National Science Foundation

NASA

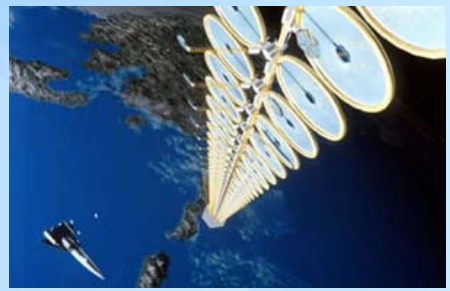
Center for Energy System Control
Department of Electrical Engineering
Howard University
Washington, DC 20059

EPRI
Providing Science and Technology Solutions to Our Global Energy Cust

Cost Effective, Efficient Monitoring & Control of Space Solar Power Management

Principal Investigator: James H. Johnson Ph.D.

NSF-NASA-EPRI Initiative for Joint Technical Exchange on SSP
NASA-Glenn Research Center
September 10th through 11th , 2002



Center For Energy Systems and Control (CESaC)

- CESaC is one of the research Centers in the College of Engineering, Architecture and Computer Sciences (CEACS) at Howard University.
- Its research is directed to enhancing the efficiency and economics of power system operation through the application of expert knowledge systems and programs and power utilization analysis.
- CESaC research has been largely supported by grants from the NSF, DOE, BPA, ONR, and NASA-(Lewis).
- CESaC is also a member of PSERC.

CESaC Mission

CESaC is dedicated to:

- Research and development of efficient tools for analysis and design of power system operations and planning.
- Use of system theories and emerging technologies such as AI, ES, ANN, and fuzzy logic in improving quantitative and qualitative analysis of decision making for power system studies.
- Modern control theories for solving large-scale engineering problems.

Objectives of the Center

- To engage in research that addresses national and international needs in the power industry using modern state-of-the-art technology.
- To attract and utilize outstanding faculty in preparing graduate students for a career in power systems and control.
- To promote and encourage cooperation and excellence through a teamwork approach.
- To engage in outreach, programs that facilitate:
    1. Technology transfer via conferences
    2. Educate the general community about power engineering career opportunities

For more information contact us at:
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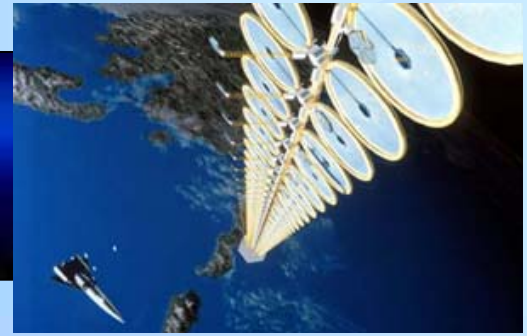
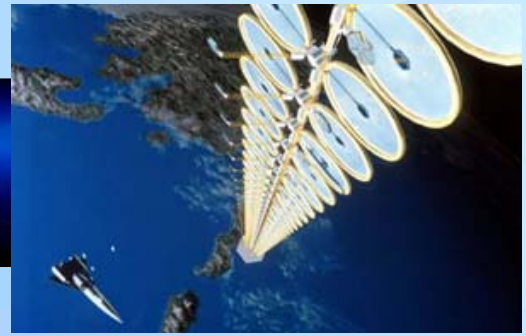
Previous Related Research Work



- Rule-based decision support system for delta-delta connected distributed systems.
- Fault simulator program for modeling subsystems with a set of feeders connected to a transformer with the ability to vary fault type, fault impedance, fault location, load level, load configuration, and faulted phase.
- AI-based fault diagnosis tool for arcing fault detection, fault type classification, and faulted phase for grounded and ungrounded systems using a supervised clustering ANN.
- Back propagation ANN for evaluating DC arcing fault features in PMAD.
- AI-based fault detection and location using Wavelet transforms and Clustering ANN.

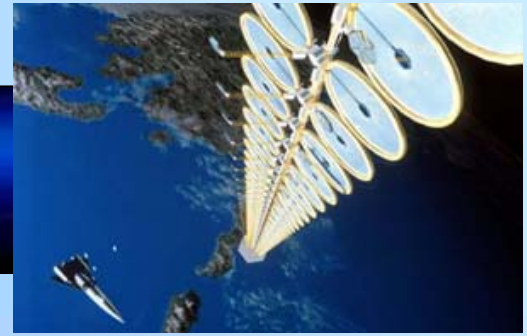
Space Solar Power Management Objectives and Goals



- Show that currently used tools for investigation of utilities' cable insulation failures due to arcing faults are insufficient for adequate diagnosis of insulation aging and fault detection.

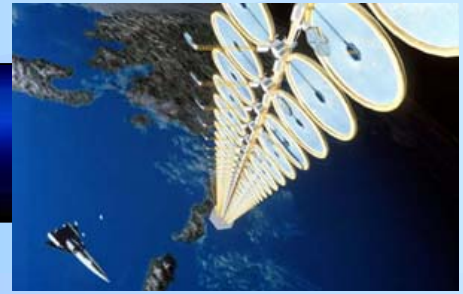
- Design an integrated system incorporating state-of-the-art technologies, primarily advanced Artificial Neural Network (ANN)/wavelet techniques for continuous and periodic monitoring of space power systems with emphasis on detecting and diagnosis of corona and soft faults.

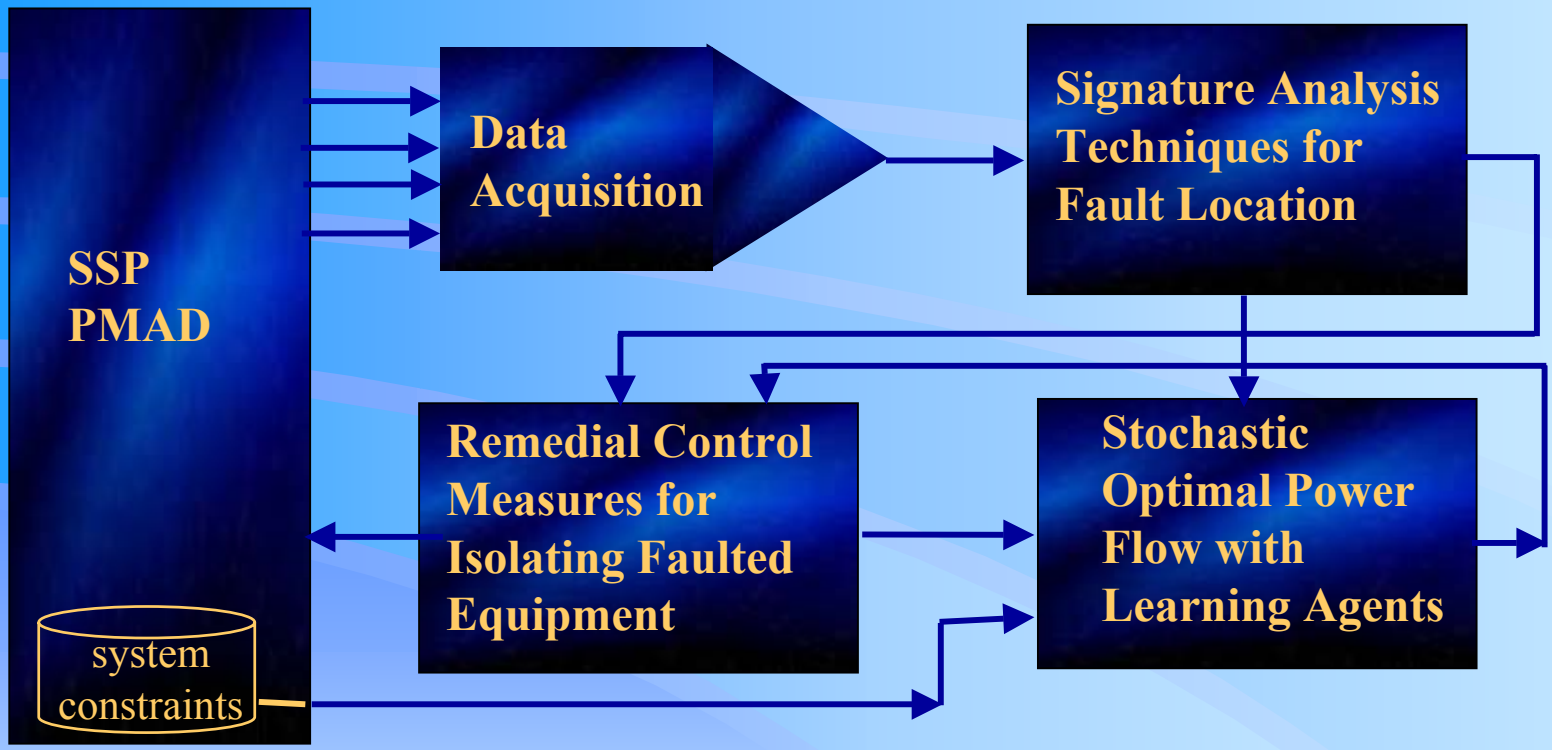
Space Solar Power Management Environmental Impacts



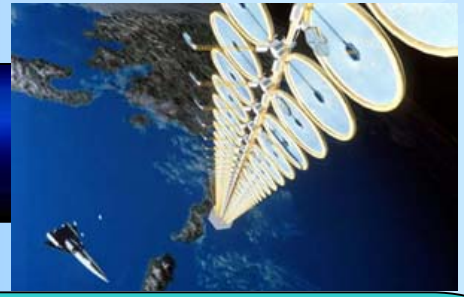
- Environmental impacts stem from public awareness and risk perception of the safety factors inherent in SSP system implementation.
- They include health hazards to the the Earth associated with power beaming (laser or microwave) transmission to a ground receiving station.
- Obtained through a statistical study, a consumer perception index (CPI) will be incorporated into the SSP PMAD scheme to measure how consumers perceive risks and what spatial distributions of risk are preferred.

Space Solar Power Management System Components





Space Solar Power Management
Fault Location



Signature Analysis Techniques for Fault Location

- Analyzes the fault information, current state, and load profile
- Correlates it with information from the device ID, and thresholds to determine the fault location.

Key Factors:

Loss of load-- detected electrically, and gives an indication of fault location

Over current fault level -- a brief over current fault in conjunction with a high impedance fault, and correlated with the PMAD feeder map of possible fault current paths

Faulted Phase Indication -- determined easily with single-phase laterals

Device characteristics-- the interruption and re-closure characteristics can be correlated with the known interruption devices to locate the fault

Outer boundary location -- by calculating the fault impedance during substantial arc bursts, one can derive the farthest possible electrical distance to a fault

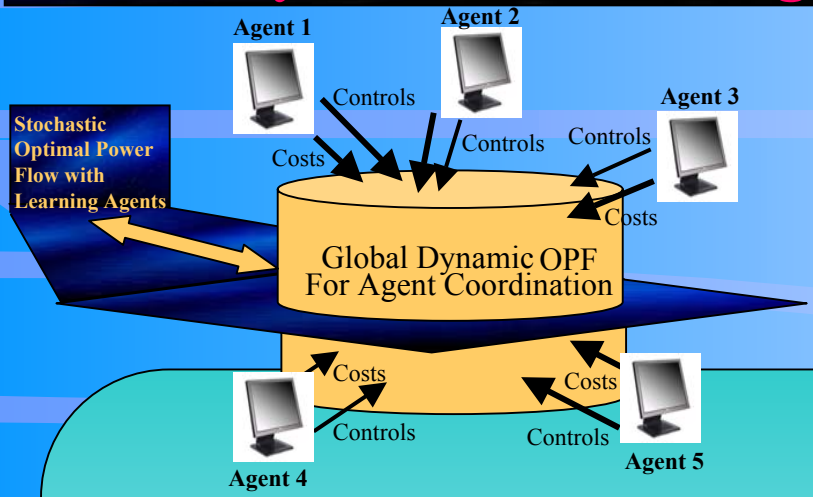
Database correlation-- information from the fault database can be correlated with electrical information to further identify the fault location.

Space Solar Power Management
Global Dynamic OPF for Agent Co-Ordination

The proposed scheme will provide:

1. Optimum solution for the power system using:
   - •Fault detection module
   - •Diagnosis module,and
   - •Location module
2. Coordinate the autonomous agents for the remedial control

Space Solar Power Management
Global Dynamic OPF for Agent Co-Ordination



Agent One

Maximize the line loading for most useful transmission to loads subject to limited generation.

Agent Two

Maximize line flows through the transmission and generation side of the system subject to the demand on the distribution side.

Agent Three

Minimize System Power Loss subject to generation and line capacity constraints.

Agent Four

Optimize distributed Capacitive and Inductive sites for Var optimization and voltage profile improvement.

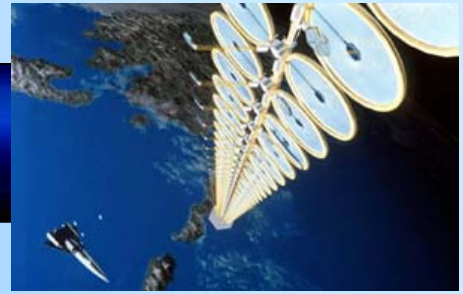
Agent Five

Maximize the total payoff of a proposed load shedding schedule.

-----Overall Problem Formulation------

Maximize payoff function for co-ordination the autonomous agents for remedial control.

Space Solar Power Management
TASKS OUTLINE



1. Data acquisition through simulation/ experimentation to obtain input for the proposed scheme for Corona discharge faults and Arcing faults

2. Create a signature analysis technology for fault analysis, diagnosis and location using:

   - Enhance FFT technique and Wavelets technique derived from signal processing, Back Propagation ANN, Radial basis ANN, and Wavelet ANN.

   - Expert system rules, model-based reasoning, ANN based, and traveling wave for location strategy.

3. Evaluate remedial control measures for isolating equipment identified in failure mode and reconfigure the power system network.

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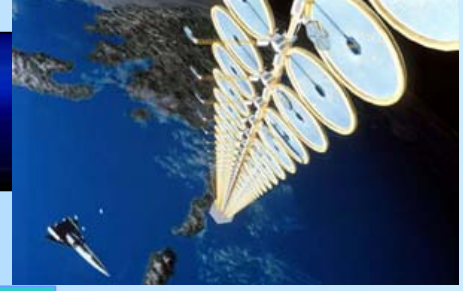
4. Stochastic Optimal Power Flow with learning agent for obtaining adaptive optimum solutions for the power system network based on the remedial control measures and the system performance constraints.

5. Integration of the technology to SSP system database with two major modes:

   a) Adapt existing power system software component base to interface with the new proposed technology.

   b) Evaluate robustness of the scheme by validation, reliability assessment and cost benefit analysis.

Space Solar Power Management
TASKS Timeline



- Year One
  - Literature Review
    Design data acquisition strategy
    Review experimental procedures
  - Develop Experimental Setup
    Low & high voltage vacuum chamber studies
    NASA Glenn Research Center
  - Annual Reports & Paper Presentations
- Year Two
  - Design the fault detection, diagnosis and location modules
  - Design the remedial control agents for specific emergency conditions
  - Construct the data test set for scheme validation
- Year Three
  - Design of global OPF scheme with learning agent for adaptive optimum system solution to a problem
  - Preparation of Final report, papers, thesis and publications