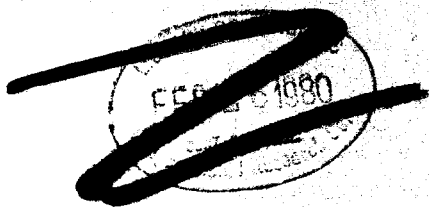


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DOE/ER-0037

SP (Marcia Smith)

Satellite Power System (SPS) FY 79 Program Summary



January 1980

U.S. Department of Energy
Office of Energy Research
Satellite Power System Project Office



DOE/NASA
SATELLITE POWER SYSTEM
Concept Development
and
Evaluation Program

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PREFACE

The Satellite Power System (SPS) program is a joint effort of the U.S. Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). It is managed by the SPS Project Office within DOE's Office of Energy Research. SPS project organization is shown in Figure 1.

The SPS Project Office was established in 1978 and is responsible for the planning, management and integration of SPS research in four areas: systems definition, environmental assessment, societal assessment, and comparative assessment. In fulfilling its responsibilities, the SPS Project Office directs research and assessment efforts to determine the feasibility of the SPS concept, funds organizations supporting the program, and disseminates information developed from project research and assessments.

The objective of the SPS program is to develop an initial understanding of the technical feasibility, the economic practicality, and the social and environmental acceptability of the SPS concept. This is being accomplished through implementation of the Concept Development and Evaluation Program Plan which is scheduled for completion by the end of fiscal year 1980.

The SPS Project Office annually issues a Program Summary which describes the research undertaken during the preceding fiscal year. This Program Summary covers fiscal year 1979. It includes work completed in fiscal years 1977 and 1978 in order to give a comprehensive picture of the DOE involvement in the SPS concept development and evaluation process.

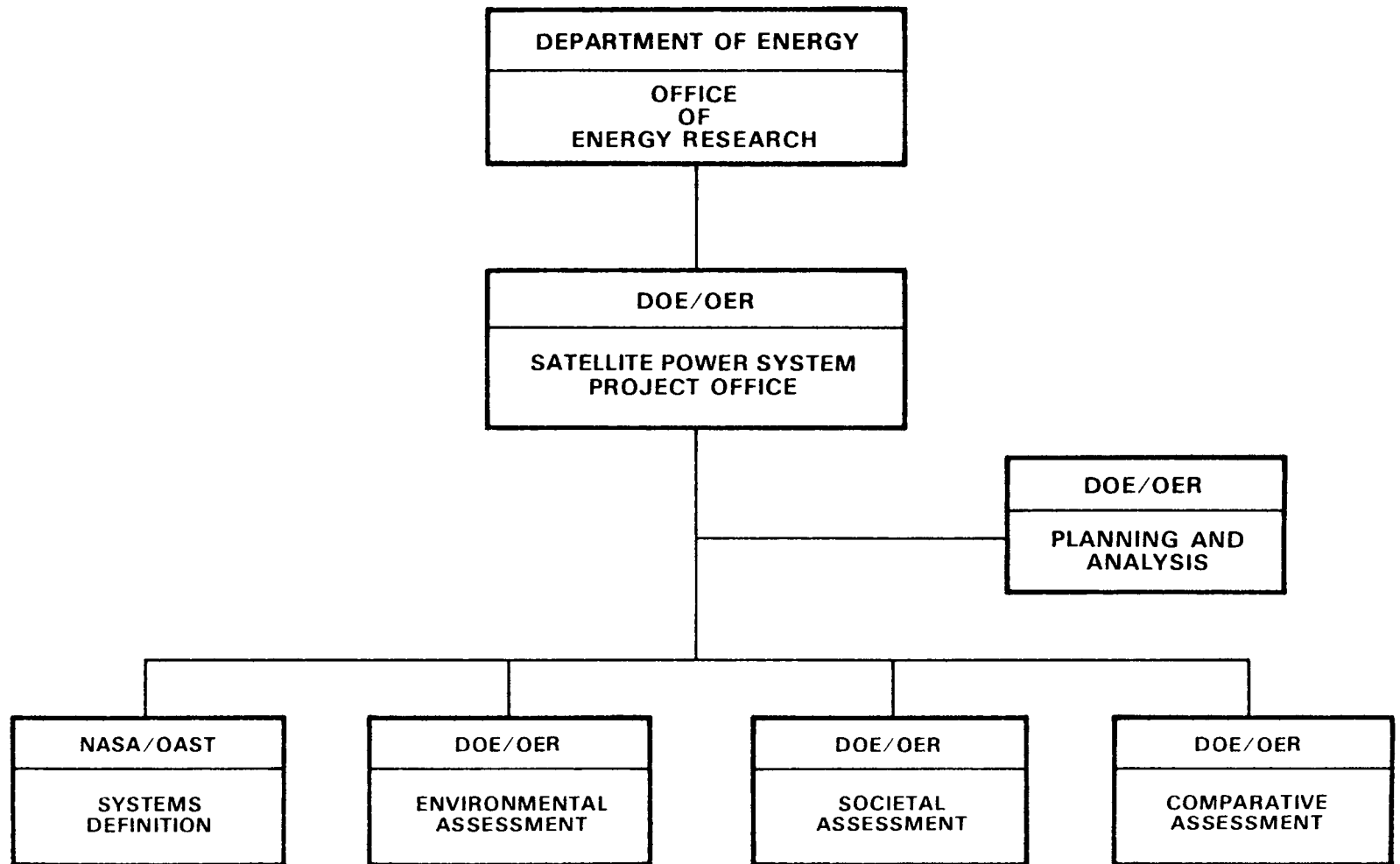


Figure 1. SPS Organization

INTRODUCTION

The Satellite Power System (SPS) transforms solar energy collected in space into electrical energy for use on earth. The SPS concept is illustrated in Figure 2. In a geostationary orbit 36,000 kilometers above the Earth's equator, each SPS would be illuminated by sunlight more than 90% of the time and in continuous line-of-sight contact with its ground receiving station. Electrical power produced on the satellite by photovoltaic or heat engine conversion of the sunlight would be converted to electromagnetic energy at high efficiency, and formed into a narrow beam precisely aimed at the SPS ground stations. The ground station receiving antennas would convert the energy back into electricity for distribution. Solar power satellites are intended to serve as producers of baseload electricity for utility service. The Satellite Power System is not a substitute for other solar energy options but a complement that would allow solar energy to more competely serve the nation's energy needs.

DOE/NASA activities are described in the SPS Concept Development and Evaluation Program (July 1977 - August 1980): Department of Energy Report DOE/ET-0034, February 1978. NASA is conducting systems definitions studies of the SPS while DOE is evaluating health, safety, and ecological impacts; examining economic, international, institutional issues; and developing comparative assessments of SPS relative to alternative power sources for the future. The Concept Development and Evaluation Program will generate the information needed to make a rational decision regarding direction of the SPS program after 1980.

An SPS "reference system" had been developed by NASA and is described in the Concept Development and Evaluation Program Reference System Report

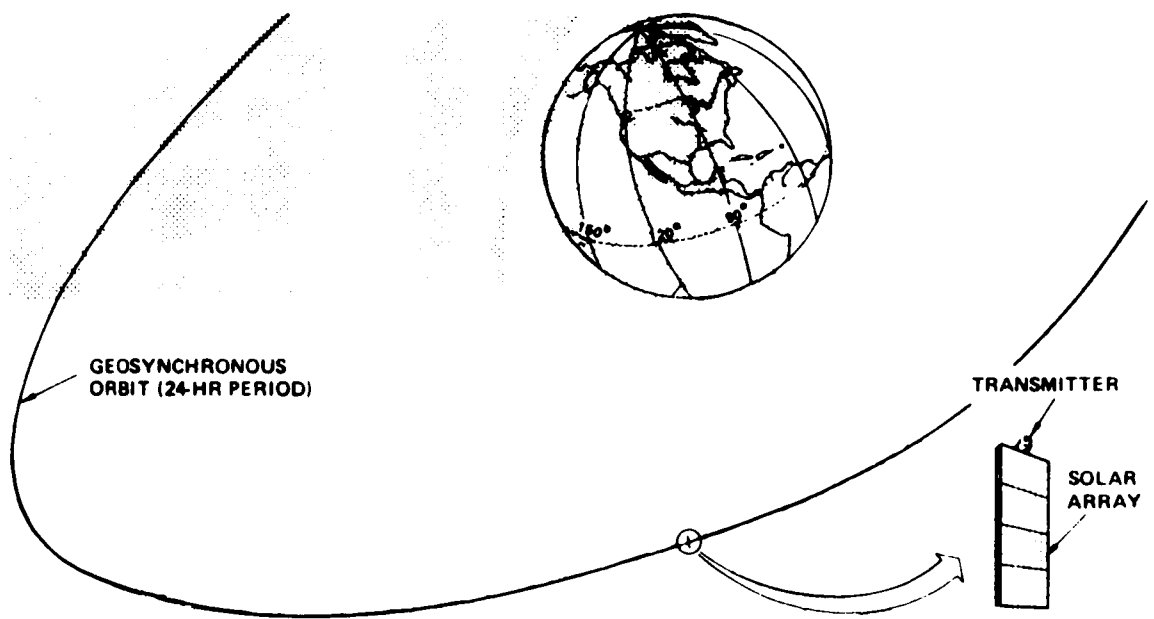


Figure 2. Solar Power Satellites: The Concept

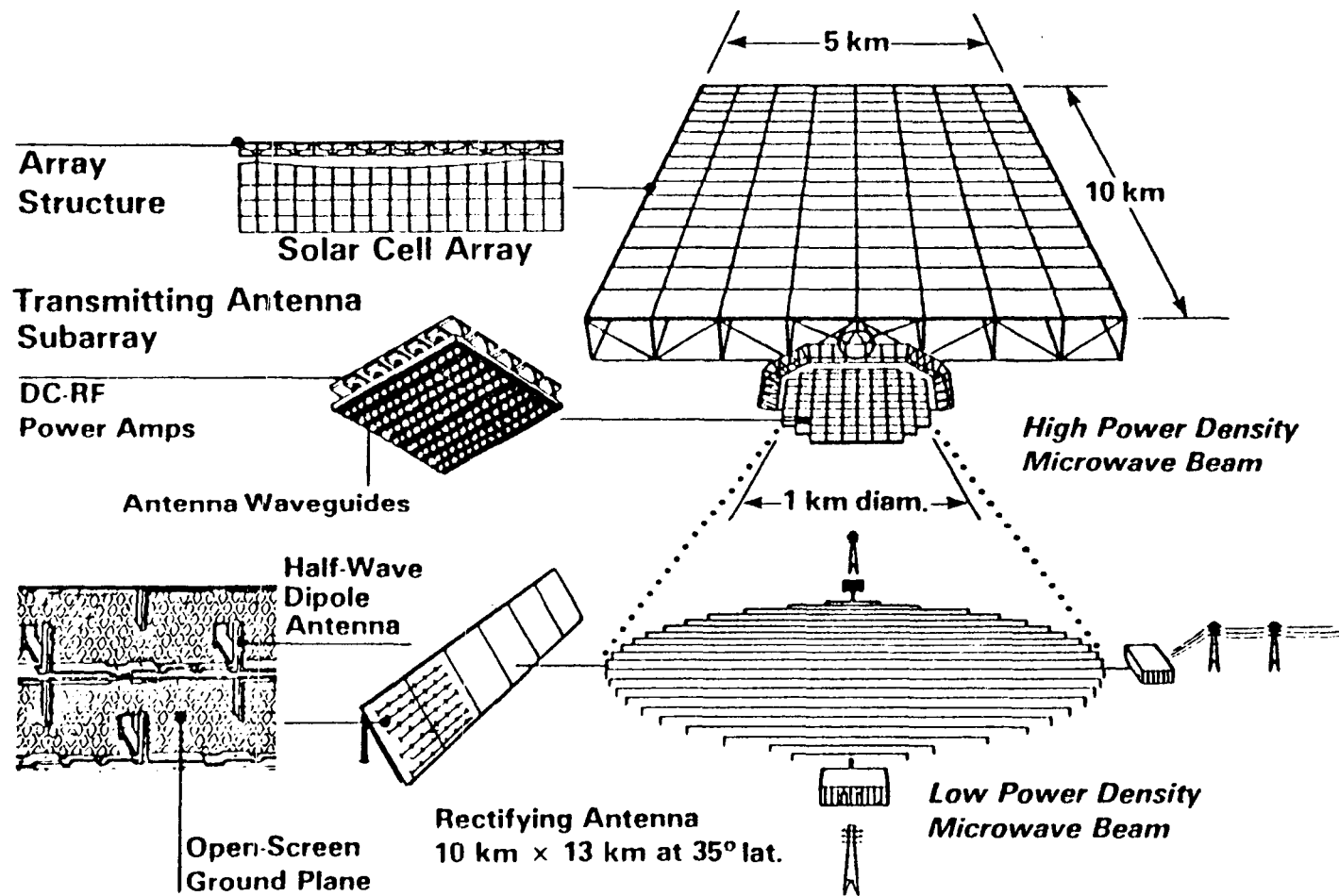


Figure 3. Basic SPS Reference System Characteristics

(Department of Energy Report DOE/ER-0023, October 1978). The reference system is an interim working concept which provides the technical and operational information needed to conduct environmental, socioeconomic, and comparative assessment studies. NASA's current systems definition work provides a more complete understanding of the satellite power system while present assessment studies will provide information to influence future system designs.

An SPS satellite, as specified in the reference system, would be a planar solar-cell array of about 50 square kilometers built on a graphite-fiber-reinforced structure. It is illustrated in Figure 3. A microwave transmitting antenna one kilometer in diameter would be mounted on one end of the satellite. The satellite would be constructed in geosynchronous orbit (GEO) as illustrated in Figure 2. A ground receiving station (rectenna) for each satellite would be completed at the same time (see Figure 3). The reference system presumes 60 satellites could be constructed over a 30-year period.

Construction bases in space, launch and mission control bases on earth, and fleets of space vehicles would be needed to construct and maintain the satellites. The transportation vehicles would include heavy-lift launch vehicles, personnel launch vehicles, cargo orbit-transfer vehicles, and personnel orbit-transfer vehicles.

SATELLITE POWER SYSTEM PROGRAM

The objective of the SPS Concept Development and Evaluation Program (CDEP) is to develop by the end of FY 1980 an initial understanding of the technical feasibility, economic practicality, and social and environmental acceptability of the SPS concept. Major program milestones in the CDEP are:

- o October 1977 Initiate studies
- o October 1978 Reference system definition
Preliminary environmental,
societal and comparative
assessments
- o June 1979 Revised environmental, societal
and comparative assessments
- o September 1979 Preliminary program assessment
- o July 1980 Final program assessment

In order to meet the program objective, the SPS program is organized in four discrete yet interrelated program elements, each directed toward specific program objectives. The four program elements are:

- o Systems Definitions
- o Environmental Assessment
- o Societal Assessment
- o Comparative Assessment

The objectives and accomplishments of each element are discussed very briefly in the following subsections. Lists of specific projects and detailed project summaries are deferred to the next section. A bibliography of selected reports follows and an index to program participants closes the report.

Systems Definition

The objective of the systems definition is to define a reference SPS

concept, to evaluate its technical feasibility, to provide the requisite technical information for the environmental, societal, and comparative assessments, and to investigate emerging technologies. NASA and its contractors have established a reference concept that emphasizes technical and operational information in support of the assessment activities.

In FY 1979 efforts were devoted to the use of solid state devices for conversion of the photovoltaic electricity to microwave energy and to the use of lasers for power transmission. Considerable attention was devoted to study of the pilot beam characteristics and to the transmitting antenna phase control and phase reference distribution. SPS operations, materials requirements, costs and schedules were also addressed during the fiscal year.

A preliminary design of an offshore rectenna is in progress. An investigation of the potential hazard to the SPS satellite from "spacecraft charging," and to the rectenna from lightning, together with recommended mitigating measures were concluded during the fiscal year.

Environmental Assessment

Several major environmental research and assessment projects were initiated in FY 1979. The goal of these tasks was to advance the state of knowledge by the end of FY 1980 to the point where the probability and severity of SPS environmental impacts can be assessed.

The four fundamental issues related to the SPS construction and operations have been defined as:

- o Human Health, particularly the effects of microwave radiation on the general public and SPS workers and the effects of ionizing radiation on space workers.
- o Ecosystems, particularly the effects of launch activities and rectenna operations on ecosystems.

- o Atmosphere, particularly the effects of SPS launch activities on atmosphere, weather, and climate.
- o Communications, particularly the effects of SPS microwave power transmission on ionospheric-dependent telecommunication systems and the Radio Frequency Interference (RFI)/Electromagnetic Interference (EMI) effects of microwave sidelobes on other communications systems.

Each of these issues is further subdivided and addressed in assessment, planning and research phases. Assessment activities involve a review of what is known, unknown, and uncertain about each critical issue or subissue. The planning activities involve the design of statistically valid experiments to generate the data that were identified as inadequate in the assessment phase. The research activities involve conducting experiments to meet the goals and objectives set forth in the planning stage.

In the human health area, a literature survey conducted in FY 1978 indicated a significant need for additional data on the health effects of microwave radiation.

Experiments identified to begin a preliminary investigation of the potential effects of microwaves are:

- o response of birds, bees, and other airborne biota to microwave transmission;
- o teratogenic (birth defects) effects of microwave power transmission;
- o immunological/hematological (blood-related) effects of microwave beam transmission; and,
- o perturbations in behavior resulting from the interaction of drugs with SPS microwave radiation.

The design of these experiments was initiated in FY 1979.

Experiments on the effects of microwave radiation on bees were initiated. These experiments are investigating the survival, longevity, flight orientation, foraging, and inter-colony behavior of the European honey bee after exposure to varying levels of microwave radiation.

Through various workshops and other preliminary assessment activities, many of the specific impacts of the SPS on the atmosphere were identified. Because of the different properties of the atmosphere caused by the difference in ionic and molecular composition, the same materials inserted into different layers of the atmosphere may produce drastically different effects. Vehicle effluent effects on the ionized atmosphere are of particular concern. Study efforts in FY 1979 indicated that the efforts of launch activities on local and global climate may be an important SPS concern. Theoretical and experimental research projects designed specifically to resolve these issues have been identified.

Potential communications problems caused by the SPS operation have been identified. Experiments conducted in FY 1979 included the verification of electron temperature enhancement experiments completed in FY 1978. This was done by sending high-power, pulsed frequency into the ionosphere where changes in densities were measured. Theoretical studies on the ionosphere were also conducted. The effect of the SPS microwave beam on communications satellites was identified as a communications problem that needs to be resolved. In addition, RFI/EMI problems caused by the SPS microwave beam sidelobes and spurious emissions are under study. The results will indicate the extent of degradation and recommended mitigation measures.

Societal Assessment

The objectives of the Societal Assessment program are to identify social issues which relate to the development of the SPS and to establish an information base regarding these issues to be used in the Comparative Assessment. The approach to the Societal Assessment has been to identify social issues or impacts in four major categories: resources, international issues, institutional factors, and public acceptance.

Resource research has focused on materials requirements, net energy analyses, and rectenna siting studies. Potential manufacturing and raw material supply problems related to alternative SPS designs have been identified. Some analyses of the SPS using some of the widely varying techniques available have shown SPS to have rated marginally favorable to very favorable when compared to other energy sources. There are, however, large uncertainties associated with the SPS design and with the energy analysis techniques themselves. A rectenna siting methodology and an initial data base has been developed. Additionally, a societal impact assessment of a hypothetical rectenna facility has been initiated.

Research of international issues related to SPS has included questions of national and international security, international collaboration in the development, construction, and operation of an SPS systems, and the existence and adequacy of current international mechanisms and agreements to address SPS problems. The potential military applications have been explored along with an estimate of the vulnerability of SPS to military or terrorist activity. International organizations interested in SPS development have been identified and possible financial and international organization scenarios have been developed. Additionally, a range of international agreements, including those dealing with orbital availability, frequency allocations, and microwave standards that would be required for SPS implementation, has been determined.

Studies of institutional factors have been designed to ascertain whether the SPS can become part of the electrical power portfolio of the U.S. without major disruption in our institutions or social values. Projections of power demand characteristics, institutional and regulatory interfaces, and technical capabilities and problems associated with integrating SPS power into the electric utility system are under investigation. Analyses are also providing information on SPS system reliability, stability, and power transmission

characteristics. Federal regulatory implications for SPS are being studied, particularly as they deal with microwave radiation exposure standards. In addition, an effort has been initiated whereby the SPS risks, as perceived by the insurance industry, will be identified and the probable responses to these risks will be described.

Public acceptance efforts have focused on establishing a dialogue between the systems definition and assessment activities and interested publics. A public outreach experiment to make the SPS known to several segments of society has been designed and is being implemented. Another study to determine the attitudes of various publics to high technology in general and to SPS in particular is in progress. This study will also recommend ways to enhance communication with the public.

A significant ingredient of the SPS program is the SPS Participatory Technology Process shown in Figure 4. This process promotes public participation in the formulation of research questions as well as in the review of research findings. Two levels of participation are integral to the process. A peer group of experts outside the SPS program assists in defining issues and in assessing research findings. Peer group participation improves the quality of the work performed in the program and serves as the first level of public outreach. A larger group comprising diverse, concerned and interested advocacy organizations is informed of program findings and is encouraged to participate actively in the SPS dialogue. The quantity and quality of responses from peer reviews and larger outreach efforts indicate that the Participatory Technology Process will be a positive factor in SPS program evaluation.

Comparative Assessment

The objective of this assessment activity is to compare the SPS with other

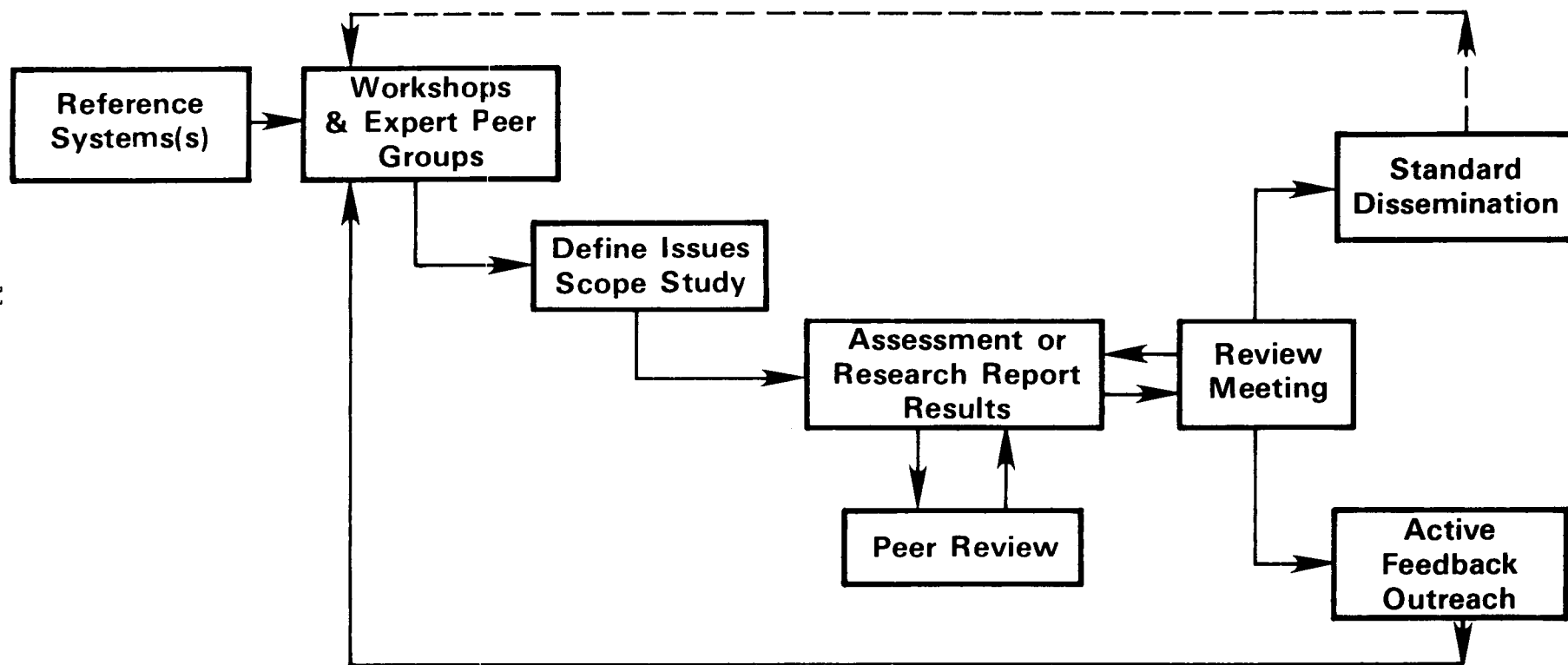


Figure 4. SPS—Participatory Technology Process for Environmental, Societal and Comparative Assessments

advanced energy technologies that are likely to be implemented in the year 2000 time-frame. This comparison will permit the selection of energy options that would be most favorable to the American people. To achieve this goal, four fundamental questions must be answered:

- o Which energy technology alternatives should the SPS be compared against?
- o Which issues, including environmental ones, should be compared?
- o How should the issues and technologies be compared?
- o What assumptions about the future state of the world affect the comparisons?

Activities in the FY 79 period included: (1) alternative design selection; (2) key issues selection and preliminary analysis; (3) development of an assessment methodology that allows a side-by-side comparison with other energy alternatives; and (4) economic analysis, including auditing of cost data and establishing uncertainties in cost analysis. Alternative technologies include (1) advanced clean coal systems; (2) combined coal cycles; (3) nuclear breeders; (4) nuclear fusion; (5) nuclear lightwater reactors; and (6) central station photovoltaics. The comparisons will be based on cost, performance, health safety, resource requirements, and environmental issues.

Planning and Analysis Support

Although it is not a discrete SPS program element, planning and analysis support to the Project Office is an integral element of the SPS Program. The activity maintains a library and documentation service and prepares long-range plans. Of particular importance during FY 1979 has been the preparation of the plan for the next potential SPS program phase - the Ground Based Exploratory Development (GBED). The GBED plan would be implemented if a decision is made that the work on SPS should proceed further.

LIST OF PROJECTS

SYSTEMS DEFINITION LIST OF PROJECTS

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
<u>FY-78 Program Element</u>		
Marshall Space Flight Center	Comparative Analysis of Metallic and Composite Materials for SPS-Related Large Space Structures	Identifies relative benefits and risks associated with use of composite and metallic materials for space structures.
Johnson Space Center	Support Studies: Analysis of S-Band Solid State Transmitter	Analyzes and develops design requirements of an S-Band solid state transmitter to be incorporated into the system definition study.
<u>FY-79 Program Element</u>		
Marshall Space Flight Center	Concept Definition	Refines and updates Reference System concept, evolves viable systems and subsystems.
Marshall Space Flight Center	Cost Model Development	Provides accurate and reliable estimates of the costs of certain SPS elements.
Marshall Space Flight Center	Electrostatic Protection of the Solar Power Satellite and Rectenna	Investigates potential hazards to SPS from "spacecraft charging" and hazard to rectenna due to lightning.
Marshall Space Flight Center	Economic Factors Relating to the Development and Implementation of the Satellite Power System	Evaluates impact of economic evaluation methodologies on SPS concept selection.
Marshall Space Flight Center	Accuracy Analysis of a Pointing Control System of the Satellite Power System	Analyzes mechanisms by which SPS mechanical and electronic control subsystems affect power beam pointing accuracy and stability.
Marshall Space Flight Center	Class E Amplifier Development	Investigates solid state amplifiers for potential application to obtain high power and efficiency.
Marshall Space Flight Center	Pilot Beam and Communication Subsystem Investigation	Develops design information on the pilot transmitter and communications subsystem.
Marshall Space Flight Center	SPS Offshore Rectenna Design Study	Designs a practical preliminary off-shore rectenna; includes cost estimates.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Marshall Space Flight Center	Materials Evaluation Recommendations	Recommends alternatives to user requirements for critical materials.
Marshall Space Flight Center	Magnetron Tube Assessment	Evaluates potential role of magnetrons in the SPS concept.
Marshall Space Flight Center	Solid State Amplifier (DC-RF) Investigations	Evaluates the potential of solid state amplifiers to meet SPS environmental and performance requirements.
Marshall Space Flight Center	Solid State Microwave Concepts Investigations	Defines the solid state "sandwich" concept and other potential solid state system concepts.
Marshall Space Flight Center	High-Accuracy Radiation Efficiency Measurement Techniques	Investigates the measurement techniques required to test SPS-type microwave systems.
Johnson Space Center	Critique, Modify, Maintain Reference System	Critiques all parts of the baseline system, modifies and integrates latest support studies into the system.
Johnson Space Center	Refine Space Construction and Maintenance Approach and Construction Facilities	Analyzes and refines construction, fabrication, assembly and related activities which occur in LEO and GEO orbit locations and at the rectenna site.
Johnson Space Center	Define Industrial and Earth Transportation Complex	Defines industrial and earth-based transportation requirements imposed on the U.S., identifies expansion in production capability and creation of new industry to support SPS.
Johnson Space Center	Conduct Launch Site Location Analysis and Complex Definition	Defines potential launch complex and funding requirements for facilities, equipment and staff for increased launch activity of a commercial scale SPS.
Johnson Space Center	Define and Analyze Operation Activity from Manufacturing through Space Construction	Defines the flow and flow rates of raw materials, components, sub-assemblies and assemblies from source to launch site to the construction site, analyzes system operations, and identifies options.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Johnson Space Center	Analyze Integration of SPS with Ground Networks	Conducts rectenna siting analysis and creates data base for construction of a rectenna in various locations.
Johnson Space Center	Prepare Technology Advancement, Development and Facility Requirements and Plans	Develops a conceptual plan outlining technology activities including preliminary schedules and costing plans for implementation of an SPS program.
Johnson Space Center	Cost Analysis and Schedule Analysis	Performs a total cost analysis including updating and integrating identifiable and accessible elements, cost flow requirements with time, and decision milestones.
Johnson Space Center	Solid State Power Amplifier Combining Evaluation	Evaluates performance and power combining efficiencies for this class of devices.
Johnson Space Center	Dynamic Behavior of Lightweight Structures Evaluation	Provides assessment of methods to analyze SPS structure and control system interactions and provide a coupled dynamic analysis of elements of the SPS system.
Johnson Space Center	Phase Distribution and Phase Control Evaluations	Develops key experimental data on breadboard units for verification of analytical results of phase control system error buildups and system performance.
Johnson Space Center	Antenna Element Experimental Evaluation	Develops data to establish bandwidth constraints for pilot signal design and signal isolation. A slotted waveguide element will be fabricated and tested to provide these data.
Johnson Space Center	Phased Array Antenna/ Receiver Control Evaluation	Provides instrumentation and testing of a low-power microwave transmission system model available at JPL to provide basic data on beam collimation and pointing and measurements of phase control errors.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Johnson Space Center	Phase Control System Hardware Simulation	Provides a cost-effective system engineering tool for evaluating phase control system effects on overall performance.
Marshall Space Flight Center	SPS Critical Mater- ials Assessment	Develops information base for selecting materials for the SPS.

ENVIRONMENTAL ASSESSMENT LIST OF PROJECTS

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
<u>FY-77 Program Element</u>		
Argonne National Laboratory	SPS Preliminary Environmental Assessment	Completes preliminary environ- mental assessment against guidelines that have been promulgated.
Argonne National Laboratory	SPS Management Analysis and Control	Develops quantitative control techniques to aid management.
Argonne National Laboratory	SPS Guidelines and Criteria	Supports review and development of guidelines for SPS concept development and evaluation.
Battelle Pacific Northwest Laboratory	SPS Microwave Radiation Effects	Estimates the effects of micro- wave radiation on health and ecosystems.
Los Alamos Scientific Laboratory	SPS Atmospheric Effects of Microwaves	Investigates the effects of SPS microwave radiation on atmosphere (ionosphere, magnetosphere).

FY-78 Program Element

Lawrence Berkeley Laboratory	SPS Non-Microwave Im- pacts on Space Worker Health and Safety Program Guidance	Provides data on non-microwave impacts on space worker health and safety for preliminary environmental impact assess- ment.
Argonne National Laboratory, Boston University	Preliminary Identifi- cation of Effects of Rocket Effluents in Upper Atmosphere, of Research Needs, and Preliminary Assess- ment of Impacts	Identifies current state of knowledge and assesses rocket effluent impacts on the atmosphere.
Argonne National Laboratory, South Dakota School of Mines and Technology	Preliminary Identifica- tion of Possible Issues and Impacts of Rectenna Operations	Assesses potential atmospheric effects of rectenna operations and the impacts on climate and weather.

FY-78 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Los Alamos Scientific Laboratory and EG&G	Reduction of LAGOPEDO Data	Identifies information from LAGOPEDO experiments re: effects of (multiple launch) rocket effluents in the upper atmosphere.
Science Applications, Incorporated	Preliminary Assessment of Effects of Rocket Effluents in Troposphere	Assesses probable impacts of rocket launches in the troposphere.
Rice University, Dept. of Commerce/ITS	SPS Magnetospheric and Ionospheric Heating Facility	Identifies experimental program for ionosphere and magnetosphere heating tests for Arecibo and Platteville facilities.
Department of Commerce/ITS, NOAA	SPS Microwave Radiation Interactive Effects on Magnetosphere and Ionosphere	Predicts synergistic effects of SPS microwave and vehicular emissions on EM scattering properties of the magnetosphere and ionosphere.
Department of Commerce/ITS	SPS Microwave Radiation Effects on Ionosphere, Magnetosphere, and Local Field Intensity, Program Management Distributions	Provides management support for all DOE studies on SPS microwave radiation effects.
Department of Commerce/ITS	SPS Microwave Radiation, Energy Storage in Vehicles and Habitable Structures	Identifies energy storage in habitable structures and vehicles for health and safety assessment, estimates effects on electro-magnetically sensitive systems.
Department of Commerce/ITS	SPS Electromagnetic Interference (EMI) Effects	Predicts SPS-microwave effects on electromagnetic systems.
Department of Commerce/ITS	SPS Radiofrequency Interference (RFI) Effects	Predicts and assesses RFI effects.
Department of Commerce/ITS	SPS Geographic Distribution of Field Intensities	Identifies geographic power distribution and provides data to determine field strengths.
Battelle Pacific Northwest Laboratory	SPS RFI/EMI Interference	Provides potential SPS RFI/EMI problems and the equipment and procedures for reducing these problems.
Environmental Protection Agency	Microwave Exposure Chambers for Assessment of Public Health	Develops increased capacity to study effects of exposure to microwave radiation.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Argonne National Laboratory	SPS Environmental Assessment Program- Integration and Documentation	Provides information for inte- grated assessment and liaison and coordination services.
JASON Committee	Review of Environmental Assessment Program Elements	Provides expert advice and evaluation to the SPSP0.
Environmental Protection Agency	SPS Microwave Impacts on Public Health and Safety Assessment	Provides an environmental assessment of potential impacts on human health and ecosystems from microwave exposure.
Environmental Protection Agency	Program Planning on Microwave Impacts on Public Health and Safety	Establishes and coordinates re- search and development program to reduce uncertainties of hazards from operation of SPS Reference System.
Argonne National Laboratory	Design of Experiments for Late Effects in Human Populations Exposed to Low Microwave Densities Due to SPS	Provides a research plan to determine if there are late effects in human populations exposed to low microwave densities.
Battelle Columbus Laboratories	Experimental Design support for the SPS Microwave Health and Safety Assessment	Provides statistical guidance to produce design of experiments and assist the SPSP0 in evaluating these experiments.
University of California, Davis	Study of Biological and Ecological Effects of SPS Microwave on the European Honeybee	Assesses and evaluates microwave radiation on the behavioral effects on the honeybee. Detects performance decrements.
Environmental Protection Agency	Response of Airborne Biota to Microwave Transmission	Determines any detrimental microwave effects on avian species flying through the beam.
Environmental Protection Agency	Teratogenetic Effects of Microwave Power Transmission	Determines teratogenetic and/or embryopathic effects of micro- wave radiation on mice.
Environmental Protection Agency	Perturbations in Behavior Resulting from the Inter- action of Drugs with SPS	Determines drug-microwaves synergism used in assessing health impact of SPS and the threshold of drug-radiation interaction.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Environmental Protection Agency	Immunological/Hematological Effects of Microwave Beam Transmission	Confirms results of existing immune effects studies.
Environmental Protection Agency	Dependence of Microwave Biological Effects on Field Intensity	Provides a methodology for correlating different microwave exposure conditions with biologic effects.
Environmental Protection Agency	Quality Assurance of Microwave Health and Safety Research	Develops data quality assurance for microwave health and safety research program.
Lawrence Berkeley Laboratory	SPS-Assessment of Non-Microwave Effects on Health and Ecosystems	Assesses potential non-microwave impacts on human health and ecosystems.
Lawrence Berkeley Laboratory	Program Planning on Non-Microwave Impacts on Health and Ecosystems	Provides an R&D plan to resolve microwave impacts on human health and ecosystems.
Johnson Space Center	Health Impacts of Zero Gravity	Defines the hazards of weightlessness for space workers on the SPS.
Bolt, Beranek and Newman, Inc.	Evaluation of the Noise Impact of SPS Vehicles on the Community and Ecology at the Launch Site	Provides a more accurate estimate of noise levels generated by SPS launches and an assessment of the impacts of the noise on space center personnel, the surrounding communities, and ecology.
Argonne National Laboratory	Characterization of Reflected Light from the Satellite Power System	Provides the reflectance, ground illumination, and sky brightness of various SPS vehicles. Assesses reflected light effects on the human eye, biota and optical astronomy.
Lawrence Berkeley Laboratory	Ionizing Radiation in Space	Assesses potential impacts on space workers exposed to ionizing radiation.
Environmental Resources Group	Ecological Impacts of Rectenna	Identifies and assesses potential environmental impacts in the construction and operations of SPS rectenna sites.
Lawrence Berkeley Laboratory	Review Committee	Provides an independent evaluation the significance of non-microwave related impacts of the SPS on health and ecosystems.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Argonne National Laboratory	SPS-Assessment of Atmospheric Effects	Provides climatic impacts of atmospheric disturbances resulting from SPS Reference System operations.
Argonne National Laboratory	SPS Atmospheric Effects Planning	Defines research to resolve atmospheric and climatic impacts resulting from SPS Reference System operations.
The LaJolla Institute	Workshop on Upper Atmospheric Experiments	Recommends studies to resolve uncertainties of potential atmospheric effects of SPS in the upper atmosphere.
Science Applications, Inc.	Rocket Exhaust Emission Inventory	Provides detailed rocket exhaust emission inventory for use in the atmospheric environment impact assessment.
Argonne National Laboratory	Meteorological Effects of Microwave Propaga- tion and Rectenna Operation	Assesses rectenna waste heat and other microwave-related effects in the troposphere.
Argonne National Laboratory	Quantitative Assess- ment of Atmospheric Effects due to Rectenna Waste Heat Release	Provides assessment of possible atmospheric effects of rectenna operation and guidelines for rectenna design and site selection.
Science Applications, Inc.	Effects of Launch Site Operations on the Troposphere	Assesses the effects of air pollutants emitted into troposphere from launch site operations and examines air quality aspects of public health and welfare.
Argonne National Laboratory	Assessment of Possible Tropospheric Weather Modification from SPS Rocket Launches	Assesses possible inadvertent weather modification resulting from heat and moisture released in the troposphere during HLLV launches.
Argonne National Laboratory	Assessment of Photo- chemical Related Effects in the Troposphere	Assesses the impact of oxidant levels relative to Federal EPA standards.
Science Applications, Inc.	Air Quality Impacts of Launch Site Operations	Determines air quality and back-ground pollutant levels near launch sites from launch site operations.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Argonne National Laboratory	Stratospheric and Mesospheric Impact Assessment	Coordinates stratospheric-mesospheric impact assessment task activities incorporating new high altitude research findings.
Ames Research Center	Estimation of Produc- tion of Nitrogen Oxides by HLLV and PLV Upper Stage Re-entry	Provides detailed estimates of re- entry nitrogen oxide production for use in impact assessments.
Ames Research Center	Estimation of Upper Atmospheric Composi- tion Perturbations Due to SPS-Related Space-Flight Activity	Assesses high altitude composition perturbations expected to result from proposed SPS-related space- flight activity for the year 2000 and beyond.
Ames Research Center	Effects Due to Changes in Noctilucent Cloud Formation	Assesses potential effects from a change in noctilucent cloud formation due to water injections from HLLV and PLV space flights
Argonne National Laboratory	Potential Effects of Local Energy Injec- tion in the Strato- sphere and Mesosphere	Establishes potential environmental effects of localized energy injection from rocket exhaust and microwave absorption.
Argonne National Laboratory	Overall Assessment of Ionospheric and Magnetospheric Effects	Coordinates, integrates, and completes an assessment of environmental effects of the SPS in the ionosphere and magnetosphere.
Argonne National Laboratory	Electron Density and Conductivity Changes in D- and E- Regions	Determines electron density and conductivity changes caused by ion composition changes resulting from water injection in D- and E- regions.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Boston University	Research of Archived Records Concerning Ionospheric Effects of Rocket Launchings	Provides an understanding of the effects of a massive rocket launching campaign on the ionosphere and examines, collates, and assembles archival information.
Ames Research Center	Metal Ion and Atom Ablation from Spacecraft in D- and E-Regions	Estimates the magnitude and determines the probable impacts of ionic and atomic metal mass ablated from spacecraft.
Stanford University	3-D Simulation of Local Ionospheric Effects of SPS Rocket Launches	Determines nature, extent, and potential local impacts of SPS rocket exhaust injection in D-, E-, and F-regions of ionosphere and permits estimation of global impacts.
Los Alamos Scientific Laboratory	Modeling of Global Ionospheric Effects of Satellite Power System Rocket Exhaust	Assesses potential climate change and human health and telecommunication effects resulting from rocket exhaust products on the upper atmosphere.
The Aerospace Corporation	Effects of Argon Ion Injection into the Magnetosphere	Estimates environmental impacts of large injections of Argon ions into the plasmasphere and magnetosphere and estimates changes in Van Allen Belt radiation environment.
University of Washington/Colorado State University	Rocket Launch Monitoring and Launch Site Experiments	Obtains information needed for both air quality and inadvertent weather modification impact analyses of liquid fuel rocket launches.
Department of Commerce/ITS	SPS-Assessment of Ionospheric Heating and Telecommunications Impacts	Determines which telecommunication systems may be impacted by ionospheric disturbances produced by SPS Reference System operations.
Department of Commerce/ITS	Program Planning on Ionospheric Heating and Telecommunications Effects	Provides an R&D plan to resolve impacts on telecommunication services of ionospheric disturbances produced by SPS Reference System operation.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Department of Commerce/ITS	D- Region Transmission Experiment	Provides actual observations of telecommunication system performance in understanding D- region heating scenarios scalable directly to SPS operation.
Los Alamos Scientific Laboratory	Experimental Studies of Electron Heating and D- Region Instabilities	Assesses the importance of enhanced electron heating and the development of plasma instabilities in the lower ionosphere.
Rice University	SPS Magnetosphere and Ionosphere Heating Facility- Arecibo Heater Design	Provides detailed cost estimates for modification of an ionospheric heating facility.
National Center for Atmospheric Research/ United Technologies Research Center	Theoretical and Numerical Modeling of Heated Ionospheres	Provides an experimentally corroborated model of iono- spheric changes resulting from heating.
Battelle, Pacific Northwest Laboratory	SPS Electromagnetic Compatibility Assessment	Assesses electromagnetic impacts of the SPS Reference System and coordinates task activities.
Battelle, Pacific Northwest Laboratory	Electromagnetic Compatibility- Program Planning and Management	Provides an R&D plan to re- duce uncertainties impacting electromagnetic sensitive systems and establishes coordination with the EMC and frequency management.
Department of Commerce/ITS	SPS EMC Evaluation	Evaluates EMC impact on equipment and systems not associated with specific rectenna sites.
Department of Commerce/ITS	Field Intensity Map and Population Exposure	Indicates the microwave field intensities expected at the earth's surface and the population exposure to microwaves.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Department of Commerce/ITS	EMC Evaluation of Representative Rectenna Sites	Provides the basis for EMC impact estimation at any site and determines the importance of EMC considerations for site selections.
Department of Commerce/ITS	SPS-Analysis of Higher Operating Frequencies	Determines the potential and/or desirability of other frequencies for the microwave power transmission system.

SOCIETAL ASSESSMENT LIST OF PROJECTS

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
	<u>FY-78 Program Element</u>	
International Technical Services	Federal Involvement	Identifies the government bodies in SPS development and operation.
Allan D. Kotin Economic Consultants	State and Local Regulations as Applied to Satellite Power System Microwave Receiving	Identifies probable state and local government regulation that would impact SPS development.
Carl Q. Christol and Stephen Gorove	International Agreements	Determines international agreements, including orbital assessment, frequency allocations, and microwave standards that would be required for SPS implementation.
Science Applications Incorporated and Herbert E. Kierulff, Jr.	Financial/Management Scenarios	Assesses alternative financial management scenarios to develop and operate the SPS.
International Technical Services	International Organizations	Evaluates the advantages of developing an international organization to manage and finance the SPS.
PRC Energy Analysis Co. and Michael J. Ozeroff	Military Implications	Addresses SPS vulnerability issues and military implications.
Argonne National Laboratory	Relocation of Industry and Population	Identifies potential industrial and population relocation to the SPS power source.
Center for Policy Process	Centralization of Electric Power	Assesses historical trends and potential SPS-caused societal centralization.
Environmental Resource Group	Public Acceptance	Identifies public acceptability determinants and public interest groups that will play a role in SPS public acceptance.
Forum for the Advancement of Students in Science and Technology	Student Involvement in SPS	Involves the college student community in SPS project planning.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
PRC Energy Analysis Company	SPS Management and Liaison Activities	Provides general management support activities to Project Office, coordinates all Societal Assessment activities, and provides program recommendations.
PRC Energy Analysis Company	SPS Societal Assessment	Directs, reports, and provides integrated document on SPS societal impacts.
Rice University and Economic Consultants	Resources-Rectenna Siting Studies	Determines land requirements and distribution of rectenna sites.
Environmental Resources Group	Coso Hot Springs Prototype Rectenna Impact Assessment	Assesses environmental and human impacts for those living near a hypothetical rectenna facility.
PRC Energy Analysis Company	Review of SPS Work of International Interest	Explores international cooperation in SPS planning, research and technology.
PRC Energy Analysis Company	Strategy for International Involvement	Identifies international organizations with an interest in the SPS and provides a method to involve them in the SPS program.
PRC Energy Analysis Company	Military Implications	Explores the vulnerability aspects of the SPS and provides an assurance that the SPS will be used only for peaceful purposes.
PRC Energy Analysis Company	Utility Integration-Rectenna to End-User Hardware Requirements	Identifies anticipated technical problems associated with integrating SPS power into the electric utility system.
PRC Energy Analysis Company	Utility Integration-Anticipated Power Pooling	Provides SPS interface with electric utilities, projected power demand, and institutional and regulatory interfaces.
PRC Energy Analysis Company	Federal Regulations of Microwave Radiation Standards	Identifies the federal regulatory processes that set microwave exposure standards, their history and trends.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
PRC Energy Analysis Company	Institutional Issue-Insurance	Identifies insurance industry re- sponse to SPS requirements including costs, benefits and limitations.
Citizens' Energy Project, L-5 Society, and FASST	Public Outreach Experiment	Establishes a method to obtain views and comments, provides a feedback method, and enables the public to participate in SPS program.
Rice University	Cultural Attitudes	Provides an insight into the cul- tural attitudes and acceptance by the public of the SPS concept.
PRC Energy Analysis Company	Strategy for Citizen Participation	Identifies citizen participation programs to involve an informed public in the SPS program.
PRC Energy Analysis Company	On-Going Citizen Participation Program	Maintains public dialogue and permits interested groups to evaluate the SPS program.

COMPARATIVE ASSESSMENT LIST OF PROJECTS

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
<u>FY-77 Program Element</u>		
Argonne National Laboratory	SPS Comparative Assessment Methodology	Develops methodology for comparing SPS to alternative energy systems.
<u>FY-78 Program Element</u>		
Argonne National Laboratory and Harza Engineering	SPS Utility Integration	Provides a review of utility systems that could employ SPS power and determines the problems of SPS integration into the utility systems.
<u>FY-79 Program Element</u>		
Argonne National Laboratory	Comparative Assessment Methods	Develops a comparative data base and a comparative assessment methodology to compare different energy systems on a common basis.
Argonne National Laboratory and TRW, Inc.	Alternatives Characterization- Technologies	Provides a traceable basis and descriptive documentation for com- parative assessment activities and defines deficient areas in the var- ious technologies.
Argonne National Laboratory	Alternatives Characterization- Cost	Places various costs on a somewhat uniform basis and provides a con- sistent traceable cost data set for comparison.
Argonne National Laboratory	Comparative Evaluations- Cost and Performance	Enables comparisons of costs of energy of the SPS with alternative energy sources and their effective- ness in an electric utility system.
Argonne National Laboratory	Comparative Evaluations- Environmental Welfare Effects	Identifies and provides comparative evaluations of the non-health and safety effects of SPS to alterna- tive technologies.
Argonne National Laboratory	Comparative Evaluations- Climatic Effects	Identifies, qualifies, and compares climatic impacts of the SPS with alternative technologies.

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Argonne National Laboratory	Health and Safety Evaluation-Public and Occupational	Identifies level and manner in which health and safety effects are in- curred and compares them with alternatives to the SPS.
Argonne National Laboratory	Health and Safety Evaluation-Radiation Wastes and Safeguards	Provides a statement of range of radiation waste and nuclear safe- guard issues and their solutions.
Argonne National Laboratory	Resources Utilization- Land	Compares the amount of, the type of, and the duration of use of land for the SPS and alternative technologies.
Argonne National Laboratory	Resources Utilization- Net Energy Analysis	Identifies problems related to net energy and compares the SPS and other technologies with respect to net energy balance.
Argonne National Laboratory	Comparative Assessment Program Management and Documentation	Provides planning and management for integrating individual assessment products into a comparative assess- ment document.
Argonne National Laboratory	Comparative Assess- ment-Energy Systems Scenarios	Describes and quantifies a range of possible U. S. energy futures within which the SPS and alterna- tive technologies can be con- sistently evaluated.
Argonne National Laboratory	Comparative Assess- ment Review Committee	Establishes a committee of independent experts to examine, evaluate, compare, integrate and provide guidance for the various studies of the comparative assessment program.

PLANNING & ANALYSIS LIST OF PROJECTS

FY-79 Program Element

<u>Organization</u>	<u>Title</u>	<u>Projected Contribution</u>
Argonne National Laboratory	SPS-ANL Program Management	Develops management plans and a management information system to integrate and coordinate ANL SPS programs.
Argonne National Laboratory	Satellite Power System, Program Services	Performs planning and analysis functions and provides management support to the Director, SPSP0.
Argonne National Laboratory	SPS Ground Based Exploratory Devel- opment Planning	Provides detailed and long-range SPS planning capabilities.
Argonne National Laboratory	Technical Support	Provides a wide range of technical support on SPS operational problems and on problems assigned by DOE.
PRC Energy Analysis Company	SPS Program Planning and Analysis	Supplies specific support and analysis services to the SPS program including efforts in the GBED preparation, contingency planning, management and environmental guidelines, and general report preparation and support.

PROJECT SUMMARIES

TITLE

Comparative Analysis of Metallic and
Composite Materials for SPS Related
Large Space Structures

ORGANIZATION

Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

AMOUNT

FY-78 \$20,000

PRINCIPAL INVESTIGATOR

S. J. Denton

WORK LOCATION

Vought Corporation
Dallas, TX

DURATION-AWARD DATA

4 mos. - May 1, 1978

CONTRACT NO.

NAS8-33062

PROJECT SUMMARYObjective

Perform an independent analysis and evaluation of typical concepts (materials, designs, and fabrication) for SPS related large space structures.

Approach

1. Evaluate available data from previous SPS NASA and contractor efforts to identify typical material, design and fabrication concept approaches.
2. Identify the factors and methodologies employed to assess relative benefits and potential problems.
3. Analyze and evaluate candidate options.

Benefit

Independent evaluation of the relative benefits and risks of composite and metallic materials for SPS large space structures.

Reference: Vought Corporation, "Comparative Analysis of Metallic and Composite Materials for SPS-Related Large Space Structures - Final Review," September 19, 1978.

TITLE

Support Studies: Analysis of S-Band
Solid State Transmitter

ORGANIZATION

Johnson Space Center
Houston, TX 77058

AMOUNT

FY-78 \$30,000

PRINCIPAL INVESTIGATOR

L. Leopold

WORK LOCATION

RCA/David Sarnoff
Research Center
Princeton, NJ

DURATION-AWARD DATA

6 mos. - Dec 1978

CONTRACT NO.

NAS9-15755

PROJECT SUMMARYObjective

Determine the applicability of solid-state technology to the SPS microwave transmitter by conducting studies emphasizing fundamental tradeoffs and concepts and establish technical feasibility of utilizing solid-state amplifiers such as current allium arsenide devices.

Approach

1. Conduct concept and feasibility investigations, tradeoff studies.
2. Analyze a minimum of two alternative approaches or concepts for the field effect transistors (FET).
3. Perform analysis by assuming a single-stage distributed circuit FET amplifier demonstrating a minimum of 1.4 W of output RF power at 80% efficiency and a module gain of 30 dB.
4. Perform study by assuming a gallium-arsenide lumped-element amplifier with power added efficiency of 80%.

Benefit

Provides a summary of tradeoff exercise parameters and conclusions. Lists the guidelines aimed at yielding designs compatible with projected space applications.

TITLE

Concept Definition

ORGANIZATIONMarshall Space Flight Center
Marshall Space Flight Center, AL 35812

AMOUNTFY-78 \$550,000
FY-79 \$500,000**PRINCIPAL INVESTIGATOR**C. H. Guttman

WORK LOCATIONRockwell International
Corp., Downey, CA**DURATION-AWARD DATA**

9 mos. - Jun 18, 1979

CONTRACT NO.NAS8-32475

PROJECT SUMMARYObjective

Further investigations of the SPS System Concept(s) evolving viable system/sub-system design concepts.

Approach

1. Perform in-depth investigation of solid state microwave power transmission transistor.
2. Carry out a space transportation analysis to derive preferred concepts data supportive of the SPS design concept.
3. Conduct analysis to define specific tests, technology, components, hardware, etc., that will become part of the experimental/verification demonstration program.
4. Perform systems engineering and integration analysis.
5. Generate cost and programmatic data based on new technical analyses and systems integration data.

Benefit

Provide DOE and NASA with sufficient data and information to select a preferred viable SPS Concept(s) by FY 1980.

Reference: Rockwell International Corporation, Satellite Power System (SPS) Concept Definition Study, Final Report, Volumes I through VII, March 1979, Contract NAS 8-32475.

Rockwell International Corporation, Satellite Power System (CPS), Concept Definition Study, Final Report, Volumes I through VI, and VIIA and VIIB, April, 1978, Contract NAS 8-32475.

Rockwell International, "Satellite Power System (SPS) Research and Development Planning Network - SPS Photovoltaic Power Conversion Subsystem," July 1978.

TITLE

Cost Model Development

ORGANIZATIONMarshall Space Flight Center
Marshall Space Flight Center, AL 35812

AMOUNTFY-78 \$35,000
FY-79 \$25,000**PRINCIPAL INVESTIGATOR**J. W. Hamaker

WORK LOCATIONPlanning Research Corp.
Huntsville, AL**DURATION-AWARD DATA**

12 mos. - Feb. 1, 1979

CONTRACT NO.NAS8-31645

PROJECT SUMMARYObjective

Develop Cost Estimating Relationships (CER's) for the MSFC SPS cost model.

Approach

1. Develop CER's which will include:
 - . The conventional system/subsystem approach, and others.
 - . The Red Star data base, and additional data collected from other sources.
2. Analyze selected data for each program/project application to ensure that the data used are the best available predictors of the expected costs of the intended application.
3. Stratify data within a CER to reflect varying degrees of hardware complexity.

Benefit

Provides reliable cost estimates of certain SPS cost elements.

Reference: PRC System Services Company, "Satellite Power System (SPS) Cost Model," September 19, 1978.

TITLE

Electrostatic Protection of the
Solar Power Satellite and Rectenna

ORGANIZATION

Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

AMOUNT

FY-78 \$50,000

PRINCIPAL INVESTIGATOR

L. W. Brantley

WORK LOCATION

Rice University
Houston, TX

DURATION-AWARD DATA

6 mos. - Jun 15, 1978

CONTRACT NO.

NAS8-33023

PROJECT SUMMARYObjective

Investigate the potential hazard that electrostatic charging presents to the satellite and the rectenna, and determine the implications on the reference SPS design.

Approach

1. Investigate the rectenna lightning hazard including:
 - . The nature and distribution of natural lightning.
 - . The reference rectenna design.
 - . The effectiveness of compatible lightning protection devices.
2. Investigate satellite electrostatic space charging hazard including:
 - . Areas on the satellite likely to receive high voltages and vulnerable to resulting arcs or breakdowns.
 - . The magnitude of the hazard in each area.
 - . Specific design changes to eliminate or reduce the hazard.

Benefit

Reduces potential hazard from electrostatic charges to the satellite and rectenna.

Reference: Rice University, "Electrostatic Protection of the Solar Power Satellite and Rectenna," September 28, 1978.

TITLE

Economic Factors Relating to the
Development and Implementation of
the Satellite Power System

ORGANIZATION

Marshall Space Flight Center
Marshall Space Flight Center, A1 35812

AMOUNT

FY-78 \$95,000

PRINCIPAL INVESTIGATOR

M. A. Page

WORK LOCATION

ECON, Inc.
Princeton, NJ

DURATION-AWARD DATA

8 mos. - Apr 1, 1978

CONTRACT NO.

NAS8-33002

PROJECT SUMMARYObjective

Investigate the effects that economic factors have on SPS Concept(s) selection.

Approach

1. Utilize the available methodologies and computer software previously developed.
2. Investigate the consideration of economic factors in the SPS system studies that relate to the selection of the SPS satellite configuration.
3. Perform an analysis to determine the proper rate of interest to use in SPS systems definition studies.
4. Investigate the impacts of differential inflation on SPS system definition costing procedures.
5. Investigate the impact of energy system evaluation methodologies on SPS system definition studies.
6. Investigate utility interface issues that could result on SPS system design impacts.

Benefit

Provides an overview as to the relationship between various economic evaluation methodologies and their impacts on SPS concept selection.

- Reference:
- (a) Econ, Inc., "A Study of Some Economic Factors Relating to the Development and Implementation of a Satellite Power System," 77-146-1, January 25, 1978.
 - (b) Econ, Inc., and Arthur D. Little, Inc., "Assessment of Economic Factors Affecting the Satellite Power System," September 19, 1978.
 - (c) Hazelrigg, George A., "Costing the Satellite Power System," ECON, Inc., American Astronomical Society, November 2, 1978.

TITLE	ORGANIZATION
Accuracy Analysis of a Pointing Control System of a Satellite Power System	Marshall Space Flight Center Marshall Space Flight Center, AL 35812

AMOUNT	PRINCIPAL INVESTIGATOR
FY-78 \$10,000	J. T. Howell
FY-79 \$20,000	

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
University of Tennessee Knoxville, TN	8 mos. - Jul 1, 1979	TBD

PROJECT SUMMARY

Objective

Determine overall pointing accuracy, the resolution required for pilot beam sensors, and define control system requirements and constraints.

Approach

1. Analyze the microwave beam pointing control subsystem and design a control command scheme with the command signal generated from (1) a single reference subarray at the center of the antenna and (2) a multiple subarray distributed throughout the antenna.
2. Investigate and determine the microwave beam pointing accuracy and the effects of the following on accuracy:
 - . Mechanical gimbal accuracy.
 - . Resolution and sensitivity of pilot beam sensors.
 - . Phased array pointing accuracy.
 - . Structure alignment.
 - . Dynamic structural bending displacement and frequency.
 - . Distortions in pilot and power beams.
3. Develop a set of control subsystem requirements and design constraints.

Benefit

Systems affecting SPS microwave beam pointing accuracy and stability will be analyzed and a pointing control system will be designed.

Reference: University of Tennessee, Accuracy Analysis of a Pointing Control System of the Satellite Power System, February 1979.

TITLE

Class E Amplifier Development

ORGANIZATIONMarshall Space Flight Center
Marshall Space Flight Center, AL 35812

AMOUNT

FY-78 \$18,000

PRINCIPAL INVESTIGATORW. Finnell

WORK LOCATIONMarshall Space Flight
Center, AL**DURATION-AWARD DATA**

12 mos. - Apr 1, 1978

CONTRACT NO.In-House

PROJECT SUMMARYObjective

Determine the applicability of Class E Amplifiers to the solid-state SPS concept.

Approach

1. Construct low frequency laboratory model of circuit and determine performance characteristics.
2. Construct intermediate frequency laboratory model of circuit and determine performance characteristics.
3. Construct 2.45 GHz model of circuit and determine performance parameters.
4. Develop series strings and increase power levels and determine performance characteristics.

Benefits

Provides improved reliability and low noise characteristics. Enables operation at drastically reduced voltages.

TITLE		ORGANIZATION
Pilot Beam and Communication Subsystem Investigations		Marshall Space Flight Center Marshall Space Flight Center, AL 35812

AMOUNT	PRINCIPAL INVESTIGATOR
FY-78 \$24,500	W. Finnell

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Raytheon Company Wayland, MA	6 mos. - Sep 1, 1978	NAS8-33157

PROJECT SUMMARY

Objective

Provide design information on the pilot transmitter and SPS communication link and an analysis of RFI generated by the pilot transmitter.

Approach

1. Select a baseline phase control system.
2. Define the design characteristics of the pilot transmitter.
3. Determine the RFI generated by the pilot system.
4. Define the design characteristics of the communications system.
5. Determine the number of different frequencies required for the SPS scenario of 50-100 satellites.

Benefit

Develops improved pilot beam characteristics and establishes RFI levels. Provides tradeoffs in phase control system for least cost and complexity. Identifies subsystems requirements to reduce program cost. Determines the extent of RFI on communications.

Reference: Raytheon Company, Pilot Beam and Communications Subsystem Analysis, February 1979.

TITLE		ORGANIZATION
SPS Offshore Rectenna Design Study		Marshall Space Flight Center Marshall Space Flight Center, AL 35812
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$65,000	C. H. Guttman	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Rice University Houston, TX	8 mos. - Jun 15, 1979	TBD

PROJECT SUMMARY

Objective

Provide a practical preliminary design for an offshore rectenna which would be compatible with a 5 GW solar power satellite.

Approach

1. Select an offshore rectenna site(s).
2. Define the offshore environment.
3. Design the offshore rectenna.
4. Develop cost estimate of offshore rectenna.
5. Determine secondary uses of the offshore rectenna.

Benefit

Could provide sites in proper geographic areas. Provides sites near power distribution and demand centers since dedicated land sites may not be available. May result in fewer environmental and ecological issues.

TITLE		ORGANIZATION	
Materials Evaluation Recommendations		Marshall Space Flight Center Marshall Space Flight Center, AL	35812
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-79 \$10,000		C. H. Guttman	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
University of Virginia Charlottesville, VA	12 mos. - Feb 1, 1979	H-34356B	

PROJECT SUMMARY

Objective

Estimate SPS material requirements and assess the impact of those materials determined to be "critical."

Approach

1. Define needed materials technology.
2. Assess critical materials availability, characteristics and application.
3. Provide recommendations on the suitability of materials for application.

Benefit

Determines the availability of materials and identifies areas for alternative design to replace critical or less abundant material. Determines best material candidate for reducing costs.

TITLE		ORGANIZATION
Magnetron Tube Assessment		Marshall Space Flight Center Marshall Space Flight Center, AL 35812
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$150,000		W. Finnell
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Raytheon Company Wayland, MA	10 mos. - Jul 1, 1979	TBD

PROJECT SUMMARY

Objective

Develop experimental magnetron DC-RF converter data for evaluation of the potential role of magnetrons in the SPS microwave concept.

Approach

1. Extend the laboratory data base on the injection locked magnetron.
2. Project the magnetron directional amplifier technology.
3. Provide comparative data so the projected magnetron directional amplifier can be compared with the Klystron amplifier

Benefit

Could result in higher RF-DC conversion efficiency and overall microwave system efficiency.

TITLE	ORGANIZATION
Solid State Amplifier (DC-RF) Investigations	Marshall Space Flight Center Marshall Space Flight Center, AL 35812

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$300,000	B. Reed

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Rockwell International Corp., Downey, CA	12 mos. - Jun 18, 1979	NAS8-32475

PROJECT SUMMARY

Objective

Evaluate the potential of solid state amplifiers to meet SPS environmental and performance requirements.

Approach

1. Build and test one Class E and one Class C off-the-shelf type transistor amplifiers.
2. Build and test one Class E and one Class C advanced-state-of-the-art type transistor amplifiers.
3. Integrate the amplifiers into a solid state microwave transmission demonstration unit.

Benefit

Provides attractive alternatives to power-tube amplifiers especially in the area of low noise and increased reliability.

TITLE		ORGANIZATION
Solid State Microwave Concepts Investigations		Marshall Space Flight Center Marshall Space Flight Center, AL 35812
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$50,000		W. Finnell
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Raytheon Company Wayland, MA	8 mos. - Jun 1, 1979	NAS8-33157

PROJECT SUMMARY

Objective

Develop solid state microwave concept parametric system data which can be integrated into an overall SPS satellite design. Emphasize the solid state sandwich concept.

Approach

1. Construct a math model of the performance specifications required.
2. Generate an initial concept design of the microwave generator, power distribution system and antenna array.
3. Investigate solutions for aperture weighting for sidelobe control.
4. Identify problem areas and outline approaches for solutions.
5. Develop cost estimates.

Benefit

Develops rationale and provides data for possibly using advanced solid state technology in the SPS microwave system.

TITLE	ORGANIZATION
High Accuracy Radiation Efficiency Measurement Techniques	Marshall Space Flight Center Marshall Space Flight Center, AL 35812

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$20,000	R. Inman

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Georgia Institute of Tech., Atlanta, GA	4½ mos. - Jul 1, 1979	NAS8-33605

PROJECT SUMMARY

Objective

Investigate the measurement techniques required to test SPS type microwave systems.

Approach

1. Determine preferred measurement techniques.
2. Evaluate measurement accuracy limitations.
3. Determine facilities required to accomplish measurement goals.
4. Equipment survey of state-of-the-art antenna instrumentation equipment; evaluation of their measurement accuracies and limitations.

Benefit

Information base to assist in SPS microwave test facility design.

TITLE		ORGANIZATION
Critique, Modify, Maintain Reference System		Johnson Space Center Houston, TX 77058
AMOUNT		PRINCIPAL INVESTIGATOR
FY78	\$293,000	H. E. Benson
FY79	19,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Company Seattle, WA	16 mos. - Jun. 19, 1978	NAS 9-15636 Task I

PROJECT SUMMARY

Objective

Critique of and further investigations of the SPS Reference System concept including alternative approaches to provide sufficient data inputs for the NASA/DOE concept evaluation studies in 1979 and final recommendations and documentation in 1980.

Approach

1. Subcontractors to perform an independent critique of the preliminary base-line system concept.
2. Typical activities of further investigation include: transmitter antenna structural integration and development of an SPS Reference Design employing a solid-state transmitter.
3. The system description will be updated incorporating results of tasks as they influence the System Description.

Benefit

Provides a critique of the SPS Reference System and identifies those design features requiring further analysis. Develops a rationale for any proposed effort intended to result in a major system element design change. Critically analyzes SPS system elements including the criteria of reduced cost and/or the reduction of risk and technology advancement.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE		ORGANIZATION
Refine Space Construction and Maintenance Approach, Construction Facilities		Johnson Space Center Houston, TX 77058
AMOUNT		PRINCIPAL INVESTIGATOR
FY78	\$150,000	H. E. Benson
FY79	65,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Company Seattle, WA	16 mos. - Jun. 19, 1978	NAS 9-15636 Task II

PROJECT SUMMARY

Objective

Iterate and optimize construction and maintenance approach and investigate the possibility of reducing the size and complexity of the construction base and operations with a subsequent reduction in construction costs.

Approach

1. Satellite Construction

- Critique baseline concept and analyze other innovative concepts.
- Analyze alternative concepts.
- Maintenance analysis

2. Rectenna Construction

- Analyze construction of rectenna from three design standpoints:
 - a. Automated construction equipment and techniques.
 - b. Cost impact of innovative structural modifications.
 - c. Structural analysis for alternative electronic approaches.

Benefit

Identifies an alternative construction concept. Provides the design analysis of the construction base. Develops an approach for automated construction of rectenna, the maintenance requirements for the satellite and rectenna, and the space maintenance requirements for construction and transportation systems.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE

Define Industrial and Earth
Transportation Complex

ORGANIZATION

Johnson Space Center
Houston, TX 77058

AMOUNT

FY-78 \$18,000
FY-79 36,000

PRINCIPAL INVESTIGATOR

H. E. Benson

WORK LOCATION

Boeing Aerospace Company
Seattle, WA

DURATION-AWARD DATA

16 mos. - Jun 19, 1978

CONTRACT NO.

NAS 9-15636
Task III

PROJECT SUMMARYObjective

Define the industrial and earth-based transportation requirements to implement a commercial SPS system.

Approach

1. Select areas of production capacity issues.
2. Review and select candidate solar cell process.
3. Provide inputs for launch vehicle, structural and propellant manufacturer.
4. Update, review and analyze production flow concept.
5. Identify potential transportation problems.

Benefit

Identifies new production capacity requirements, size and type of major factories, equipment, personnel and resources, potential transportation problems, facility costs and personnel, and packaging concepts.

References:

- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
- (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE

Conduct Launch Site Location Analysis and
Complex Definition

ORGANIZATION

Johnson Space Center
Houston, TX 77058

AMOUNT

FY78 \$23,000
FY79 57,000

PRINCIPAL INVESTIGATOR

H. E. Benson

WORK LOCATION

Boeing Aerospace Co.
Seattle, WA

DURATION-AWARD DATA

16 mos. - Jun.19, 1978

CONTRACT NO.

NAS 9-15636
Task IV

PROJECT SUMMARYObjective

Define the potential launch complex for increased launch activity and the funding requirements for the facilities, equipment and staff to support the required traffic.

Approach

1. Collate compatible launch vehicle and site options.
2. Conduct trade studies between space transportation rates, possible environmental impacts versus ground logistics and other impacts.
3. Analyze off-shore and on-shore launch and recovery sites for various vehicles and relative costs and problems of several approaches.
4. Define functional requirements of launch site.

Benefit

Provides parametric data of launch site options. Recommends preferred launch site latitude. Identifies emissions from a trajectory analysis. Defines the launch complex, personnel and funding requirements.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE		ORGANIZATION
Define and Analyze Operational Activity From Manufacturing Through Space Construction		Johnson Space Center Houston, TX 77058
AMOUNT		PRINCIPAL INVESTIGATOR
FY78	\$ 16,000	H. E. Benson
FY79	140,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Company Seattle, WA	16 mos. - Jun. 19, 1978	NAS 9-15636 Task V

PROJECT SUMMARY

Objective

Define the flow and flow rates of raw materials, components, subassemblies from space to launch site to the construction site.

Approach

1. Develop payload packaging concepts.
2. Analyze program elements for options of system operations (i.e., control of flights from central mission control, a LEO construction, a GEO construction base, or some other alternative).
3. Define physical interfaces between program elements and manpower and computational requirements for each of the control centers.
4. Summarize all operations defined in other sections of the study.

Benefit

Provides a description of the concise end-to-end operations as well as the continuity of launch and recovery site operations. Integrates the space logistics and defines the ground flow, LEO transportation and rectenna hardware.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE		ORGANIZATION
Analyze Integration of SPS with Ground Networks		Johnson Space Center Houston, TX 77058
AMOUNT	PRINCIPAL INVESTIGATOR	
FY78 \$14,000	H. E. Benson	
FY79 93,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Co. Seattle, WA	16 mos. - Jun. 19, 1978	NAS 9-15636 Task VI

PROJECT SUMMARY

Objective

Achieve data base of requirements and considerations involved in constructing a rectenna in any location.

Approach

1. Prepare information package and solicit utility inputs.
2. Estimate environmental (latitude) variables.
3. Define land requirements.
4. Develop site selection criteria.
5. Perform rectenna-grid interconnects and operating systems analysis.
6. Analyze SPS-grid operations.

Benefit

Provides a data base for the requirements and alternatives before reaching a decision involved in constructing a rectenna in any location with emphasis on sensitivities associated with the total range of variables inherent in a wide range of geographical locations and classes of terrain. Develops a design criteria for various elements of the rectenna, established in order to relate to cost of construction in any location. Assesses utility grid connections and operations.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE

Prepare Technology Advancement, Development,
and Facility Requirements and Plans

ORGANIZATION

Johnson Space Center
Houston, TX 77058

AMOUNT

FY78 \$35,000
FY79 60,000

PRINCIPAL INVESTIGATOR

H. E. Benson

WORK LOCATION

Boeing Aerospace Co.
Seattle, WA

DURATION-AWARD DATA

16 mos. - Jun. 19, 1978

CONTRACT NO.

NAS 9-15636
Task VII

PROJECT SUMMARYObjective

Develop a conceptual plan outlining the technology activities required for implementation of an SPS program.

Approach

1. Update, circulate for comments, and revise technology advancements requirements.
2. Update and improve preliminary estimate of ground-based experimental research plan.
3. Develop initial estimate of shuttle flight experiments.
4. Analyze flight project and initial commercial SPS options.
5. Input technology advancement and development requirements for space construction, rectenna and avionics.
6. Develop initial overall development approach.

Benefit

Advances technology and develops a schedule and cost plan for laboratory and earth-based development and testing, shuttle flight experiment and equipment, flight projects, SPS commercial development, and facility development requirements.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE	ORGANIZATION
Cost Analysis and Schedule Analysis	Johnson Space Center Houston, TX 77058

AMOUNT	PRINCIPAL INVESTIGATOR
FY78 \$ 6,000	H. E. Benson
FY79 55,000	

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Co. Seattle, WA	16 mos. - Jun. 19, 1978	NAS 9-15636 Task VIII

PROJECT SUMMARY

Objective

Provide an updated system cost estimate to reflect system changes and support the system definition document update.

Approach

1. Update work breakdown structure.
2. Update costs for space construction.
3. Estimate costs for avionics.
4. Integrate and update baseline costs.
5. Update launch site costs.
6. Automate schedule analyses and development costs.

Benefit

Incorporates SPS costs in WBS format. Develops program plan with options, examines the program critical path, and assesses cost/risks to provide for key decision points.

- References:
- (a) "Satellite Power System (SPS) System Definition Study (Part III) Preferred Concept System Definition," Boeing, March 1978.
 - (b) "Solar Power Satellite System Definition Study," Vols. I-VII, Boeing Aerospace, April 1979.

TITLE		ORGANIZATION
Solid-State Power Combining Amplifier Experiments		NASA Johnson Space Center Houston, TX 77058
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$150,000	L. Leopold	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Company Seattle, WA	7 mos. - Jun 1979	NAS9-15363

PROJECT SUMMARY

Objective

Provide the analysis, measurements and tradeoffs of a combining power amplifier that will guide the design of the SPS FET amplifier.

Approach

1. Compare sufficient test results and parameters and weigh to establish an optimum design.
2. Perform tests of impedances, losses, combining of devices, microwave circuitry and antenna to complement the devices.

Benefit

Evaluates the capability of the solid-state power combining amplifier and antenna as one of the many requirements leading to the successful operation of a solid-state transmitter/antenna applicable to the SPS.

TITLE

Dynamic Behavior of Lightweight
Structures Evaluation

ORGANIZATION

Johnson Space Center
Houston, TX 77058

AMOUNT

FY-79 \$200,000

PRINCIPAL INVESTIGATOR

R. C. Ried

WORK LOCATION

Jet Propulsion Lab
Pasadena, CA
Rensselaer Poly Inst.
Troy, NY

DURATION-AWARD DATA

12 mos - Jul 1979

CONTRACT NO.

TBD

PROJECT SUMMARYObjective

Develop an overall assessment of the interacting structure and control function for an SPS and characterize control philosophies which can guide the development of SPS concepts. Assess the dynamic stability of the combined solar array and MPTS for a total operative SPS and investigate the dynamic performance with the interaction of the structure and control systems.

Approach

The overall interaction assessment and characterization of control philosophies will be performed by R.P.I. Detailed analytical investigations of large lightweight multi-mass dynamic structures will be conducted at JPL in collaboration with JSC.

Benefit

These overall assessments and analyses will establish confidence in the current control system and structure design approaches.

TITLE	ORGANIZATION
Phase Distribution and Phase Control Evaluation	NASA Johnson Space Center Houston, TX 77058

AMOUNT	PRINCIPAL INVESTIGATOR
FY79 \$200,000	J. W. Seyl

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Lockheed Electronics Co. Houston, TX Boeing Aero- space Company, Seattle, WA	13 mos. - May 1979	NAS 9 - 15800 NAS 9 - 15636

PROJECT SUMMARY

Objective

Develop and evaluate SPS phase distribution control electronics and power transponder breadboard units. Verify the feasibility of meeting assumed phase error constraints. Consider fiberoptic links as a means of phase reference distribution.

Approach

1. Sufficient hardware will be fabricated to allow buildup of a portion of the SPS Reference Phase Control System.
2. System level tests will be conducted to evaluate the capability of the phase control system to maintain equal and constant phase at several points separated by more than 100 meters of cabling.
3. Tests will be conducted to validate phase conjugation techniques and determine the ability to isolate the coded pilot signal from the power signal.
4. Overall phasing accuracy will be assessed.

Benefit

Identifies where present simulations performance assumptions are soft and establishes potential technological deficiencies in existing techniques and hardware for accomplishing the SPS phase control functions.

TITLE		ORGANIZATION
Antenna Element Experimental Evaluation		NASA Johnson Space Center Houston, TX 77058

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$100,000	J. S. Kelley

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Aerospace Company Seattle, WA Johnson Space Center	9 mos. - July 1979	NAS9-15636

PROJECT SUMMARY

Objective

Assess the suitability of the slotted waveguide radiator for meeting SPS high power, high radiation efficiency, retro-directive array antenna requirements.

Approach

An S-band waveguide slot transmitting array and pilot signal receiving antenna assembly will be designed, built, and tested to simulate the space component of an SPS system. The understanding of how dimensional tolerances affect electrical performance will be emphasized. Diagnostic measurement techniques will tell how the design needs to be refined. Laboratory hardware will be constructed and tested.

The transmitting antenna will be essentially that for the minimum size power module as defined by the current SPS Reference System. Modifications to this design will be made based on the on-going Boeing in-house scale model "Stick" testing results.

Multi-pacting tests will be included.

Benefit

Provides experimental results required to assess the effects of RF band width on SPS pilot signal design and phase control system configuration/performance.

TITLE		ORGANIZATION
Phased Array Antenna/Receiver Control Evaluation		NASA Johnson Space Center Houston, TX 77058
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$100,000	R. H. Dietz	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Jet Propulsion Laboratory Pasadena, CA	TBD	TBD

PROJECT SUMMARY

Objective

Provide instrumentation and testing of a low power microwave transmission system model to obtain data required for SPS system performance evaluation.

Approach

Expand portions of the planned JPL experimental evaluations of a 16-element retro-directive S-band array by increasing the instrumentation capabilities.

Perform additional/new tests to provide data pertinent to evaluation of SPS system performance.

Benefit

The requested phase control system test parameters will provide needed hardware performance capability assessments.

TITLE		ORGANIZATION
Solar Power Satellite (SPS) Phase Control System Hardware Simulation		Johnson Space Center Houston, TX 77058
AMOUNT		PRINCIPAL INVESTIGATOR
FY78	\$ 70,000	J. W. Seyl
FY79	125,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
LinCom Corporation Pasadena, CA	15 mos. - Dec. 15, 1978	NAS 9-15782

PROJECT SUMMARY

Objective

Develop a full-scale SPS microwave system computer simulation to provide NASA/DOE with a cost-effective system engineering tool for evaluation of phase control system effects on overall SPS performance. Conduct system performance tradeoffs to assure realistic baseline system technique selection and parameter criteria for hardware development phases.

Approach

Apply systems engineering/analysis to define and mathematically model the baseline phase control system. Simulate with this model the SPS phase control system and provide the microwave transmission channel with parametric capabilities. Include parameters such as phase distribution system error buildup, conjugation phase errors, power amplifier phase noise, ionospheric phase distortion, antenna mechanical alignment and pointing, and relative spacetenna/rectenna areas and motions in the simulation as variables. Provide with the computer simulation end-to-end SPS microwave system performance such as antenna pattern, power transfer efficiency, pointing error, power density distribution, and noise characteristics.

Benefit

Investigates various system hardware configurations and parameter values to establish the overall system performance (efficiency) sensitivity to each. Selects basic system hardware specification values with reasonable assurance of meeting overall system performance capabilities.

- References:
- (a) "Automatic Phase Control in Solar Power Satellite Systems," LinCom Corporation, TR-7809-0977, September 1977.
 - (b) "A Solar Power Satellite Transmission System Incorporating Automatic Beamforming, Steering and Phase Control," LinCom Corporation, TR-7806-0977, June 1978.
 - (c) "SPS Phase Control Systems Performance via Analytical/Computer Simulation," LinCom Corporation, TR-7903-0977, March 1979.

TITLE		ORGANIZATION
SPS Critical Materials Assessment		Marshall Space Flight Center Marshall Space Flight Center, AL 35812
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$62,000		R. Grause A. Whitaker
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Marshall Space Flight Center, AL	7 mos. - Jul. 1979	In-House

PROJECT SUMMARY

Objective

Identify the most promising candidate materials to meet SPS functional requirements.

Approach

1. Establish type of materials required and the orbital environmental and function performance requirements.
2. Assess the potential long term effects of the orbital environment on these materials by the compilation, evaluation and extrapolation of existing environmental effects data and the generation of accelerated test data for selected materials.
3. Define critical materials problems and define the technology development effort required to resolve these problems.

Benefit

Develops information base for selecting materials for the SPS.

TITLE		ORGANIZATION
SPS Preliminary Environmental Assessment		Argonne National Laboratory 9700 Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
\$60,000	T. D. Wolsko	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	9 mos. - Sep., 77	189-ANL49576

PROJECT SUMMARY

Objective

Complete a preliminary environmental impact assessment against criteria guidelines, and standards that have been promulgated for SPS.

Approach

1. Develop a file of environmental and socioeconomic data and study results.
2. Complete a preliminary environmental assessment as a function of criteria and guidelines.
3. Report results.

Benefit

1. Environmental assessment information to aid NASA in carrying out their SPS concept definition work
2. SPS environmental data for Congress, the public, environmentalists, governmental agencies, etc.

- References:(a) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 1, Argonne National Laboratory, DOE/ER-0021/1, October 1978.
- (b) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol.2, Argonne National Laboratory, DOE/ER-0021/2, October 1978.

TITLE

SPS Management Analysis and Control

ORGANIZATIONArgonne National Laboratory
9700 Cass Avenue
Argonne, IL 60439

AMOUNT

\$25,000

PRINCIPAL INVESTIGATORT. D. Wolsko

WORK LOCATION

Argonne, IL

DURATION-AWARD DATA

9 mos. - Sep., 77

CONTRACT NO.189-ANL49576

PROJECT SUMMARYObjective

Develop and apply control techniques to enable DOE to analyze the many program variables and their interactions for use in the management process.

Approach

Complete management analysis, venture analysis, and SPS evaluation methodology, and produce decision trees for the SPS Concept Evaluation Program.

Benefit

Control techniques for decision making and for the development of recommendations.

TITLE

SPS Guidelines and Criteria

ORGANIZATIONArgonne National Laboratory
9700 Cass Avenue
Argonne, IL 60439

AMOUNT

\$50,000

PRINCIPAL INVESTIGATORT. D. Wolsko

WORK LOCATION

Argonne, IL

DURATION-AWARD DATA

12 months - August, 1978

CONTRACT NO.189-ANL49576

PROJECT SUMMARYObjective

To review and support development of environmental, public health, safety, economic, and socioeconomic guidelines and criteria for SPS concept development and evaluation.

Approach

1. Review existing environmental and socioeconomic guidelines, criteria and standards.
2. Isolate existing guidelines, criteria and standards that are relevant to the development and evaluation of SPS concepts.
3. Identify areas where guidelines, standards, etc. are needed.
4. Extend guidelines, standards, etc. and develop new ones as required.

Benefit

Guidelines and criteria to be used during SPS concept development and evaluation.

TITLE		ORGANIZATION
SPS Microwave Radiation Effects		Battelle Pacific Northwest Laboratory Richland, WA
AMOUNT	PRINCIPAL INVESTIGATOR	
\$75,000	R. D. Phillips	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Richland, WA	12 mos. - Sep., 77	EY-76-C-06-1830 08132-81028

PROJECT SUMMARY

Objective

Evaluate effects of SPS microwave radiation on public health, environment, and terrestrial ecology.

Approach

1. Assess risks involved in exposure to microwave radiation.
2. Identify key areas of uncertainty and gaps in current knowledge.
3. Plan and undertake research to fill these voids and to improve microwave exposure effects predictive capability.
4. Up to date predictions as feasible.

Benefit

Improved microwave effects data base upon which to base SPS concept definition and evaluation decisions.

Reference: Justesen, D. R., et al., Compilation and Assessment of Microwave Bioeffects, Final Report, A Selective Review of the Literature on Biological Effects of Microwaves in Relation to the Satellite Power System (SPS), PNL-2634(Rev), May 1978

TITLE		ORGANIZATION
SPS Atmospheric Effect of Microwaves		Los Alamos Scientific Laboratory Los Alamos, NM
AMOUNT	PRINCIPAL INVESTIGATOR	
\$75,000	J. Zinn	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Alamos, NM	12 mos. - Aug., 77	LASL D-511 W7405-ENG-36

PROJECT SUMMARY

Objective

Determine indirect public health and environmental impacts from microwave beam interactions with atmosphere.

Approach

1. Determine effects of beam interactions with the ionosphere and magnetosphere.
2. Determine beam climatological effects, and heat "island" effects.
3. Analyze these effects to determine impacts on public health and environment.

Benefit

Will provide some of the base data needed to develop guidelines defining maximum permissible power levels within the microwave beam.

TITLE

SPS Non-Microwave Impacts on Space
Worker Health and Safety Program
Guidance

ORGANIZATION

Lawrence Berkeley Laboratory
Berkeley, CA 94720

AMOUNT

\$43,000

PRINCIPAL INVESTIGATOR

M. White

WORK LOCATION

Berkeley, CA

DURATION-AWARD DATA

6 mos. - Apr. 1, 78

CONTRACT NO.

ANL# 31-109-38-4465

PROJECT SUMMARYObjective

Coordinate non-microwave study efforts to determine the effects of non-microwave effects on space worker health and safety.

Approach

1. Review planned DOE studies for non-microwave effects, and coordinate program plans.
2. Provide detailed statement of work, research proposals, contractual documents, and act as liaison between DOE and subcontractors, as required.

Benefit

Qualified specialists will coordinate the study of non-microwave effects on space workers, and provide a data base for preliminary impact assessment.

- Reference: (a) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 1, Argonne National Laboratory, DOE/ER-0021/1, October 1978.
- (b) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 2, Argonne National Laboratory, DOE/ER-0021/2, October 1978.

TITLE	ORGANIZATION
Preliminary Identification of Effects of Rocket Effluents in Upper Atmosphere, of Research Needs and Preliminary Assessment of Impacts	Argonne National Laboratory 9700 Cass Avenue Argonne, IL 60439

AMOUNT	PRINCIPAL INVESTIGATOR
\$115,500	D. Rote, M. Mendillo*

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL Boston, MA	6 mos - Apr 1, 1978	189-ANL49576

PROJECT SUMMARY * M. Mendillo of Boston University, Consultant to ANL.

Objective

Summarize current state of knowledge, and identify the effects of rocket effluents in the upper atmosphere and assess the impacts. Identify information and analytical technique requirements and recommend research priorities.

Approach

The following tasks were required to achieve the stated objective:

1. Present state-of-knowledge regarding upper atmospheric effects of rocket effluents (ionospheric modifications) is assessed, through a critical review of experimental and theoretical investigations.
2. Evaluate NASA space lab experiments and recommend any additional measurements that would be required.
3. Use LAGOPEDO data to simulate multiple launch effects on the upper atmosphere. Evaluate the need for a more refined model.
4. Organize workshop on possible climatic/weather modification mechanisms and impacts of rocket effluents in atmosphere.
5. Investigate possible effects of ion-engine propellents used for inter-orbit vehicles.
6. Organize in-depth workshop to identify known or predicted effects, characterize existing basis for predicting effects, and determine additional information requirements.
7. Prepare preliminary assessment of rocket effluents impacts in the upper atmosphere.

Benefit

Provides data base and preliminary impact analysis on upper atmosphere.
Serves as basis for determination of additional research that may be required.

- Reference: (a) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 1, Argonne National Laboratory, DOE/ER-0021/1, October 1978.
- (b) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 2, Argonne National Laboratory, DOE/ER-0031/2, October 1978.

TITLE		ORGANIZATION
Preliminary Identification of Possible Issues and Impacts of Rectenna Operations		Argonne National Laboratory 9700 Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
\$38,000	J. Lee/T. Yamada/H.D. Orville*	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL Rapid City, SD	6 mos. - Apr. 1, 78	189-ANL49576

PROJECT SUMMARY

Objective

Qualitatively assess the atmospheric effects of rectenna operations and their impacts on climate and weather in order to provide inputs to the analysis of microwave propagation.

Approach

This project required the following tasks:

1. Perform literature review.
2. Planetary boundary layer and convective cloud modeling will be used to analyze atmospheric effects of rectenna operations.
3. Trial simulation using a 3-D model under specific rectenna configuration and atmospheric conditions will be performed.
4. Investigate the possibility of generating an organized convective flow in the vicinity of the rectenna site and the consequences, using a 2-D modeling approach.
5. Organize a workshop to identify other issues of potential importance, and recommend additional research.
6. Prepare a preliminary assessment of impacts.

Benefits

Provides a preliminary assessment of the potential atmospheric effects of rectenna operations. This assessment will form the basis for rectenna design and site selection guidelines, and will serve as input to the assessment of public health and welfare impacts, and microwave propagation impacts. Issues requiring further research will be identified.

* H.D. Orville of South Dakota School of Mines and Technology, Consultant to ANL.

TITLE		ORGANIZATION
Reduction of LAGOPEDO Data	EG&G	-and- Los Alamos Scientific Lab.
	Los Alamos, NM	Los Alamos, NM 87545
AMOUNT	PRINCIPAL INVESTIGATOR	
\$25,000	J. Zinn	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Alamos, NM	6 mos. - April 1, 1978	LASL R-468 W7405-ENG-36

PROJECT SUMMARY

Objective

To extract information from the LAGOPEDO experiments relevant to the assessment of upper atmospheric effects of rocket effluents.

Approach

Reduce, analyze, and summarize relevant data from the LAGOPEDO experiments for SPS assessment.

Benefit

Provides information regarding the nature and extent of ionospheric holes caused by multiple launch rocket emissions.

TITLE		ORGANIZATION
Preliminary Assessment of Effects of Rocket Effluents in Troposphere		Science Applications, Inc. Huntsville, AL
AMOUNT	PRINCIPAL INVESTIGATOR	
\$38,812	A. Goldford	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Huntsville, AL	5 mos. - Apr. 1, 78	ANL# 31-109-38-3764

PROJECT SUMMARY

Objective

Prepare a preliminary assessment of rocket propellants emitted into the troposphere and their impacts. Estimate rocket effluents including thermal energy and water release into the troposphere.

Approach

1. Perform a literature review on theoretical launch vehicle tropospheric interaction phenomena including hydrocarbon.
2. Collect, review, and analyze data from past launches of expendable vehicles, and correlate data to the HLLV.
3. Assess possible environmental effects of HLLV system configurations, including chemical and mechanical (acoustic) phenomena.
4. Estimate source terms to be used in inadvertent weather modification predictions.
5. Examine the feasibility and advisability of using more sophisticated simulation techniques to analyze launch vehicle ground clouds.
6. Organize a workshop on tropospheric environmental effects related to HLLV launch activity.

Benefits

1. Provides a comprehensive overview of probable impacts of rocket propellants released into atmosphere (long and short term), and probable impacts of rocket launches in the troposphere.
2. Provides info needed to assess impacts on public health and welfare, launch site ecology, and inadvertent weather modification.
3. Prioritizes additional information and research requirements.

TITLE		ORGANIZATION
SPS Magnetosphere and Ionosphere Heating Facility		Rice University Houston, TX 77001
AMOUNT	PRINCIPAL INVESTIGATOR	
\$58,000	W. E. Gordon/R. Dyce	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Houston, TX	8 mos - Apr 1, 1978	ANL# 31-109-38-4636

PROJECT SUMMARY

Objective

Design physical experiments to assess the EMC of SPS.

Approach

Provide detailed experimental program definition for ionosphere and magnetosphere heating tests.

Benefit

Identifies cooperative test program for Arecibo, P.R. and Platteville, CO facilities.

Reference: Gordon, W. E., F. T. Djuth, and L. M. Duncan, Full Scale Power Density Test Definition for Studying Ionosphere/Magnetosphere Microwave Beam Interactions at Arecibo, Puerto Rico. Task I - Design of Heating Experiment, William Marsh Rice University, Houston, TX, April 1979.

TITLE		.ORGANIZATION
SPS Magnetosphere and Ionosphere Heating Facility		Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT	PRINCIPAL INVESTIGATOR	
\$33,000	C. Rush	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	8 mos. - Apr. 1, 78	Interagency Agreement No. E-(49-26)-1041

PROJECT SUMMARY

Objective

Design and determine engineering specifications for an ionosphere heating facility.

Design physical experiments to assess the EMC of SPS.

Approach

Provide detailed equipment specifications, and experimental program definition for ionosphere and magnetosphere heating tests utilizing the Platteville, CO facility.

Benefit

1. Provides detailed cost estimates for modification of testing facility.
2. Identifies cooperative test program for Arecibo, P.R. and Platteville, CO facilities.

TITLE

SPS Microwave Radiation Interactive
Effects on Magnetosphere and Ionosphere

ORGANIZATION

Department of Commerce
Institute for Telecommunications Sciences
Boulder, CO 80302

AMOUNT

\$30,000

PRINCIPAL INVESTIGATOR

C. Rush

WORK LOCATION

Boulder, CO

DURATION-AWARD DATA

8 mos. - Apr. 1, 78

CONTRACT NO.

Interagency Agreement No.
E-(49-26)-1041

PROJECT SUMMARYObjective

Characterize the expected effects of SPS microwave radiation on the EM scattering properties of the magnetosphere and ionosphere.

Approach

1. Obtain data on realistic model from atmospheric impact assessment.
2. Using realistic models of the ionosphere and magnetosphere, predict microwave beam interactive effects.

Benefit

Refines early predictions of SPS microwave beam interactions with the ionosphere and magnetosphere, perturbed by SPS vehicular emissions.

TITLE SPS Microwave Radiation Effects on Ionosphere, Magnetosphere, and Local Field Intensity, Program Mgmt. Distributions	ORGANIZATION U.S. Department of Commerce Inst. for Telecommunications Sciences Boulder, CO 80302
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AMOUNT \$25,000	PRINCIPAL INVESTIGATOR C. M. Rush
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WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	8 months-Apr. 1, 1978	Interagency Agreement No. E-4926-1041

PROJECT SUMMARY

Objective

Provide program management and support for studies to determine SPS microwave radiation effects on the magnetosphere and ionosphere and on local field intensities at or near the surface of the earth.

Approach

1. Review existing study program.
2. Provide detailed statements of work, research proposals, data and contractual documents, as required.
3. Act as liaison between DOE and research subcontractors.
4. Coordinate research program with information required by DOE, the Environmental Societal and Comparative Assessment programs, and the NASA Systems Definition program.

Benefit

Provides a coordinated effort by qualified specialists on microwave effects on the atmosphere, and provides reports and data set for preliminary environmental impact statement. This information will be used as an input to the societal and comparative assessments.

TITLE		ORGANIZATION
SPS Microwave Radiation, Energy Storage in Vehicles and Habitable Structures		Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT	PRINCIPAL INVESTIGATOR	
\$20,000	H. Liebe	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	8 mos. - Apr. 1, 78	Interagency Agreement No. E-(49-26)-1041

PROJECT SUMMARY

Objective

Identify and quantify microwave energy storage in habitable structures and vehicles. Quantify increase in local field intensity due to energy storage.

Approach

Utilizing analytical or experimental methods, determine any increases in local field intensities caused by energy storage in habitable structures or vehicles, for peak and average power density values from the SPS microwave beam at the rectenna site.

Benefit

Quantifies microwave energy storage in habitable structures and vehicles. This data will provide useful information to estimate effects on electromagnetically sensitive systems in the rectenna site vicinity, and for the microwave health and safety impact assessment.

Reference: Liebe, H. J., Field Maxima Inside Habitable Structures Exposed to 2.45 GHz Plane Wave Radiation, Institute for Telecommunications Sciences, Boulder, CO, October 1979.

TITLE		ORGANIZATION
SPS Electromagnetic Interference (EMI) Effects		Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT	PRINCIPAL INVESTIGATOR	
\$65,000	W. Grant/K. Davis	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	8 mos. - Apr. 1, 78	Interagency Agreement No. E-(49-26)-1041

PROJECT SUMMARY

Objective

Predict interference effects on electromagnetic systems and devices not intended to receive radio signals.

Approach

1. Identify critical and non-critical equipment that predicts potential effects on systems within the rectenna exclusion area and that predicts effects on critical systems outside the rectenna exclusion zone.

Benefit

Provides an assessment of potential range of EMI effects, and identifies systems that could be affected.

TITLE		ORGANIZATION
SPS Radiofrequency Interference (RFI) Effects		Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT	PRINCIPAL INVESTIGATOR	
\$84,000	W. Grant/K. Davis	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	8 mos. - Apr. 1, 78	Interagency Agreement No. E-(49-26)-1041

PROJECT SUMMARY

Objective

Predicts effects on systems and devices not intended to receive SPS microwave radiofrequency signals.

Approach

1. Identify sensitive systems.
2. Quantify system performance degradation at SPS Radiofrequencies.
3. Estimate the probability of coupling prohibitive amounts of energy to the systems.

Benefit

Assesses the probability and potential of unacceptable radiofrequency interference effects caused by the SPS.

TITLE SPS Geographic Distribution of Field Intensities		ORGANIZATION Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT FY 78 \$38,000	PRINCIPAL INVESTIGATOR W. Grant	
WORK LOCATION Boulder, CO	DURATION-AWARD DATA 8 mos. - Apr. 1, 78	CONTRACT NO. Interagency Agreement No. E-(49-26)-1041

PROJECT SUMMARY

Objective

Quantify geographic power distribution for entire SPS system.

Approach

1. Obtain information from NASA SPS Systems Definition on MPTS radiation characteristics for a single SPS system, GEO locations for the total multi-station system and frequency-intensity spectrum.
2. Predict the field strengths expected at and near the surface of the earth from SPS microwave beam emissions.

Benefits

Provides a determination of peak and average field strengths as a function of RF and geographic location. This information will support health and safety and communication impact assessments.

TITLE		ORGANIZATION
SPS RFI/EMI Interference		Battelle Memorial Institute Pacific Northwest Laboratory Richland, WA 99352
AMOUNT		PRINCIPAL INVESTIGATOR
FY 77	\$75,000	K. C. Davis
FY 78	\$38,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Richland, WA	12 mos. - Aug., 77	EY-76-C-06-1830 D8132-81028

PROJECT SUMMARY

Objective

Determine terrestrial, airborne, and space-borne communications; navigation; radar; radio astronomy; and other electronic systems affected by SPS.

Approach

1. List all electronic systems and equipments that might be adversely affected (RFI/EMI) by SPS operations.
2. Assess impact of SPS radiation on these systems.
3. Evaluate devices and procedures for mitigating these impacts.
4. Identify information gaps and plan and initiate research to fill these voids.

Benefit

An understanding of potential SPS RFI/EMI problems and the equipment and procedures for reducing these problems.

TITLE	ORGANIZATION
Microwave Exposure Chambers for Assessment of Public Health Impacts	Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711

AMOUNT	PRINCIPAL INVESTIGATOR
FY-78 \$100,000	J. S. Ali, C. Weil

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Research Triangle Park, NC.	16 mos. - Jun 10, 1978	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Expand EPA 2450 MHz animal exposure system facility.

Approach

Expand facility, including:

1. A 1kW generator with continuous wave, pulsed, and amplitude modulated modes of operation and power level control.
2. A free-field irradiation anechoic chamber with temperature, humidity and light control.
3. Linear and circularly polarized, waveguide exposure cells.
4. Orthogonal field probes.

Benefit

Increased capacity to study in-vivo exposure to 2450 MHz radiation.

TITLE

SPS Environmental Assessment
Program - Integration and Documentation

ORGANIZATION

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

AMOUNT

FY-79 \$215,000

PRINCIPAL INVESTIGATOR

A. Valentino

WORK LOCATION

Argonne, IL

DURATION-AWARD DATA

12 months - October 1, 1979

CONTRACT NO.

WPAS ANL-49576

PROJECT SUMMARYObjective

Produce an integrated Environmental Assessment. Produce a plan for R&D to reduce the uncertainty in this assessment.

Approach

1. Provide an integration effort for the five EA task areas -- Microwave Health and Ecology (I); Non-Microwave Health and Ecology (II); Atmospheric Impacts (III); Ionospheric Heating (IV); and Electromagnetic Compatibility. Include information or results which contribute to more than one task.
2. Provide assistance to the DOE EA Manager in defining tasks, analyzing funding requirements, monitoring the progress of work, coordinating with the task managers, and preparing progress and other reports.
3. Integrate into an Environmental Assessment those assessments prepared by the task area managers indicating what is known and not known in each area.
4. Integrate the R&D plans prepared by each task area manager into an Environmental Assessment R&D Plan for input into the Ground Based Exploratory Development Program Plan.

Benefit

Assures that all assessments are progressing satisfactorily. Provides information for an integrated assessment. Provides liaison and coordination services between task managers.

- References:
- (a) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 1, Argonne National Laboratory, DOE/ER-0021/1, October 1978.
 - (b) Halverson, Steven L., et al., Preliminary Environmental Assessment for the Satellite Power System (SPS), Vol. 2, Argonne National Laboratory, DOE/ER-0021/2, October 1978.

TITLE		ORGANIZATION
Review of Environmental Assessment Program Elements		JASON Committee
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$10,000		G. McDonald
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
San Diego, CA	11 mos - Jan 1979	

PROJECT SUMMARY

Objective

Critically review and evaluate elements of the CDEP environment assessment.

Approach

Panels of the JASON Committee will critically review existing information and, on the basis of discussion with program principals, provide evaluations to SPSP0 management after review and approval by the parent committee of the following elements:

- . physical basis for microwave bioeffects
- . SPS effects on the atmosphere
- . the program plan for evaluating potential impacts of ionospheric heating.

Benefit

Provides expert advice and evaluation to the SPSP0.

TITLE	ORGANIZATION
SPS Microwave Impacts on Public Health and Safety Assessment	Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711

AMOUNT	PRINCIPAL INVESTIGATOR
FY-78 \$25,000	D. F. Cahill
FY-79 -0-	

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Research Triangle Park NC	24 mos. - Jun 10, 1978	Interagency Agreement No. DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Identify, define and assess potential impacts on human health and ecosystems of microwave exposure resulting from operation of SPS Reference Systems. Identify possible procedures to mitigate microwave environmental impacts of Reference System operation. Provide support for the preparation of an integrated environmental assessment. Provide technical and management support.

Approach

1. Formulate a plan to assess the potential health and ecosystem impacts of microwave exposures produced by operation of SPS Reference Systems and include methods for identifying and defining potential impacts, assessing potential impacts, and for documenting, reviewing, and presenting results.
2. Prepare an assessment of what is known, unknown, and uncertain regarding the potential microwave impacts on human health and ecosystems of SPS Reference System operations.
3. Assist in the preparation of an integrated environmental assessment of SPS Reference System operations.
4. Manage and coordinate all work under the SPS Microwave Effects on Health and Ecosystems Task.

Benefit

Provides reports and data for an environmental assessment of potential impacts on human health and ecosystems of microwave exposure.

TITLE		ORGANIZATION
Program Planning on Microwave Impacts on Public Health and Safety		Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$40,000	D. F. Cahill
FY-79	-0-	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Research Triangle Park NC	24 mos. - Jun 10, 1978	Interagency Agreement No. DE-AO01-79ER10060

PROJECT SUMMARY

Objective

Establish and develop a plan for the conduct of research and development to reduce uncertainties in the assessment of potential environmental impacts of microwave exposures resulting from operation of SPS Reference Systems. Provide technical and management support for the preparation of an integrated environmental assessment R&D plan for inclusion in the SPS Ground Based Exploratory Development Plan.

Approach

1. Develop a plan of research activities to obtain the information required to reduce uncertainty in the assessment of potential environmental impacts.
2. Assist in integrating the results of (1) into an environmental assessment R&D plan for inclusion into the GBED plan. Utilize all relevant existing information on microwave bioeffects and SPS Reference Design operations (i.e., spatial, frequency, and temporal distribution of microwave power densities).
3. Develop protocols for the conduct of research to be undertaken and estimate the cost and time requirements.
4. Solicit, evaluate, and select research proposals for award and supply post award management.

Benefit

Coordinates the microwave impact study effort. Provides insight on hazards of microwave exposure from operation of SPS Reference Systems.

TITLE		ORGANIZATION
The Design of Experiments for Late Effects in Human Populations Exposed to Low Microwave Densities Due to SPS		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$8,000	G.A. Sacher	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos.- Oct. 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Design of experiments to determine late effects in human populations exposed to low microwave densities due to SPS.

Approach

After appropriate discussions, consultations, and deliberations on the statistical aspects of the experimental design, initiate a proposal to undertake planning and experimental design efforts.

Benefits

Provides a research plan to determine if there are late effects in human populations exposed to low microwave densities due to SPS.

TITLE		ORGANIZATION
Experimental Design Support for the SPS Microwave Health and Safety Assessment		Battelle Columbus Laboratories Columbus, Ohio
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$10,000	R. E. Thomas	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Columbus, OH	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide statistical guidance to produce design of experiments for the SPS Microwave Health and Safety Assessment and assistance to SPSP0 in evaluation of the above experiments.

Approach

1. Provide information on the statistical aspects of experimental design to SPS program participants in the area of microwave health and safety.
2. Assist SPSP0 in the evaluation of the experimental programs of the SPS program participants in this area.

Benefits

Improves experimental program designs.

TITLE		ORGANIZATION
Study of Biological and Ecological Effects of SPS Microwave on the European Honeybee		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$ 38,000	N. Gary
FY-79	\$ 136,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
University of California Davis, CA		WPAS ANL-49576 ANL No. 31-109-38-4442

PROJECT SUMMARY

Objective

Obtain experimental information on the response of the European Honeybee to microwave exposure under SPS operating conditions.

Approach

1. Complete initial field and laboratory experiments on the survival and longevity, orientation and flight behavior, and dosage mortality bioassays of European Honeybees irradiated with continuous wave 2.45 gigahertz microwaves at a range of power densities centered at 25 milliwatts per square centimeter.
2. Continue ongoing laboratory and field experiments on behavioral and biological responses.
3. Prepare preliminary cost and experimental design of the microwave field exposure area.
4. Interpret experimental results in terms of assessing potential health and ecosystems impacts of microwaves resulting from operation of the SPS Reference System.
5. Provide support for incorporating results and interpretations into environmental assessments of SPS operations.

Benefit

Assesses and evaluates microwave radiation on the behavioral effects on a species whose behavior is stereotyped and well understood. Detects performance decrements. Enables an impact assessment to be made.

TITLE		ORGANIZATION
Response of Airborne Biota to Microwave Transmission		Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$800,000		D. F. Cahill
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
A.D. Little, Inc.	TBD	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Evaluate the effects of the SPS microwave beam on airborne biota, especially birds.

Approach

1. Perform wind-tunnel experiments on small flying birds, such as passerines and larger birds such as ducks and geese to determine lethal and sublethal responses.
2. Perform navigational experiments with birds such as homing pigeons or migratory birds to determine whether microwaves interfere with navigational abilities.
3. Determine behavioral response of birds exposed to microwaves under a variety of ambient conditions.

Benefit

Determines whether the added heat load of microwaves will be detrimental to birds flying through the beam under a variety of environmental conditions. Also, determines whether the microwave beam will have any effects on birds' navigation systems. Assesses effects of microwave radiation on bird behavior and determines attraction to or avoidance of the rectenna site.

TITLE

Teratogenic Effects of Microwave
Power Transmission

ORGANIZATION

Environmental Protection Agency
Environmental Research Center
Research Triangle Park, NC 27711

AMOUNT

TBD

PRINCIPAL INVESTIGATOR

D. F. Cahill

WORK LOCATION

TBD

DURATION-AWARD DATA

TBD

CONTRACT NO.

DE-AI01-79ER10060

PROJECT SUMMARYObjective

Determine whether continuous wave 2,450 MHz microwave radiation is teratogenic or embryopathic in mice.

Approach

1. Establish experiment that includes the following:
 - a. expose mice at 5 power densities (0.1, 0, 10 and 30) mW/cm².
 - b. Exposure in a uniform \pm .5 (dB) far-field of a plane wave.
Whole body SAR are to be obtained on representative-sized animal.
 - c. Animals will be exposed on the dorsal surface in an anechoic chamber, an environmental condition of 21^o to 24^o C and 40-60% relative humidity.
 - d. Duration of exposure is daily from 1, post breeding through day 18.

Benefit

Determines teratogenic and/or embryopathic effects of microwave radiation on mice.

TITLE	ORGANIZATION
Perturbations in Behavior Resulting from the Interaction of Drugs with SPS Microwave Radiation	Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711

AMOUNT	PRINCIPAL INVESTIGATOR
TBD	D. F. Cahill

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Identify and evaluate main beam powered densities within a controlled exclusion zone at a rectenna site. Evaluate low level microwave exposure to the general public and ecology outside the controlled area from scatter from the main beam, side lobe radiation and antenna reradiation.

Approach

1. Validate prior experiments indicating exposures as low as $1\text{mW}/\text{cm}^2$ have resulted in behavior perturbations in rodents.
2. Evaluate acute and chronic effects of microwaves appropriate to the SPS (2,450 MHz CW) on operant behavior using small laboratory animals that have been acutely or chronically dosed with several classes of widely used drugs.
3. Assess perturbation of stable baseline operant performance during the microwave exposure regimen.
4. Establish degree of persistence of effects after termination of dosing by microwaves and drugs.

Benefit

Obtains results of potentially serious consequence of drug-microwaves synergism which would be useful in assessing the health impact of SPS. Also obtains data on dose-response relationships useful for determining the threshold of drug-radiation interaction.

TITLE	ORGANIZATION
Immunological/Hematological Effects of Microwave Beam Transmission	Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711

AMOUNT	PRINCIPAL INVESTIGATOR
TBD	D. F. Cahill

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Determine whether previous studies of microwave immunological systems effects are reproducible, and if reproducible, whether immunological competence of the animal is impaired.

Approach

1. Determine the threshold of microwave immunological/hematological system effects by following the procedures of Wictor-Jedrzejczak, et al., as well as by using a free-field exposure system.
2. If appropriate, employ infectivity/disease models (i.e., bacteria, virus, tumor) to assess the effect of 2,450 MHz microwave radiation on immunocompetence of exposed animals.
3. Perform an interspecies comparison of microwave effects.

Benefit

Confirms results of previous immune effects studies and determines whether immunocompetence of animals (mice) is impaired.

TITLE		ORGANIZATION
Dependence of Microwave Biological Effects on Field Complexity		Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711
AMOUNT	PRINCIPAL INVESTIGATOR	
TBD	D. F. Cahill	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Assess the effects of the exposure system on known microwave biological effects.

Approach

1. Determine thresholds for unipath and multipath irradiation systems for;
 - a. microwave-induced febrile convulsions.
 - b. microwave-altered responses to physically or chemically-induced systems.
 - c. microwave-induced work stoppage.
 - d. sensory detection of the microwave field.
2. Experiments may be performed at power densities greater than that produced by the SPS microwave field and at frequencies which produce whole and partial body resonances.
3. Assist in interpreting existing literature.
4. Assist in the definition of exposure parameters for future experiments.

Benefit

Provides a method for correlating effects obtained at low microwave intensities that use different exposure systems.

TITLE		ORGANIZATION
Quality Assurance of Microwave Health and Safety Research		Environmental Protection Agency Environmental Research Center Research Triangle Park, NC 27711
AMOUNT	PRINCIPAL INVESTIGATOR	
TBD	D. F. Cahill	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AI01-79ER10060

PROJECT SUMMARY

Objective

Assures that the quality of the physical research facilities and operations in a program evaluating the health and safety aspects of microwave power transmission is at the state of the art.

Approach

1. Visit the various research laboratories involved in various aspects of the SPS biceffects research program.
2. Make periodic qualitative and quantitative reviews of the quality control program at each research laboratory.
3. Provide guidance as necessary to each contractor to assure optimum laboratory performance.

Benefit

Assures the quality of the microwave health and safety research program.

TITLESPS-Assessment of Non-Microwave
Effects on Health and Ecosystems**ORGANIZATION**Lawrence Berkeley Laboratory
Berkeley, CA 94720

AMOUNTFY-78 \$20,000
FY-79 \$87,000**PRINCIPAL INVESTIGATOR**M. R. White

WORK LOCATION

Berkeley, CA

DURATION-AWARD DATA

12 mos. - Oct. 1, 1978

CONTRACT NO.ANL No31-109-38-4992

PROJECT SUMMARYObjective

Develop and provide a comprehensive assessment of impacts on human health and ecosystems (other than those produced by microwave exposures) that might be produced by SPS Reference Systems. Identify and evaluate procedures to mitigate potential non-microwave impacts. Provide support for an integrated environmental assessment. Provide technical and management support.

Approach

1. Formulate a plan for assessing the potential non-microwave health and ecosystem impacts of installing, operating and decommissioning SPS Reference Systems, including methods for identifying and defining potential impacts; assessing potential impacts; and documenting, reviewing and presenting results.
2. Prepare an assessment regarding potential non-microwave impacts on health and ecosystems of installing, operating and decommissioning SPS Reference Systems.
3. Assist in the preparation and review of an integrated environmental assessment of SPS Reference Systems.
4. Establish coordination and communications with other SPS Environmental Assessment Program Areas.
5. Manage and coordinate all work under the SPS Non-Microwave Effects on Health and Ecosystem Task.

Benefit

Provides an assessment of potential non-microwave impacts on human health and ecosystems.

TITLE

Program Planning on Non-Microwave
Impacts on Health and Ecosystems

ORGANIZATION

Lawrence Berkeley Laboratory
Berkeley, CA 94720

AMOUNT

FY-78 \$10,000
FY-79 \$10,000

PRINCIPAL INVESTIGATOR

M. R. White

WORK LOCATION

Berkeley, CA

DURATION-AWARD DATA

12 mos. - Oct. 1, 1979

CONTRACT NO.

ANL No.31-109-38-4992

PROJECT SUMMARYObjective

Develop and provide a plan for the conduct of research to reduce uncertainty in the assessment of non-microwave impacts on human health and ecosystems that might be produced by SPS Reference Systems.

Approach

1. Develop a plan of research activities to obtain information required to reduce uncertainty in assessing potential non-microwave impacts.
2. Assist in developing an integrated program of R&D (GBED) to reduce uncertainty in assessing potential impacts.

Benefit

Provides an R&D plan to resolve non-microwave impacts on human health and ecosystems resulting from SPS Reference System operations.

TITLE		ORGANIZATION
Health Impacts of Zero Gravity		National Aeronautics and Space Administration, Johnson Space Center Houston, TX 77058
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$40,000	L. Dietlein S. Vinograd
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Houston, TX	TBD	Interagency Agreement No. DE-AI02-79CH 10025

PROJECT SUMMARY

Objective

Assess potential impacts of zero gravity (weightlessness) on space workers during construction and operation of the SPS Reference Systems.

Approach

1. Review NASA's findings of the effects of weightlessness on astronauts and subsequent research to explain and ameliorate these effects.
2. Relate the expected effects of weightlessness to currently-defined SPS flight and work schedules.
3. Project the probable effects of weightlessness on SPS space workers.

Benefit

Defines potential impacts of weightlessness for space workers during construction and operation of the SPS Reference Systems.

TITLE		ORGANIZATION
Evaluation of the Noise Impact of SPS Vehicles on the Community and Ecology at the Launch Site		Bolt, Beranek and Newman, Inc. Canoga Park, California
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$10,000		J. F. Wilby
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Canoga Park, CA	3 mos. - Sep. 24, 1979	WPAS ANL-49576 ANL No. 31-109-38-5358

PROJECT SUMMARY

Objective

Assess the effects of noise generated by SPS rocket launches on space center workers, nearby communities and the ecology.

Approach

1. Determine vehicle configurations and launch site characteristics.
2. Provide noise level predictions for the launch site.
3. Make an assessment of the effects of the predicted noise on space center personnel, surrounding communities and the ecology.

Benefits

Provides a more accurate estimate of the noise levels generated by SPS vehicle launches and an assessment of the impacts of the noise on space center personnel, the surrounding communities, and ecology.

TITLE		ORGANIZATION
Characterization of Reflected Light from the Satellite Power System		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$10,000	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boeing Company Seattle, WA	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Quantify and describe the light-reflecting characteristics of SPS vehicles and satellites. Provide data for assessments of SPS-reflected light effects on: the human eye, ecosystems, and optical astronomy.

Approach

1. Obtain inputs from other SPS Environmental Assessment task managers and define the data and format required for an assessment of reflected light effects.
2. Examine in detail and establish the reflection characteristics of primary surface areas of major structures and vehicles of the SPS Reference System.
3. Evaluate several baseline configurations where bright reflections are directed earthward to ascertain the level of ground illumination.

Benefit

Provides the reflectance of the various Satellite Power System structures and vehicles as presently defined. Determines ground illumination and sky brightness levels for various configurations. Enables an assessment of reflected light effects on the human eye, biota and optical astronomy.

TITLE		ORGANIZATION
Ionizing Radiation in Space		Lawrence Berkeley Laboratory Berkeley, CA 94720
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$17,000	M. R. White
FY-79	\$50,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Berkeley, CA	18 mos - Apr 1, 1978	ANL# 31-109-38-4992

PROJECT SUMMARY

Objective

Provide an assessment of what is known, unknown and uncertain regarding the potential impacts on space workers exposed to ionizing radiation encountered in the construction, operation and decommissioning of an SPS.

Approach

1. Convene a panel of scientists, expert in space radiation, physics, dosimetry and biological effects of ionizing radiation, to assemble, document and interpret current knowledge relevant to assessing potential health impacts of ionizing radiation in space relevant to SPS construction, operation and decommissioning.
2. Prepare panel report on findings and recommendations.
3. Panel to assist in:
 - . preparation of an assessment of non-microwave effects
 - . preparation of the Preliminary Environmental Assessment of the SPS
 - . preparation of an overall research plan to reduce uncertainty in assessments

Benefit

Provides basis for describing and evaluating the potential impacts of SPS and for planning research required to reduce uncertainty.

TITLE

Ecological Impacts of
Rectenna

ORGANIZATION

Environmental Resources Group
6380 Wilshire Blvd., Suite 804
Los Angeles, CA 90048

AMOUNT

FY-79 \$35,000

PRINCIPAL INVESTIGATOR

A. Bachrach

WORK LOCATION

Los Angeles, CA

DURATION-AWARD DATA

TBD

CONTRACT NO.

TBD

PROJECT SUMMARYObjective

Identify and assess potential environmental impacts associated with construction and operation of SPS rectenna sites (excluding microwave impacts.)

Approach

1. Determine potential critical ecological issues relating to SPS rectenna.
2. Describe the level of knowledge and make an assessment concerning the relationship of rectenna operation to ecological processes.
3. Define technological and ecological data gaps and determine research needs.

Benefits

Provides guidance for further research. Provides an assessment based on existing conditions. Defines research priorities and develops mitigation strategies or alternate site location patterns for areas that have potentially great ecological impacts.

TITLE		ORGANIZATION
Review Committee		Lawrence Berkeley Laboratory Berkeley, CA 94720
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$43,000	M. R. White	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Berkeley, CA		

PROJECT SUMMARY

Objective

Assess the non-microwave health and ecological impacts of SPS terrestrial and space operations on the public, workers, and ecosystems.

Approach

Provide an overview function to appraise non-microwave related health and safety effects of the SPS.

Benefit

Provides an independent evaluation of the significance of non-microwave related impacts of the SPS on the health of the public and workers and on the ecology.

TITLE		ORGANIZATION
SPS-Assessment of Atmospheric Effects		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-78 \$26,500 FY-79 \$30,000	D. Rote	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct. 1, 1978	WPAS ANL 49576

PROJECT SUMMARY

Objective

Assess the potential climatic effects of SPS Reference Systems. Provide information on atmospheric impacts required for assessments being prepared by other tasks of the Environmental Assessment Program.

Approach

1. Manage and coordinate all work in the Atmospheric Effects task area.
2. Provide coordination with others studying SPS atmospheric effects within ANL, the DOE, and NASA.
3. Formulate a plan to assess the climatic effects of SPS Reference Systems including identifying and defining potential impacts; assessing potential impacts; and documenting, reviewing, and presenting results.
4. Prepare an assessment of the potential impact of SPS Reference System operations on climate.

Benefit

Provides climatic impacts of atmospheric disturbances resulting from SPS Reference System operations.

TITLE		ORGANIZATION
SPS Atmospheric Effects Planning		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	-0-	D. Rote
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Develop a research and development plan for post-1980 Ground Based Exploratory Development.

Approach

Establish and prepare a research and development plan, consistent with GBED goals to reduce uncertainties about potential atmospheric and climatic effects of SPS Reference System operations.

Benefit

Provides an R&D plan to resolve atmospheric and climatic impacts resulting from SPS Reference System operations.

TITLE

Workshop on Upper Atmospheric
Experiments

ORGANIZATION

The LaJolla Institute
LaJolla, CA

AMOUNT

FY-79 \$25,000

PRINCIPAL INVESTIGATOR

E. Bauer

WORK LOCATION

LaJolla, CA

DURATION-AWARD DATA

3 mos - Sep 1979

CONTRACT NO.

WPAS ANL-49576

PROJECT SUMMARYObjective

Design, conduct, and prepare report on a workshop that will critically examine, evaluate, and recommend experiments concerned with issues related to atmospheric effects of SPS in the upper atmosphere and ionosphere.

Approach

Design and conduct a 2-3 day workshop to:

1. Define atmospheric effects issues that must be addressed in the near term with field experiments and/or observational programs in the upper atmosphere.
2. Define atmospheric effects issues that should be addressed in the 5-year term with such programs.
3. Define, discuss, and evaluate specific experimental approaches (and/or proposals).
4. Prepare recommendations for:
 - . experimental approaches for specific purposes
 - . specific experiments and/or proposals
5. Support recommendations with statements addressing:
 - . relevance to SPS issues
 - . potential of success based on current technology
 - . potential long-term contribution to a continuing assessment program
 - . cost
 - . other

Benefits

Recommends experiments concerned with issues related to potential atmospheric effects of SPS in the upper atmosphere.

TITLE		ORGANIZATION
Rocket Exhaust Emission Inventory		Science Applications, Inc.
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$23,000	A. Goldford	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
St. Louis, MO	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Prepare a detailed rocket exhaust emission inventory giving HLLV and PLV exhaust emissions as functions of altitude, latitude, and longitude.

Approach

1. Obtain, or conduct if necessary, chemical analyses of proposed launch vehicle propellants.
2. Estimate emission rates of trace contaminants such as heavy metals and sulfur based upon propellant mass flowrates as specified for the proposed launch vehicles.
3. Carry out detailed plume and afterburning calculations on the complete trajectories for the proposed launch vehicles.
4. Update the emission estimates as vehicle designs change and evolve.

Benefit

Provides detailed rocket exhaust emission inventory for use in the atmospheric environmental impact assessments for the troposphere, stratosphere, mesosphere, and ionosphere.

TITLE		ORGANIZATION
Meteorological Effects of Microwave Propagation and Rectenna Operation		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$21,000	J. Lee
FY-79	\$15,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Define areas on microwave- and rectenna-related effects, resolve questions regarding these effects, provide technical liaison among investigations, and make a final overall assessment of tropospheric microwave-related effects.

Approach

1. Define and implement research based on recommendations made by the workshop panel in August 1978.
2. Provide technical coordination among research investigations.
3. Prepare final environmental assessment of the SPS rectenna-related effects.

Benefit

Provides overall assessment of rectenna waste heat and other microwave-related effects in troposphere. Coordinated technical investigations and provides liaison between these studies and the SPS program in general.

TITLE		ORGANIZATION
Quantitative Assessment of Atmospheric Effects Due to Rectenna Waste Heat Release		Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$10,000	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Perform quantitative studies of atmospheric effects of heat release at the rectenna site through model simulations.

Approach

1. Conduct literature survey and analytical calculations of the radiative and roughness characteristics of the rectenna.
2. Carry out energy balance calculations to yield estimates of local variations of temperature, moisture, etc. at the lower boundary of the rectenna site.
3. Utilize existing 3-D mesoscale hydrodynamic model, with surface energy balance model included, to study the potential temperature and momentum perturbations produced by the combined effects of the release of waste heat and the change in the albedo, emissivity, and surface roughness of the rectenna site. (The models used in this approach have been utilized in studies of urban heat island effects.) Simulations will be performed for both severe and nonsevere weather situations.

Benefits

Provides a quantitative assessment of the possible atmospheric effects of rectenna operation and their impacts. Provides the initial basis for guidelines in rectenna design and site selection. Serves as input to the assessments of public health and welfare impacts and microwave propagation impacts.

TITLE		ORGANIZATION
Effects of Launch Site Operations on the Troposphere		Science Applications, Inc.
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$27,000	A. Goldford
FY-79	\$25,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
St. Louis, MO	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Assess the effects of all air pollutants emitted into the troposphere from launch site operations. Provide input to the air quality aspects of public health and welfare impact analyses.

Approach

1. Implement high priority research recommendations of tropospheric effects workshop participants:
 - . define and implement specific research tasks
 - . coordinate related investigations and the transfer of information
 - . coordinate rocket launch monitoring and provide photographic coverage
2. Integrate and summarize contributions of investigators into an overall assessment.

Benefits

Provides the necessary technical management coordination and support activities needed to implement the high priority research tasks already identified in FY78 studies. Results in an integrated assessment of tropospheric effects including both air quality and inadvertent weather modification impacts.

TITLE		ORGANIZATION
Assessment of Possible Tropospheric Weather Modification from SPS Rocket Launches		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$25,000		J. Lee
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Assess possible inadvertent weather modification resulting from heat and moisture released in the troposphere during HLLV launches.

Approach

1. Estimate thermal energy and water substance released into the atmosphere during rocket launches.
2. Validate existing cloud models (1-D and 2-D) with field data acquired during rocket launches, including Atlas/Centaur launch 11/78.
3. Perform numerical simulation of cloud formation and the associated precipitation using validated models for various meteorological conditions.
4. Prepare final assessment of the meteorological effects of rocket effluents in troposphere.

Benefits

Assess potential of ground cloud formation and possible inadvertent weather modification due to HLLV launches. Prediction of final cloud height will provide inputs for air quality study.

TITLE		ORGANIZATION
Assessment of Photochemical Related Effects in the Troposphere		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$10,000		K. Brubaker
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Impact of rocket launch and other launch site activities on oxidant levels in vicinity of launch site.

Approach

Utilize estimated and/or measured pollutant effluent rates and precursor pollutant concentrations to determine changes in photochemical oxidant concentrations applying state-of-the-art techniques.

Benefits

Permits the public health impact task group to assess the impact on oxidant levels relative to Federal EPA standards.

TITLE		ORGANIZATION
Air Quality Impacts of Launch Site Operations		Science Applications, Inc.
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$66,000	A. Goldford	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
St. Louis, MO	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Determine air quality in vicinity of launch sites resulting from launch site operations and background pollutant levels. Provide necessary input information for analyses of air quality aspects of public health, safety, and welfare impacts.

Approach

1. Acquire meteorological data at generic launch sites.
2. Characterize atmospheric dispersion conditions.
3. Estimate or acquire air pollutant emission rates from rocket launches and supporting launch site operations.
4. Acquire information on background pollutant levels at launch sites.
5. Estimate net pollutant levels in vicinity of launch sites using existing models and available data including that obtained from the November 1978 Atlas/Centaur launch.

Benefits

Provides air quality impacts of launch site operations for use in the overall assessment of tropospheric effects; in the analysis of impacts on public health, safety, and welfare; and possibly in the analysis of ecological impacts.

TITLE		ORGANIZATION
Stratospheric and Mesospheric Impact Assessment		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$21,000	K. Brubaker
FY-79	\$45,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Implementation of research recommendations of September workshop participants. Coordinate stratospheric and mesospheric impact assessment task activities and incorporate new research developments and findings into the stratospheric-mesospheric impact assessment.

Approach

1. Implement research recommendations and coordinate the stratospheric-mesospheric impact assessment activities.
2. Establish liaison with researchers and organizations either supplying data, results, or information for use in the stratospheric-mesospheric impact analysis or will have need of data, results, or information produced by the stratosphere-mesosphere task activities.
3. Establish and maintain liaison with researchers involved in ongoing high altitude research programs.

Benefits

Provides coordination of stratosphere-mesosphere impact assessment task activities. Incorporates new high-altitude research findings into the SPS environmental impact assessment.

TITLE

Estimation of Production of Nitrogen
Oxides by HLLV and PLV Upper
Stage Re-entry

ORGANIZATION

National Aeronautical and Space Administration
Ames Research Center
Moffett Field, CA 94035

AMOUNT

FY-79 \$20,000

PRINCIPAL INVESTIGATOR

R. C. Whitten

WORK LOCATION

Moffett Field, CA

DURATION-AWARD DATA

6 mos. - Jan 2 1979

CONTRACT NO.

Interagency Agreement

PROJECT SUMMARYObjective

Estimate the quantities of NO_x produced as functions of altitude, latitude and longitude by reentry of HLLV and PLV upper stages.

Approach

Carry out detailed kinetic calculations for proposed HLLV and PLV upper stage design masses and reentry trajectories.

Benefit

Provides detailed estimates of reentry NO_x production as a function of altitude, latitude, and longitude for use in the assessment of impacts in the mesosphere and ionosphere.

TITLE		ORGANIZATION
Estimation of Upper Atmospheric Composition Perturbations Due to SPS-Related Spaceflight Activity		National Aeronautics and Space Administration Ames Research Center Moffett Field, CA 94035
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$70,000		R. C. Whitten
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Moffett Field, CA.	TBD	Interagency Agreement

PROJECT SUMMARY

Objective

Estimate extent to which upper atmospheric composition will be perturbed by HLLV and PLV launch and reentry for projected SPS-related levels of spaceflight activity.

Approach

- Using available state-of-the-art one-dimensional (zonally and latitudinally averaged) simulation models, and based upon the detailed rocket exhaust emission inventory and reentry NO_x production estimates to be supplied by ANL subcontractors, estimate:
 - high altitude composition changes due to rocket launch and reentry emissions for various possible stratospheric and mesospheric chloro-fluoromethane (CFM) levels predicted for the year 2000 and beyond.
 - maximum acceptable levels of injection of H_2O and NO_x for various CO_2 and CFM levels.
 - effects of including temperature feedback processes on model estimated composition changes, including effects of CO_2 , fuel impurities such as sulfur, and ablation material produced on reentry.
- Using available state-of-the-art two-dimensional (zonally averaged) simulation models, and based upon the same exhaust emission inventory and reentry NO_x production estimates as above, estimate the latitudinal dependence of high altitude composition perturbations ("corridor effect") for various projected levels of spaceflight.

Benefits

Provides state-of-the-art level assessment of the high altitude composition perturbations expected to result from proposed SPS-related spaceflight activity for the year 2000 and beyond.

TITLE	ORGANIZATION
Effects Due to Changes in Noctilucent Cloud Formation	National Aeronautics and Space Administration Ames Research Center Moffett Field, CA 94035

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$45,000	R. C. Whitten

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Moffett Field, CA	TBD	Interagency Agreement

PROJECT SUMMARY

Objective

Assess potential effects of changes in noctilucent cloud formation due to water vapor deposition from SPS-related spaceflight.

Approach

1. Survey the current state of knowledge regarding the formation and effects of noctilucent clouds.
2. Acquire available data on mesospheric temperature and water vapor concentrations as necessary for estimating the extent of cloud formation.
3. Based upon these data together with model estimates of the expected change in the mesospheric water vapor concentration, estimate the extent to which noctilucent cloud formation will be changed.
4. Estimate the impacts of the expected change, based upon current understanding of the effects of noctilucent clouds.

Benefit

Provides an assessment of the likely effects arising from a change in noctilucent cloud formation due to water injections from SPS-related HLLV and PLV spaceflights.

TITLE

Potential Effects of Local Energy
Injection in the Stratosphere and Mesosphere

ORGANIZATION

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

AMOUNT

FY-79 \$15,000

PRINCIPAL INVESTIGATOR

K. Brubaker

WORK LOCATION

Argonne, IL

DURATION-AWARD DATA

12 mos. - Oct 1, 1978

CONTRACT NO.

WPAS ANL-49576

PROJECT SUMMARYObjective

Assess the potential effects of localized energy injection from rocket exhaust and microwave absorption in the stratosphere and mesosphere.

Approach

1. Estimate the thermal energy deposited by rocket exhaust in the stratosphere and mesosphere as a function of altitude.
2. Estimate the microwave energy absorbed from the beam as a function of altitude, based upon available microwave absorption cross sections and atmospheric composition data.
3. Compare the estimates of (1) and (2) to the individual terms in the natural atmosphere energy budget, particularly the radiative energy absorption components.

Benefit

Provides an assessment of the potential environmental effects of localized energy injection from rocket exhaust and microwave absorption.

TITLE		ORGANIZATION
Overall Assessment of Ionospheric and Magnetospheric Effects		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$30,000		D. Rote
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Prepare an overall assessment of upper atmospheric effects of SPS. Implement research recommendations of FY78, coordinate investigations and integrate results for incorporation into the FY80 environmental assessment.

Approach

1. Define and implement specific research in accordance with recommendations.
2. Coordinate separate investigations.
3. Maintain surveillance of "targets of opportunity."
4. Prepare periodic progress reports.
5. Review and integrate results of separate investigators.
6. Consult with advisors and experts in appropriate fields.
7. Participate in symposium that will review draft assessment in Fall 1979.
8. Prepare draft and final atmospheric effects assessment documents.

Benefits

Provides coordinated program to assess environmental effects of SPS in the ionosphere and magnetosphere. Integrates and completes an assessment for inclusion in FY80 environmental assessment document.

TITLE	ORGANIZATION
Electron Density and Conductivity Changes in D- and E-Regions	National Aeronautics and Space Administration Ames Research Center Moffett Field, CA 94035

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$30,000	R. C. Whitten

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Moffett Field, CA	TBD	Interagency Agreement

PROJECT SUMMARY

Objective

Determine electron density changes caused by ion composition changes resulting from water injection in D- and E-regions. Determine if conductivity changes in dynamo region can significantly alter magnetospheric processes. Coordinate results with investigation of atmospheric electricity impacts in a timely manner.

Approach

1. Review literature and existing experimental observational data.
2. Carry out appropriate calculations using available methods.
3. Distribute results to investigators concerned with atmospheric electricity impacts.
4. Prepare final report.

Benefits

Determines electron density and conductivity changes in D- and E-region of ionosphere. Determines subsequent magnetospheric effects. Transfers information needed by investigators of atmospheric electricity.

TITLE		ORGANIZATION
Research of Archived Records Concerning Ionospheric Effects of Rocket Launchings		Department of Astronomy Boston University Boston, MA
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$15,000		C. Chacko M. Mendillo
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boston, MA	TBD	WPAS ANL-49576 ANL# 31-109-38-5326

PROJECT SUMMARY

Objective

Perform a search of the archives for data to assess the effects of rocket launches on the ionosphere. Search also for any new effects.

Approach

1. Assemble all available ionospheric observations appropriate for each of some 400 major NASA rocket launches.
 - . Categorize the launches by size, fuel composition, height of burning flight path, etc.
 - . Differentiate among the various observations on a phenomenological basis or preferably on the basis of the causative processes involved.
 - . Determine the dependence of the observed phenomena on launch parameters.
 - . Specify extent and duration of each effect.
 - . List new effects.
2. Prepare a scenario of possible effects to be expected from SPS rocket launches in accordance with NASA's SPS Concept Design.
3. Complete collection of data base and prepare a preliminary report containing interim results in FY79.
4. During FY80, analyze the data in greater depth and prepare final report.

Benefits

Provides an understanding of the effects of a massive rocket launching campaign on the ionosphere. Examines and assembles the existing archival information and collates it for use in the assessment program. Establishes a firmer basis for effects already tentatively identified. New effects may be uncovered. Results in a comprehensive study.

TITLE	ORGANIZATION
Metal Ion and Atom Ablation from Spacecraft in D- and E-Regions	National Aeronautics and Space Administration Ames Research Center Moffett Field, CA 94035

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79. \$10,000	R. C. Whitten

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Moffett Field, CA	TBD	Interagency Agreement

PROJECT SUMMARY

Objective

Estimate the magnitude of ionic and atomic metal mass ablated from spacecraft during launch and reentry in the D- and E-regions of the ionosphere and determine the probable impacts.

Approach

Develop estimates on data available in literature and rough calculational procedures.

Benefits

Determines magnitude of ionic and atomic metal mass injected into D- and E-regions of ionosphere and probable impacts.

TITLE		ORGANIZATION
3-D Simulation of Local Ionospheric Effects of SPS Rocket Launches		Stanford University Stanford, CA
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$30,000		P. Bernhardt
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Stanford, CA	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Characterize nature and extent of "holes" formed in ionosphere because of injection of rocket exhaust from the rocket traffic specified in the NASA SPS system design (October 1978).

Approach

1. Compare existing 3-D model simulation of history of ionospheric holes with observations.
2. Simulate history of rocket exhaust injected into lower ionosphere (D- and E-regions) by HLLV boosters and into the upper ionosphere (F region) by the circularization, maneuvering, and reentry burns.
3. Investigate lifetime of these holes and their potential for adverse impacts.

Benefits

Determines nature, extent, and potential local impacts of SPS rocket exhaust injection into D-, E-, and F-regions of ionosphere. Permits estimation of global impacts for evaluations using 2-D models.

TITLE		ORGANIZATION
Modeling of Global Ionospheric Effects of Satellite Power System Rocket Exhaust		Los Alamos Scientific Laboratory Box 1663 Los Alamos, NM 87545
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-78 \$65,000 FY-79 -0-	J. Zinn	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Alamos, NM	TBD	LASL R-468 W-7405-ENG-36

PROJECT SUMMARY

Objective

Provide information required for assessments of potential climate change and human health and telecommunications effects resulting from rocket exhaust products on the upper atmosphere created during the construction and operation of the SPS Reference System.

Approach

1. Establish a model of the ionosphere/thermosphere using computer codes and compare code results with observational data. Perform computations of ionospheric perturbations produced by space transportation activities associated with SPS construction and operation.
2. Plan and execute ground-based observations of the launch of the NASA Atlas-Centaur Rocket Satellite HEAO-C, including measurements of ionospheric electron distributions, electron temperatures and airglow using the radiotelescope and other facilities at Arecibo, PR.
3. Coordinate this work with related studies at Boston University and Stanford University.

Benefit

Examines the chemical changes produced in the ionosphere and thermosphere by exhaust products emitted by large rockets approximating SPS vehicles. Permits estimates to be made on environmental effects associated with the construction and operation of Solar Power Satellites.

Reference: Zinn, J., C. D. Sutherland, and M. B. Pongratz, Effects of Rocket Exhaust Products in the Thermosphere and Ionosphere, Los Alamos Scientific Laboratory, LA 7926-MS, July, 1979.

TITLE		ORGANIZATION
Effects of Argon Ion Injection into the Magnetosphere		The Aerospace Corporation P. O. Box 92957 Los Angeles, CA 90009
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$35,000	Y. T. Chiu	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	TBD	WPAS ANL-49576

PROJECT SUMMARY

Objective

Estimate the effects of Ar^+ ion injection upon the plasmasphere and the natural radiation belts. Calculate the time history of injected Ar ions and to assess their impacts on naturally occurring magnetospheric phenomena. Evaluate impacts on communication systems, optical earth sensors, and other impacts including modification of the radiation environment of the Van Allen Belts.

Approach

1. Phase I - Theoretically investigate, using available simulation techniques or minor refinements thereof, modifications of the natural plasmasphere and Van Allen radiation belts by injection of energetic non-thermalized Ar^+ ions and by the modified background plasma that is the resultant of the redistributed natural plasma and thermalized Ar^+ ions.
2. Make comparisons with calculations and information available from observations of natural, unperturbed phenomena.
3. Summarize preliminary results by October 1979.
4. Phase II - Make quantitative estimates of consequential effects of radiation belt modification including change in airglow background, change in auroral and magnetic storm dynamics and provide results by October 1980.
5. Provide theoretical support and interpretation, for SPS assessment, of results on beam-plasma turbulence to be obtained in the CAMEO and SCATHA rocket experiments to be conducted in FY79.

Benefits

Estimates environmental impacts of large injections of Ar^+ ions into the plasmasphere and magnetosphere. Estimates changes in Van Allen Belt radiation environment that will be useful in later determinations of radiation exposure of space workers and materials.

TITLE		ORGANIZATION
Rocket Launch Monitoring and Launch Site Experiments		University of Washington, Seattle, WA 98105 Colorado State University, Fort Collins, CO 80521
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$53,000		University of Washington - Radke Colorado State University - Hindman
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Cape Canaveral, FL	6 mos - Nov 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Characterize pollutants and ground cloud associated with liquid fuel rocket launch.

Approach

1. Monitor Atlas/Centaur launch of November 1978.
2. Determine plume size and dispersion characteristics, meteorology, and pollutant characteristics of ground cloud formed after Atlas/Centaur launch using aircraft borne instruments and sampling devices.
3. Compare results with earlier measurements of solid fuel rockets and note distinctive characteristics of liquid fuel rockets.

Benefits

Obtains information needed for both air quality and inadvertent weather modification impact analyses of liquid fuel rocket launches. Characterizes the effluents and dispersion phenomena as well as provides basic information needed for simulation of cloud rise, growth, transport, and potential weather modification.

TITLE		ORGANIZATION	
SPS-Assessment of Ionospheric Heating and Telecommunications Impacts		U. S. Department of Commerce Institute for Telecommunication Sciences Boulder, CO 80302	
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-78	\$25,000	C. M. Rush	
FY-79	\$15,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
Boulder, CO	12 mos. - Oct. 1, 1978	DE-A102-79CH10003	

PROJECT SUMMARY

Objective

Assess the potential impacts on telecommunications services of ionospheric disturbances produced by SPS Reference Systems operations.

Approach

1. Formulate a plan for assessing the effects on telecommunications of ionospheric disturbances caused by the SPS Reference System and include methods for identifying and defining issues, and documenting, reviewing and presenting results.
2. Prepare an assessment regarding the effects of SPS Reference Systems on ionospheric-dependent telecommunications.
3. Provide estimates of the confidence level of assessments of ionospheric effects expected from SPS operations.
4. Manage and coordinate all work under the SPS Ionospheric Heating Task including related work at Los Alamos Scientific Laboratory.

Benefit

Determines which telecommunications systems may be impacted by ionospheric disturbances produced by SPS Reference System operations. Provides an assessment of SPS-induced ionospheric and telecommunications changes.

TITLE		ORGANIZATION	
Program Planning on Ionospheric Heating and Telecommunications Effects		U. S. Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302	
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-78	\$40,000	C. M. Rush	
FY-79	\$50,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
Boulder, CO	12 mos. - Oct. 1, 1979	DE-A102-79CH10003	

PROJECT SUMMARY

Objective

Develop and provide a plan for activities to reduce uncertainty in the assessment of potential impacts on telecommunication services of ionospheric disturbances produced by SPS Reference System operation.

Approach

Develop updated program plans for ionospheric heating studies for inclusion in the SPS post FY-80 Ground Based Exploratory Development.

Benefit

Provides an R&D plan to resolve impacts on telecommunication services of ionospheric disturbances produced by SPS Reference System operation.

TITLE		ORGANIZATION
D-Region Transmission Experiment		U. S. Department of Commerce Institute for Telecommunication Sciences Boulder, CO 80302
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$200,000	C. Rush E. Violette	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	12 mos.-Oct. 1, 1978	DE-A102-79CH10003

PROJECT SUMMARY

Objective

Determine transmission characteristics of telecommunication systems whose signals are reflected from a D-region heated with SPS-comparable energy densities.

Approach

1. Utilize the Platteville Heating Facility to heat the D and lower E regions at 4-6 MHz;
2. Operate receiver sites to measure phase and amplitude of WWVB, OMEGA signals, LORAN-C transmissions and selected AM broadcast stations;
3. Correlate transmission characteristics with heating of the D-E region.

Benefit

Provides actual observations of telecommunication system performance in under-dense D region heating scenarios scalable directly to SPS operations.

Reference: Rush, C. M., J. C. Carroll, and E. J. Violette, High-Powered HF Facility to Simulate the Effects of Satellite Power System Ionospheric Heating, National Telecommunications and Information Administration, Boulder, CO, NTIA TM 79-27, October, 1979

TITLE		ORGANIZATION
Experimental Studies of Electron Heating and D-Region Instabilities		Los Alamos Scientific Laboratory Box 1663 Los Alamos, NM 87545
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-78 \$130,000	L. Duncan	
FY-79 \$220,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Alamos, NM Arecibo, PR	12 mos.-Oct. 1, 1978	LASL R-467 W7405 - ENG - 36

PROJECT SUMMARY

Objective

Conduct an experimental program to assess the importance of enhanced electron heating and the development of plasma instabilities in the lower ionosphere.

Approach

1. Utilize the Arecibo Ionospheric Heating Facility to heat the D and lower E regions with SPS-comparable energy;
2. Utilize the incoherent scatter radar and other diagnostics at Arecibo to measure changes in electron density and temperature;
3. Assess overall potential for D and E region heating to limit SPS performance.

Benefit

Provides experimental evidence to corroborate theoretical models and to understand the phenomena leading to underdense ionospheric heating.

Reference: Duncan, Lewis M. and John Zinn, Solar Power Satellite: The Ionospheric Connection, Submitted to the American Institute of Aeronautics and Astronautics Journal

TITLE		ORGANIZATION
SPS Magnetosphere and Ionosphere Heating Facility - Arecibo Heater Design		Rice University Houston, TX 77001
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$58,000	W. E. Gordon	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Houston, TX	TBD	TBD

PROJECT SUMMARY

Objective

Design and determine engineering specifications for an ionosphere heating facility.

Approach

Provide detailed equipment specifications for the ionospheric and magnetospheric heating test program using the Arecibo, P.R. facility.

Benefit

Provides detailed cost estimates for modification of testing facility.

Reference: Gordon, W.E. and D. Oehme, Full Scale Power Density Test Definition for Studying Ionosphere/Magnetosphere Microwave Beam Interactions at Arecibo, Puerto Rico. Tasks II and III - Design of Arecibo Facility Modification and Integration with Facility Under Construction, William Marsh Rice University, Houston, TX, April 1979.

TITLE	ORGANIZATION
Theoretical & Numerical Modeling of Heated Ionospheres	Nat'l. C'tr. for Atmospheric & United Technologies Research (NCAR) Boulder, CO Research C'tr (UTRC) Hartford, CN

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$100,000	R. Noble/NCAR G. Meltz/UTRC

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO Hartford, CN	12 mos.-Oct. 1, 1978	DE-A102-79CH10003

PROJECT SUMMARY

Objective

Improve models of ionospheric heating and related ionospheric density changes.

Approach

1. Include latest theory for underdense heating in NCAR model;
2. Simulate electron density and temperature changes for Platteville heating experiment and use simulated changes to predict transmission experiment results;
3. Develop model for underdense plasmas using linear and nonlinear theory for frequency, time, and space thresholds; and,
4. Incorporate HLLV effects into NCAR model.

Benefit

Provides an experimentally corroborated model of ionospheric changes resulting from heating that can be extrapolated with confidence to the SPS scenario.

TITLE	ORGANIZATION
SPS Electromagnetic Compatibility Assessment	Battelle, Pacific Northwest Laboratory P. O. Box 999 Richland, WA 99352

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$100,000	K. C. Davis

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Richland, WA	8½ mos. - Apr 15, 1979	ANL No. 31-109-38-5083

PROJECT SUMMARY

Objective

Develop and provide an assessment of the electromagnetic compatibility of a Satellite Power System.

Approach

1. Formulate a plan for assessing the electromagnetic compatibility (EMC) of SPS Reference System operation and development which includes methods for identifying and defining potential impacts; assessing potential impacts; and documenting, reviewing and presentation of results.
2. Prepare an assessment of the EMC of the SPS.
3. Assist in the preparation of an integrated environmental assessment of SPS Reference System operations.
4. Establish coordination and communication between other SPS Environmental Tasks.

Benefit

Assesses electromagnetic impacts of the SPS Reference System. Provides coordination of task activities.

Reference:

Justesen, D. R., et al., Compilation and Assessment of Microwave Bioeffects, Final Report, A Selective Review of the Literature on Biological Effects of Microwaves in Relation to the Satellite Power System (SPS), PNL-2634(Rev), May 1978

TITLE

Electromagnetic Compatibility -
Program Planning and Management

ORGANIZATION

Battelle, Pacific Northwest Laboratory
P. O. Box 999
Richland, WA 99352

AMOUNT

FY-79 \$15,000

PRINCIPAL INVESTIGATOR

K. C. Davis

WORK LOCATION

Richland, WA

DURATION-AWARD DATA

8½ mos. - Apr 15, 1979

CONTRACT NO.

ANL No. 31-109-38-5083

PROJECT SUMMARYObjective

Develop and provide a plan for research and development to reduce uncertainties impacting electromagnetic sensitive systems by the Satellite Power System. Establish coordination with the EMC and frequency management community. Provide management activities in the SPS EMC area.

Approach

1. Develop a plan for conducting assessments and research to reduce uncertainty regarding EMC of SPS experiments and Reference System operation.
2. Assist in developing an integrated R&D program (GBED) for reducing the uncertainty in assessment of potential impacts of the SPS Reference System.
3. Manage the Institute for Telecommunications Sciences (U.S. Department of Commerce) efforts (U.S. DOE-funded) in SPS EMC.
4. Solicit, evaluate and recommend to DOE proposals for DOE funding and PNL funding to support objectives of Task V.
5. Maintain active liaison with the EMC and astronomy communities regarding potential impacts of the SPS.

Benefit

Provides an R&D plan to resolve issues related to SPS effects on electromagnetic systems. Coordinates the various technical investigations proposed and underway.

Reference: Workshop on Satellite Power System Effects on Optical and Radioastronomy, Held at Battelle Conference Center, May, 1979 (to be published October, 1979).

TITLE	ORGANIZATION
SPS EMC Evaluation	U. S. Department of Commerce Institute for Telecommunication Sciences Boulder, CO 80302

AMOUNT	PRINCIPAL INVESTIGATOR
FY-78 \$179,000	W. B. Grant
FY-79 65,000	

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	7 mos. - Jun. 1979	DE-AI06-79RL10077

PROJECT SUMMARY

Objective

Evaluate the effects of emissions from the reference SPS Microwave Power Transmission System on existing and foreseen electronic systems throughout the hemisphere exposed to SPS microwave radiation including estimates of costs and analysis of possible mitigating techniques and costs.

Approach

1. Compute emissions expected from the Microwave Power Transmission System.
2. Determine the effects of the propagation media on the spatial distribution of SPS microwave power and compute resulting microwave field strengths and the statistical variability.
3. Identify and characterize potential victim systems and develop current investment summary for identified potential victim systems.
4. Identify possible mitigating techniques and strategies to restore acceptable operation of victim systems in an SPS environment and determine costs.
5. Provide summary reports on electronic and electromagnetic systems degradation.
6. Provide design guidelines and function modification recommendations for operation in an SPS environment and indicate cost penalties due to the modifications.

Benefit

Evaluates EMC impact on equipment and systems not associated with specific rectenna sites.

TITLE		ORGANIZATION
Field Intensity Map and Population Exposure		U. S. Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$38,000	W. B. Grant
FY-79	\$25,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	7 mos. - Jun. 1979	DE-AI06-79RL10077

PROJECT SUMMARY

Objective

Establish and produce a hemishpheric map of microwave field intensities expected from a proposed multisatellite SPS and assess the numbers of people exposed to different microwave field intensities.

Approach

1. Generate a map of a complete hemisphere showing microwave field intensities expected at or near the surface of the Earth from a proposed multi-satellite SPS with specific rectenna and satellite locations (use information developed in the task SPS EMC Evaluation).
2. Combine the field intensity map of 1 with population distribution data to compute the number of persons exposed to different microwave field intensities.

Benefit

Indicates the microwave field intensities expected at the Earth's surface.
Indicates the population exposure to microwaves.

TITLE

EMC Evaluation of Representative
Rectenna Sites

ORGANIZATION

U. S. Department of Commerce
Institute for Telecommunication Sciences
Boulder, CO 80302

AMOUNT

FY-79 \$50,000

PRINCIPAL INVESTIGATOR

W. B. Grant

WORK LOCATION

Boulder, CO

DURATION-AWARD DATA

7 mos. - Jun. 1979

CONTRACT NO.

DE-AI06-79RL10077

PROJECT SUMMARYObjective

Evaluate the impact of SPS microwave energy on potential victim systems located near proposed rectenna sites. Illustrate EMC concerns in rectenna siting.

Approach

1. Select four or more proposed rectenna sites, representative of different climates and population densities, and determine the impact on potential victim systems for these site choices and the related costs.
2. Predict for these sites the rectenna power output fluctuations expected due to effects of the propagation media at these sites.

Benefit

Provides the basis for EMC impact estimation at any site. Determines the importance of EMC considerations for site selection.

Reference: Ott, R. H., E. L. Morrison, and W. B. Grant, Antenna Patterns for the Satellite Power System, National Telecommunications and Information Administration, Boulder, CO, NTIA-TM-79-5, January, 1979.

TITLE		ORGANIZATION
SPS-Analysis of Higher Operating Frequencies		U. S. Department of Commerce Institute for Telecommunications Sciences Boulder, CO 80302
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$35,000	W. B. Grant
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Boulder, CO	7 mos. - Jun. 1979	DE-AI06-79RL10077

PROJECT SUMMARY

Objective

Analyze the possibility and desirability of using frequencies higher than 2.45 GHz for the SPS Microwave Power Transmission System.

Approach

1. Determine the technological possibilities for MPTS above 2.45 GHz, including costs, and analyze the microwave spectrum to determine the potential for EMC problem reduction by using these higher frequencies.
2. Consider environmental factors of higher frequency use, both environmental effects on the MPTS and MPTS effects on the environment.
3. Summarize the above data for a tradeoff analysis and make preliminary recommendations.

Benefit

Determines the potential and/or desirability of other frequencies for MPTS.

TITLE		ORGANIZATION
Federal Involvement		International Technical Services, Inc. 2001 Jefferson Davis Highway Arlington, VA 22202
AMOUNT	PRINCIPAL INVESTIGATOR	
\$12,200	H. G. Edler	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Arlington, VA	4 mos. - Jun. 1, 78	ANL# 31-109-38-4387

PROJECT SUMMARY

Objective

Identify and characterize the role of the federal government bodies in SPS development and operation.

Approach

1. Identify all federal government entities within whose purview the SPS would lie and be periodically reviewed.
2. Characterize the roles of these entities.
3. Develop a sequential flow chart of governmental involvement that would indicate information flow and critical paths of governmental decision-making for an SPS development program, should one be implemented.

Benefit

Preliminary description of governmental involvement in an operational SPS.

Reference: Edler, Henry G., Satellite Power System (SPS): An Overview of Prospective Organizational Structures in the Solar Power Satellite Field, TID-29094, October 1978.

TITLE

State and Local Regulations as Applied
to Satellite Power System Microwave
Receiving Antenna Facilities

ORGANIZATION

Allan D. Kotin Economic Consultants
10960 Wilshire Blvd.
Los Angeles, CA 90024

AMOUNT

\$8,060

PRINCIPAL INVESTIGATOR

A. Kotin

WORK LOCATION

Los Angeles, CA

DURATION-AWARD DATA

4 mos. - Jun. 1, 78

CONTRACT NO.

EG-77-C-01-4024
PRC PO# W4080

PROJECT SUMMARYObjective

Identifies the types of regulations applying at levels that would be necessary to manage distribution of SPS electrical power.

Approach

1. Characterize the current regulatory process as it applies to the provision of electrical power.
2. Evaluate utilization of this regulatory process to the SPS.
3. Define problem areas and identify a means to resolve them.

Benefit

Develops a preliminary assessment of the nature and extent of regulatory impacts on SPS and establishes a base for further work.

Reference: Kotin, Allan D., Satellite Power System (SPS) State and Local Regulations as Applied to Satellite Power System Microwave Receiving Antenna Facilities, HCP/R-4024-05, October 1978.

TITLE		ORGANIZATION
International Agreements		Carl Q. Christol 1041 Anoka Place Pacific Palisades, CA 90270
AMOUNT	PRINCIPAL INVESTIGATOR	
\$16,500	C. Q. Christol	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	4 mos. - June 1, 78	EG-77-C-01-4024 PRC PO# W4086

PROJECT SUMMARY

Objective

Assess problems in obtaining agreements on geostationary orbit assignments, microwave frequency allocations and microwave exposure standards.

Approach

1. Identify the international agreements that must be obtained in the three areas; define problems to be resolved and potential delays in the process, based on historical precedents.
2. Identify and make a preliminary evaluation of alternative strategies to facilitate obtaining the required international agreements.
3. Identify areas requiring additional study, and provide a recommended approach.

Benefit

Develops a preliminary assessment of international agreements that will be required for an SPS, and establishes a basis for further systematic study.

Reference: Christol Carl Q., Satellite Power System (SPS) International Agreements, HCP/R-4024-08, October 1978.

TITLE International Agreements		ORGANIZATION Stephen Gorove 320 Country Club Road Oxford, MS 38655
AMOUNT \$15,400	PRINCIPAL INVESTIGATOR S. Gorove	
WORK LOCATION Oxford, MS	DURATION-AWARD DATA 4 mos. - Jun. 1, 78	CONTRACT NO. EG-77-C-01-4024 PRC PO# W4076

PROJECT SUMMARY

Objective

Assess problems in obtaining agreements in geostationary orbit assignment, microwave frequency allocation, and microwave exposure standards.

Approach

1. Identify the international agreements that must be obtained in the three areas, define the problems to be resolved and potential delays in the process, based on historical precedents.
2. Identify and make a preliminary evaluation of alternative strategies to facilitate obtaining the required international agreements.
3. Identify areas requiring additional study, and provide a recommended approach.

Benefit

Develops a preliminary assessment of international agreements that will be required for an SPS, and establishes a basis for further systematic study.

Reference: Gorove, Stephen, Satellite Power System (SPS) International Agreements, HCP/R-4024-12, October 1978.

TITLE		ORGANIZATION
Financial/Management Scenarios		Science Applications, Inc. 80 Mission Drive Pleasanton, CA 94566
AMOUNT	PRINCIPAL INVESTIGATOR	
\$13,792	J. Vajk	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Pleasanton, CA	4 mos. - Jun. 1, 78	EG-77-C-01-4024 PRC PO# W4078

PROJECT SUMMARY

Objective

Assess the potential feasibility and advantages of alternative SPS financing and management scenarios.

Approach

1. Identify initial investment and cash flow capital requirements for SPS development and operation.
2. Determine feasible alternative policies and organizations to provide this capital, including private institutions, joint private and government, government-owned institutions, and the potential for international institutions to develop and operate the SPS.
3. Determine feasible alternative management concepts consistent with the alternative financing arrangements and considerations of public acceptance.
4. Characterize the benefits and disadvantages of each alternative and identify preferable concepts under various possible scenarios for the socioeconomic conditions prevailing during the SPS implementation time frame.
5. Identify any additional studies that are required and determine methodologies for accomplishing them.

Benefit

Develops a preliminary approach to alternative SPS financing and management strategies, and provides a basis for further study.

Reference: Vajk, J. Peter, Satellite Power System (SPS) Financial/Management Scenarios, HCP/R-4024-03, October 1978.

TITLE	ORGANIZATION
Financial/Management Scenarios	Herbert E. Kierulff, Jr. 776 Foxkirk Road Glendale, CA 91206

AMOUNT	PRINCIPAL INVESTIGATOR
\$13,880	H. E. Kierulff

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	4 mos. - Jun. 1, 78	EG-77-C-01-4024 PRC PO# W4079

PROJECT SUMMARY

Objective

Assess the potential feasibility and advantages of alternative SPS financing and management scenarios.

Approach

1. Identify initial investment and cash flow capital requirements for SPS development and operation.
2. Determine feasible alternative policies and organizations to provide this capital, including private institutions, joint private and government, government-owned institutions, and the potential for international institutions to develop and operate the SPS.
3. Determine feasible alternative management concepts consistent with the alternative financing arrangements and considerations of public acceptance.
4. Characterize the benefits and disadvantages of each alternative, and identify preferred concepts under various possible scenarios for the socioeconomic conditions prevailing during the SPS implementation time frame.
5. Identify any additional studies that are required and determine methodologies for accomplishing them.

Benefit

Develops a preliminary approach to alternative SPS financing and management strategies, and provides a basis for further study.

Reference: Kierulff, Herbert E., Satellite Power System (SPS) Financial/Management Scenarios, HCP/R-4024-13, October 1978.

TITLE	ORGANIZATION
International Organizations	International Technical Services, Inc. 2001 Jefferson Davis Highway Arlington, VA 22202

AMOUNT	PRINCIPAL INVESTIGATOR
\$12,000	H. G. Edler

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Arlington, VA	2 mos. - Apr 15, 78	ANL# 31-109-38-4387

PROJECT SUMMARY

Objective

Identify International Organizational options for SPS financial development and management.

Approach

1. Characterize the organizational structures which have been formed for purposes similar to SPS that might serve as a model for SPS organization.
2. Survey expert opinion as to the suitability, costs and effectiveness of such organizational structures.
3. Provide a report including a critical comparison of organizational structures, and an analysis of the political, environmental and economic issues and impacts of such organizational options, including institutional factors such as international law and U.N. resolutions.

Benefit

Preliminary survey of SPS international organizational structures that will and will not work.

Reference: Edler, Henry G., Satellite Power System (SPS): An Overview of Prospective Organizational Structures in the Solar Power Satellite Field, TID-29094, October 1978.

TITLE		ORGANIZATION
Military Implications		PRC Energy Analysis Co. 7600 Old Springhouse Road McLean, VA 22102
AMOUNT	PRINCIPAL INVESTIGATOR	
\$10,000	C. Bain	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
McLean, VA	4 mos. - Jun. 1, 78	EG-77-C-01-4024

PROJECT SUMMARY

Objective

Determine the role, if any, that the SPS has in the U.S. military posture, both offensively and defensively, with particular attention to SPS vulnerability.

Approach

1. Investigate SPS potentialities as a weapon or other supportive element of U.S. military preparedness.
2. Determine the potential impact on international relations of SPS tactical weapons capabilities.
3. Investigate the relative vulnerability of SPS to military action, terrorist attack, or sabotage.
4. Identify questions needing further study and develop approaches that can be taken (1) without security clearance and (2) with security clearance.

Benefit

Develops preliminary description of the potential military interest in SPS and system vulnerability. Identifies an approach to further study required to clarify the issues.

Reference: Bain, Claud N., Satellite Power System (SPS) Military Implications, HCP/R-4024-11, October, 1978.

TITLE		ORGANIZATION
Military Implications		Michael J. Ozeroff 537 Ocampo Drive Pacific Palisades, CA
AMOUNT	PRINCIPAL INVESTIGATOR	
\$11,980	M. J. Ozeroff	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	4 mos - Jun 1, 1978	EG-77-C-01-4024 PRC PO# W4121

PROJECT SUMMARY

Objective

Characterize what role the SPS would have, if any, in the U.S. military posture, both offensively and defensively, with particular attention to SPS vulnerability.

Approach

1. Investigate SPS potentialities as a weapon or other supportive element of U.S. military preparedness.
2. Determine the potential impact on international relations of tactical weapon capability.
3. Investigate the relative vulnerability of SPS to military action, terrorist attack or sabotage.
4. Identify questions needing further study and develop approaches that can be taken (1) without security clearance, and (2) with security clearance.

Benefit

Develops preliminary description of the potential military interest in SPS, and system vulnerability. Identifies an approach to further study required to clarify the issues.

Reference: Ozeroff, Michael J. Satellite Power System (SPS) Military Implications, HCP/R-4024-01, October 1978.

TITLE		ORGANIZATION
Relocation of Industry and Population		Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
\$10,000	T. Baldwin	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	4 mos. - June 1, 78	189-ANL49576

PROJECT SUMMARY

Objective

Survey existing demographic work with respect to SPS and assess impacts of SPS energy availability on geographic distribution of industry and population in the U.S. and other countries receiving SPS output. Establish basis for further study.

Approach

1. Perform literature review and determine the impacts of SPS large energy source on the distribution of industry and population.
2. Evaluate the potential acceptability of these impacts by appropriate interest groups.
3. Identify the approach to additional study.

Benefit

Develops a preliminary demographic assessment of the SPS and provides an approach to further systematic study of the problem.

Reference: Baldwin, Thomas E. et al., Economic and Demographic Issues Related to Deployment of the Satellite Power System: (SPS), AN/EES-TM-23, October 1978.

TITLE

Centralization of Electrical Power

ORGANIZATIONCenter for Policy Process
1755 Massachusetts Ave., N. W.
Washington, DC 20036

AMOUNT

\$10,525

PRINCIPAL INVESTIGATORJ. Naisbitt

WORK LOCATION

Washington, DC

DURATION-AWARD DATA

4 mos. - Jun. 1, 78

CONTRACT NO.EG-77-C-01-4024
PRC PO# 4125

PROJECT SUMMARYObjective

Establish the relationship and influence an SPS centralized electrical power source would have on society.

Approach

1. Survey recent SPS and related work.
2. Characterize the trends toward centralization (decentralization), the public reaction to these trends and estimate the anticipated public response to an SPS.
3. Determine areas requiring further study and recommend an approach to accomplishing these studies.

Benefits

Develops a preliminary assessment of the SPS Centralization issue, characterizes the probable public response, and defines a basis and approach to further systematic study.

Reference: Naisbitt, John, Satellite Power System (SPS) Centralization/Decentralization, HCP/R-4024-09, October 1978.

TITLE

Public Acceptance

ORGANIZATION

Environmental Resource Group
6380 Wilshire Boulevard
Los Angeles, CA 90048

AMOUNT

\$11,952

PRINCIPAL INVESTIGATORA. Bachrach

WORK LOCATION

Los Angeles, CA

DURATION-AWARD DATA

4 mos. - Jun. 1, 78

CONTRACT NO.

EG-77-C-01-4024
PRC PO# W4077

PROJECT SUMMARYObjective

Develop a preliminary perspective of the public acceptability of the SPS concept, and the means to monitor it.

Approach

1. Identify and characterize primary SPS characteristics that would impact the "quality of life," and establish methodologies for evaluating the public (national and international) balancing of the potential benefits and disadvantages.
2. Evaluate initial views of relatively informed public interest (activist) groups, as well as studies by social scientists.
3. Identify the specific potential SPS benefits and disadvantages that are likely to be critical to public acceptance.
4. Develop a method for determining and influencing public acceptance of the SPS as a function of time. Recommend additional studies which would clarify this issue.

Benefit

Develops a preliminary assessment of public acceptance, and defines an approach to further systematic study.

Reference: Bachrach, Arrie, Satellite Power System (SPS) Public Acceptance, HCP/R-4024-04, October 1978.

TITLE	ORGANIZATION
Student Involvement in SPS	Forum for the Advancement of Students in Science & Technology, Inc. 2030 M Street, N. W., Suite 402 Washington, DC 20036

AMOUNT	PRINCIPAL INVESTIGATOR
\$9,447	A. Ladwig

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Washington, DC	4 mos. - Jun. 1, 78	EG-77-C-01-4024 PRC PO# W4130

PROJECT SUMMARY

Objective

1. Identify a methodology to communicate information to the college community, regarding the concept and implications of SPS.
2. Investigate models and methods of conflict management which can be applied to the dissemination of SPS information.

Approach

1. Survey existing mechanisms successful in disseminating information to the college community.
2. Consult with communication specialists, student program directors, students active in campus programs as to the effectiveness of various communications methods to disseminate information on the SPS concept.
3. Identify potential use of student networks and direct mail lists.
4. Determine methodologies for incorporating SPS into the educational curriculum.
5. Conduct literature search on conflict management for models which can be applied to the SPS, and identify models that have proven to be successful.

Benefit

Develops a preliminary determination of models and methodologies of disseminating info on SPS to the college community, and possible conflict management models to reduce polarization of models. Acts as basis for further study.

Reference: Ladwig, Alan and David, Leonard, Satellite Power System (SPS) Student Participation, HCP/R-4024-06, October 1978.

TITLE		ORGANIZATION
SPS Management and Liaison Activities		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-78 \$16,700	C. E. Bloomquist	
FY-79 \$30,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	6 months - April 1, 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Establish a management function to coordinate all the PRC subtasks internally and schedule these activities with the SPSPO to reflect shifting priorities. Maintain liaison with the Project Office and other SPS assessments and activities.

Approach

1. Provide internal management of all PRC SPS program activities.
2. Prepare progress reports on all PRC managed activities, and meet with the SPSPO, as required.
3. Maintain liaison with other SPS program activities, including the environmental, societal, and comparative assessment programs, system definition, and other activities.

Benefit

Provides general management support activities to assist in the operation of the SPS Project Office. Provides timely and efficient coordination of all societal assessment activities. Provides societal assessment program recommendations and includes the preparation of all necessary reports, etc., that may be required for the support of the SPS program.

Reference: Bloomquist, Charles, A. Daurio, and S. Shotland, Satellite Power System (SPS) Preliminary Societal Assessment, PRC Energy Analysis Co., HCP/R4024-01/14, May 1979.

TITLE		ORGANIZATION	
SPS Societal Assessment		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, Virginia 22102	
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-78	\$37,600	C. E. Bloomquist	
FY-79	\$30,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
Los Angeles, CA McLean, VA	6 months - April, 1979	DE-AC01-79ER10041	

PROJECT SUMMARY

Objective

Manage and coordinate studies in four areas, including resources, institutions, international, and public acceptance, and determine SPS impacts on society.

Approach

1. Determine areas that require investigation for a fully integrated SPS societal assessment.
2. Provide detailed statements of work, research proposals, data and contract documents as required.
3. Provide a comprehensive integrated document on SPS societal impacts for decisionmakers.

Benefits

Provide direction, reports, and an integrated document on SPS societal impacts for decisionmakers.

Reference: Bloomquist, Charles et al., Satellite Power System (SPS)
Preliminary Societal Assessment, HCP/R4024-01/14, May 1979

TITLE		ORGANIZATION	
Resources-Rectenna Siting Studies		Rice University and P.O. Box 1892 Houston, TX 77001	Allan D. Kotin Economic Consultants 10960 Wilshire Boulevard Los Angeles, CA 90024
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-78	\$32,000	J. Blackburn/RICE	
FY-79	\$60,000	A. Kotin/EC	
FY-80	TBD		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
Houston, TX Los Angeles, CA	9 months - September 1, 1979	DE-AC01-79ER10041 PRC PO #W5152 (RICE) PRC PO #W5154 (EC)	

PROJECT SUMMARY

Objective

Further develop siting methodology, refine data base, develop and rank a pool of rectenna-eligible areas and coordinate efforts with other SPS studies.

Approach

Refine the initial siting and land use analysis completed in the preliminary assessment phase:

- consider sea sites, RFI effects, air borne biota
- validate use of exclusion/inclusion criteria
- perform sensitivity analysis for variable site size
- develop ranking of eligible areas by region
- identify potential regional/local impacts

Benefits

Essential information to determine if land requirements and distribution of rectenna sites will be a problem and impede development of the SPS.

- References:
- (a) Blackburn, James B. Jr., and Bavinger, Bill A., Satellite Power System (SPS) Mapping of Exclusion Areas for Rectenna Sites, HCP/R4024-10, October 1978
 - (b) Kotin, Allan D., Satellite Power System (SPS) Resources Requirements (Critical Materials, Energy, and Land), HCP/R-4024-02, October 1978

TITLE		ORGANIZATION
Coso Hot Springs Prototype Rectenna Impact Assessment		Environmental Resources Group 6380 Wilshire Boulevard Los Angeles, CA 90048
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$15,000	A. Bachrach	
FY-80 TBD		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	6.5 mos.-Sept. 1, 1979	DE-AC01-79ER10041 PRC PO #W5153

PROJECT SUMMARY

Objective

Create a comprehensive prototype assessment of the impacts on the human environment of the "reference design" rectenna in both construction and operational phases for a site in the California high desert, close to L. A.

Approach

Develop description of reference design rectenna facility: specs/configuration of structures, transportation network, volume flow of materials, personnel requirements, construction process. Develop baseline environmental setting: land use, socio-economics, visual/cultural resources. Assess impacts for each of the environmental components, projected over a 50-year time frame. Incorporate baseline data from concurrent geothermal study.

Benefits

Develop site-specific understanding of socio-economic impacts and public acceptance factors for population living near a hypothetical rectenna facility.

TITLE		ORGANIZATION
Review of SPS Work of International Interest		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$4,500	A. Daurio
FY-80	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	12 mos.-July 1, 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Monitor relative importance of various SPS-related issues as reflected in the work of international agencies such as the IAF and ESA.

Approach

Obtain copy (copies) of papers on SPS subjects from international agencies which are beginning to investigate the concept. Identify major concerns and suggestions, summarize agency positions and prepare responses that can be sent back to officials for their consideration. Use the information derived from these papers for on-going SPS studies.

Benefits

Development of a dialogue on the SPS with the international scientific community and awareness of foreign interest in the SPS concept.

TITLE		ORGANIZATION
Strategy for International Involvement		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$10,000	C. E. Bloomquist	
FY-80 TBD		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA	10 mos.-August, 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Prepare a strategy showing how best to approach the international community with respect to SPS.

Approach

1. Classify the international community according to regions, voting blocs, energy needs, level of industrialization.
2. Identify up-coming international conferences dealing with SPS-related issues and possible positions of important participants to these conferences.
3. Identify pertinent international agencies and their potential role in SPS R&D.
4. Synthesize the above information and develop a plan for approaching the international community (resources needed, timing, positions to be defined, etc.)

Benefits

A basis for dealing with the international community during the GBED.

TITLE		ORGANIZATION
Military Implications		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-78 \$21,980	TBD	
FY-79 \$ 5,000		
FY-80 TBD		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

1. In that the SPS could be perceived as a weapon system, determine and confidently demonstrate that the SPS is not and will not become a weapon system.
2. Explore the vulnerability aspects of the SPS, determine methods to reduce these aspects to a reasonable level (if necessary) and demonstrate that these levels can be confidently achieved.

Approach

1. Determine for each major SPS component (i.e., satellites, transportation systems, rectennas, command and control, etc.) the real and perceived potential military threat and identify countermeasures to prevent the threat from materializing.
2. Determine for each component its real and perceived vulnerability and identify countermeasures to reduce it to an acceptable level.
3. Combine the results of the first two items into an overall statement of the potential military threat and vulnerability of the SPS together with viable countermeasures.
4. Identify further actions and studies that should be undertaken to assure that the SPS does not become a key factor in military considerations.

Benefits

A preliminary resolution of the weapon system and vulnerability questions and guidelines for assuming that the SPS will be used only for peaceful purposes.

- References: (a) Ozeroff, Michael J., Satellite Power System (SPS) Military Implications, HCP/R-4024-01, October 1978.
- (b) Bain, Claud N., Satellite Power System (SPS) Military Implications, HCP/R-4024-11, October 1978

TITLE Utility Integration-Rectenna to End-User Hardware Requirements		ORGANIZATION PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT FY-79 \$5,000 FY-80 TBD	PRINCIPAL INVESTIGATOR TBD	
WORK LOCATION TBD	DURATION-AWARD DATA TBD	CONTRACT NO. DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Determine the technical capability to integrate the SPS power into the electric utility system.

Approach

1. Identify and characterize major components of the SPS ground power transmission system. Include analyses of: components and performance, components with significant technical problems, and system reliability and stability.
2. Identify SPS components which pose significant technical problems to utility integration, and recommend approaches to resolve them.
3. Investigate SPS system reliability and stability characteristics. Include treatment of system size, reserve margin requirements, power interruption (MPTS and rectenna downtime), load conditions and impact of weather.
4. Perform studies of the following key issues as part of items 1 to 3 above or separately: limits of present thyristor technology, inverter lighting and surge protection, optimum low and medium voltage levels, effects of loss of rectenna field output, non-sinusoidal transformer inputs, AC or HVDC transmission, and limits of present components.

Benefits

Defines the anticipated technical problems associated with integrating SPS power into the electric utility system. Provides SPS system reliability and stability, SPS operations interface with the utility, and projected power transmission characteristics.

TITLE		ORGANIZATION
Utility Integration-Anticipated Power Pooling		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$5,000	TBD
FY-80	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AC01-79ER-10041

PROJECT SUMMARY

Objective

Investigate the projected energy transmission and delineate the anticipated institutional and regulatory environments associated with integrating SPS power into the electric utility system.

Approach

1. Perform parametric studies of rectenna power output and utility pool size, including anticipated growth rates of power pools and reliability regions in relation to development of 1, 2, and 5 GWe SPS units.
2. Determine transmission characteristics and strategies, and expected regional power demand, in the SPS timeframe and include treatment of siting/distance to load centers and interregional interties.
3. Assume and examine institutional changes (scale, distribution, transmission capabilities) that are likely to accompany various SPS development scenarios.

Benefits

Provides SPS operations interface with the utility, projected power demand characteristics, and institutional and regulatory interfaces. Reflects current status of this issue with respect to SPS, and identifies further investigations that may be required to clarify the issue.

TITLE		ORGANIZATION
Federal Regulation of Microwave Radiation Standards		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$18,000		TBD
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
McLean, VA	4 months - TBD	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Identify federal regulatory processes which will have a major impact on the permissible levels of microwave radiation emitted by the SPS/MPTS.

Approach

1. Review historical development of microwave standards.
2. Identify major federal agencies with control over standards, scope of responsibility, and jurisdiction.
3. Determine comprehensive regulatory process for the setting of federal microwave exposure standards, regulatory review intervals, procedures for determining safe levels, time-dependent decision points.
4. Identify trends of regulations and likely impact of these trends on SPS design, R&D schedule and operations.

Benefits

Determines compatibility between SPS program requirements and design and federal regulations which are/will be governing a major program parameter - microwave radiation level.

TITLE		ORGANIZATION
Institutional Issue - Insurance		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102 .
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$5,000	TBD
FY-80	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
TBD	TBD	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Identify SPS risks as perceived by the insurance industry and describe probable responses by the insurance industry to these risks.

Approach

1. Assemble and analyze relevant literature and experience regarding insurance of space programs including work in progress and prepare a bibliography of such materials.
2. Identify the major SPS risks by component (satellite, transportation, rec-tenna, command and control, etc.) and program phase (R&D, construction, transportation, operation, decommissioning, etc.) to include both liability and loss of investment.
3. For each risk identified in item 2 suggest a probable response by the insurance industry.
4. Determine what proportion of the total SPS risk the insurance industry would be willing to cover and what the cost to the program might be.
5. Identify additional research that should be conducted and recommend other actions that should be undertaken.

Benefits

Determines the costs and limitations of providing insurance for risks associated with the SPS. Provides insight into liability insurance and its limitations. Sets forth the current status and likely projection of the insurance industry response to the requirements of the SPS.

TITLE		ORGANIZATION
Public Outreach Experiment		Citizens' Energy Project (C.E.P.) 1110 - 6th Street, N.W. Washington, DC
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$21,000	K. Bossong
FY-80	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Washington, DC	10 mos.-Jan. 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Set up a method to communicate with various publics and involve them in the SPS evaluation process.

Approach

Phase I - Select individuals from C.E.P. to develop packages on SPS Preliminary Assessment. Up to 20 documents will be summarized (including 14 Societal Assessment, Preliminary Environmental Assessment, and the Reference System Report), each summary being 4-5 pages.

Phase II- Develop and distribute (to 3,000 members) information packages consisting of summaries of up to 20 documents from the Preliminary Assessment, allowing for comments to be forwarded to the DOE and replies distributed back to respondees.

Benefits

Establishes public dialogue, disseminates information on SPS, and allows interested groups to comment on the SPS program, in this case the solar/environmental/consumer activist community.

TITLE		ORGANIZATION
Public Outreach Experiment		L-5 Society 1620 N. Park Tucson, AZ 85719
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$18,000	C. Henson	
FY-80 TBD		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Tucson, AZ	10 mos.-Jan. 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Set up a method to communicate with various publics and involve them in the SPS evaluation process.

Approach

Phase I - Up to 20 documents will be summarized (including 14 Societal Assessment Reports, Preliminary Environmental Assessment, and the Reference System Report).

Phase II- Develop and distribute (to 3,000 members) information packages consisting of a precis of up to 20 documents from the Preliminary Assessment, allowing for comments to be forwarded to the DOE and replies distributed back to respondees.

Benefits

Establishes public dialogue, disseminates information on SPS, allows interested groups to comment on the SPS program, in this case, space industrialization enthusiasts.

TITLE		ORGANIZATION
Public Outreach Experiment		Forum for the Advancement of Students in Science and Technology, 2030 M St., N.W., Suite 402, Washington, D.C. 20036
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$20,000	A. Ladwig
FY-80	TBD	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Washington, D. C.	9.5 mos - Jan 15, 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Set up a method to communicate with various publics and involve them in the SPS evaluation process.

Approach

Phase I - Select persons from the student community to develop formation packages on the SPS Preliminary Assessment. Up to 20 documents will be summarized (including 14 Societal Assessment Reports, Preliminary Environmental Assessment and the Reference System Report), each summary being 4-5 pages.

Phase II- Develop and distribute (to 3,000 members) information packages consisting of summaries of up to 20 documents from the Preliminary Assessment, allowing for comments to be forwarded to the DOE and replies distributed back to respondees.

Benefits

Involves members of the student community in establishing the program. Establishes public dialogue, disseminates information on SPS, and allows interested groups to comment on the SPS program.

TITLE		ORGANIZATION
Cultural Attitudes		Rice University Houston, TX 77001
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$5,000*	S. Klineberg C. Gordon	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Houston, TX	5 mos. - May, 1979	* DOE Grant

PROJECT SUMMARY

Objective

Determine and document attitudes of various American publics to advanced technology in general, and the SPS in particular, and recommend ways to ensure effective communications with these publics.

Approach

1. Review and analyze sociological research on the public debate surrounding the supersonic transport (SST), communication satellites, and nuclear power.
2. Determine public attitudes and opinions of various American publics to advanced technologies and document with public opinion polls.
3. Identify attitudes and opinions social actor groups have concerning the SPS.
4. Delineate methods to ensure that effective communications can and will be established with various publics.

Benefits

Provides an insight into the cultural attitudes and acceptance by the public of the SPS concept.

TITLE

Strategy for Citizen
Participation

ORGANIZATION

PRC Energy Analysis Company
7600 Old Springhouse Road
McLean, VA 22102

AMOUNT

FY-79 \$20,000

PRINCIPAL INVESTIGATOR

C. E. Bloomquist

WORK LOCATION

Los Angeles, CA

DURATION-AWARD DATA

4 mos.-July, 1979

CONTRACT NO.

DE-AC01-79ER10041

PROJECT SUMMARYObjective

Develop a strategy for securing and effectively utilizing citizen input for SPS program planning.

Approach

1. Review past/on-going federal citizen participation programs, especially those concerned with complex, technical and social issues and identify:
 - techniques for encouraging broad-based involvement and promoting a thorough understanding of issues;
 - role of staff vis-a-vis citizens;
 - problems encountered and ways to resolve them.
2. Develop case studies of official reaction to public concern over projects/issues pertinent to the SPS. Identify basic issue and genesis of opposition, "actors", official outreach attempts, reasons for success/failure of outreach attempt/project.
3. Develop a strategy for a citizen participation program for the SPS, including program elements, build-up schedule, resource requirements.

Benefits

Develops plan specifically adapted to the SPS program to provide an expanded citizen participation program as a follow-up to the public outreach projects of FY-79.

TITLE

On-Going Citizen Participation
Program

ORGANIZATION

PRC Energy Analysis Company
7600 Old Springhouse Road
McLean, VA 22102

AMOUNT

FY-79 \$5,000
FY-80 TBD

PRINCIPAL INVESTIGATOR

TBD

WORK LOCATION

TBD

DURATION-AWARD DATA

TBD

CONTRACT NO.

DE-AC01-79ER10041

PROJECT SUMMARYObjective

Maintain communications with various publics about SPS research and involve them in the evaluation process, as a prelude to implementing a full-scale program involving the general public.

Approach

Identify groups which can receive and distribute information concerning SPS research among members and the broader public. Prepare reports summarizing comments for use by program planners and apprise contacted groups of actions taken.

Benefits

Maintains public dialogue, raises level of public knowledge about the SPS and allows interested groups to evaluate the SPS program.

TITLE		ORGANIZATION
SPS Comparative Assessment Methodology		Argonne National Laboratory 9700 Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
\$20,000	T. D. Wolsko	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	8 mos. - Sep., 77	189-ANL49576

PROJECT SUMMARY

Objective

Develop a methodology by which the total social cost of SPS may be compared to that of other energy alternatives.

Approach

1. Develop data base for SPS, fossil, nuclear, and terrestrial solar energy systems.
2. Define a preliminary comparative assessment methodology for use in conducting the SPS Environmental Assessment.
3. Update SPS comparative assessment methodology as appropriate during the evaluation program.

Benefit

A tool based on the latest available information and current procedures/practices that will allow a detailed and comprehensive assessment of the SPS to alternate systems.

TITLE		ORGANIZATION
SPS Utility Integration		Harza Engineering & Argonne National Laboratory Chicago, IL 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
\$60,000	K. Hub	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL Chicago, IL	6 mos.-Apr. 1, 1978	189-ANL 49576 ANL No. 31-109-38-4142

PROJECT SUMMARY

Objective

Determine the problems of SPS integration into utility systems.

Approach

1. Characterize utility systems that might employ the SPS technology.
2. Assess SPS energy integration problems, including system reliability, system stability, reserve margin requirements, system performance, transmission and distribution.
3. Assess SPS maximum market penetration rates, based on system constraints, unit size and other parameters.

Benefit

Develop a perspective of energy system integration problems that would accompany SPS energy technology/interaction.

Reference: Donalek, P.J. and J. L. Whyson, Utility Interface Requirements for a Satellite Power System. Harza Engineering Co., DOE/ER-0032, September 1978.

TITLE		ORGANIZATION
Comparative Assessment Methods		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-77 \$ 60,000	T. D. Wolsko	
FY-78 \$ 75,000		
FY-79 \$ 85,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide a framework for and methods by which economic, environmental, technical, and social comparisons of alternate energy technologies can be made.

Approach

1. Review methods and approaches utilized by previous energy/environmental assessments.
2. Draft a preliminary comparative analysis framework and set of methods to be used in the comparative evaluations. These methods include:
 - . issue definition
 - . units of measure
 - . methods or models for obtaining units of measure
 - . data bases
3. Subject the candidate methodology to extensive peer review.
4. Update methodology to include new needs or approaches to comparative assessment.

Benefits

Comparative methodology responsive to goals of SPS Program.

Reference: Wolsko, T. D., et al., Preliminary Comparative Methodology for SPS and Alternative Technologies, Argonne National Laboratory, 1979.

TITLE		ORGANIZATION	
Alternatives Characterization - Technologies		TRW, Inc. 7600 Colshire Drive McLean, VA 22012	<u>and</u> Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-79 \$68,000		Burnworth/TRW M. Samsa/ANL	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
McLean, VA Argonne, IL	8 mos. - Dec 1, 1978	WPAS ANL-49576 ANL No. 31-109-38-4905	

PROJECT SUMMARY

Objective

Collect or develop characterization data of alternative energy technologies for use in comparison of SPS with them.

Approach

1. Select ten technologies for first level characterizations.
2. Define technology parameters and perform initial characterization.
3. Select 4-6 technologies for full characterization.
4. Characterize 4-6 technologies.
5. Define issues and data deficiencies.
6. Distribute preliminary report on technology characterization.
7. Expand depth of characterization for important issue areas and estimate values for deficient data (if feasible).
8. Distribute final characterization report.

Benefit

Provides traceable data base for the comparative assessment activities. Provides a descriptive documentation of the technologies and defines data deficient areas in the various technologies.

TITLE	ORGANIZATION
Alternatives Characterization-Cost	United Engineers and Constructors (UE&C) Philadelphia, PA Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$107,000	Ziegler /UE&C M. Samsa/ANL

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL Philadelphia, PA	8 mos. - Dec 1, 1979	WPAS ANL-49576 ANL No. 31-109-38-4664

PROJECT SUMMARY

Objective

Collect cost characterization data for SPS and alternatives for use in the "cost and performance" evaluation.

Approach

1. Part I - Cost Normalization: The costs for all technologies will be placed on a common basis. The Energy Economic Data Base (EEDB) of DOE will be the primary source of capital and O&M cost data. For those technologies not in this data base, the literature-obtained data will be placed on the same basis using an EEDB format.
2. Part II - SPS Cost Accounting Review: At this stage of development, the SPS capital cost is highly uncertain and a review is needed to improve the understanding of the uncertainty.
3. Review NASA work breakdown structure and cost model for a reference version of the SPS concept.
4. Review input parameters for cost estimating relationship for a select few plant items.
5. Request NASA to make sensitivity analyses of the impact of changes in some of these parameters on the SPS cost and show the resulting uncertainty.
6. Review the cost estimate for the rectenna based on the subcontractor's experience in the construction of large scale power projects.

Benefit

Costs are placed on an as uniform basis as possible. Provides a consistent, traceable cost data set for comparison. This activity also provides an "audit" of SPS costs to aid uncertainty determination.

TITLE		ORGANIZATION
Comparative Evaluations - Cost and Performance		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$100,000		M. Samsa
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1979	WPAS ANL-49576

PROJECT SUMMARY

Objective

Compare the costs of energy (mills/kWh) of SPS with alternatives. Estimate the value of SPS and selected alternatives in an electric utility system.

Approach

1. Use existing available methodologies and data and make the Energy Economic Data Base of DOE the prime data source.
2. Estimate economic impacts of alternative scenario conditions.
3. Use results of other select studies or compare results with them, where applicable.
4. Show general levels of uncertainties in costs and performance.

Benefits

The costs of electrical energy from SPS vs those of other prominent technologies will be displayed under a number of conditions through a consistent traceable data set. The results will indicate conditions that enhance the economic feasibility of SPS. Uncertainty for all costs will be displayed pointing out ability to estimate costs for known as well as relatively unknown technologies.

Reference: Wolsko, T.D., et al., Preliminary Comparative Methodology for SPS and Alternative Technologies, Argonne National Laboratory, See Appendix, 1979.

TITLE		ORGANIZATION
Comparative Evaluations - Environmental Welfare Effects		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$14,000	R. R. Cirillo	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	18 mos. - Oct 15, 1979	WPAS ANL-49576

PROJECT SUMMARY

Objective

Identify the public welfare impacts (i.e., other than health and safety related) resulting from environmental degradation due to SPS operation and compare these to the welfare impacts of the technologies.

Approach

1. For the energy supply technologies chosen for comparison, identify the environmental welfare impacts for the entire fuel cycle. Initiate the study by determining the environmental media affected (e.g., air pollution) and the impact of that effect (e.g., agricultural crop damage).
2. Select a set of metrics to be used in quantifying the effects and comparing effects among technologies (e.g., cost, number of people affected, etc.).
3. Quantify, where appropriate, each of the impacts and qualitatively evaluate those impacts that do not lend themselves to numerical description. Include an evaluation of the potential for mitigating strategies to minimize the impact.
4. Synthesize the results by setting up a method for comparing the effects across technologies (e.g., effects on people in the vicinity of a facility, regional effects, national effects, etc.).

Benefits

Provides comparative evaluation of the non-health and safety effects of SPS to alternative technologies through a consistent traceable data set.

TITLE		ORGANIZATION
Comparative Evaluations - Climatic Effects		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL. 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$39,000		D. Kellermeyer
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	17 mos. - Nov 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Identify, qualify, and compare the climatic impacts of SPS and alternative technologies.

Approach

1. Identify potential climatic effects of SPS and alternative technologies.
2. Review existing research studies to understand the case, probability of effect, and severity of impact resulting from energy production from SPS or alternative technologies.
3. Discuss major climatic effects issues with DOE to solicit evaluations from responsible DOE organizations.
4. Utilize DOE policy statements and assessment reports for preparing the comparative evaluations of climatic impacts.
5. Evaluate the differences in climatic impacts that may exist for different energy supply/demand futures.

Benefits

Identifies and qualifies climatic effects for SPS and alternative technologies and compares impacts such that policy implications can be determined.

Reference: Kellermeyer, D. A., Climatic and Energy: Comparative Assessment of Energy Technologies, Argonne National Laboratory, 1979.

TITLE		ORGANIZATION
Health and Safety Evaluation - Public and Occupational		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$79,000	L. Habegger	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide information on the known and potential public and occupational health and safety impacts of alternative energy systems in a format which can be utilized in the SPS energy policy decision making process including uncertainties.

Approach

1. Provide from existing studies health and safety issues of nuclear, coal, geothermal, solar terrestrial, and SPS total energy cycles. Identify quantitative "severity indicators" for later use. Compare health and safety impacts between technologies and distinguish between different types of impacts: occupational vs public, accident vs disease, catastrophic vs non-catastrophic, immediate vs delayed effects, and fuel cycle partitioned (i.e., extraction, processing, etc.).
2. Major issue description will include:
 - Impact Category: e.g., occupational health, inhalation.
 - Problem Source Description: Sources of pollutant emission or hazard.
 - Health and Safety Impact Description: Disease or accident imposed by pollutant or safety hazard.
 - Quantitative Impact Estimate: Estimate of impact (e.g., deaths or person-days-lost) expected, or other indicators such as quantifiable hazards.
 - Major Uncertainties, R&D Requirements: Identify research to define and quantify impacts.
 - Mitigation Potential/Regulatory Status: Current regulations, new regulations, cost and effectiveness of alternate strategies.
 - Severity Rating: Rating of the issue relative to other issues.
 - References: Existing and ongoing studies addressing the issue.

Benefits

The level and the manner in which health and safety effects are incurred will be identified and compared for the alternatives to SPS. Uncertainties, lack of data, quantification, etc. will be specified.

TITLE	ORGANIZATION
Health and Safety Evaluation - Radiation Wastes and Safeguards	Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$8,000	L. Poch

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	16 mos. - Nov 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Characterize the range of radiation waste/safeguards issues, briefly describe the potential solutions and identify the resultant health and safety impacts of these activities.

Approach

1. Identify and characterize the range of radiation waste and nuclear safeguards issues using current research and assessment studies.
2. Briefly describe issues and potential solutions as background for overall comparative health and safety evaluation.

Benefit

Provide concise statement of range of radiation waste and nuclear safeguards issues and their solutions as background for the health and safety evaluation and for societal issues evaluation.

TITLE		ORGANIZATION
Resources Utilization - Land		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79	\$23,000	D. E. Newsom
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL.	17 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Compare the amount of land consumed, the type of land, and the duration of use, for SPS and alternative technologies.

Approach

1. Compile data from existing studies such as the Rice University and Allan D. Kotin studies for SPS (disregard social and opportunity costs of land-use for now because of the speculative nature of such data and resource constraints on the project).
2. Measure land area, normalized to plant size, categorized according to its manner of use (e.g., fuel mining, construction, plant, transmission, waste disposal) and the corresponding duration.
3. Plant siting, hence data on the type of land used, will be at a regional level only.

Benefits

Establishes a consistent traceable land use data set for comparison of alternatives, and will identify data deficiencies.

TITLE	ORGANIZATION
Resources Utilization Net Energy Analysis	Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$28,000	R. R. Cirillo

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	18 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Conduct a preliminary study of the net energy balance of an SPS system and compare it to other technologies.

Approach

1. Compare SPS to selected coal systems, nuclear systems, and terrestrial solar systems.
2. Select an appropriate net energy analysis method to maximize the use of existing information and document any differences in results from differences in assumptions.
3. Using existing data and other net energy analyses, characterize the energy balance of each system including such items as primary resource input, operating energy inputs, capital energy requirements, conversion efficiencies, gross energy outputs, and internal energy use.
4. Compute selected energy balance parameters for each system (e.g., gross efficiency, operating efficiency, lifetime efficiency, operating energy ratio, lifetime energy ratio, energy payback period).
5. Compare SPS system performance to other technologies. Identify key parameters that control the results and compare to results of existing studies.

Benefits

Provides traceable consistent net evaluation of an energy SPS system as compared to other technologies, and to other analyses.

Reference: Cirillo, R. R., et al., Net Energy Analysis of the Satellite Power System and Alternatives, Argonne National Laboratory, 1979.

TITLE		ORGANIZATION
Comparative Assessment Program Management and Documentation		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$80,000		T. D. Wolsko
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide guidance to comparative evaluators, integrate and document the resultant products into program outputs, and communicate this information to the SPS Project Office and other parties involved in the SPS Evaluation Program.

Approach

1. Develop a task structure to conduct comparative evaluations.
2. Develop a program plan and schedule of activities to meet program output requirements.
3. Establish common assumptions and standards for evaluation activities to ensure consistency.
4. Provide monthly briefings, progress reports, and special reviews as are necessary to communicate the comparative assessment activity status and results to the SPS Project Office and to others involved in the SPS Evaluation Program.
5. Integrate comparative evaluations, characterizations, and methodology work into program outputs.

Benefits

Communicates progress and outputs to SPS Project Office and other program constituents. Communicates SPS Project Office policies and externally generated information to comparative evaluation staff.

TITLE	ORGANIZATION
Comparative Assessment - Energy Systems Scenarios	Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439

AMOUNT	PRINCIPAL INVESTIGATOR
FY-79 \$20,000	M. Samsa

WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL and TBD	12 mos. - Oct 1, 1978	WPAS ANL-49576 ANL No.

PROJECT SUMMARY

Objective

Define state-of-the-world conditions in the nominal era between the years 2000 and 2030 appropriate for electrical energy system comparisons.

Approach

1. Develop three state-of-the-world cases that range from favorable to unfavorable for commercialization and growth of SPS electrical technology.
 - . Define major scenario parameters needed for each evaluation activity in its analysis of impacts; establish ranges for parameter values.
 - . Establish relationships (if any) among parameters that will allow the collection of parameter values into internally consistent conditions.
 - . Set forth expected ranges of occurrences that will yield an indication of meaningfulness of each of the three cases.
2. Relate scenarios to those extant in other federal activities and to international scenarios on energy demand and supply.

Benefits

The scenario development and information is required for use in the evaluation activities. The scenario work will produce a basis for the assessment and will link the comparative assessment scenarios with those used in other evaluations.

TITLE		ORGANIZATION
Comparative Assessment - Review Committee		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$30,000		B. D. LaMar
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	12 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide expert critical review of the comparative assessment products against the methodology and program plan to ensure consistency, traceability, objectivity, and overall quality.

Approach

1. A 8-12 member committee with members representing state government, industry, utilities, academia, decentral energy, and environmental and consumer groups will be selected.
2. The committee shall provide oral and written comments on all comparative assessment products, particularly the final comparative assessment.

Benefits

Traceable external review of the goals, methods and output of the comparative assessment by recognized authorities in the energy assessment area. Direct interaction with recognized authorities who will provide a wide perspective to the comparative assessment deliverables.

TITLE		ORGANIZATION
SPS-ANL Program Management		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT	PRINCIPAL INVESTIGATOR	
FY-79 \$242,000	B. D. LaMar	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Argonne, IL	36 mos. - Oct 1, 1979	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide program management for all ANL SPS efforts.

Approach

1. Provide the staff, maintain the project team, and determine work to be sub-contracted obtaining DOE concurrence on subcontractor scope of work.
2. Establish work priorities within the ANL area of effort and provide work schedules.
3. Provide the management plans to ensure proper organization of all functions in areas where ANL has either a line or an integration responsibility.
4. Provide a management information system to give visibility to budgetary status, fund control, and progress vs. schedule for all areas of ANL cognizance.

Benefit

Provides an integrated ANL program.

TITLE		ORGANIZATION
Satellite Power System- Program Services		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$214,000	C. A. Sandahl
FY-79	\$222,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Washington, D.C.	36 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Provide near-term planning, administrative support, quick response program analysis, and information data bank services to the DOE SPS Program.

Approach

1. Maintain near-term program execution plans which delineate the functional organization and the DOE-specified resource allocations for the SPS program.
2. Maintain an information data bank for storage and retrieval of information pertinent to the SPS program, responding to requests for information and distributing reports as directed.
3. Prepare material for use by the SPS program managers in briefings and Congressional hearings.
4. Provide presentations, information summaries and other support for SPS program review meetings, peer review group meetings, and other meetings as required, including records of proceedings or precis.
5. Prepare monthly newsletter and perform technical analyses as requested by the DOE SPS Program Manager.

Benefit

Provides management support on a real time, continuous basis to meet demands placed on the Director, SPS Project Office.

TITLE		ORGANIZATION
SPS-Ground based Exploratory Development Planning		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439
AMOUNT		PRINCIPAL INVESTIGATOR
FY-79 \$97,000		J. J. English
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Battelle Memorial Inst. Columbus, OH	36 mos. - Oct 1, 1978	WPAS ANL-49576

PROJECT SUMMARY

Objective

Develop and provide the Ground Based Exploratory Development Plan which will include projects to reduce uncertainty in key outstanding questions, products at specific key new knowledge points, and resources and scheduling.

Approach

1. Develop, with DOE participation, the objectives of the GBED Program and distribute them to all planning participants.
2. Develop decision structures and control strategies to support the GBED Plan.
3. Collect and integrate inputs to the plan into a final cohesive structure.
4. Maintain the plan and update it to meet the changing needs of the program.

Benefit

Provides detailed and long-range SPS planning capabilities.

TITLE		ORGANIZATION	
Technical Support		Argonne National Laboratory 9700 S. Cass Avenue Argonne, IL 60439	
AMOUNT		PRINCIPAL INVESTIGATOR	
FY-77	\$ 89,000	B. D. LaMar	
FY-78	\$231,000		
FY-79	\$ 41,000		
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.	
Argonne, IL	36 mos. - Oct 1, 1978	WPAS ANL-49576	

PROJECT SUMMARY

Objective

Coordinate the investigation and selection of the system design options to be explored further in the system definition effort. Coordinate and manage analyses of SPS operational problems such as implementation, decommissioning, and inadvertent re-entry.

Approach

1. Prepare a history of the SPS design options tradeoffs, the ground rules affecting those tradeoffs, and reference assumptions affecting new design option tradeoff investigations. Coordinate preliminary screening of candidate design options and recommend to DOE those options deemed promising enough to be investigated further for final selection.
2. Provide planning for and analyses of operational problems.
3. Perform technical analyses as DOE may assign.

Benefit

Provides a wide range of technical support to the NASA and DOE SPS Project Manager.

TITLE		ORGANIZATION
SPS Program Planning and Analysis		PRC Energy Analysis Company 7600 Old Springhouse Road McLean, VA 22102
AMOUNT		PRINCIPAL INVESTIGATOR
FY-78	\$47,000	C. E. Bloomquist
FY-79	\$60,000	
WORK LOCATION	DURATION-AWARD DATA	CONTRACT NO.
Los Angeles, CA McLean, VA	6 mos. - Apr 1, 1979	DE-AC01-79ER10041

PROJECT SUMMARY

Objective

Establish planning activities to guide SPS program functions. Anticipate changes and recommend the most effective planning response. Maintain support of all SPS activities including general preparation of reports and summaries.

Approach

1. Perform program planning and planning support activities.
2. Provide analysis of ongoing program activities, prepare and update guidelines, program summaries, and provide general program support.
3. Prepare contingency plans, and develop and update plans for post FY-80 program phases.

Benefits

Provides a Ground Based Exploratory Development plan for post FY-80 efforts. Maintains up-to-date environmental guidelines. Provides analyses of likely changes in the technology and budgeting guidelines. Enables preparation of program summaries, annual progress reports, briefings, status reports, etc.

- References:
- (a) Bloomquist, Charles, A. Daurio, and S. Shotland, Satellite Power System (SPS) Societal Assessment Research Needs Document, PRC Energy Analysis Company, PRC R-1867, November 1978
 - (b) Wei, Michael S., Final Environmental Guidelines for Satellite Power System (SPS), PRC Energy Analysis Company, EG-77-C-01-4024, July 1979
 - (c) U. S. Department of Energy and the National Aeronautics and Space Administration, Satellite Power System (SPS) Concept Development and Evaluation Program Plan July 1977 - August 1980, DOE/ET-0034, February 1978

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SPS PROGRAM PARTICIPANTS

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 Institute for Telecommunication Sciences
Department of Energy
Environmental Protection Agency
National Aeronautics and Space Administration
 Ames Research Center
 Johnson Space Center
 Marshall Space Flight Center

NATIONAL LABORATORIES

Argonne National Laboratory
Jet Propulsion Laboratory
Lawrence Berkeley Laboratory
Los Alamos Scientific Laboratory

UNIVERSITIES

Boston University
Colorado State University
University of California at Davis
Georgia Institute of Technology
Rensselaer Polytechnic Institute
Rice University
South Dakota School of Mines and Technology
Stanford University
University of Tennessee
University of Virginia
University of Washington

NON-PROFIT ORGANIZATIONS

Citizens' Energy Project
Forum for the Advancement of Students in Science and
 Technology
JASON Committee
The LaJolla Institute
L-5 Society

INDUSTRY

The Aerospace Corporation
Battelle Memorial Institute/Columbus
Battelle, Pacific Northwest Laboratory
Boeing Aerospace Company
Bolt, Beranek and Newman, Inc.
Center for Policy Process
ECON, Inc.
Economic Consultants
EG & G
Environmental Resource Group
Harza Engineering Company
International Technical Services, Inc.
LinCom Corporation
A. D. Little, Inc.
Lockheed Electronics Company
National Center for Atmospheric Research
Planning Research Corporation
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