power Industry and Climate Change – Discussion Paper (M-19)**
Summary	Interest in identification of possible research topics that address the interaction between the power system and climate change was expressed at the 2006 PSERC summer workshop. Conversations at the workshop called for clarification of possible research topics that could be considered by the Stem Committees. In response to these conversations, this project proposes a short discussion paper (10 to 15 pages) to identify possible research topics related to the power system-climate change interaction, in order to inform Stem Committee deliberations on their research plans for the 2007 and future research solicitations.
Research Stem	All three stems, with the Markets Stem as the lead stem.
Academic Team Members	Project Leader: Tom Overbye (UIUC, overbye@uiuc.edu, 217-333-4463) Team members: Judith Cardell (Smith College, jcardell@smith.edu); Ian Dobson (University of Wisconsin-Madison, dobson@engr.wisc.edu); Ward Jewell (Wichita State University, ward.jewell@wichita.edu); Mladen Kezunovic (Texas A&M University, kezunov@ece.tamu.edu); PK Sen (Colorado School of Mines, psen@mines.edu); Dan Tylavsky (Arizona State University, tylavsky@asu.edu)
Industry Team Members	Lisa Beard (TVA); Hamid Elahi and Devin Van Zandt (GE); Floyd Galvan (Entergy); Jay Giri and Lawrence Jones (AREVA T&D); David Hawkins (CAISO); Mariann Quinn (DUKE); Bob Saint (NRECA), Bob Wilson (WAPA)
Start Date and End Date	January 1, 2007 – June 30, 2007
Status	Final report (07-16) available in 2007 Reports Folder.

2.2 Systems Stem

Project Name	**Identification and Tracking of Parameters for a Large Synchronous Generator (S-1)**
Summary	The research objective of this project is to identify the transient and subtransient parameters of the field winding of a large synchronous generator from operating data, and to develop a visual GUI-driven software package as a support tool. Particular emphasis will be placed on the deterioration of shorted field turns. Results will allow identification of shorted field turns and incipient failures of the field of a large synchronous generator, and tracking of selected parameters in both time and with respect to operation.
Project Team	Jerry Heydt (Arizona State – lead), Dick Farmer (Arizona State) and J. Rico (Arizona State)
Industry	Baj Agrawal and Douglas Selin (Arizona Public Service)
Start Date and End Date	December 1996 to December 2001
Status	Final report (02-18) available in 2002 Reports Folder.

Project Name	**Voltage Collapse Margin Monitor (S-2)**
Summary	In this project, the researchers are developing a prototype software tool for systematically monitoring and assessing how close a power system is to voltage collapse considering variations in demand, power transactions and other system operating conditions.
Project Team	Hsiao-Dong Chiang (Cornell – lead), Pete Sauer (Illinois) and Ian Dobson (Wisconsin)
Start Date and End Date	October 1997 to December 2000
Status	Final report (01-02) available in 2001 Reports Folder.

Project Name	**Avoiding and Suppressing Oscillations (S-3)**
Summary	This determined the feasibility of computations to advise operators on how to avoid or suppress large-scale system oscillations. It provided the basic understanding of the problem, developed approaches to solving the problem, and tested them to determine their feasibility.
Project Team	Ian Dobson (Wisconsin – lead), Fernando Alvarado (Wisconsin), Chris DeMarco (Wisconsin), and Pete Sauer (Illinois)
Start Date and End Date	October 1997 to September 1999
Status	Final report (00-01) available in 2000 Reports Folder.

Project Name	**Impact of Protection Systems on Reliability (S-4)**
Summary	This project is developing tools for computing the increase in transmission system reliability from investments in new equipment, and from changes in relaying philosophy or in operating policy. A statistical approach is used to investigate where changes in the protection system could be most effective and to evaluate the reliability improvement obtained from monitoring the protection system.
Project Team	Jim Thorp (Cornell – Lead) and Jim Bucklew (Wisconsin)
Start Date and End Date	January 1998 to December 2000
Status	Final report (01-01) available in 2001 Reports Folder.

Project Name	**Automated Operating Procedures for Transfer Limits (S-5)**
Summary	This project concerns automation of the operating procedures governing the establishment of transfer limits across major tie lines. This work integrates off-line studies with more general methods for ensuring dynamic security, thus improving on procedures that rely on predetermined intertie limits. The project focuses on the California - Oregon interties because specific operating procedures are available for study.
Project Team	Kevin Tomsovic (Washington State – lead) and Anjan Bose (Washington State)
Industry	Bob Stuart (PG&E)
Start Date and End Date	October 1998 to September 2000
Status	Final report (01-05) available in 2001 Reports Folder.

Project Name	**New System Control Methodologies (S-6)**
Summary	This project examined new automatic generation control methodologies to accommodate alternative scenarios for competitive markets. This examination included the separate ancillary services of scheduling and dispatch, frequency control, voltage control, loss allocation, and spinning reserve requirements. The project identified the interaction and issues between technical requirements and economic incentives of alternative operating scenarios. Prototype control designs were studied in a MATLAB-based dynamic test.
Research Stem	Systems
Academic Team Members	Chris DeMarco (Wisconsin – lead), Ian Dobson (Wisconsin), M. A. Pai (Illinois) and Ian Hiskens (Illinois)
Start Date and End Date	October 1999 to September 2002
Status	Final report (05-64) available in 2005 Reports Folder.

Project Name	**Integrated Security Analysis (S-7)**
Summary	This project is investigating the integration of existing tools for static, dynamic, voltage and steady-state stability security assessment into a comprehensive security analysis framework. The objective is to improve efficiency for determining security results from both off-line and on-line computations, and for effectively conveying those results to system operators. The project will exploit new concepts in intelligent systems.
Academic Team Members	Kevin Tomsovic (Washington State University – lead) and Pete Sauer (Illinois)
Start Date and End Date	October 1999 to September 2001
Status	Final report (02-41) available in 2002 Reports Folder.

Project Name	**Coordination of Line Transfer Capability Ratings (S-8)**
Summary	Power transfer capacity is limited by non-linear phenomena including constraints on reactive power reserves, transient stability limits and damping of inter-area oscillations. This project will develop tools for computing optimal transfer capability of strategic transmission paths under power-flow and small-signal stability constraints.
Academic Team Members	Mani V. Venkatasubramanian (Washington State University – lead)
Start Date and End Date	October 1998 to September 2001
Status	Final report (02-28) available in 2002 Reports Folder.

Project Name	**Visualization of Power Systems (S-9)**
Summary	This project's goal is to develop innovative methods to assist players in the electricity industry to extract and visualize knowledge concerning power system capacity and constraints. Researchers will explore the use of techniques for knowledge extraction using two-dimensional displays and a three-dimensional virtual environment.
Academic Team Members	Tom Overbye (Illinois – lead), Bob Thomas (Cornell), and Doug Wiegmann (Illinois)
Industry Team Members	TVA, Entergy, Wisconsin Electric, ComED, and WAPA.
Start Date and End Date	January 1, 2000 to December 31, 2001
Status	Final report (02-36) available in 2002 Reports Folder.

Project Name	**Power System State Estimation and Optimal Measurement Placement For Distributed Multi-Utility Operation (S-10)**
Summary	Industry restructuring calls for fundamental changes in how state estimation is done in power systems. This research investigates (1) optimal design of metering systems (particularly to maintain full system observability during switching actions), (2) distribution of data and computational burdens of state estimation among participating control areas, and (3) methods for estimating controller and system parameters as well as state variables.
Research Stem	Systems
Academic Team Members	Ali Abur (Texas A&M – lead) and Garng M. Huang (Texas A&M)
Industry Team Members	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P and Oncor
Start Date and End Date	September 2000 to August 2002
Status	Final report (02-45) available in 2002 Reports Folder.

Project Name	**Steady State Voltage Security Margin Assessment (S-11)**
Summary	This project focuses on the determination of the steady state voltage security margin of a given high voltage transmission grid, under specified transactions and loading conditions. Implemented procedures, with associated software, will produce security margin estimates for any selected bilateral transaction in a power system, and allocate reactive power usage to loads and transactions.
Research Stem	Systems
Academic Team Members	Garng M. Huang (Texas A&M – lead) and Ali Abur (Texas A&M)
Industry Team Members	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P and Oncor
Start Date and End Date	September 2000 to August 2002
Status	Final report (02-49) available in 2002 Reports Folder.

Project Name	**Robust Control of Large-Scale Power Systems (S-12)**
Summary	This research extends existing methods for robust stability analysis to deal with large-scale power system problems resulting in part from the restructuring of the electric power industry to achieve competitive market-based decision-making. It applies modern robust control methods to develop computationally tractable algorithms suitable for large-scale problems.
Research Stem	Systems
Academic Team Members	Vijay Vittal (Arizona State University – lead), Mustafa Khammash (Iowa State University), Chris DeMarco (University of Wisconsin), and Peter Young (Colorado State University)
Industry Team Members	Innocent Kamwa (IREQ) and Dale Stevens (MidAmerican)
Start Date and End Date	September 1, 2000 to August 31, 2002
Status	Final report (02-43) available in 2002 Reports Folder.

Project Name	**Comprehensive Power System Reliability Assessment (S-13)**
Summary	This project uses an integrated approach to reliability assessment to address issues associated with component reliability as well as system reliability. The proposed reliability analysis methods will provide reliability indices at the customer site, and sensitivities of reliability levels to specific power market transactions. The results will enable cost benefit analyses (since design options can be easily characterized with cost) and risk assessment.
Research Stem	Systems
Academic Team Members	A. P. Meliopoulos (Georgia Tech – lead), David Taylor (Georgia Tech), and Chanan Singh (Texas A&M)
Industry Team Members	Mike Agee (Duke Energy)
Start Date and End Date	January 2001 to December 2003
Status	Final report (05-13) is available in 2005 Reports Folder.

Project Name	**Risk-Based Maintenance Allocation and Scheduling for Bulk Transmission System Equipment (S-14)**
Summary	The objective of this project was to develop a method of allocating economic resources and scheduling maintenance activities among bulk transmission system equipment (e.g., lines, transformers, generators, and protection systems) as a function of system risk associated with network security problems such as overloads, low voltages, cascading overloads, and voltage instability.
Research Stem	Systems
Academic Team Members	Jim McCalley (Iowa State - lead), Tim Van Voorhis (Iowa State University) and A. P. Meliopoulos (Georgia Tech)
Industry Team Members	Ali Chowdury (Mid-American Energy)
Start Date and End Date	July 2001 to August 2003
Status	Final report (03-26) available in 2003 Reports Folder.

Project Name	**Extended State Estimation for Synchronous Generator Parameters (S-15)**
Summary	This project will produce a practical, accurate method for on-line identification of synchronous generator parameters. Also, the development of an estimate of the confidence of the model is included in the work. The project includes an innovative concept in the identification of synchronous generator exciters. The value of these models is an accurate representation of the synchronous generator in ETMSP and other day-to-day studies for power systems. A graphic user interface is under design. The GUI will include a user friendly data input linker, parameter estimator and tracker, user friendly output of data, and a confidence indicator.
Research Stem	Systems
Academic Team Members	George Karady (Arizona State – lead) and Gerald T. Heydt (Arizona State – lead) Research team members: Keith Holbert (ASU), Vijay Vittal (ASU), and Garng Huang and Chanan Singh (TAMU)
Industry Team Members	Arizona Public Service (Baj Agrawal, Doug Selin) and TVA (Dale Bradshaw)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (05-36) available in 2005 Reports Folder.

Project Name	**Security Enhancement through Direct Non-Disruptive Load Control (S-16)**
Summary	Incorporating direct load control at times when the system is vulnerable can significantly enhance system security. Modern technology facilitates direct load control schemes in which customer loads having special characteristics can be effectively controlled with minimum disruption to the customer. This project examines the benefits, methods of analysis, and potential control structures that can be used.
Research Stem	Systems
Academic Team Members	Ian Hiskens (Illinois-lead) Vijay Vittal (Arizona State)
Industry Team Members	Entergy (Sharma Kolluri) GE Power Systems (Nick Miller) IREQ Hydro Quebec (Innocent Kamwa)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Reports for Parts I and II are available in 2006 Reports Folder. PSERC Documents 06-01 and 06-02.

Project Name	**Techniques for the Evaluation of Parametric Variation in Time-Step Simulations (S-17)**
Summary	The results of time-step simulations are used to make crucial decisions in planning and operation; however the models used in such simulations contain many parameters that are poorly known or may take on a range of values. Tools are required to efficiently relate uncertainty bounds or probability distributions on parameter values to variations in critical outcomes of time-step simulations.
Research Stem	Systems
Academic Team Members	Christopher DeMarco (Wisconsin-lead) Sandip Roy and Mani Venkatasubramanian, Washington State University
Industry Team Members	IREQ (Luc Audette, Alain Valette)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report in preparation

Project Name	**Visualization of Power Systems and Components (S-18)**
Summary	Electric power systems are characterized by an overwhelming amount of data. The goal of this project is the continued development of better visualization techniques to help glean useable information from this data.
Research Stem	Systems
Academic Team Members	Tom Overbye (Illinois-lead) Doug Wiegmann (Illinois) and Sakis Meliopoulos (Georgia Tech)
Industry Team Members	TVA (Keith Morris and Warren Wu), Exelon (Dan Sleezer and David Schooley), ATC (Paul Walter and Don Morrow), WAPA (Paulette Kaptain), PowerWorld (Ray Klump and Jamie Weber)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (05-65) available in 2005 Reports Folder.

Project Name	**Detection, Prevention and Mitigation of Cascading Events (S-19)**
Summary	This project will investigate novel approaches using new technologies to provide effective control of cascading disturbances and to enhance reliability. When a power system is subjected to large disturbances, and the vulnerability analysis indicates that the system is approaching a potential catastrophic failure, control actions need to be taken to steer the system away from severe consequences, and to limit the extent of the disturbance. We are approaching the problem in three steps: 1. Detection of major disturbances and protective relay operations leading to cascading events. 2. Wide area measurement based remedial action. 3. Adaptive islanding with selective underfrequency load shedding.
Research Stem	Systems
Academic Team Members	Vijay Vittal (Arizona State University-lead) Mladen Kezunovic (Texas A&M) and Mani Venkatasubramanian (Washington State)
Industry Team Members	Hydro Quebec, IREQ (Innocent Kamwa) MidAmerican Energy (Miodrag Djukanovic) Entergy (Sharma Kolluri)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Parts I, II and III are complete and available in the 2005 Reports Folder. PSERC Documents 05-59 to 05-61.

Project Name	**New Implications of Power System Fault Current Limits (S-20)**
Summary	This is a research project on the operating limitations imposed by the appearance of high fault currents in power systems. The higher fault current is a consequence of the appearance of new generation sources in power systems.
Research Stem	Systems
Academic Team Members	Lead: G. T. Heydt (Arizona State University) Team: Anjan Bose (Washington State University) and Sakis Meliopoulos (Georgia Tech)
Industry Team Members	Exelon (Jim Crane), General Electric (Nick Miller)
Start Date and End Date	December 2003 to January 2006
Status	Final report (05-62) available in 2005 Reports Folder.

Project Name	**On-Line Transient Stability Assessment (S-21)**
Summary	Scoping study to review the state of the art and establish requirements for on-line transient stability analysis and preventive and corrective control following transient insecurity.
Research Stem	Systems
Academic Team Members	Lead: Vijay Vittal (Arizona State University) Team members: Peter Sauer (Univ. of Illinois) and Sakis Meliopoulos (Georgia Tech)
Industry Team Members	Mike Miller (Southern Company), Miodrag Djukanovic (MidAmerican Energy) and Kolluri Sharma (Entergy)
Start Date and End Date	December 2003 to April 2005
Status	Final report (05-04) available in 2005 Reports Folder.

Project Name	**Enhanced State Estimators (S-22)**
Summary	This is a research project on enhancements for power system state estimators. The main objective is to increase accuracy and robustness to the point that operators will have a high level of confidence in the use of these software tools. A second objective is to utilize automated features for self-tuning and improved models for high accuracy.
Research Stem	Systems
Academic Team Members	Lead: Ali Abur (Northeastern University; abur@ece.neu.edu; 617-373-3051) Team: G. T. Heydt (Arizona State University), A. P. S. Meliopoulos (Georgia Tech)
Industry Team Members	Dale Krummen (AEP), Jay Giri (ESCA), Jerome Ryckbosch (RTE-France), Ram Adapa (EPRI), Dr. Choo (KEPRI), Peter Hirsch (EPRI)
Start Date and End Date	June 2004 to August 31, 2006.
Status	Final report available in the 2006 Reports folder as PSERC Document 06-45. A project-related thesis by Rice is available in the 2007 Reports Folder. PSERC Document 07-08.

Project Name	**Optimal Placement of Phasor Measurement Units for State Estimation (S-23G)**
Summary	This project is concerned about optimal placement of phasor measurement units in order to make a power system fully observable.
Research Stem	Systems
Academic Team Members	Lead: Ali Abur, TAMU Team members: Ali Abur, TAMU
Industry Team Members	Warren Wu (TVA) and Lisa Beard (TVA)
Start Date and End Date:	June 2004 to July 2005
Status	Final report (05-58) available in 2005 Reports Folder.

Project Name	**Optimal Allocation of Static and Dynamic VAR Resources (S-24)**
Summary	Develop methodologies for optimal selection and placement of static and dynamic VAR resources in a system. Criteria for determining the optimal level and location of dynamic VAR sources will be investigated and proposed including voltage recovery requirements, protective relay response, voltage stability margin requirements and other. A methodology to optimize the amount and placement of static and dynamic VAR sources will be developed that satisfies the criteria. The issue of modeling load dynamics will be addressed and methodologies for accounting for the variability of loads and their dynamics will be developed.
Research Stem	Systems
Academic Team Members	Lead: A. P. Meliopoulos (GIT, sakis.meliopoulos@ece.gatech.edu, 404-894-2926) Team Members: V. Ajjarapu (ISU, vajjarap@engr.iastate.edu), Jim McCalley (ISU, jdm@iastate.edu), Ian Hiskens (UW, Madison, hiskens@engr.wisc.edu), V. Vittal (ASU, vijay.vittal@asu.edu)
Industry Team Members	Sharma Kolluri/Floyd Galvan (Entergy), Jiuping Pan, ABB, Mike Ingram/Lisa Beard (TVA), Raymond Vice (Southern Co.), Ali Chowdury (Mid-American), Ed Ernst (Duke), Dale Krummen (AEP), Baj Agrawal (APS), Aty Edris (EPRI)
Start Date and End Date	June 1, 2005 to August 31, 2007.
Status	Final report preparation in progress.

Project Name	**Effective Power System Control Center Visualization (S-25)**
Summary	Electric power systems are characterized by an overwhelming amount of data. The goal of this project is the continued development of better visualization techniques to help glean useable information from this data with an emphasis on control room applications.
Research Stem	Systems
Academic Team Members	Lead: Tom Overbye (U of Illinois, overbye@ece.uiuc.edu, 217-333-4463) Team members: Sakis Meliopoulos (Georgia Tech, sakis.meliopoulos@ece.gatech.edu) Esa Rantanen (replacing Doug Wiegmann) (U of Illinois, dwiegmann@uiuc.edu)
Industry Team Members	PJM (Ken Huber, Jianzhong Tong), TVA (Lisa Beard), Exelon (David Schooley), AEP (Dale Krummen), PowerWorld (Jamie Weber and Ray Klump), Entergy (Floyd Galvan), AREVA (Jay Giri), Southern Company (Ray Vice), Powertech/BCTC (Kip Morison), ISO New England (Eugene Litvinov), Khoi Vu (ABB), Paulette Kaptain (WAPA), Pei Zhang (EPRI)
Start Date and End Date	June 1, 2005 to August 31, 2007.
Status	Final report preparation in progress.

Project Name	**Risk of Cascading Outages (S-26)**
Summary	We will develop tools for monitoring and managing the risk of cascading outages. These tools will identify contingencies that could initiate cascading outages, estimate the overall risk (high, medium or low), and provide advice to operators on how to reduce the risk.
Research Stem	Systems
Academic Team Members	Lead: Sarosh Talukdar (Carnegie Mellon, talukdar@cmu.edu) Team members: Jim McCalley (Iowa State) and Ian Dobson (Wisconsin)
Industry Team Members	Yuri Makarov CAISO Jianzhong Tong PJM Kip Morison Powertech Labs Inc Eugene Litvinov ISO New England Ali Chowdhury MidAmerican Energy Co Floyd Galvan Entergy Corporation Khoi Vu ABB Anatoliy Meklin PG&E Lawrence Jones AREVA Ram Adapa EPRI Rod Hardiman Southern Co
Start Date and End Date	Project Period: June 2005 to August 31, 2007.
Status	Final report preparation in progress.

Project Name	**A Tool for On Line Stability Determination and Control for Coordinated Operating between Regional Entities Using PMUs (S-27)**
Summary	This project deals with the development of an analytical tool to determine *on line* transient stability limits using phasor measurements from PMUs and to coordinate operating criteria between widely dispersed regional operating areas.
Research Stem	Systems
Academic Team Members	Lead: Vijay Vittal (Iowa State University, vijay.vittal@asu.edu, 515-294-8963) Team members: G. T. Heydt (Arizona State University, heydt@asu.edu) A. P. Meliopoulos (Georgia Tech University, sakis@comcast.net)
Industry Team Members	Sharma Kolluri – Entergy Corporation Navin Bhatt – AEP Lisa Beard – TVA Peter Hirsch – EPRI Kip Morison – Powertech Labs
Start Date and End Date	June 1, 2005 to August 31, 2007.
Status	Final report preparation in progress.

2.3 Transmission and Distribution Technologies Stem

Project Name	**Corona Discharge Caused Deterioration of All Dielectric Self-Supporting (ADSS) Fiber-Optic Cables (T-1)**
Summary	This project reports on experimental studies for identifying the severity of corona-caused deterioration of fiber-optic cable, and for determining the effect of rain and fog on the severity of the deterioration. Comparisons are made of cables made by different manufacturers.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	George Karady (Arizona State – lead)
Industry Team Members	Monty W. Touminen (BPA)
Start Date and End Date:	June 1996 to December 2001
Status	Final report (02-17) available in 2002 Reports Folder.

Project Name	**Differential GPS Measurement of Overhead Conductor Sag (T-2)**
Summary	This research project will develop a device for measuring overhead conductor sag using a global positioning satellite. Use of this device in an on-line EMS will aid power system operators by providing additional data on system condition.
Project Team	Jerry Heydt (Arizona State – lead) and Robert Olsen (Washington State)
Industry	John Schilleci (Entergy) and Baj Agrawal (Arizona Public Service)
Start Date and End Date:	August 1997 to December 2001
Status	Final report (02-24) available in 2002 Reports Folder.

Project Name	**On-Line Peak Loading of Substation Distribution Transformers Through Accurate Temperature Prediction (T-3)**
Summary	This project's objective is to develop a production-grade software application that can be used to predict transformer top-oil and hot-spot temperature. This software will allow planners to more accurately know when an additional substation distribution transformer bay is needed.
Project Team	Dan Tylavsky (Arizona State – lead)
Start Date and End Date:	August 1998 to July 2001
Status	Final report (01-21) available in 2001 Reports Folder.

Project Name	**Electrical Transmission Line Insulator Flashover Predictor (T-4)**
Description	Under this research project, a technique is developed to measure and analyze the "signature" of leakage current in transmission line insulators to predict the probability of a flashover and to estimate the insulator's "pollution level" (as measured by the equivalent salt deposit density). To test the technique, a leakage current monitor will be constructed with a cellular phone interface and installed on an actual transmission tower.
Project Team	George Karady (Arizona State – lead)
Industry	Salt River Project
Start Date and End Date	August 1999 to July 2001
Status	Final report (01-16) available in 2001 Reports Folder.

Project Name	**Intelligent Substation (T-5)**
Summary	To advance the effective use of predictive maintenance, this project integrates technological advances from artificial intelligence, fault diagnostics, and data processing to provide the technical capability at substations for self-monitoring, self-diagnosis and communication of self-assessment results to a substation maintenance authority.
Academic Team Members	Rahmat A. Shoureshi, University of Denver (lead) and Mladen Kezunovic (Texas A&M)
Industry Team Members	John Work and Paulette Kaptain (Western Area Power Administration); Luke van der Zel (EPRI)
Start Date and End Date:	September 1999 to March 2004
Status	Final report (04-26) available in 2004 Reports Folder.

Project Name	**Condition Monitoring and Maintenance Strategies for In-Service Nonceramic Insulators (NCI), Underground Cables and Transformers (T-6)**
Summary	This project focuses on assessment of the condition of nonceramic insulators for preventive maintenance planning, and development of laboratory test methods for rapid and meaningful prediction of future performance. Topics in the research include: • Effect of electrical discharges (corona and arcing) on housing performance under humid conditions. • Brittle fracture research on fiberglass rods for nonceramic insulators. • Aging tests on nonceramic distribution insulators. • Inspection guide for replacing nonceramic insulators.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	Ravi Gorur (Arizona State – lead)
Industry Team Members	Salt River Project
Start Date and End Date	August 2000 to August 2001
Status	Final report (02-25) available in 2002 Reports Folder.

Project Name	**Redesign and New Interpretation of Power Acceptability Curves for Three Phase Loads (T-7)**
Summary	The principle objective of this project is the modification of power acceptability curves to improve their accuracy with three phase loads. Curves will be analyzed considering energy disturbances and different load levels. One result of the work will be the development of a method for determining whether short and longer transient voltage sags are acceptable or unacceptable.
Project Team	Gerald T. Heydt (Arizona State – lead) and Raja Ayyanar (Arizona State)
Industry	Rao Thallam, John Blevins and Tom LaRose (Salt River Project)
Start Date and End Date	August 2000 to December 2001
Status	Final report (01-28) available in 2001 Reports Folder.

Project Name	**Investigation of Fuel Cell Operation and Interaction within the Surrounding Network (T-8)**
Summary	In this research, technical and economic issues associated with the use of fuel cells will be investigated by studying the operation of a 200 kW gas-fired fuel cell installed in Mesa, Arizona State. Potential problems due to interaction with the local distribution network will be identified and the effects of several fuel cells operating in parallel will be assessed.
Project Team	George Karady (Arizona State – lead)
Industry	Salt River Project
Start Date and End Date	August 2000 to December 2001
Status	Final report (02-26) available in 2002 Reports Folder.

Project Name	**Enhanced State Estimation via Advanced Substation Monitoring (T-9)**
Summary	This project concerns innovative methods for using new types of analog and digital measurements at substations for improving state estimation. The new measurements are provided by a new generation of digital relays and other IEDs. The project will investigate a range of state estimation issues and will develop a prototype computer program that will be used to illustrate the effectiveness of the developed methods using real-life scenarios.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	Ali Abur (Texas A&M – lead), Mladen Kezunovic (Texas A&M) and A.P. Meliopoulos (Georgia Tech)
Industry Team Members	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P and Oncor
Start Date and End Date	September 1, 2000 to August 31, 2002
Status	Final report (02-48) available in 2002 Reports Folder.

Project Name	**Accurate Fault Location in Transmission and Distribution Networks Using Modeling, Simulation and Limited Field-Recorded Data (T-10)**
Summary	This research is to develop algorithms for accurate fault location in transmission and distribution systems. Accurate fault location will enhance quick restoration of the system. Genetic algorithms, short circuit studies, transmission line traveling wave theory and the wavelet transform will be used to develop the algorithms.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	Mladen Kezunovic (Texas A&M – lead) and Ali Abur (Texas A&M)
Industry Team Members	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P and Oncor
Start Date and End Date	September 1, 2000 to August 31, 2002
Status	Final report available in 2002 Reports folder. PSERC Document 02-44.

Project Name	**Power System Monitoring Using Wireless Substation and System-Wide Communications (T-11)**
Summary	This project investigates wireless power system monitoring applications that communicate real-time data from substations. Research will be conducted on issues associated with data acquisition and collection, and algorithms for system-wide communications using mobile agents. A particular application, monitoring circuit breaker operations for maintenance decision-making, will be studied.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	Mladen Kezunovic (Texas A&M – lead), Costas Georghiades (Texas A&M) and Rahmat A. Shoureshi (Colorado School of Mines)
Industry Team Members	ABB ETI, ABB NM, Entergy Services, Mitsubishi ITA, Reliant Energy HL&P and Oncor
Start Date and End Date	September 1, 2000 to August 31, 2002
Status	Final reports (02-46 and 02-47) available in 2002 Reports Folder.

Project Name	**Distribution System Electromagnetic Modeling and Design for Enhanced Power Quality (T-12)**
Summary	This research focuses on the development of comprehensive analysis tools for evaluating the power quality performance of typical distribution systems (5 kV to 35 kV). The project will produce an understanding of the root causes of power quality and safety problems. Conclusions will be drawn on the effectiveness of various design practices in improving the performance of distribution systems.
Academic Team Members	A. P. Meliopoulos (Georgia Tech – lead), E. Glytsis (Georgia Tech), and Mladen Kezunovic (Texas A&M)
Industry Team Members	Marty Brett and Richard Loyd (Steel Tube Institute of North America) and Steven G. Whisenant (Duke Energy)
Start Date and End Date	January 2001 to December 2003
Status	Final report (05-14) available in 2005 Reports Folder.

Project Name	**Personnel Grounding and Safety Issues / Solutions Related to Servicing Telecommunications Equipment Connected to Fiber Optic Cables in Optical Ground Wire (T-13)**
Summary	In this project, a study will be made to identify measures that can be taken to insure the safety of personnel who work on optical ground wires (OPGW) cables during faults or lightning strikes.
Research Stem	Transmission and Distribution Technologies
Academic Team Members	Robert Olsen (Washington State-lead); George Karady (Arizona State University) and A. P. Sakis Meliopoulos (Georgia Tech)
Industry Team Members	Paulette Kaptain (Western Area Power Administration), Art Mander (Tri-State), Dale Bradshaw (TVA), Ani Chitambar (Entergy), Bruce Dietzman (Oncor) and Phil Overholt (DOE)
Start Date and End Date	July 1, 2001 to July 1, 2002
Status	Final report (02-35) available in 2002 Reports Folder.

Project Name	**Evaluation of Critical Components of Nonceramic Insulators In-Service: Role of Seals and Interfaces (T-14)**
Summary	The project goal is to study the mechanisms of degradation, establish the threshold limits of degradation, and create a ranking for resistance to corona damage of various NCI used presently by participating utilities.
Academic Team Members	Ravi Gorur (Arizona State-lead) Bob Olsen (Washington State)
Industry Team Members	Salt River Project (Art Kroese), Western Area Power Administration (Fred Cook), Andrew Phillips (EPRI)
Start Date and End Date	June 1, 2002 to August 31, 2004
Status	Final report (04-32) available in 2004 Reports Folder.

Project Name	**Differential GPS Measurement of Overhead Conductor Sag: Software Implementation (T-15)**
Summary	The objective of this project is to implement a visual graphic depiction for easy use for work already completed in developing conductor sag instrument. A Global Positioning Satellite based method for the measurement of overhead conductor sag was developed conceptually in an on-line EMS aid to operators.
Research Stem	T&D Technologies
Academic Team Members	G. T. Heydt (Arizona State-lead) Robert Olsen (Washington State)
Industry Team Members	John Schilleci, Floyd Galvan (Entergy) Baj Agrawal, Doug Selin (Arizona Public Service)
Start Date and End Date	June 1, 2002 to December 31, 2002 (Note: project is in place at this time and researchers are continuing work uninterrupted.)
Status	Final report (02-31) available in 2002 Reports Folder.

Project Name	**Voltage Dip Effect on Loads in Electric Power System (T-16)**
Summary	The purpose of the project is to determine the effect of voltage dips on power system operation. Both the amplitude/depth and the duration of a dip will be investigated.
Research Stem	T&D Technologies
Academic Team Members	George G Karady (Arizona State-lead) Rahmat Shoureshi (Colorado School of Mines)
Industry Team Members	Arizona Public Service Co. (Baj Agrawal) Western Area Power Administration (Paulette Kaptain)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (05-63) available in 2005 Reports Folder.

Project Name	**Enhanced Reliability of Power System Operation Using Advanced Algorithms and IEDs for On-Line Monitoring (T-17)**
Summary	Introduction of Intelligent Electronic Devices (IEDs) in power systems enables new monitoring applications. This project introduces new fault location, substation state estimation and wireless communication applications.
Research Stem	T&D Technologies
Academic Team Members	Mladen Kezunovic (Texas A&M-lead) Co-Leader: Ali Abur (Texas A&M) Sakis Meliopoulos (Georgia Tech) and Rahmat Shoureshi (Colorado School of Mines)
Industry Team Members	TVA (M. Ingram), Reliant Energy HL&P (D. Sevcik), ABB (M. Subramanian), AEP (D. Krummen), Entergy (L. Priez), Mitsubishi (D. Wong), Tri-State G&T Association (A. Mander), Oncor (J. Bell), WAPA (P. Kaptain)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final reports available in the 2005 Reports Folder. Parts I and II in PSERC Documents 05-56 and 05-57.

Project Name	**MicroGrid Protection and Control (T-18)**
Summary	The key research focus is the coordination of protection and control within a MicroGrid.
Research Stem	T&D Technologies
Academic Team Members	Robert Lasseter (Wisconsin-lead) Mladen Kezunovic (Texas A&M)
Industry Team Members	Jerry C Thompson and Mike Agee (Duke Power) Dale Krummen (AEP)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (06-03) available in 2006 Reports Folder.

Project Name	**Automated Integration of Condition Monitoring with an Optimized Maintenance Scheduler for Circuit Breakers and Power Transformers (T-19)**
Summary	Cost-effective transmission equipment maintenance requires on-going integration of information from multiple sources. This project will develop a real-time software solution that performs this information integration automatically.
Research Stem	T&D Technologies
Academic Team Members	Jim McCalley (Iowa State, EE-lead) Mladen Kezunovic (Texas A&M, EE), Chanan Singh (Texas A&M, EE), Vasant Honavar (Iowa State, Computer Science)
Industry Team Members	Mid American Energy (Andrew Geest), CenterPoint Energy (Don Sevcik), Oncor Electric Delivery (Jim Bell)
Start Date and End Date	June 1, 2002 to August 31, 2005
Status	Final report (06-04) available in 2006 Reports Folder.

Project Name	**Smart Sensor Development for Power Transmission and Distribution (T-20)**
Summary	On-line monitoring systems require an intelligent system to analyze and interpret large amounts of data into meaningful conclusions. This research integrates advances in power electronics, intelligent control and new sensory systems to automatically (and without major efforts of maintenance personnel) provide real-time health assessment of the T&D infrastructure. This study concentrates on the development of an intelligent optical sensor monitoring for on-line health assessment of HV oil based transformers and oil based breakers.
Academic Team Members	Rahmat Shoureshi (University of Denver, lead), Marcelo Simoes (Colorado School of Mines) and Mladen Kezunovic (Texas A&M)
Industry Team Members	Art Mander (Tri-State) and Paulette Kaptain (Western Area Power Administration); Barry Ward (EPRI)
Start Date and End Date	June 1, 2002 to August 31, 2004
Status	Final report (04-27) available in 2004 Reports Folder.

Project Name	**Evaluation of Distributed Electric Energy Storage and Generation (T-21)**
Summary	The key research focus is evaluation of the actual costs and benefits of distributed electric generation and distributed electric energy storage.
Academic Team Members	Ward Jewell (Wichita State)
Industry Team Members	Dale Bradshaw (TVA)
Start Date and End Date	June 1, 2001 to June 1, 2004
Status	Final report (04-25) available in 2004 Reports Folder.

Project Name	**Performance Assessment of Advanced Digital Measurement and Protection Systems (T-22)**
Summary	The objective of this proposal is to provide quantitative comparison between an integrated measurement and protection solution based on optical CT and PT connected to the protection system with a digital link and the traditional magnetic CT and PT supplying analogue signals to the traditional measurement and protection system
Research Stem	T&D Technology
Academic Team Members	Lead: George G. Karady (ASU) Co-PI: Mladen Kezunovic (TAMU)
Industry Team Members	American Electric Power (Dale Krummen), NxtPhase (Farnoosh Rahmatian), Oncor Electric Delivery (Kevin Allen), CenterPoint Energy (Don Sevcik), Salt River Project (Don Pelley), WAPA (Lane Cope), Duke Energy, TVA (Mike Ingram), Exelon (James Crane), IREQ (Luc Audette)
Start Date and End Date	January 2004 to December 2005
Status	Final reports (Parts I and II) available in the 2006 Reports folder. PSERC Documents 06-22 and 06-23.

Project Name	**Prioritizing Maintenance of Underground Cables (T-23)**
Summary	This is a research project for predicting the need for maintenance and cable replacement. The goal is to develop guidelines based on failure probability, material analysis and electrical tests on short sections of cables removed during routine field work.
Research Stem	T&D Technologies
Academic Team Members	Ravi Gorur, (Lead: ravi.gorur@asu.edu, Arizona State University) Ward Jewel (Wichita State University)
Industry Team Members	SRP (Mike Dyer); Arizona Public Service (Baj Agrawal); Bob Saint (NRECA), Rob Keefe (EPRI)
Start Date and End Date	June 2004- August 31, 2006.
Status	Final report (06-40) available in 2006 Reports Folder.

Project Name	**Risk-Based Maintenance Resource Allocation for Distribution System Reliability Enhancement (T-24)**
Summary	Develop a risk-based optimal maintenance schedule for tree-trimming, poles, and reclosers to meet reliability targets in a distribution system subject to budgetary and personnel constraints
Research Stem	T&D Technologies
Academic Team Members	Lead: Ward Jewell Team Members: Jim McCalley, Iowa State University Consultant: S. S. Venkata (Clarkson University)
Industry Team Members	Duke Energy (Jerry Ivey); NRECA (Robert Saint); MidAmerican Energy (Ali Chowdhury); Ashok Sundaram (EPRI)
Start Date and End Date	June 1, 2004 to December 31, 2005
Status	Final report (06-26) available in 2006 Reports Folder.

Project Name	**Liquid-Filled Power Transformers (T-25)**
Summary	The primary objectives of the proposed research are to develop a detailed mathematical model for liquid-filled power transformers health assessment and the remaining life expectancy estimation, economical model for replacement strategies and to develop user-friendly software for applications to retrofit design and procurement of new transformers (Figure 1). An optimization technique is also proposed to maximize the utilization of all major T & D power equipment in large-scale power system and to have a better asset management tool.
Academic Team Members	P.K. Sen (lead: Colorado School of Mines, 303.384.2020, psen@mines.edu M. Simoes, Colo. School of Mines, Karen Butler-Purry, Texas A & M
Industry Team Members	(1) Tri-State G and T (Art Mander), (2) Western (WAPA) (Paulette Kaptain), (3) NRECA (Bob Saint), (4) MidAmerican Energy Co. (Ali Chowdhury), (5) Barry Ward (EPRI)
Start Date and End Date	August 1, 2004 to August 31, 2006
Status	Final report preparation in progress.

Project Title	**Tool for Insulator Condition Assessment (T-26G)**
Summary	This is a research project for condition assessment of outdoor insulators in service, especially in contaminated areas. The goal is to develop a portable tool and guidelines for assessment of insulators in stations and overhead lines (both transmission and distribution).
Research Stem	T&D Technologies
Academic Team Members	Ravi Gorur (Arizona State University, ravi.gorur@asu.edu, 480-965-4894) Bob Olsen, Washington State University (advisory)
Industry Team Members	Exelon (Victor Hernandez), EPRI (Andrew Phillips)
Start Date and End Date	April 2004 to August 31, 2006
Status	Final report (06-42) available in 2006 Reports Folder.

Project Name	**Reliability Based Vegetation Management Through Intelligent System Monitoring (T-27)**
Summary	This project will compare measurements from Distribution Fault Anticipator prototypes, indicating intrusion of vegetation into overhead distribution lines, with standard reliability indices (e.g., SAIFI) to correlate reliability with vegetation measurements. Correlation will enable customization of vegetation management schedules for desired levels of distribution reliability. This project will replace Texas A&M's existing project of the same title and add support for collaboration with researchers at two other universities who currently are working on a synergistic PSERC project (T-24) regarding optimal allocation of maintenance resources.
Research Stem	T&D Technologies
Academic Team Members	Lead: Don Russell (Texas A&M University: bdrussell@tamu.edu, 979-845-7912) Team members: Carl Benner (Texas A&M University, benner@tamu.edu) Jim McCalley (Iowa State University, jdm@iastate.edu) Ward Jewell (Wichita State University, ward.jewell@wichita.edu)
Industry Team Members	James Crane, Exelon Corporation; MidAmerican Energy (Ali Chowdhury); Oncor Electric Delivery (James Fangue); American Electric Power (Dale Krummen); EPRI (Ashok Sundaram)
Start Date and End Date	June 1, 2005 to August 31, 2007. Initial supplemental funding began in Sep. 2004.
Status	Final report available in the Reports for PSERC Member Viewing Only Folder. PSERC Document 07-31.

Project Name	**Satellite Imagery for the Identification of Interference with Overhead Power Lines (T-28)**
Summary	The objective of the project is to develop software which determines the location of objects or vegetation interfering with overhead transmission lines. The input data are derived from satellite images and the GPS coordinates of the towers. The code determines the location of trees or objects that are penetrating in a safety envelope (e.g., 20 ft radius) surrounding the conductors.
Research Stem	T&D Technologies
Academic Team Members	Lead: George G. Karady (Arizona State University, karady@asu.edu) Team members: Gerald T. Heydt (ASU, heydt@asu.edu), Matthias Moeller (ASU, matthias.moeller@asu.edu), Yoshihiro Kobayashi, (ASU, ykobaya@asu.edu), Robert Olsen (Washington State University, olsen@eecs.wsu.edu)
Industry Team Members	American Electric Power (Dale Krummen), Duke Energy (Ed Ernst), Exelon (James Crane), ABB (David Lubkeman), Oncor Electric Delivery, (W. Bruce Dietzman), Salt River Project (Don Pelley), EPRI (Jeff Young)
Start Date and End Date	June 2005 to August 31, 2007.
Status	Final report preparation in progress.

Project Name	**Digital Protection System Using Optical Instrument Transformers and Digital Relays Interconnected by an IEC 61850-9.2 Digital Process Bus (T-29)**
Summary	The objective of this proposal is to investigate the feasibility of an all-digital protection system using optical instrument transformers directly interconnected through an IEC 61850-9.2 digital process bus with digital relays. The system operation will be evaluated using computer simulation, laboratory measurements and limited field tests.
Research Stem	T&D Technology
Academic Team Members	Lead: Mladen Kezunovic (TAMU), kezunov@ee.tamu.edu, 979-845-7509; Co-PI: George G. Karady (ASU), karady@asu.edu
Industry Team Members	ABB (Christoph Brunner), American Electric Power (John F. Burger), AREVA (Dennis Chatrefou), Entergy (Galvan Floyd), EPRI (Luke vd Zel), Exelon (James Crane), G.E. (Mark Adamiak), IREQ (Luc Audette), Midamerican (Ali A. Chowdhury), Oncor (Kevin Allen), CenterPoint Energy (Don Sevcik), Salt River Project (Don Pelley), TVA (Mike Ingram), Tri-State (Jeff Selman), WAPA (Lane Cope), EPRI (Dave Rueger)
Start Date and End Date	June 2005 to August 31, 2007.
Status	Final report preparation in progress.

Project Name	**Transient Testing of Protective Relays: Study of Benefits and Methodology (T-30)**
Summary	This proposal is aimed at investigating comprehensive test methods to be applied so that the unexpected protective relaying behavior, such as the one occurring during the recent Northeast blackout of August 14, 2003, can be better understood and avoided in the future. This project will provide comprehensive methodology for transient testing and will assess the benefits and practical means of performing transient tests.
Research Stem	T&D Technologies
Academic Team Members	Lead: Mladen Kezunovic (TAMU, kezunov@ee.tamu.edu, 979-845-7509); Team members: Sakis Meliopoulos (GaTech, Sakis.Meliopoulos@ece.gatech.edu), Ward Jewell (Wichita State, ward.jewell@wichita.edu)
Industry Team Members	Bajarang Agrawal (APS), Tom Key (EPRI), Ali A. Chowdhury (MidAmerican), Hyder DoCarmo (CenterPoint Energy), Michael Ingram (TVA), Jeff Selman (Tri-State G&T), Paulette Kaptain, Dan Hamai (WAPA), Devin VanZandt (G.E.), Joe Hughes (EPRI)
Start Date and End Date	June 2005 to August 31, 2007.
Status	Final report preparation in progress.

3 Description of the Markets Research Stem and Its Current Projects

The electric power industry in the US and worldwide is undergoing a major transformation. It is changing from a vertically integrated industry in which generation transmission and distribution system in a geographical region were owned by single entities with tight coordination of the planning scheduling and operations of these industry components. By contrast the new industry paradigm is based on dispersed ownership, separation of the generation transmission and distribution and on coordination through markets. This transition is propelled by social, political and economic forces and by technological developments, particularly the emergence of small scale generation, advances in power electronics, reliable and inexpensive communication, metering and computer technologies and by the rapid growth in electronic commerce. As new technologies emerge or become economically feasible we may see further evolution in the industry structure as well as in the planning, scheduling and operational paradigms. For example in the long term, mass deployment of FACTS devices may result in a switch able transmission system that will lead to different market organization. Similarly proliferation of distributed generation and storage technologies could lead to new operational paradigms, direct access at the distribution level and new market structures.

Our primary research goal in this thrust area is to focus on short to medium term issues concerning the interaction between the technical and economic aspects of the restructured industry given the current technological landscape. In particular this stem focuses on a new market based paradigm that will replace the traditional functional timeline leading from years to cycles prior to real time, which includes long term demand forecasting, capacity planning and expansion, maintenance, short term forecasting, scheduling, dispatch, and real time control. The research under this stem emphasizes the design and analysis of market institutions, mechanisms and computational tools that will facilitate coordination, efficient investment, operational efficiency and system reliability while recognizing the economic and technical realities of the electric power industry. The scope of work under this stem can be broken down by subject area and by methodological approach recognizing the fact that some approaches may be better suited for certain problem areas.

These general goals are pursued by means of the following methodological approaches that complement and support each other:

- *Analytical methods* that can be further classified into:
    - Theoretical analysis focusing on conceptual abstract modeling and analysis, employing techniques of operations research, systems analysis, microeconomics, stochastic modeling, game theory and auction theory.
    - *Empirical analysis* focusing on interpretation of empirical data and on estimation and validation of theoretical models using econometric methods, financial engineering approaches, statistical analysis and data mining.
- *Computational methods* employing numerical methods and agent-based models to simulate and forecast market outcomes under realistic modeling of the electric power system in conjunction with behavioral models of economic agents that control various aspects of the system and interact in the marketplace.
- *Experimental economic* approaches employing controlled laboratory experiments with live and artificial agents in order to explore decision patterns under alternative rules and system conditions, and to test behavioral assumptions upon which such rules are founded.

3.1 Agent Modeling for Integrated Power System, Power and Fuel Market Simulation (M-13)

Summary	Provide a methodology to simulate the financial response of multiple participants of a two sided auction including reliability, substitutes, and other ancillary services. Methodology would provide justification for generation and customer equipment as required for system expansion with an optimal portfolio of equipment to maximize system operation at a specified level of reliability.
Research Stem	Primary: Markets, Secondary: T&D Technologies and Systems
Academic Team Members	Lead: Chen-Ching Liu, Iowa State University, liu@iastate.edu, 515-294-4763 Team members: Anjan Bose, Washington State University, bose@wsu.edu, 509-335-5593; Judith Cardell, Smith College, 413-585-4222, jcardell@smith.edu
Industry Team Members	Mark Sanford, GE Energy, Jianzhong Tong, PJM Interconnection, Jay Giri, AREVA T&D Corporation James Price, California ISO Bob Entriken, EPRI
Start Date and End Date	June 1, 2005 through August 31, 2008.

3.2 Economic Impact Assessment of Transmission Enhancement Projects (M-14)

Summary	The project will develop a practical approach for assessing the economic worth of transmission network enhancements. The valuation methodology will asses the impacts and economic benefits of transmission projects from the perspectives of the system social welfare and market power mitigation requirements. In addition, the impacts on both consumers and producers will be determined while taking into consideration the effects of transmission expansion projects on market prices, generation costs and potential generation investment response strategies.
Research Stem	Markets
Academic Team Members	Lead: Shmuel Oren (UC Berkeley, oren@ieor.berkeley.edu, (510) 642-1836) Team member: George Gross (University of Illinois UC, gross@ uiuc.edu)
Industry Team Members	Tom Gentile, National Grid USA Jim Price, California ISO
Start Date and End Date	June 1, 2006 - August 31, 2008

3.3 Tools for Assessment of Bidding into Electricity Auctions (M-15)

Summary	This project develops practical and user-friendly analytical tools that market monitors can use to assess the competitiveness of bidding into electricity auctions. These tools enable users to analyze prices and distinguish between market power and scarcity rents.
Research Stem	Markets
Academic Team Members	Lead: Steve Puller (Texas A&M, puller@econmail.tamu.edu, 979-845-7349) Team member: Ross Baldick (The University of Texas, Ross.Baldick@engr.utexas.edu)
Industry Team Members	Mark Sanford (GE Energy) Mario DePillis (ISO-New England) Robert de Mello (NYISO)
Start Date and End Date	June 1, 2006 - August 31, 2008

3.4 Integrating Electric System Planning with Efficient Markets to Provide Adequate Investment (M-16)

Summary	Integrated system planning is an important component for ensuring adequate, timely investment in the electric industry. With deregulated, market-based allocations, the consequences of any plan are less certain and more complex, but nevertheless essential for guiding the provision of low-cost reliable service. What is needed are guidelines that integrate the timing and components of the planning process with the particular nature and structure of markets. This project will survey existing planning procedures, relate those processes to both existing and proposed advanced market structures (forward and options markets), and prepare a white paper outlining preferred integrated approaches whose objective is to elicit adequate investment in generation and transmission. An ISO/RTO forum will be convened to discuss the paper, and issues raised will frame proposed experimental trials that would be used to test the efficacy of alternative procedures. Supplemental funds would be sought from the forum's participants to conduct these experiments in the following year.
Research Stem	Markets (with Systems Overlap)
Academic Team Members	Lead: Richard E. Schuler (Cornell Univ., res1@cornell.edu,607-255-7579) Team members: William Schulze (Cornell, wds3@cornell.edu), Tim Mount (Cornell, tdm2@cornell.edu), Fernando Alvarado (Wisc., flalvarado@engr.wisc.edu)
Industry Team Members	Robert DeMello (NYISO), Eugene Litvinov (ISO New England)
Start Date and End Date	June 1, 2006 – December, 31, 2007

3.5 Integrated Financial and Operational Risk Management in Restructured Electricity Markets (M-17)

Summary	We propose to investigate the integration of financial and operational risk management mechanisms to facilitate market operations and enhance market efficiency in the restructured electricity industry. We will study financial and operational hedging strategies utilizing existing standard and prospective instruments and develop methods for pricing such instruments and assessing their effectiveness.
Research Stem	Markets
Academic Team Members	Project Leader: Shi-Jie Deng (Georgia Tech, deng@isye.gatech.edu , (404) 894-6519) Team members: Shmuel Oren (UC Berkeley, oren@ieor.berkeley.edu (510) 642-1836), Sakis Meliopoulos (Georgia Tech, sakis.meliopoulos@ece.gatech.edu, (404) 894-2300)
Industry Team Members	Art Altman (EPRI), Hung-Po Chao (ISO-New England), Mark Sanford (GE Energy), Todd Strauss (PG&E).
Start Date and End Date	June 1, 2007 – August 31, 2009

3.6 Improved Investment and Market Performance Resulting from Proper Integrated System Planning (M-18)

Summary	While central planning and efficient markets are popularly thought to be contradictory, ongoing PSERC research identifies ways in which these activities can and should be complementary. The output of this "planning" project and its Spring 2007 Forum will be used to augment ongoing experimental research on the effect of forward and capacity markets on investment and spot electricity prices. By providing information at the proper time on strategic issues like needed new generation and plans to construct transmission, the subsequent improvements in efficiency of market-based investment decisions for both generation and transmission can be gauged against a variety of market structures currently in use and proposed. The tools utilized in this analysis will also provide mechanisms to study the cost distribution and beneficiaries over time that result from a transmission expansion, and that may effect the initial approval process.
Research Stem	Markets
Academic Team Members	Project Leader: Richard Schuler (Cornell,res1@cornell.edu,607-255-7579) Team members: Tim Mount (Cornell,tdm2@cornell.edu) Ray Zimmerman(Cornell,rz10@cornell.edu) Fernando Alvarado(Wisconsin,flalvarado@lcra.com) Bernie Lesiutre (Wisconsin, lesieutre@engr.wisc.edu)
Industry Team Members	Jonathan Mayo (NYISO), Eugene Litvinov and Robert Ethier (ISO-New England), Mark Sanford (GE Energy), Terry Boston (TVA)
Start Date and End Date	June 1, 2007 – August 31, 2008

3.7 Facilitating Environmental Initiatives While Maintaining Efficient Markets and Electric System Reliability (M-20)

Summary	Recent environmental standards like mandatory percentages of renewable-based generation or regional limits on greenhouse gas emissions can be implemented in various ways that may have widely different effects on the reliability and cost of operating the power grid and on the performance of its markets. To study these interactions, the current PSERC analysis that identifies the public goods aspects of reliability would be revised and extended to consider effluent emissions and dispersion in the overall calculation of net benefits. Using this analytic benchmark together with alternative environmental scenarios, technical parameters would be calibrated and model simulations would be run to estimate and compare the interactive environmental, reliability and cost consequences of alternative rules and regulations, together with the implications for electricity market design and the evolution of emerging technologies like distributed generation.
Research Stem	Markets
Academic Team Members	Project Leader: William Schulze (Cornell, wds3@cornell.edu, 607-255-9611) Team members: Richard E. Schuler (Cornell, res1@cornell.edu) Dan Tylavsky (Ariz. State U., tylavsky@asu.edu) Judy Cardell (Smith College, jcardell@smith.edu)
Industry Team Members	NYISO (Jonathan Mayo), GE (Mark Sanford), Entergy (Floyd Galvan), WAPA (Paulette Kaptain)
Start Date and End Date	June 1, 2007 to August 31, 2009

3.8 Technical and Economic Implications of Greenhouse Gas Regulation in a Transmission Constrained Restructured Electricity Market (M-21)

Summary	The effects on costs and operations of new California regulations on electric generator CO_2 production will be investigated.
Research Stem	Cross-stem: Markets (lead) and Systems.
Academic Team Members	Project Leader: Ward Jewell (Wichita State, ward.jewell@wichita.edu, 316.978.6340) Team members: Shmuel Oren (Berkeley, oren@ieor.berkeley.edu) Chen-Ching Liu (ISU, liu@iastate.edu) Yishu Chen (UC Merced, ychen26@ucmerced.edu)
Industry Team Members	Jim Price, CAISO; Mariann Quinn, Duke Energy; Floyd Galvan, Entergy; Mark Sanford, GE; Jay Giri, AREVA; Tongxin Zheng, ISO-New England
Start Date and End Date	June 1, 2008 to August 31, 2010

4 Description of the Systems Research Stem and Its Current Projects

Systems research focuses in all aspects of complex dynamical systems with emphasis on power systems. The basic premise is that restructuring of the electric power industry leads to larger and more complex operational entities (ISO, RTO) than previous structures. At the same time, alternate energy sources (solar, fuel cells, wind, etc.) are expected to increase their penetration in electric energy systems. Power electronic devices (FACTS) are also expected to have an increased presence in electric energy systems and improve the controllability and complexity of the system. Environmental issues and constraints are expected to play a bigger role in power systems operations and planning. The complexity of "systems" problems increases nonlinearly with system size, new technology options and environmental constraints. At the same time, advances in information technology, communications and mathematics demand that systems problems be re-examined and formulate new approaches. The Systems Stem supports development of new frameworks and approaches that will effectively cope with the complexity and mega scale issues of the restructured industry. Examples of such frameworks and approaches include:

- Development of new framework and methodologies for operations, planning, optimization and system reliability/security and risk management of the restructured electric industry,
- Development of new frameworks for communications and control, data management, system monitoring, self healing and self restoration of mega scale systems,
- Address issues of computational complexity arising in operation and control of complex mega scale systems, and
- Development of fundamental mathematical frameworks to address operation, control and protection of distributed energy source systems in an autonomous or non-autonomous operation (grid connected).

Restructuring is leading to large and complex operational entities (such as Independent System Operators or Regional Transmission Organizations), while small-scale, dispersed generation technologies are increasing their penetration in power systems. The challenge is to develop new operations frameworks and approaches that will effectively cope with the growing complexity of a restructured industry. Systems research concentrates on all aspects of planning, design and operation of complex, dynamical systems, some of which are:

- Security, reliability and adequacy criteria
- Real-time security assessment and preventive control
- System control
- Computational methods
- Interactions of complex systems
- Component modeling and system identification
- Simulation platforms and visualization tools
- Advanced algorithms and computational methods
- Networked distribution system issues to cope with distributed generation
- Short term operation and scheduling of uncertain renewable resources
- System restoration issues.

The Systems Stem has identified the following thrust areas in which we intend that the Stem will have impact in the coming years.

I. Control Center Technologies
II. Wide-area Control and Cascading Defense
III. Reliability (Operational and Long-term)
IV. Sustainability of Energy Supply and Transport

4.1 Reactive Power Planning against Voltage Collapse with respect to Undesirable Component Protection (S-28)

Summary	Adaptive control strategies are proposed against voltage collapse computed with the aid of integrated models (power and protection system) extracted from SCADA and GPS-synchronized data. Since the protection system is integrated in the model, the proposed methodologies can identify adequacy or deficiency of control resources as well as hidden and unintended protection system operations.
Research Stem	Systems
Academic Team Members	Lead: Venkataramana Ajjarapu, Iowa State University (ISU), vajjarap@iastate.edu, 515-294-7687 Team members: A. P. Meliopoulos, Georgia Institute of Technology (GIT), sakis.meliopoulos@ece.gatech.edu, 404- 894-2926
Industry Team Members	Ali Chowdury (Mid-American), Navin Bhat (AEP), Tong (PJM), Mahendra Patel (PJM), Floyd Galvan(Entergy), Sharma Kolluri (Entergy), Bruce Fardanesh (NYPA), Chetty Mamandur (MISO)
Start Date and End Date	June 1, 2006 - August 31, 2008

4.2 Detection, Prevention, and Mitigation of Cascading Events – Prototype Implementations (S-29)

Summary	The project aims to implement the algorithms developed in the recently ended PSERC project (S19) on cascading events to the power systems of the collaborating PSERC companies. The algorithms are based on wide-area PMU measurements as well as raw data from IED's, together with model based simulations. They address three subproblems: a) Detection of major disturbances and protective relay operations leading to cascading events. b) Wide area measurement based remedial action. c) Adaptive islanding with selective underfrequency load shedding The proposed project is a two-year continuation of S19, solely focused on the prototype implementation of the novel algorithms that have been previously developed in the S19 project.
Research Stem	Systems (and T&D)
Academic Team Members	Lead: Mani V. Venkatasubramanian (Washington State University, Pullman, WA, mani@eecs.wsu.edu, 509-335-6452) Team members: Mladen Kezunovic (Texas A&M, College Station, TX, kezunov@ee.tamu.edu) Vijay Vittal, (Arizona State University, Tempe, AZ, vijay.vittal@asu.edu)
Industry Team Members	Galvan Floyd (Entergy), Lisa Beard (Tennessee Valley Authority), Jay Giri (Areva T&D), Kip Morrison (Powertech Labs), Navin Bhatt (American Electric Power), Richard Young (American Transmission Company), Ram Adapa (Electric Power Research Institute).
Start Date and End Date	June 1, 2006 - August 31, 2008

4.3 Development and Evaluation of System Restoration Strategies from a Blackout (S-30)

Summary	The purpose of this project is to develop a practical algorithm for system restoration from a blackout. The project involves the development of system restoration algorithms and the evaluation of the algorithm with respect to steady-state and dynamic constraints. The method will be tested with realistic scenarios from PSERC industry members.
Research Stem	Systems
Academic Team Members	Project Leader: Chen-Ching Liu (Iowa State University, liu@iastate.edu, 515-294-4763) Team members: Vijay Vittal, Arizona State University, Vijay.Vittal@asu.edu Gerald T. Heydt, Arizona State University, heydt@asu.edu Kevin Tomsovic, Washington State University, kevin_tomsovic@wsu.edu
Industry Team Members	Larry Anderson (AEP), Jiangzhong Tong (PJM Interconnection), Floyd Galvan (Entergy), Jinan Huang (Hydro Quebec), Ray Vojdani (WAPA)
Start Date and End Date	June 1, 2007 – August 31, 2009

4.4 Real-Time Security Assessment of Angle Stability and Voltage Stability Using Synchrophasors (S-31)

Summary	The objective of the project is to develop real-time tools for the system operators to assess the operational reliability of the power system by using wide-area synchrophasor measurements. The tools are meant to enhance the situational awareness of the operators by giving them insight into the current system stress level in the context of angle stability and voltage stability. The angle stability assessment will use real-time wide-area phase angle differences and certain active power-flow sensitivities to monitor the proximity to angle stability limits, while the voltage stability assessment will be carried out by processing the voltage profile and reactive power-flow measurements.
Research Stem	Systems
Academic Team Members	Project Leader: Mani V. Venkatasubramanian (Washington State University (WSU), Pullman, WA, mani@eecs.wsu.edu, 509-335-6452) Team members: Venkataramana Ajjarapu (Iowa State University (ISU), Ames, IA, vajjarap@iastate.edu)
Industry Team Members	Floyd Galvan (Entergy), Lisa Beard (TVA), Kip Morrison (Powertech Labs), Mahendra Patel and Jianzhong Tong (PJM), Navin Bhatt (AEP), Jay Giri (Areva T&D), Jim Gurney (BCTC), Jim Gronguist (BPA), Bob Wilson (WAPA), Roy Boyer (Oncor)

Start Date and End Date	June 1, 2007 - August 31, 2009

4.5 Fast Simulation, Monitoring, and Mitigation of Cascading Failures (S-32)

Summary	Monitoring and responding to the risk of cascading failure leading to widespread outages is a challenging problem. We will develop methods for fast simulation to support real time operational decision support, mitigation of cascading risk using available controls, including generalized islanding and reconfiguration, and monitoring the overall cascading risk from real data.
Research Stem	Systems
Academic Team Members	Project Leader: Ian Dobson (Wisconsin, dobson@engr.wisc.edu 608 262 2661) Team members: Jim McCalley (Iowa State, jdm@iastate.edu) Chen-Ching Liu (Iowa State, liu@iastate.edu) Sarosh Talukdar (Carnegie-Mellon, talukdar@ece.cmu.edu)
Industry Team Members	Ali Chowdhury (MidAmerican Energy), Innocent Kamwa (IREQ), Lawrence Jones (AREVA), Mahendra Patel (PJM), Jim Viikinsalo (Southern Company), Dan Hamai (WAPA)
Start Date and End Date	June 1, 2007 - August 31, 2009

4.6 Implementation Issues for Hierarchical, Distributed State Estimators (S-33)

Summary	Although the algorithms for hierarchical, distributed state estimators have been worked out, the handling of time skew in real-time data and the errors in external modeling remain hurdles in implementation. The recent interest by Congress/DOE/FERC/ERO for monitoring all the North American interconnections provides the incentive to finally solve these issues.
Research Stem	Systems
Academic Team Members	Project Leader: Anjan Bose (WSU, bose@wsu.edu, 509-335-1147) Team members: Ali Abur (NEU, abur@ece.neu.edu)
Industry Team Members	Jay Giri (AREVA), Jianzhong Tong (PJM), Lisa Beard (TVA), Floyd Galvan (Entergy), Robert Kingsmore (Duke Energy), David Bogen (Oncor)
Start Date and End Date	June 1, 2007 - August 31, 2009

4.7 Impact of Increased DFIG Wind Penetration on Power System Reliability and Consequent Market Adjustments (S-34)

Summary	This project examines the impact of increased penetration of doubly fed induction generator based wind generation on power system dynamic performance with regard to transient stability, frequency response, regulation, and load-following capability and examines suitable market mechanisms and operational solutions in the event of reduced reliability to meet NERC standards.
Research Stem	Lead Stem – Systems Stem Secondary Stem – Markets Stem which would involve the study of the market mechanisms in the event of reduced reliability because of increase wind penetration.
Academic Team Members	Project Leader: Vijay Vittal (ASU, vijay.vittal@asu.edu, 480-965-1879) Team members: James McCalley (ISU, jdm@iastate.edu) Venkataramana Ajjarapu (ISU, vajjarap@iastate.edu) Uday Shanbhag (UIUC, udaybag@uiuc.edu) Ian Hiskens (UW, hiskens@engr.wisc.edu)
Industry Team Members	Ali Chowdhury – MidAmerican Energy, Nicholas Miller – GE, Mark Sanford GE, Jinan Huang – IREQ, Hydro Quebec, Dale Osborn – MISO, Larry Reiter – Oncor, Bob Easton, Ed Weber - WAPA
Start Date and End Date	June 1, 2007 - August 31, 2009

4.8 Special Protection Schemes: Limitations, Risks, and Management (S-35)

Summary	The objective of the proposed work is to provide a structured framework for assessing SPS risk, identifying limits of SPS deployment within a system, and maintaining SPS reliability over its lifetime.
Research Stem	Systems
Academic Team Members	Project Leader: J. McCalley (Iowa State, jdm@iastate.edu, 515-294-4844) Team members: C. Singh (TAMU, singh@ece.tamu.edu)
Industry Team Members	Ali Chowdhury (CAISO), Jim Gronquist (BPA), Wenyuan Li (BCTC), Dede Subakti (MISO, and chair of 2007-08 Midwest Reliability Organization SPS Review Team)
Start Date and End Date	June 1, 2008 to August 31, 2010.

4.9 Using PMU Data to Increase Situational Awareness (S-36)

Summary	The goal of this project is to determine how information obtained from PMU data that can be best used to increase situational awareness of system operators. In order to achieve this goal, we will examine the usage of PMU data to determine steady-state information about the power system based on event detection and power system equivalents. Then we will examine ways to present information derived from PMUs such that operators' knowledge of the power system is enhanced with the goal of helping them make more effective decisions.
Research Stem	Systems
Academic Team Members	Project Leader: Tom Overbye (UIUC, Overbye@uiuc.edu, 217-333-4463) Team members: Pete Sauer (UIUC, sauer@ece.uiuc.edu), Chris DeMarco (Wisc, demarco@wisc.edu), Ian Hiskens (Wisc, Hiskens@wisc.edu), Bernie Lesieutre (Wisc, Lesieutre@wisc.edu), Mani Venkatasubramanian (WSU, mani@eecs.wsu.edu).
Industry Team Members	AEP (Navin Bhatt), Areva (Jay Giri), BCTC (Jim Gurney), CAISO (David Hawkins), Entergy (Floyd Galvan), EPRI (Paul Myrda), Exelon (Jim Crane), IREQ (Innocent Kamwa), ITC (Archie Gupta), PowerTech (Kip Morison and Lei Wang), PowerWorld (Jamie Weber), TriState (Larry Shivers), TVA (Lisa Beard). Other IAB members are welcome to join.
Start Date and End Date	June 1, 2008 to August 31, 2010.

5 Description of the Transmission and Distribution Technologies Stem and Its Current Projects

Industry Background

The electrical utility industry is experiencing major changes from its historical business structure of a vertically integrated utility to a combination of several different models. However, the basic function of the industry, to produce and to deliver power, safely and reliably, has not changed. The restructuring of the industry has created uncertainty that has contributed to limited investment and improvements in the infrastructure. Additionally, pressures continue to reduce the cost of the electricity. The following key industry factors characterize the industry today:

- Increasing reliability demands
- Aging infrastructure
- Increasing loading of components
- Increasing availability of operational data
- More dynamic power flows due to wholesale merchant transactions and increased use of distributed generation
- Declining ability to isolate and remove components from service for maintenance.

Research Areas

Data Integration and Enhanced Functions

A key element in the electric power infrastructure is the transmission or distribution substation. To ensure reliability and to gain additional value, the assets must be managed in new ways using available data as well as expanded data sets. Opportunities exist to capture and better utilize presently available data from relays, DFRs, and other IEDs, to better monitor assets, locate faults, and perform new functions. Additional opportunities exist to improve sensors, communications, capture new information and present information in new ways to enhance performance.

Examples:

- Transformer loading
- Fault anticipation, location, low –current arcing, low-voltage arcing, and outage management
- Automated analysis of data from DFRs and other IEDs
- Power quality instrumentation
- New communication techniques, e.g. wireless, video.
- Data security/confidentiality
- Wide area measurements

Enhancing the T&D Infrastructure

The transmission and distribution infrastructure is aging and being stressed as loads have increased. New methods need to be developed to better assess the condition of assets, especially methods that can be used without taking the asset out of service. Additional study is needed aimed at understanding the impact of increased loading and aging of assets such as transformers, breakers, conductors, and underground cable.

Examples:

- Life assessment and extension
- Upgrading and rerating
- Enhanced utilization of rights-of-way

- Risk management and related maintenance strategies
- Advanced diagnostics, monitoring and maintenance
- Better understanding of failure and stress mechanisms
- Maximizing the utilization of the existing components and infrastructures
- Evaluation of transmission line and feeder structures
- Compact designs
- Innovative transmission and distribution infrastructures such as phase order, frequency, and other configurations
- Reduction of losses throughout the T&D systems.
- Better use of communication infrastructures

Distribution and Transmission Automation

Technology improvements and increasing need to better manage assets have facilitated the implementation of substation automation. The use of automation increases the availability of information and the ability to improve control over the system. However, more work is required to better manage the information and develop methods and algorithms to automate systems to improve system performance and reliability.

Examples:
- EMS and DMS
- Improved monitoring and diagnostics
- Automated fault assessment and outage management
- Advanced communication infrastructures
- New DMS functions
- Power quality assessment, quantification and mitigation
- Load control and impact on efficiency.

New Devices and Related Control Concepts

Opportunities exist to study the increasing amounts of available data and identify new phenomena that can lead to the development of new devices and operating practices. Universities have played a major role in the development of foundation theories that have led the industry to new devices and systems in the past. Additionally, universities are positioned to view broad issues impacting the power delivery industry.

Examples:
- New power device concepts
- Advanced power electronic devices
- New sensors and related measurement systems
- Novel devices and controls for distributed resources
- Electric storage devices and related control issues to meet varied business and system objectives
- Alternative and distributed energy sources (e.g., fuel cells, wind generation, photovoltaic cells, microgrids) with related interfaces and controls
- Physical and cyber security (e.g., fault tolerance, redundancy, self healing, resiliency)
- Advanced materials and hardware designs (e.g., insulators, conductors)
- Advanced battery technologies
- New methods of energy storage such as flywheels and ultra-high capacity capacitors.
- Integration of superconducting technology in transmission and distribution engineering
- Applications of nanotechnologies

New Paradigms and Designs

Existing monitoring, control, and protection systems are driven by established practices that have been proven in the utility market. However, opportunities to evaluate new control or protection systems exist that leverage the availability of more information and new devices. Universities are positions to have a broad and unbiased view and may identify new basic designs, controls and protection paradigms.

Examples:

- Dynamic rating concepts and related controls
- Project management enhancement
- Demand side management
- System-wide relaying coordination with control strategies, new concepts in relay implementation
- Integration of substation and feeder automation into EMS and DMS
- Advanced tools and methodologies for testing, evaluation and setting coordination
- Customer focused energy delivery (energy needs from a customer perspective)
- Innovative data mining, data management, decision-support and visualization approaches
- Interactive customer/supplier load control and protection
- Use of satellite technologies for innovative power system applications
- Risk-based and cost-based analysis and design
- New approaches to AC and DC transfer of power
- New fault current management (devices, strategies, and systems).
- Phasor and time/frequency paradigms
- Wireless power transmission

5.1 Massively Deployed Sensors (T-31)

Summary	The main objective of this proposed project is to utilize a large number of distributed sensors, including non-conventional sensors and innovative instrumentation, located in the power system by some prioritized strategy that includes metrics associated with system observability, power usage, enhancement of communication capabilities, and size of data for operations and enhanced operational decision making, to detect potential intrusions and sabotage, and for post-mortem studies after failures.
Research Stem	T&D Technologies
Academic Team Members	Lead: ASU, G. Heydt, heydt@asu.edu, 480 965 8307 Team members: Wichita State University, W. Jewell, ward.jewell@wichita.edu, 316 978 6340 P. K. Sen, Colorado School of Mines, psen@mines.edu, 303 384 2020
Industry Team Members	David Allen, AREVA T&D Jay Giri ,AREVA T&D Ali Chowdhury, MidAmerican Jeff Selman, Tri-State G&T Robert Saint, NRECA Dan Hamai, WAPA
Start Date and End Date	August 15, 2006 - August 31, 2008

5.2 Integration of Substation IED Information into EMS Functionality (T-32)

Summary	Currently large amounts of information are collected by Intelligent Electronic Devices (IEDs) at the substation level. Beyond the traditional SCADA data collected by RTUs, very little of other IED information is integrated into the current EMS solutions. The goal of the project is to investigate the potential benefits of integrating the substation IED information, beyond RTU data, into the EMS.
Research Stem	T&D Technologies
Academic Team Members	Project Leader: Mladen Kezunovic (TAMU, kezunov@ee.tamu.edu, 979-845-7509) Team member: Tom Overbye (UIUC, Overbye@ece.uiuc.edu)
Industry Team Members	Jim Stoupis (ABB), Ron Allen (AEP), David Allen (AREVA), Roland H White (Duke Power), Bhavin Desai (EPRI), Steven Hedden (Exelon), Ali A. Chowdhury (MidAmerican), Mark J. Laufenberg (Power World), Paul M. Skare (Siemens), Bruce Rogers (TVA), Byron Reid (Oncor)
Start Date and End Date	June 1, 2006 - August 31, 2008

5.3 Characterization of Composite Cores for High Temperature-Low Sag (HTLS) Conductors (T-33)

Summary	Characterization of core materials based on spectroscopic, electrical and mechanical properties will be performed. This will help utilities identify differences in critical properties due to formulation differences, determine safe operating temperature and specify performance requirements in technical specifications.
Research Stem	T&D Technologies
Academic Team Members	Project Leader: Ravi Gorur (ASU, ravi.gorur@asu.edu, 480-965-4894), Team Members: Barzin Mobasher (ASU, barzin@asu.edu) Bob Olsen (Washington State University, olsen@eecs.wsu.edu)
Industry Team Members	M. Dyer and J. Hunt (SRP) J. Gutierrez (Arizona Public Service) J. Gurney (British Columbia Transmission Corp) R. Clark (Western Area Power Authority)
Start Date and End Date	June 1, 2007 - August 31, 2009

5.4 Power System Level Impacts of Plug-In Hybrid Cars (T-34)

Summary	At present, the U.S. is importing crude oil at the rate of 9.8 Mb/day and an additional 5.4 Mb/day is produced domestically. Two-thirds is refined into gasoline and diesel fuel to power U.S. passenger vehicles and trucks. High petroleum prices, high emissions from gasoline powered vehicles, dependence on foreign oil amounts to a well-known national problem. Less known is that the electric power industry could provide the energy needed for most transportation needs at less than one third of the present cost and with lower pollution via existing technology in the form of pluggable hybrid vehicles. The objective of this proposal is to perform a scoping study looking at the system level benefits from this technology.
Research Stem	Systems (Lead Stem), with overlap in Markets and T&D.
Academic Team Members	A. P. Meliopoulos, Lead (GIT, sakis.m@gatech.edu, 404-894-2926) Team Members: Jerome Meisel, (GIT, jmeisel@ee.gatech.edu, 404-894-6292), and Tom Overbye, (UIU, overbye@ece.uiu.edu, 217-333-4463)
Industry Team Members	Jim Crane (Exelon), Raymond Vice (Southern Company), James Stoupis (ABB), Floyd Galvan (Entergy), Sharma Kolluri (Entergy), Bruce Fardanesh (NYPA, Ali Chowdury (Mid-American), Navin Bhat (AEP), Jeff Gerken (AEP), Mahendra Patel (PJM), Darlene Radcliffe (Duke), Bob Gibson (NRECA), Bob Wilson (WAPA)
Start Date and End Date	June 1, 2007 - August 31, 2009

5.5 Comparative Characterization of Parallel Distribution Sensors Under Field Conditions (T-35)

Summary	This project will perform comparative analysis of power system signals derived from unconventional, lower cost current and potential sensors with those derived from conventional current and potential transformers, thereby providing the basis for utilities to consider sensors with lower overall installed costs for a variety of applications. Special emphasis will be given to sensor response to subtle signals processed by advanced applications.
Research Stem	T&D Technologies
Academic Team Members	Project Leader: B. Don Russell (Texas A&M, bdrussell@tamu.edu, 979-845-7912) Team Member: Carl L. Benner (Texas A&M, benner@ece.tamu.edu, 979-845-6224) Team Member: Ward Jewell (Wichita State University, ward.jewell@wichita,edu, 316-978-6340)
Industry Team Members	Charles Wallis (Southern Company), Bill Muston (Oncor Electric Delivery), Tom Anthony (Oncor Electric Delivery), James Crane (Exelon), Doug Fitchett (American Electric Power), Simon Chiang (Pacific Gas and Electric), Floyd Galvan (Entergy), Ali Chowdhury (MidAmerican Energy), Thomas Gentile (National Grid), Mirrasoul J. Mousavi (ABB)
Start Date and End Date	June 1, 2007 - August 31, 2009

5.6 Integration of Asset and Outage Management Tasks for Distribution Applications (T-36)

Summary	This project will explore integration of asset and outage management tasks using data related to: a) equipment rating and system models available from asset management and planning databases, b) trouble calls and operational records created during outages, and c) operational and non-operational data available from a variety of IEDs used for power system monitoring. The proposed integration leads to major improvements in the following areas: savings in equipment maintenance, reduced outage time, increased service quality, and improved business processes.
Research Stem	T&D Technologies
Academic Team Members	Project Leader: Mladen Kezunovic (Texas A&M University, email address: kezunov@ece.tamu.edu, phone: 979-845-7509) Team member: Ward Jewell (Wichita State University, email address: ward.jewell@wichita.edu)
Industry Team Members	Ali Chowdhury (Mid American), Devin Van Zandt (GE), Robert Saint (NRECA), Doug Fitchett (AEP)
Start Date and End Date	June 1, 2007 - August 31, 2009

5.7 The 21st Century Substation Design (T-37)

Summary	Today's substation designs have shortcomings since they are selected to meet the requirements of the early 20th century power system. This project will look at the 21st century requirements and outline strategic substation design concepts that will meet the following criteria: improved reliability, security, re-configurability, controllability, maintainability, flexibility, and cost
Research Stem	T&D Technologies
Academic Team Members	Project Leader: Mladen Kezunovic (Texas A&M University, kezunov@ece.tamu.edu , 979-845-7509) Team members: George Karady (Arizona State University, karady@asu.edu, 480-965-6569)
Industry Team Members	D. Angell (National Grid), A. Bajarang (Arizona Public Service), L. Beard (TVA), N. Bhatt (AEP), Y. Boutwell (Duke Energy), S. Chiang (PG&E), B. Fardanesh (NYPA), T. Gentile (National Grid), J. Giri (AREVA), A. Gupta (ITC Holdings), J.H. Gurney (BCTC), K. Kutlev (ABB), A. Mander (Tri State), P. Myrda (EPRI), M. Reichard (G.E.)
Start Date and End Date	June 1, 2008 to August 31, 2010.

5.8 Substation of the Future: A Feasibility Study (T-38)

Summary	Digital technologies for data acquisition, automation and control have been continuously evolving for the last three decades. We propose a revolutionary utilization and integration of existing technologies for the design of the substation of the future. The proposed approach minimizes wiring requirements, provides for reliable and accurate filtering of data, provides accurate data for all applications and facilitates data security (cyber security). We propose three phases for this project: (I) A feasibility study with laboratory experiments, (II) Construction of a laboratory prototype and (III) Field implementation. This proposal addresses Phase I.
Research Stem	T&D (Lead Stem), with overlap in Systems.
Academic Team Members	Project Leader: Sakis Meliopoulos (GIT, sakis.m@gatech.edu, 404-894-2926) Team Member: Anjan Bose (WSU, bose@wsu.edu, 509-335-1147).
Industry Team Members	Raymond Vice (Southern Company), Floyd Galvan (Entergy), Shannon Watts (Entergy), Bruce Fardanesh (NYPA), Paul Myrda (EPRI), Lisa Beard (TVA), Jamshid Afnan (ISO-NE), Simon Chiang (PG&E)
Start Date and End Date	June 1, 2008 to August 31, 2010