Progress Report

on the

Electric and Magnetic Fields Research and Public Information Dissemination Program

December 1995

The EMF Interagency Committee
Progress Report

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FOREWORD

Section 2118 of the Energy Policy Act (EPAct) of 1992 (42 USC 13478) authorized the five-year Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program. The EMF Interagency Committee, established under Section 2118, is required to submit a report summarizing the progress of the research program to Congress and to the Secretary of Energy by December 31, 1995. That requirement is fulfilled by this progress report.

The EMF RAPID Program is "a comprehensive program to determine whether or not exposure to EMF from the generation, transmission, and use of electricity affects human health." Although the Interagency Committee is only required to report on the progress of the research aspects of the RAPID Program, information is provided in the context of the overall program strategy that guides the research, as well as of related Federal programs. Accordingly, this report describes the work to date on the entire RAPID Program. It also includes information about related Federal efforts.

The Electric and Magnetic Fields (EMF) Interagency Committee

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EXECUTIVE SUMMARY

The Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program was authorized by the Energy Policy Act of 1992 (enacted October 24, 1992) to determine whether or not exposure to EMF produced by the generation, transmission, and use of electric energy affects human health. Two Federal agencies, the Department of Energy (DOE) and the National Institute of Environmental Health Sciences (NIEHS), have primary responsibility for the program, but other Federal agencies are key participants as well. This program requires that Federal appropriations be matched by contributions from non-Federal sources. The authorized level of funding for the program was $65 million over a 5-year period (fiscal years 1993-1997 inclusive). For EMF RAPID to be a fully funded program, $32.5 million over 5 years will have to be appropriated by Congress and matched by non-Federal contributions.

- The first funded year of the program was fiscal year (FY) 1994. Federal appropriations of $3.9 million were fully matched by industry to yield a total budget of $7.8 million. Figure 1 shows the anticipated division of total program funds.

Figure 1

**Planned EMF RAPID Program Funding Distribution**

- Health Effects Research 65%
- Cellular Studies 25%
- Animal Studies 25%
- Replication Research 10%
- Directed Research 6%
- Engineering Research 15%
- Risk Assessment 10%
- Communication 5%
- Administration, Review, and Monitoring 5%

Anticipated Division of Total Funds

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• In fiscal year 1995, Federal appropriations for the program were $7.7 million. Non-Federal contributions of $6.0 million were received making the total budget for 1995 $13.7 million.

• Non-Federal commitments for contributions over the life of the RAPID Program currently total $23.6 million. An additional $8.9 million will be necessary to fully match the $32.5 million in Federal funds authorized. Both the Department of Energy and the National Institute of Environmental Health Sciences have made presentations to the members and/or boards of directors of 18 targeted associations to obtain additional commitments.

The EMF Interagency Committee prepared a Research Agenda and Communication Plan in consultation with the National EMF Advisory Committee (NEMFAC) that was issued in May 1994 (included as Appendix H to this report). In this document, a program consisting of four components was prescribed: health effects research, engineering, risk assessment research, and communication. Implementation plans for each of these components were developed with advice from NEMFAC and published by DOE and NIEHS in October 1994. These plans are attached as Appendices I, J, and K to this report; other documents published by the program are listed in Appendix L.

Multi-year health effects research projects and related EMF measurement and exposure assessment projects are now underway. The results of these research projects, along with the results of other relevant EMF research, will provide a scientific basis for the hazard identification/risk assessment effort, which is the focus of the EMF RAPID Program. Communication efforts are underway to distribute information about EMF in understandable terms to the public and to policymakers.

• Health effects research is underway through 27 research grants funded in fiscal years 1994 and 1995. The distribution of FY 1994 and FY 1995 funds, according to study area, is as follows: 67% for cancer, 30% for neurological effects, and 3% for reproductive effects. Most studies have a duration of 3 or 4 years.

• Health effects research is also underway through 12 in-house studies being conducted by NIEHS' own scientists. These studies have a duration of 2 years.

• Exposure chambers for replication experiments that were designed and built by DOE are in place at the Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH), and Oak Ridge National Laboratory (ORNL). A gene transcription replication experiment is underway at FDA. Other research is planned at NIOSH and ORNL. A similar exposure chamber is planned for Battelle-Pacific Northwest Laboratory (PNL).

• Five engineering contracts totalling approximately $0.7 million were awarded by DOE in February 1995. The contractors are developing guidelines for environmental field surveys, exposure assessment, and source characterization studies. They will also conduct environmental field surveys and establish a database of EMF measurements.

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A committee of the National Academy of Sciences (NAS) has been established to review and evaluate all research completed under this program. The NAS Committee to Review the Research Activities Completed Under the Energy Policy Act of 1992 submitted an interim report to the EMF Interagency Committee in September 1995. In this report, the committee made a number of recommendations regarding the research strategy of the RAPID Program. These recommendations are listed in Appendix E.

Communication efforts include:
- distribution of the public information booklet *Questions and Answers About Electric and Magnetic Fields Associated with the Use of Electric Power* (approximately 100,000 copies have been distributed thus far);
- establishment of the EMF InfoLine jointly supported by the EMF RAPID Program and the Environmental Protection Agency (EPA) to answer questions the general public has about EMF;
- and establishment of the EMF RAPID Program's Biomedical and Engineering Information Clearinghouse, which includes the EMF-Link World Wide Web site.

**DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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1 OVERVIEW OF THE EMF RAPID PROGRAM

The public has been concerned about a possible link between exposure to electric and magnetic fields (EMF) and human health effects for at least 15 years. Although some epidemiological studies have reported an association between exposure to EMF and certain types of cancer and other health effects, other studies have not (epidemiology is the study of the patterns and possible causes of diseases in human populations). Laboratory researchers are studying how such associations may be biologically possible. At this point, there is no scientific consensus about hazards, if any, posed by exposure to EMF, but there is general agreement that better information is needed.

Because epidemiological studies have raised concerns regarding the connection between exposure to EMF and certain health problems (such as childhood leukemia; brain and breast cancer; and certain adverse neurological and reproductive effects), the RAPID Program adopts the hypothesis that exposure to EMF under some conditions may lead to an unacceptable risk to human health. Although epidemiological studies have thus far produced inconclusive results, they do suggest the health outcomes that are the focus of biological mechanism and toxicological research in the RAPID Program. This focus offers the best chance for reducing scientific uncertainty.

The Energy Policy Act of 1992 authorized the five-year RAPID Program to expand and accelerate the research needed to address the EMF health effects issue. Its funding is based on annual Federal appropriations and the solicitation of non-Federal contributions (see Appendix F). Section 2118 of the Energy Policy Act required the Department of Energy and the National Institute of Environmental Health Sciences "to establish a comprehensive program to:

- "determine whether or not exposure to electric and magnetic fields produced by the generation, transmission, and use of electric energy affects human health;

- "carry out research, development, and demonstration with respect to technologies to mitigate any adverse human health effects; and

- "provide for the collection, compilation, publication, and dissemination of scientifically valid information to the public on the following subjects:

  a) possible human health effects of electric and magnetic fields;

  b) the types and extent of human exposure to electric and magnetic fields in various occupational and residential settings;

  c) technologies to measure and characterize electric and magnetic fields; and

  d) methods to assess and manage exposure to electric and magnetic fields."

As stated in Section 2118, "It is the sense of the Congress that remedial action taken by the Government on electric and magnetic fields, if and as necessary, should be based on, and consistent with, scientifically valid research..." By sponsoring carefully conducted and fully documented research, the EMF RAPID Program will significantly reduce scientific uncertainty. EMF RAPID is committed to maintaining open communication within the program.

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so that the public and other stakeholders can make informed decisions about EMF.

The Federal EMF Interagency Committee

The EMF Interagency Committee is responsible for development of the strategy and research agenda to meet the RAPID Program’s goals. Under the provisions of Section 2118, the EMF Interagency Committee was established by the President’s Office of Science and Technology Policy (OSTP) to:

- "develop a comprehensive agenda for conducting research, development, and demonstration under the program, with particular emphasis on electric and magnetic fields of the 60 hertz frequency;"

- "recommend guidelines for the coordination of the activities of Federal agencies engaged in research on human health effects related to electric and magnetic fields to ensure that such research advances the agenda and is not unnecessarily duplicative of other research activities;"

- "recommend mechanisms for communicating the results of the program to the public, including recommendations on the scope and nature of the information to be disseminated; and"

- "monitor, review, and periodically evaluate the program."

The EMF Interagency Committee is comprised of representatives from nine Federal agencies: the Department of Energy, National Institute of Environmental Health Sciences, Environmental Protection Agency, Department of Defense, Occupational Safety and Health Administration, National Institute of Standards and Technology, Department of Transportation, Rural Utilities Service, and the Federal Energy Regulatory Commission.

The National Electric and Magnetic Fields Advisory Committee

The 10-member National EMF Advisory Committee (NEMFAC) was established in January 1993. Members were chosen for their expertise in the possible human health effects of EMF, the measurement and characterization of electric and magnetic fields, and the assessment and management of electric and magnetic fields. Members represent state regulatory agencies, state health agencies, electric utilities, electric equipment manufacturers, labor unions, and the public. Current members and their affiliations are shown in Appendix D.

The purpose of the Advisory Committee is to make recommendations to the EMF Interagency Committee with respect to its duties, and to advise the Secretary of Energy and the Director of NIEHS on the design and implementation of the EMF RAPID Program. NEMFAC has conducted public meetings since August 1993 and has provided substantive input into the EMF RAPID Program Research Agenda and Communication Plan and the five-year implementation plans for the program’s research and communication activities. The Advisory Committee also provides advice on the general scope of specific projects and activities. NEMFAC has provided the following recommendations for implementing the program:

- Health effects research carried out under the RAPID Program should be targeted at studying specific disease endpoints.
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- RAPID funds should not be used to finance new epidemiology studies.
- Engineering activities should support biological research.
- Field management and mitigation research, if needed, should be deferred until the later years of the program.

Research Agenda and Communication Plan

The Research Agenda and Communication Plan (Appendix H), prepared by the EMF Interagency Committee, sets the direction and outlines the strategy for the program. This research agenda is coordinated with the planning of other EMF research programs, which are described in Appendix G. Based in part upon information provided by DOE and NIEHS, as well as the recommendations of NEMFAC, the Research Agenda and Communication Plan prescribes a program consisting of four components: health effects research; engineering; risk assessment research; and communication. Each of the program's components are briefly described below.

Health Effects Research

The health effects research carried out under this program is intended to test the hypothesis that certain human illnesses may be related to EMF exposure. By focusing research on those biological mechanisms that might lead to the health effects most often suggested by the epidemiological studies, the opportunities for investigators to identify robust and reproducible biological effects will be maximized.

In the case of EMF, where exposure is known only retrospectively and in rough terms, the epidemiological evidence is inconclusive. In this circumstance it is necessary to augment the epidemiological research with toxicological studies and basic research to identify interactions of carefully controlled electric and magnetic fields with biological processes. The purpose of toxicological and basic mechanistic studies is to establish:

- a robust and reproducible biological or biochemical response to EMF,
- an effect associated with a biologically plausible mechanism linked to a disease endpoint, and
- a measure of exposure inducing the response that can be correlated with actual human exposures.

A critical question addressed by this research is to determine the proper measure of dose for EMF. At this time the precise components or characteristics of EMF (e.g., magnitude, frequency polarization, pulse structure, etc.) that may be responsible for producing a biological response, are unknown. A knowledge of the dose metric (those features of EMF used to measure exposure) will (1) advance our understanding of mechanisms of interaction, (2) decrease uncertainty in quantitative risk analyses, and (3) aid in developing countermeasures if a significant risk is found to exist.

RAPID Program health effects research includes studies of the effects of EMF on both cellular and whole-animal models, and emphasizes finding robust and replicable bioeffects, and validating past research results that have reported finding such effects. The program's research agenda calls for a concerted effort to study specific health endpoints and is versatile enough that gaps identified in the research can be filled and research breakthroughs exploited. Interim reports from researchers and

The EMF Interagency Committee

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reviews of the research by a special committee of the National Academy of Sciences (see Appendix E) aid the Interagency Committee in making its periodic evaluations of the program's progress and direction. The principles established in the Research Agenda and Communication Plan to redirect, expand, or concentrate the areas of research and research priorities provide guidance to the National Institute of Environmental Health Sciences and the Department of Energy in their management of the program.

**Engineering**

The engineering component of EMF RAPID is primarily focused on supporting the health effects research, the risk assessment research, and the communication components. This support focuses on assessing human exposure, compiling information on technologies to measure and characterize EMF, and assessing methods for managing exposures to EMF. Field management and/or mitigation research, if needed, has been deferred until the later years of the program.

**Risk Assessment Research**

The RAPID Program's primary objective is to identify, aggregate, evaluate, and interpret the rapidly expanding volume of scientific data from health effects and exposure research in a manner that permits credible, scientifically-sound hazard identification. An important component of this effort will be to establish a dose metric for measuring exposure to EMF. If data are generated that suggest a health hazard exists from exposure to EMF, efforts will be made to quantify the magnitude of the risk to human health, and to identify and reduce the uncertainty associated with risk estimations.

**Communication**

A coordinated Federal effort is underway to disseminate information about EMF in understandable terms to the public and policymakers. The program is providing information about possible human health effects of EMF, the types and extent of human exposure, technologies for measuring and characterizing fields, and methods for assessing and managing exposure. The communication component of the RAPID Program addresses the issue of scientific uncertainty regarding EMF health effects and the overall complexity of the EMF issue, while providing information appropriate for a variety of audiences.
2 HEALTH EFFECTS RESEARCH

The Energy Policy Act of 1992 directs the Department of Energy and the National Institute of Environmental Health Sciences to conduct "research on mechanisms by which electric and magnetic fields interact with biological systems." Using the Research Agenda and Communication Plan, the National Institute of Environmental Health Sciences developed a five-year Implementation Plan for Health Effects Research and Risk Communications (Appendix I). In carrying out this component of the RAPID Program, NIEHS uses university and private research laboratories, as well as the research capabilities within the U.S. Public Health Service.

National Institute of Environmental Health Sciences RAPID Program Health Effects Research Plan

The Implementation Plan for Health Effects Research and Risk Communications provides direction for EMF toxicology and research into the complex biological mechanisms that may result in human cancer, neurobehavioral dysfunction or reproductive disabilities. These studies test the hypothesis that human exposure to electric and magnetic fields created by the generation, delivery, or use of electricity, under some circumstances, may present a carcinogenic, neurobehavioral, or reproductive hazard. Initial research studies focus on health effects suggested by epidemiological studies and on efforts to independently reproduce and build upon previously reported biological effects. The plan maintains flexibility to respond to gaps in the research and research breakthroughs.

The present total first-year cost of the 39 health effects research studies managed by NIEHS in the RAPID Program is approximately $6.3 million. Twenty-five of these were National Institutes of Health-style competitive grants primarily to university researchers. Two additional studies, begun under NIEHS' own ongoing research program, received additional support from RAPID in the form of one-year grants. Another 12 studies are being conducted at NIEHS and other laboratories in the Public Health Service. When the results of this research are added to the results of EMF health effects research conducted outside of the RAPID Program, the scientific data should significantly reduce the current uncertainty concerning the possible health effects of EMF.

Summary of RAPID Health Effects Research Studies Underway

With fiscal year 1994 being the first year of available appropriations, NIEHS announced its first requests for applications from non-governmental scientists and institutions for health effects research grants in November 1993. One of the major objectives of the RAPID Program is to reproduce reported biological responses, so this was a key requirement for these applications. All applications were reviewed by a panel of scientists convened by the National Institutes of Health, and in September 1994, NIEHS awarded grants for the first 21 health effects studies to be carried out under the RAPID Program.

In September 1994, NIEHS issued a Program Announcement inviting additional applications to conduct EMF health effects research under the RAPID Program. The request solicited research projects aimed at identifying an EMF exposure dose metric (field component or characteristics, e.g., magnitude, frequency, polarization) underlying...
biological effects reported in several laboratory studies. NIEHS also received applications for EMF research grants that were either unsolicited proposals or resubmissions of amended applications. Upon completion of the peer review, NIEHS awarded one additional grant using FY 94 RAPID funds in February 1995. Although several additional applications were judged to have relevance to the RAPID Program, there were not enough RAPID funds available in 1994 to support these projects. These applications were therefore referred to the on-going NIEHS research program for funding.

Five more grants to conduct health effects research under EMF RAPID, utilizing FY 95 funds, were awarded in the fourth quarter of fiscal year 1995.

The EMF RAPID Program health effects studies are being conducted by scientists in universities, as well as in private and Federal laboratories. These studies are summarized in Table 2-1 and described in Appendix A.

**NIEHS In-House EMF Research**

To accelerate research and expand scientific data on biological effects of EMF, some of the NIEHS senior staff scientists working in environmental carcinogenesis, cell-to-cell signalling mechanisms, teratology, reproductive biology, and experimental toxicology have added an EMF exposure component to their on-going experiments. These were reviewed for scientific merit and relevance to the priorities established in the RAPID Program’s Implementation

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**Table 2-1: EMF RAPID Program Grants by Research Area**

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<thead>
<tr>
<th>Research Area</th>
<th>Number of Grants</th>
<th>First-year Costs*</th>
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<tr>
<td>Cancer Toxicology</td>
<td>2</td>
<td>$ 400,400</td>
</tr>
<tr>
<td>Cancer Mechanisms</td>
<td>15</td>
<td>$ 3,330,000</td>
</tr>
<tr>
<td>Neurobehavioral Toxicology</td>
<td>2</td>
<td>$ 379,000</td>
</tr>
<tr>
<td>Neurobehavioral Mechanisms</td>
<td>5</td>
<td>$ 923,000</td>
</tr>
<tr>
<td>Neurobehavioral Clinical Studies</td>
<td>1</td>
<td>$ 281,000</td>
</tr>
<tr>
<td>Reproductive Toxicology</td>
<td>2</td>
<td>$ 310,000</td>
</tr>
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</table>

* As shown in Appendix A, most studies have a duration of 3 or 4 years.
Plan for Health Effects Research and Risk Communications. Under these guidelines, NIEHS has initiated 12 EMF studies to be conducted by the Institute's own scientists. These studies are summarized in Table 2-2.

NIEHS Toxicologic Research Add-On Studies

In March 1993, NIEHS, acting as the lead agency for the National Toxicology Program (NTP) and using resources from its on-going programs, began a comprehensive, toxicological assessment of the effects of a lifetime of EMF exposure on a large number of specially-bred rodents. To take advantage of opportunities presented by NTP, three add-on studies which cost the RAPID Program $0.5 million, have been completed. No RAPID funds went to the National Toxicology Program, however RAPID funds were used to support these three smaller, more directed toxicologic and mechanistic add-on studies. These studies will provide additional information on how EMF affects biochemical levels, the immune system, and the promotion of cells associated with leukemia.

Regional Research Sites

State-of-the-art regional exposure chambers have been installed at the National Institute for Occupational Safety and Health (NIOSH), the Food and Drug Administration (FDA), and the Oak Ridge National Laboratory (ORNL) for conducting experiments into the effects of EMF on living cell processes. A similar exposure chamber is planned for the Battelle-Pacific Northwest Laboratory (PNL). These exposure chambers are primarily used to conduct studies to replicate key EMF research findings. For those effects that can be replicated, the regional research sites will be used to determine what constitutes an EMF dose. They will also be used, on a secondary basis, for new EMF research studies.

Table 2-2: EMF RAPID Program

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Number of Studies</th>
<th>Total Costs*</th>
</tr>
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<tbody>
<tr>
<td>Cancer Mechanisms</td>
<td>9</td>
<td>$ 460,000</td>
</tr>
<tr>
<td>Neurobehavioral Mechanisms</td>
<td>3</td>
<td>$ 112,000</td>
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</table>

* 2-year studies.
3 ENGINEERING

Under Section 2118 of the Energy Policy Act, Congress directed the Department of Energy to conduct "research, development, and demonstration with respect to technologies to improve the measurement and characterization of electric and magnetic fields; and techniques to assess and manage exposure to electric and magnetic fields." In accordance with the Research Agenda and Communication Plan written by the Interagency Committee, DOE produced a five-year Implementation Plan for Engineering Research, Development, and Demonstration (Appendix J). This implementation plan focuses on four key areas: field measurement, exposure assessment studies, evaluation of field management strategies, and quality assurance initiatives. The engineering component of the EMF RAPID Program provides information and support for health effects research, risk assessment, and communication activities.

Hazard identification, quantified dose-response, and exposure assessment are the key components of any risk assessment. Most of the RAPID Program's engineering activities directly address exposure assessment by developing estimates of EMF exposure for the general population and population sub-groups. Engineering projects also support health researchers addressing the other two components of risk assessment. It does so by providing information on actual human exposures and by providing a program of quality assurance for exposure methods used in the laboratory. In the absence of sufficient information to assess risk, decision makers may quickly benefit from the information about exposure obtained from this program.

The EMF RAPID Program's Implementation Plan for Engineering Research, Development, and Demonstration describes a targeted set of activities that serve multiple purposes. Current plans call for 26 engineering projects, some of which are underway or have already been completed. The current status of these projects is described in Appendix B.

The main objectives of the engineering implementation plan are:

- To characterize field sources and environmental fields by measuring as many possibly relevant field parameters as practical;
- To determine the range and typical characteristics of EMF exposure for the general population as well as for various subgroups;
- To evaluate the costs, benefits, and effectiveness of options for managing EMF exposures from a variety of sources; and
- To ensure the high quality and consistency of the EMF biological studies supported under the EMF RAPID Program in terms of design, execution, and documentation.

In July 1994, the Department of Energy issued a request for proposals (RFP) for five major engineering projects. Following peer review of the proposals that were received, DOE awarded research contracts totalling nearly $0.7 million. The primary goals of these projects are:
• To develop recommendations for guidelines and protocols for EMF measurement, which will enable consistent data gathering and reporting; and

• To perform preliminary EMF measurement in typical environments and make these, and similar data, available to researchers in a standard database format.

Results and information from the engineering component of the RAPID Program are being disseminated through a variety of channels. For example, DOE plans to publish, electronically and in hardcopy, EMF measurement guidelines for scientists, engineers, and the public. DOE also plans to submit these guidelines to the Institute of Electrical and Electronics Engineers (IEEE) or another standard-setting organization for consideration as standard EMF measurement protocols. The measurement guidelines, the EMF measurement database, and the results of other engineering projects will be accessible through the Internet. Several of the communication projects listed in Appendix C contain information developed through the engineering component of the EMF RAPID Program.
4 RISK ASSESSMENT RESEARCH

Hazard identification is the first step in the risk assessment process first described by the National Research Council of the National Academy of Sciences in 1983 and reaffirmed in a subsequent report, *Science and Judgement in Risk Assessment* in 1994. According to that report, hazard identification "involves the determination of whether exposure to an agent can cause an increased incidence of an adverse health effect...and characterization of the nature and strength of the evidence of causation." Once this first step has been completed, and if it is determined that a potential human health hazard is posed by an environmental agent, the next steps in risk assessment are: dose-response assessment; exposure assessment; and risk characterization (see Figure 4-1).

The fundamental purpose of the RAPID Program health effects research is to produce sound scientific data needed to determine whether exposure to EMF presents a hazard to human health. The health effects research studies supported by the RAPID Program were selected both on the basis of their scientific merit and their potential to contribute information needed to make that determination.

Most experts in risk assessment agree that either epidemiological or toxicological data may provide sufficient evidence for judging an environmental agent to be a hazard. The most compelling scientific evidence that exposure is causally related to a health effect comes from epidemiological studies. However, in order to rely upon epidemiologic evidence alone, there must be a strong association between exposure and effect, and it must be reproducible. Confounding factors and experimental biases must also be ruled out. Epidemiologic results are given additional credibility if both exposures and/or effects have been directly measured and if there are biological or toxicological data relating the effect to the exposure.

![Figure 4-1: The Risk Assessment Process](image-url)
While several EMF epidemiological studies describe consistent effects, the associations reported are modest in strength, findings are often conflicting, and neither experimental bias or confounding factors can be completely ruled out. Further, most EMF epidemiological studies have used indirect, rather than direct, measures of exposure, such as historical data, wiring configurations and job descriptions. Under these circumstances, toxicological experiments and basic mechanisms studies are needed to clarify the existing findings and to guide other researchers in the design of new, more sensitive epidemiological studies.

Toxicological research often provides data consistent with epidemiological results indicating a human health hazard from an environmental agent. More frequently however, the results of toxicological studies serve as the initial indication of a potential health hazard. In order for toxicological results to stand alone, the findings must be unequivocal. The data from toxicological laboratory studies must demonstrate that the incidence of disease or dysfunction is significantly higher in exposed animals than it is in unexposed animals. Exposures must be carefully measured, confounding factors must be ruled out, and the studies must be reproducible. Toxicologic studies using laboratory animals have thus far been unable to establish whether a health hazard from exposure to EMF exists.

**Mechanistic Research and Hazard Identification**

Many experts in carcinogenesis and reproductive biology believe that an agent can be identified as a potential human health hazard if laboratory experiments demonstrate that the agent can alter normal biological processes so profoundly as to initiate or promote the occurrence of disease, adverse reproductive outcome, or developmental disability. The term "mechanistic research" describes studies undertaken in the laboratory of interactions between environmental agents and basic biological processes. The biomedical literature on EMF contains many reports of mechanistic research, much of which is hypothesis-driven, seeking to determine whether EMF exposure does have biological effects that can be observed in laboratory experiments. To date, most reports of effects have not produced robust findings and have not been independently and consistently reproduced in different laboratories by different scientists. These experiments however, have generated information useful in formulating hypotheses of how EMF exposure may be involved in the development or progression of certain cancers, as well as other health effects reported as weakly associated with presumed exposure to EMF in epidemiology studies.

Many scientists believe that the results of mechanistic research are most useful in establishing or rejecting the biological plausibility of unexpected findings from epidemiologic and/or toxicologic research. Thus, if it can be demonstrated in appropriately designed laboratory studies that an agent has a robust and reproducible effect that can be related to a disease process, this would support epidemiological or toxicological associations that alone are insufficient to identify an agent as a hazard. Conversely, if no such effect is observed, the likelihood that the weak epidemiological and toxicological findings were due to chance, biased sample selection, or confounding factors is greater.

The Interagency Committee targeted health endpoints first identified in epidemiological studies as the focus of mechanistic research to be carried out under the health effects research component of the RAPID Program. However, no new epidemiological
research was included in the research agenda for the program. The reasons for excluding epidemiological research as a component of the RAPID Program were:

- the high cost of additional new epidemiology studies,
- the amount of time required to design and conduct such new studies,
- the inherent limitations of epidemiology studies to establish causal associations for relatively rare diseases, and
- the expectation that several large EMF epidemiological studies already in progress were expected to report their results before the expiration of the RAPID Program.

NIEHS, in consultation with the National EMF Advisory Committee, developed an Implementation Plan for Health Effects Research and Risk Communications that responded to the guidance laid out in the EMF RAPID Program's Research Agenda and Communication Plan.

The RAPID Program's focus on toxicology and mechanistic research is consistent with the best current practices of hazard identification and risk assessment as advocated by the National Academy of Sciences. The clear challenge to NIEHS is to make meaningful extrapolations of data from animal and laboratory studies to people. This challenge is being met through research designed to identify the appropriate exposure metric and develop models for extrapolating those data.

Risk Assessment Research Methodology

NIEHS believes that the most productive approach to EMF hazard identification is to separate the task into smaller and more manageable subtasks. Rather than providing a single determination of hazard, it is more practical to evaluate the epidemiologic, toxicologic, and mechanistic research data independently using the standards for causality generally employed in the hazard identification/risk assessment process outlined by the National Research Council and substantiated in other instances of hazard assessment.

NIEHS, through the RAPID Program's EMF Information Clearinghouse, will monitor and collect all new epidemiological, toxicological, and biological mechanisms data from EMF studies underway and anticipated to be available during the term of the RAPID Program. The results of these studies will be added to the scientific data generated from toxicologic research and from RAPID Program health effects research. These data, in the aggregate, are to become the basis for an EMF hazard identification, the first step in risk assessment. Other scientific data will be collected, evaluated, and when appropriate, added to the data base.

Hazard Identification Workshops

Workshops will be sponsored in each of at least five separate scientific areas consistent with the health effects research priorities established in the RAPID Program. Examples of the workshop subjects include effects of EMF on genes and gene products; effects of EMF on reproduction and development; and effects of EMF on production of the hormone melatonin.

The goals of these hazard identification workshops are:

- to evaluate the general scientific merit of the epidemiological, toxicological, and biological mechanisms research related to EMF;
Progress Report on the EMF RAPID Program

- to evaluate the weight (the balance between positive and negative research findings) and the strength (robustness and reproducibility) of the scientific data;

- to attempt to reach a consensus on the implications and/or relevance, if any, to human health suggested by the aggregate scientific data using the generally accepted principles of hazard identification; and

- to identify any significant gaps in the research that may be needed to support a determination that a hazard to human health exists from EMF exposures.

A small group of scientific experts in each of the research areas will be joined by non-EMF researchers in that field. They will meet in open session to discuss whether the research results are adequate for that scientific area, and to determine whether a hazard to human health from EMF exposures exists.

A final workshop will be convened to seek a scientific consensus on the larger issue: What do the aggregate data indicate about the existence of any hazards to human health from exposure to electric and magnetic fields produced from the generation, delivery, and use of electricity? In this workshop, emphasis will be placed on reconciling the relevant human, animal, and mechanistic data. The guidelines and structure for this meeting would follow the principles for risk assessment issued in reports from the National Research Council of the National Academy of Sciences.

Because of the implications of these workshops to the ultimate conclusions and recommendations of the RAPID Program, it is important that NIEHS solicit advice from the Advisory Committee and members of the risk assessment research community in planning the workshops. If a hazard is identified, dose/effect relationships will have to be established for the proper assessment of risk. The exposure data developed by the engineering component of the program will also be a key input to the risk assessment effort.
5 COMMUNICATION

The Energy Policy Act of 1992 directs DOE and NIEHS to: "provide for the collection, compilation, publication, and dissemination of scientifically valid information to the public on the following subjects:

a) possible human health effects of electric and magnetic fields;

b) the types and extent of human exposure to electric and magnetic fields in various occupational and residential settings;

c) technologies to measure and characterize electric and magnetic fields; and

d) methods to assess and manage exposure to electric and magnetic fields."

Recognizing that different audiences require different information, DOE and NIEHS began work in December 1993 on a joint approach to communication activities, and in October 1994 published a five-year Implementation Plan for Communication that responded to guidance provided in the Research Agenda and Communication Plan. This document describes a program of coordinated public information projects that meet the needs of both technical and general audiences.

The first priority for the EMF RAPID Program was to develop a booklet designed for a nontechnical audience that would capture the technical community's general consensus of what is known and still not known about the possible health effects of EMF. This booklet, Questions and Answers About Electric and Magnetic Fields Associated with the Use of Electric Power, was published in January 1995 and has been widely praised for its objective, user-friendly presentation of this complex issue. Approximately 100,000 copies have been distributed. A Spanish translation was developed by the RAPID Program and published in March 1995.

The booklet has been well-received overseas as well. Plans are being made by organizations in France, China, and Japan to translate and distribute the document in those countries. Researchers in Spain have requested permission to adapt the Spanish version of the booklet for distribution in their country.

The next major public information product will be a booklet focusing on EMF in the workplace. The RAPID Program is working closely with the National Institute for Occupational Safety and Health on this project and plans to publish the booklet in 1996.

A coordinated interagency program is underway to communicate needed information on the EMF issue in a clear manner to the public, researchers, and other decision makers. The Federal government has now set up three telephone information hotlines to respond to questions about EMF. The U.S. Environmental Protection Agency manages the EMF "InfoLine" (1-800-363-2383) which responds to basic questions from the general public and distributes RAPID Program information materials. The InfoLine handles the bulk of the approximately 1,000 calls received from the public each month on this issue. The National Institute for Occupational Safety and Health hotline responds to questions from workers and those concerned about occupational EMF exposures (1-800-356-4674). Technical questions on EMF can be handled through the EMF Information Clearinghouse, established by the
National Institute of Environmental Health Sciences (1-800-643-4794). The Clearinghouse can also be accessed through a World Wide Web site on the Internet (http://infoventures.microserve.com).

Other communication projects currently underway or planned are described in Appendix C.
Appendices
## APPENDIX A: EMF RAPID PROGRAM HEALTH EFFECTS RESEARCH GRANTS

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Title</th>
<th>Dollar Amount*</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roy K. Aaron, MD</td>
<td>EMF and Early Bone Development</td>
<td>$599,114</td>
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<tr>
<td>R. Dean Astumian, PhD</td>
<td>Study of the Electric Field Sensitivity of Yeast H+ ATPase</td>
<td>$430,967</td>
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<tr>
<td>Elizabeth Balcer-Kubiczek, PhD</td>
<td>Gene Expression Following 60 Hz Magnetic Field Exposure</td>
<td>$630,288</td>
<td>3</td>
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<tr>
<td>David M. Binninger, PhD</td>
<td>Effects of 60 Hz EMF on Transcription in Yeast</td>
<td>$350,475</td>
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<tr>
<td>Craig V. Byus, PhD</td>
<td>Magnetic Field Effects on the Promotion of Cancer</td>
<td>$401,393</td>
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<tr>
<td>Om Gandhi, ScD, MSE</td>
<td>Safety of Time Varying Magnetic Fields in MR Imaging</td>
<td>$139,892</td>
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<tr>
<td>Charles Graham, PhD</td>
<td>EMF Effects on Melatonin, Hormones, and Immunity</td>
<td>$1,176,232</td>
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<tr>
<td>Sek W. Hui, PhD</td>
<td>Effects and Mechanism of EMF Signal Transduction</td>
<td>$656,495</td>
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<tr>
<td>Henry C. Lai, PhD</td>
<td>Effects of 60 Hz Magnetic Fields on the Cholinergic System</td>
<td>$665,054</td>
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<tr>
<td>Robert P. Liburdy, PhD</td>
<td>Magnetic Field Combinations and Lymphocyte Calcium Signalling</td>
<td>$1,029,036</td>
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<td>Theodore A. Litovitz, PhD</td>
<td>Studies of the Mechanism of EMF Induced Bioeffects</td>
<td>$636,288</td>
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<td>Richard Luben, PhD</td>
<td>Electromagnetic Effects on Membrane Reception Function</td>
<td>$959,171</td>
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<tr>
<td>Rosemonde Mandeville, PhD</td>
<td>In Vivo Effects of 60 Hz Magnetic Fields on Brain Tumor Promotion</td>
<td>$329,380</td>
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<tr>
<td>Andrew A. Marino, PhD</td>
<td>Effects of 60 Hz Magnetic Fields on Lymphoid Phenotype</td>
<td>$561,571</td>
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<tr>
<td>David L. McCormick, PhD</td>
<td>Mechanism of EMF Action in Human Breast Epithelial Cells</td>
<td>$1,035,251</td>
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</tbody>
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* Subject to modification
# APPENDIX A: EMF RAPID PROGRAM HEALTH EFFECTS RESEARCH GRANTS (continued)

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Title</th>
<th>Dollar Amount*</th>
<th>Duration (years)</th>
<th>End Date</th>
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<tr>
<td>Kenneth J. McLeod, PhD</td>
<td>Perturbation of Cell Processes by ELF Electric Fields</td>
<td>$330,235</td>
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<td>State University of New York at Stony Brook</td>
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<tr>
<td>Richard C. Miller, PhD</td>
<td>In Vitro Carcinogenesis by ELF Magnetic Fields</td>
<td>$714,307</td>
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<td>8/31/98</td>
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<td>Columbia University, New York</td>
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<tr>
<td>Steven C. Miller, PhD</td>
<td>EMF Induced Signal Transduction and Gene Expression</td>
<td>$808,929</td>
<td>4</td>
<td>8/31/98</td>
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<td>SRI International, Menlo Park, California</td>
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<tr>
<td>Richard L. Nuccitelli, PhD</td>
<td>Effects of 60 Hz EMF on Human Keratinocytes</td>
<td>$837,528</td>
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<td>8/31/98</td>
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<td>University of California at Davis</td>
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<tr>
<td>Russel J. Reiter, PhD</td>
<td>60 Hz Magnetic Field Effects on In Vivo Pineal Melatonin</td>
<td>$778,485</td>
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<td>8/31/98</td>
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<td>University of Texas Health Sciences Center, San Antonio</td>
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<td>Clifford Rinehart, PhD</td>
<td>Evaluation of Transforming Potential of EMF</td>
<td>$611,503</td>
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<td>8/31/97</td>
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<td>University of North Carolina at Chapel Hill</td>
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<td>Jeffrey D. Saffer, PhD</td>
<td>Cellular Effects of Weak Electromagnetic Fields</td>
<td>$1,045,199</td>
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<td>8/31/98</td>
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<td>Battelle Memorial Institute, Richland, WA</td>
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<td>Fatih M. Uckun, MD</td>
<td>Protein Tyrosine Kinases and Electromagnetic Fields</td>
<td>$447,133</td>
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<td>8/31/98</td>
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<td>University of Minnesota, Minneapolis</td>
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<tr>
<td>James C. Weaver, PhD</td>
<td>Bioelectromagnetic Mechanisms and Thresholds</td>
<td>$23,166</td>
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<td>Massachusetts Institute of Technology, Cambridge</td>
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<tr>
<td>Jerry R. Williams, ScD</td>
<td>Cellular Effects of Low Frequency Electromagnetic Fields</td>
<td>$1,355,037</td>
<td>4</td>
<td>8/31/98</td>
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<td>Johns Hopkins University, Baltimore</td>
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<tr>
<td>Gayle E. Wolochak, PhD</td>
<td>Changes in Gene Expression Accompanying Exposure to EMF</td>
<td>$415,084</td>
<td>3</td>
<td>8/31/97</td>
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<td>Argonne National Laboratory, Illinois</td>
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<td>Stanley M. Yellon, PhD</td>
<td>Effects of 60 Hz Magnetic Fields on Melatonin Rhythm in Adult Djungarian Hamsters</td>
<td>$156,745</td>
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<td>Loma Linda University, California</td>
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</table>

* Subject to modification
## APPENDIX B: EMF RAPID PROGRAM ENGINEERING PROJECTS

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>OBJECTIVE</th>
<th>CONTRACTOR/AGENCY</th>
<th>FUNDING</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMF Design Guidelines for School Buildings</td>
<td>To develop a booklet on EMF design guidelines for schools and grounds construction.</td>
<td>California State Polytechnic University</td>
<td>$25,000</td>
<td>Began 10/94 Final product due 1/96</td>
</tr>
<tr>
<td>Determination of Relationship Between Questionnaire Data and Appliance Exposures</td>
<td>To develop methods suitable for epidemiological research for assessing magnetic field exposures arising from the use of home electrical appliances and other residential sources.</td>
<td>EM Factors</td>
<td>$60,000</td>
<td>Began 10/94 Ends 12/95</td>
</tr>
<tr>
<td>Data Acquisition for Appliance Oriented EMF Exposure Assessment</td>
<td>To collect data used to develop methods suitable for epidemiological research for assessing magnetic field exposures arising from the use of home electrical appliances and other residential sources.</td>
<td>University of Bristol</td>
<td>$60,000</td>
<td>Began 8/94 Ends 12/95</td>
</tr>
<tr>
<td>Health Risk Dimensions of the EMF Problem</td>
<td>To examine (1) the role that EMF plays in the policy process, (2) prospects for significantly reducing uncertainty about health risks, and (3) the characteristics of EMF risk vs. other hazards.</td>
<td>Resources for the Future</td>
<td>$50,000</td>
<td>Began 12/94 Ends 12/95</td>
</tr>
<tr>
<td>Evaluation of EMF Conditions in Minority Communities</td>
<td>To develop a plan to measure EMF intensity as a function of location and time of day within minority communities.</td>
<td>University of South Florida</td>
<td>$30,000</td>
<td>Began 9/94 Completed 12/95 Final report received</td>
</tr>
<tr>
<td>Characterization of Exposures to EMF in the Office Environment</td>
<td>To characterize exposures to EMF in the office environment.</td>
<td>University of Washington</td>
<td>$20,000</td>
<td>Completed 9/95 Final report received</td>
</tr>
<tr>
<td>Development of Recommendations for Guidelines for Field Source Measurement</td>
<td>To develop recommendations for establishing a set of guidelines for measuring and reporting a number of field characteristics for a wide range of sources.</td>
<td>Electric Research &amp; Management, Inc.</td>
<td>$120,000</td>
<td>Began 3/95 Ends 12/95</td>
</tr>
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</table>
## APPENDIX B: EMF RAPID PROGRAM ENGINEERING PROJECTS (Continued)

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>OBJECTIVE</th>
<th>CONTRACTOR/AGENCY</th>
<th>FUNDING</th>
<th>STATUS</th>
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<tbody>
<tr>
<td>Development of Recommendations for Guidelines for Environment-Specific Field Measurement</td>
<td>To develop recommendations for establishing a set of guidelines for measuring field exposure in various environments.</td>
<td>Magnetic Measurements</td>
<td>$125,000</td>
<td>Began 3/95 Ends 12/95</td>
</tr>
<tr>
<td>Environmental Field Surveys</td>
<td>To conduct preliminary surveys in identified environments and to provide information on contributions of field sources in the surveyed environments.</td>
<td>Enertech Consultants</td>
<td>$230,000</td>
<td>Began 3/95 Ends 3/96</td>
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<tr>
<td>Development of Recommendations for Guidelines for Personal Exposure Measurement</td>
<td>To develop recommendations for establishing a set of guidelines for personal exposure measurement.</td>
<td>T. Dan Bracken, Inc.</td>
<td>$110,000</td>
<td>Began 3/95 Ends 8/96</td>
</tr>
<tr>
<td>Development of an EMF Measurement Database</td>
<td>To develop a database that contains original EMF exposure assessment and measurement data.</td>
<td>T. Dan Bracken, Inc.</td>
<td>$100,000</td>
<td>Began 3/95 Ends 8/96</td>
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<tr>
<td>Household Source Characterization</td>
<td>To develop complete information on specific sources and source groups in the home.</td>
<td>Pacific Northwest Laboratory</td>
<td>$100,000</td>
<td>Began 5/95 Ends 5/96</td>
</tr>
<tr>
<td>Exposure Assessment of Workers from Sobel-Finnish Alzheimer Study</td>
<td>To conduct an exposure assessment of workers from the Sobel-Finnish Alzheimer Study.</td>
<td>Pacific Northwest Laboratory</td>
<td>$100,000</td>
<td>Began 5/95 Work completed Analysis underway End 5/96</td>
</tr>
<tr>
<td>Conduct Environmental Field Surveys in Industrial Settings</td>
<td>To conduct a series of preliminary surveys in 10 industries in order to collect information on field levels and the contributions of individual sources to the total field level.</td>
<td>NIOSH</td>
<td>$150,000 Total</td>
<td>Began 11/94 Ends 10/96</td>
</tr>
<tr>
<td>Exposure Assessment of Common Transportation Means</td>
<td>To conduct exposure assessment of common transportation means, excluding electric rail. (Multi-year effort.)</td>
<td>DOT</td>
<td>$100,000 per year for 3 years</td>
<td>Began 9/95 Ends 9/98</td>
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<tr>
<td>Human Exposure Assessment of Transit Workers</td>
<td>To obtain detailed information about personal exposures of transit workers. (Multi-year effort.)</td>
<td>NIOSH</td>
<td>$120,000 per year for 2 years</td>
<td>Began 9/95 Ends 9/98</td>
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<tr>
<td>Transmission Line Exposure Assessment Study</td>
<td>To develop numerical models for exposure resulting from residential proximity to transmission lines.</td>
<td>ORNL</td>
<td>$10,000</td>
<td>Developing project plan</td>
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</table>
### APPENDIX B: EMF RAPID PROGRAM ENGINEERING PROJECTS (Continued)

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>OBJECTIVE</th>
<th>CONTRACTOR/AGENCY</th>
<th>FUNDING</th>
<th>STATUS</th>
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<tbody>
<tr>
<td>X-ray/EMF Line Workers Study</td>
<td>To analyze line worker exposure to EMF and possible x-rays from corona discharge.</td>
<td>ORNL</td>
<td>$50,000</td>
<td>Developing project plan</td>
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<tr>
<td>Transmission Line Exposure Assessment Study</td>
<td>To determine how many people live close to transmission lines. (Supplemental funding of ongoing ESEERCO project to provide open literature reporting of results.)</td>
<td>ESEERCO</td>
<td>$25,000</td>
<td>Proposal being processed</td>
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<tr>
<td>Transient Measurements</td>
<td>To measure transient EMF and to characterize the relationship between transients and wire-codes.</td>
<td>ORNL</td>
<td>TBD</td>
<td>Being reevaluated due to instrumentation delays</td>
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<tr>
<td>Survey of Personal Magnetic Field Exposure</td>
<td>Phase I: To conduct a pilot study to obtain detailed information about personal exposures from a randomly selected large population. (Multi-year effort.)</td>
<td>TBD competitive contract</td>
<td>$300,000 (estimated)</td>
<td>RFP issued August 11, 1995; Proposals received October 12, 1995, being peer reviewed</td>
</tr>
<tr>
<td>Development of Field Exposure Models</td>
<td>To develop methods for predicting human EMF exposure levels based on source measurement data and human activity patterns.</td>
<td>TBD competitive contract</td>
<td>$100,000 (estimated)</td>
<td>RFP issued August 11, 1995; Proposals received October 12, 1995, being peer reviewed</td>
</tr>
<tr>
<td>Evaluation of Field Reduction Technologies</td>
<td>To analyze the effectiveness, safety, reliability, environmental impacts, and associated costs of various field reduction options.</td>
<td>TBD competitive contract</td>
<td>$150,000 (estimated)</td>
<td>RFP issued August 11, 1995; Proposals received October 12, 1995, being peer reviewed</td>
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<tr>
<td>Industrial Source Characterization</td>
<td>To develop complete information on specific sources and source groups in industrial settings.</td>
<td>TBD</td>
<td>TBD</td>
<td>Procurement action expected early 1996</td>
</tr>
<tr>
<td>Conduct Environmental Field Surveys in Commercial Settings</td>
<td>To conduct a series of preliminary surveys in commercial settings in order to collect information on field levels and the contributions of individual sources to the total field level.</td>
<td>TBD</td>
<td>TBD</td>
<td>Procurement action expected early 1996</td>
</tr>
<tr>
<td>EMF Measurement Database</td>
<td>To maintain the EMF measurement database. (Multi-year effort.)</td>
<td>T. Dan Bracken, Inc.</td>
<td>TBD</td>
<td>Procurement action expected early 1996</td>
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</tbody>
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### APPENDIX C: EMF RAPID PROGRAM COMMUNICATION PROJECTS

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>OBJECTIVE</th>
<th>FUNDING</th>
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</thead>
<tbody>
<tr>
<td>Q&amp;A Booklet</td>
<td>Provide information about EMF research to nontechnical audience.</td>
<td>$50 K (develop)</td>
<td>Project completed 2/95. 100,000 copies published. Comments now being collected for 1997 revision.</td>
</tr>
<tr>
<td>Q&amp;A/Spanish</td>
<td>Translate for Spanish-speaking U.S. residents.</td>
<td>$16 K (develop)</td>
<td>Project completed 4/95. 10,000 copies published. Comments now being collected.</td>
</tr>
<tr>
<td>Workplace EMF Information</td>
<td>Target useful information to industrial and office workers. Joint project with NIOSH.</td>
<td>$50 K (develop)</td>
<td>Currently being reviewed.</td>
</tr>
<tr>
<td>Sourcebook</td>
<td>Provide guide to further information sources for EMF resource people (hardcopy and on Internet).</td>
<td>$50 K (develop)</td>
<td>Project begun 8/95.</td>
</tr>
<tr>
<td>EMF InfoLine (1-800-363-2383)</td>
<td>Quick response to public inquiries about EMF. Joint project with EPA.</td>
<td>$50 K per year</td>
<td>EPA InfoLine started 5/94.</td>
</tr>
<tr>
<td>Scholarship for EMF Research Review attendance</td>
<td>Allow representatives (2) from citizen groups concerned about EMF to attend annual research review and present poster.</td>
<td>$6K for two scholarships to cover travel costs.</td>
<td>2 winners selected 8/95. Press announcement 9/95.</td>
</tr>
<tr>
<td>Information for Policymakers</td>
<td>To give policymakers the best EMF information available now and keep it current as new research findings emerge.</td>
<td>$25K to EPA for workshop; $50K information development</td>
<td>5/95 Workshop with EPA held. Material development begun 9/95.</td>
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APPENDIX D: THE NATIONAL ELECTRIC AND MAGNETIC FIELDS ADVISORY COMMITTEE (NEMFAC)

The current members of the National EMF Advisory Committee and their affiliations are listed below:

Shirley Linde (Committee Chair) - Citizens for Safer EMF, Los Angeles, California

J. Peter Bingham, Ph.D. - President; Philips Laboratories, Briarcliff Manor, New York

Joe Garcia - Commissioner; Florida Public Service Commission, Tallahassee, Florida

Kate Maracas - Manager, Environmental Affairs; the Salt River Project, Phoenix, Arizona

James Melius, M.D., Dr.P.H. - Director, Scientific and Medical Division; The Center to Protect Workers' Rights, Washington, DC

Thomas Rozzell, Sc.D. - Director, Fellowship Programs; National Academy of Sciences, National Research Council, Washington, DC

Robert Schell, P.E. - Manager, Radiation Control Program; Maine Department of Human Services, Augusta, Maine

Margaret Seminario - Director, Occupational Safety and Health; AFL/CIO, Washington, DC

Louis Slesin, Ph.D. - Publisher; Microwave News, New York, New York

Paul Zweiacker, Ph.D. - Manager, Environmental Planning; Texas Utility Services, Dallas, Texas
APPENDIX E: THE NATIONAL ACADEMY OF SCIENCES
COMMITTEE TO REVIEW THE RESEARCH ACTIVITIES COMPLETED
UNDER THE ENERGY POLICY ACT OF 1992

Section 2118(g) of EPAct requires that a committee of the National Academy of Sciences review and evaluate all research completed under this program. The provisions of Section 2118 state that the National Academy of Sciences "shall periodically submit to the Interagency Committee and the Advisory Committee a report that evaluates research activities under the program. The report shall include recommendations to promote the effective transfer of information derived from such research projects, including the transfer to representatives of State regulatory agencies, State health agencies, electric utilities, electrical equipment manufacturers, labor unions, and the public."

The Committee consists of these noted scientists and engineers:

Charles Bean, Ph.D. (Committee Chair) - Rensselaer Polytechnic Institute; Biophysics
Fred Dietrich - Electric Research and Management, Inc.; Engineering
Maurice Fox, Ph.D. - Massachusetts Institute of Technology; Molecular Biology
Peter Marler, Ph.D. - University of California, Davis; Animal Behavior
Walter Rogers, Ph.D. - Southwest Research Institute; Endocrinology
Jan Stolwijk, Ph.D. - Yale University; Epidemiology
Jerry Williams, Ph.D. - Johns Hopkins University; Oncology

The committee held its initial meeting on March 13, 1995 and a second meeting on May 29, 1995. The NAS Committee submitted an interim report to the Interagency Committee in September 1995. In this report, entitled EMF Research Activities Completed Under the Energy Policy Act of 1992, the committee made the following remarks and recommendations regarding the research strategy, the implementation plans and completed activities of the RAPID Program:

- A great deal of care has gone into the development of the research strategy for the EMF RAPID Program.
- No glaring omissions in the program can be identified.
- Research strategies seem consistent with the goals of the program.
- The grant process used by NIEHS was not designed to promote focused research. It is recommended that a special study section, which includes individuals with a broad and specific knowledge of EMF, be used to evaluate new proposals.
- Attempts to replicate previous experiments should follow the original protocol with obsessive precision.
- In vivo efforts are focused on an extremely limited scope of exposure characteristics. Negative findings could be inconclusive.
- The existing projects for engineering quality control are clearly appropriate.
- It is difficult to understand the urgency of extensive statistical sampling projects.
to fill databases that will be needed only if adverse health effects are confirmed.

- Objectives for future field management projects are appropriate and attainable.

- A major weakness is the lack of a defined methodology for the risk assessment task. The committee strongly recommends development of a process to incorporate data into a formal risk analysis.

- The information booklet Questions and Answers About Electric and Magnetic Fields Associated with the Use of Electric Power is a commendable effort of exceptional value for providing information to the lay public.

- Congress should consider extending the program for 2 years to 1999, to allow completion of the planned research.
APPENDIX F: PROGRAM RESOURCES

The EMF Research and Public Information Dissemination Program is a cost-shared program in which DOE is required to solicit non-Federal contributions to at least match the Federal annual appropriation. Electric utilities, through the Edison Electric Institute, the American Public Power Association, and the National Rural Electric Cooperative Association have pledged to contribute two-thirds of the required non-Federal contributions, totalling $21.6 million, if full funding of $32.5 million is appropriated by Congress. The member companies of the National Electrical Manufacturers Association have pledged to contribute an additional $2 million to a fully-funded program. The contributions of these associations have been calculated based on the assumption that EMF RAPID would be a fully-funded, five-year program. Current efforts to encourage additional contribution commitments include distribution of a Sponsorship Prospectus and presentations of the program by NIEHS and DOE officials to potential sponsors, such as associations of realtors, appliance and equipment manufacturers, and builders. DOE provides public notice of its annual solicitation of non-Federal contributions through the Federal Register. Information on annual appropriations and non-Federal contributions is contained in Figure F-1 and Table F-1.

The Energy Policy Act of 1992 authorized the RAPID Program for fiscal years 1993 through 1997. It should be noted that the Energy and Water Development Appropriations Bill for fiscal year 1993 was enacted into law prior to passage of the Energy Policy Act of 1992. Consequently, the first year of available appropriations was fiscal year 1994. Therefore, in order for RAPID to be a five-year program, authorization would have to be extended to fiscal year 1998.
Progress Report on the EMF RAPID Program

Table F-1: Contributors to the EMF RAPID Program in FY 95

<table>
<thead>
<tr>
<th>Contributors</th>
<th>FY 94 ($ Thousands)</th>
<th>FY 95 ($ Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Utilities*</td>
<td>3,700</td>
<td>5,528</td>
</tr>
<tr>
<td>National Electrical Manufacturers Association</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3,950</td>
<td>6,028</td>
</tr>
</tbody>
</table>

* Contributions from electric utilities have been collected and forwarded through these organizations:

- American Public Power Association
- Edison Electric Institute
- Electric Power Research Institute
- Empire State Electric Energy Research Corporation
- National Rural Electric Cooperative Association

*Fiscal year 1996 projections*
APPENDIX G: RELATED EMF PROGRAMS

The RAPID Program has actively pursued partnerships, joint projects, and cooperative efforts to leverage Federal EMF funds and the unique resources of various Federal agencies engaged in EMF health effects research as well as engineering and communication activities. Most health effects research concerning EMF exposures is the product of programs managed by Federal agencies or by the utilities and their research organizations. At a meeting held on December 7, 1994, the EMF Interagency Working Group was officially constituted in accordance with the Recommendations for Guidelines for Federal Coordination that were developed by the EMF Interagency Committee. The Working Group was originally organized as a committee of Federal EMF experts and had held periodic meetings for several years prior to the passage of the Energy Policy Act of 1992. The purpose of the Working Group is to facilitate coordination and collaboration in EMF research and communication planning and implementation.

As an expanded and accelerated EMF research effort, the RAPID Program's health effects research is coordinated on Federal, national, and international levels. As previously stated, the EMF Interagency Working Group facilitates the coordination of Federal EMF research. In addition, there is close coordination with the Electric Power Research Institute (EPRI) and other sponsors of EMF health effects research in the United States. On an international level, EMF health effects research is facilitated by the International EMF Research Coordinators Group. Forums such as the Annual EMF Contractors' Review and the annual meeting of the Bioelectromagnetics Society provide an opportunity to share and discuss research results and research plans.

Other government agencies, at both Federal and local levels, and the private sector have significantly contributed to EMF field management and exposure research. To expand on these efforts, the RAPID Program works with these organizations on coordinated planning, the sharing of results, and the establishment of databases to improve the use of these results. As a result of this ongoing coordination, the RAPID Program's engineering component concentrates on field sources, environments, and exposures that have not been assessed by other programs. The coordination of EMF engineering and exposure research with other Federal government agencies, such as the Department of Transportation and NIOSH, has been implemented through the EMF Interagency Committee, the EMF Interagency Working Group, and interagency agreements. Cooperation has also been established between DOE (RAPID Program) and EPRI on field management and exposure research, including exposure assessment, data and integration, and field management surveys.

The Interagency Working Group is compiling a Federal EMF Resource Directory that will describe EMF activities at different Federal agencies and has also requested that all Federally-sponsored EMF scientists periodically update standardized project summary forms for inclusion in an electronic database. The database is designed to provide scientists with up-to-date information about Federally-sponsored EMF research projects. The risk assessment sponsored by the EMF RAPID Program will use and integrate all available data from the various programs to ascertain whether a health hazard from EMF exists. As shown in Figure G-1, these research efforts are being coordinated to provide needed input to the Risk Assessment component of the RAPID Program.

Department of Energy

DOE has been the leading Federal supporter of research on the biological effects of exposure to low frequency electric and magnetic fields for over 15 years. The DOE Biological Mechanisms Research Program's
The EMF RAPID Program will use inputs from other EMF research programs to reduce uncertainty about the health effects of EMF exposure.

primary goal is to identify and describe the underlying mechanisms through which EMF exposures affect biological systems.

This program works in a complementary and supportive role with the five-year EMF RAPID Program. The established base of expertise in the DOE program and quick-response nature of its directed research program complements the RAPID Program's investigator-initiated grant research. Joint activities between these two programs include multi-laboratory replication studies, workshops, information exchange, and technical conferences. The DOE program has provided state-of-the-art EMF exposure systems at the Food and Drug Administration, the National Institute of Occupational Safety and Health, Oak Ridge National Laboratory, and Pacific Northwest Laboratory to assist research efforts. DOE is also providing quality assurance support such as exposure system design and verification for new investigators in the EMF RAPID Program. Funding for DOE's EMF Biological Mechanisms Research Program generally averaged about $3 million annually from FY 78 through FY 92. Annual funding for the program has been approximately $6 million since FY 93.

EMF research has also been conducted by the Bonneville Power Administration (BPA). This research has included EMF effects on livestock; engineering studies to assess EMF exposures received by high-voltage line workers; and studies to characterize EMF produced by BPA lines.

National Institute of Environmental Health Sciences

NIEHS, within the National Institutes of Health, conducts basic research on
environmental factors that may contribute to human health problems and disease. The first announcement of the availability of funds for extramural EMF research from NIEHS was released in December 1991, nearly one year prior to the enactment of EPAct.

In March 1993, NIEHS, acting as the lead agency for the Federal National Toxicology Program (NTP) began a comprehensive, lifetime toxicological assessment of the effects of EMF exposure in a standard animal model. The study design was developed over a period of three years in consultation with experts from government, industry, and academia. It is aimed at all potential adverse health effects of EMF exposure levels such as those experienced by the American public. This toxicological study is being conducted under contract with NIEHS and under the supervision of NIEHS scientists. It is funded entirely by NIEHS at a cost of approximately $5 million. The NIEHS/NTP toxicology study will end in 1997, but research results will be available earlier. Approximately $6.2 million in NIEHS appropriations was committed to EMF research in FY 1994 under the National Toxicology Program.

Department of Defense

The Department of Defense (DOD) research covers the entire electromagnetic spectrum, including extremely low frequencies (ELF). Interservice coordination is provided by the Tri-Service Electromagnetic Radiation (EMR) Panel, with representation from all the services and the Surgeon General's office. The panel is studying whether DOD should adopt any working exposure guidelines. The three services' EMR research programs are all now co-located at Brooks Air Force Base in Texas. Most of the program's research has been on radiofrequency radiation, which has crossovers to the ELF area. DOD has conducted biological effects research, prepared dosimetry handbooks, designed exposure systems, and studied the possible ecological impacts of fields from Navy communications systems. DOD's ELF research was largely initiated to address concerns raised in siting a low frequency communication transmitter station.

Department of Transportation

The U.S. Department of Transportation (DOT) has the authority to identify and assess potential safety hazards associated with transportation systems and to develop appropriate safety requirements and regulations. The Federal Railroad Administration's Office of Research and Development (ORD) has assessed potential safety hazards associated with magnetically levitated trains and high-speed electric rail systems. ORD maintains an EMF research program that has a goal of defining the electric and magnetic fields associated with conventional, advanced, and prototype rail systems; identifying and assessing their potential health and safety effects; and determining potential EMF control, mitigation, and regulatory options. From FY 1990 to FY 1993, DOT published 11 major reports on EMF, primarily on its comprehensive measurement and analysis program. EMF issues have been included in the recently completed environmental impact statement for the electrification of the Northeast corridor (Boston to New Haven) to respond to public and workers' concerns about EMF health effects.

Environmental Protection Agency

The EPA Office of Radiation and Indoor Air (ORIA) Electromagnetic Field Program has established several projects to support its overall EMF program goals. ORIA and the EMF RAPID Program operate the EMF InfoLine (1-800-EMF-2383) as a joint project. EMF InfoLine was established as a national hotline to answer EMF questions from the general public and to help document issues of public concern. Additionally, ORIA, the Department of Energy, and the American Public Health Association co-sponsored a workshop to identify the key issues and concerns that state and local policymakers have in making decisions in matters in which
EMF is a consideration. The workshop brought together policymakers, utility representatives, Federal officials, and representatives of public interest groups to provide discussion of the full range of concerns surrounding EMF issues at the state and local level. ORIA has also compiled a database containing state and local EMF regulations and policies. The database will provide decision makers with a valuable resource for comparing existing policies and regulations. In addition, ORIA, through its National Air and Radiation Environmental Laboratory (NAREL) has the capability to conduct EMF measurements in the laboratory and in the field.

**Food and Drug Administration**

The Food and Drug Administration (FDA), within the Department of Health and Human Services, has authority under the Radiation Control for Health and Safety Act of 1968 (now incorporated into the Food, Drug, and Cosmetic Act) to regulate electronic products or medical devices that emit electromagnetic fields and to conduct research and development to minimize the emissions of and the exposure of people to unnecessary electronic product radiation. Electrical products of concern include electric blankets, dryers, electric razors, clocks, and any product with motors or transformers that produces fields to which people are exposed. FDA research focuses on replication studies. They are also conducting modeling studies of induced fields in humans, collecting bioeffects data, conducting cell-level laboratory research, and initiating pilot animal studies. FDA is one of the four sites that houses a regional exposure chamber designed and built by DOE. FDA staff have been active participants in topical workshops, with a special interest in gene expression research.

**National Institute for Occupational Safety and Health**

The National Institute for Occupational Safety and Health (NIOSH), under the Centers for Disease Control, within the Department of Health and Human Services, is a research organization with the mission to investigate workplace conditions, evaluate suspected workplace hazards, develop prevention strategies and control technology, and conduct research. Several years ago, NIOSH convened an EMF workshop to develop a research strategy to address workplace exposures and potential health hazards. NIOSH also has developed a methodology manual for EMF exposure assessment, funded several EMF epidemiology studies, measured and evaluated workplaces for EMF exposure, and funded laboratory studies. NIOSH is another agency that serves as the host site for an EMF regional exposure chamber. NIOSH research at this facility will concentrate on cellular studies.

**National Institute of Standards and Technology**

With support provided by the Department of Energy, the National Institute of Standards and Technology (NIST) has developed a program to share its expertise in field measurement with researchers interested in characterizing extremely low frequency EMF. The NIST program includes, among other things, the standardization of EMF measurement techniques and the characterization of measurement equipment. NIST also plays an important role in providing quality assurance for biological and health effects research carried out under the EMF RAPID and DOE EMF Biological Mechanisms Research Programs. NIST conducts site visits to laboratories during which fields in biological exposure systems are thoroughly characterized. This is done to minimize the chances that experimental results will be compromised by inadequate control of exposure fields, as well as by stray fields associated with nearby electrical equipment.

In collaboration with working groups in professional societies, such as the Institute of Electrical and Electronics Engineers (IEEE) and the International Electrotechnical Commission (IEC), NIST has prepared drafts of both national and international
measurement standards for extremely low frequency EMF. NIST has also produced primers for EMF investigators planning to conduct in vivo and in vitro experiments.

Electric Utility Programs

The U.S. utility industry has been a major sponsor of EMF research, and the results from this work have made major contributions to our present understanding of EMF effects and exposures.

The Electric Power Research Institute is the research arm of the U.S. electric utility industry. EPRI has been the largest sponsor of EMF research in the U.S. Their work spans all scientific disciplines, including epidemiology, in vivo and in vitro biology, exposure assessment, mitigation, policy, and communications. In recent years, their EMF research budget has averaged between $10 and $13 million annually.

EPRI has established a Magnetic Field Technical Information Center in Lenox, Massachusetts, that also serves as a measurement laboratory with simulated exposure environments. EPRI's EMF communication activities include the publication of an annual report, research brochures, resource papers, *EPRI Journal* articles, and the Magnetic Field Technical Information Center. EPRI, on behalf of its member utilities, collects and forwards their contributions to the RAPID Program.

The Empire State Electric Energy Research Corporation (ESEERCO) is a research organization for New York State utilities. ESEERCO monitors, evaluates, and supports EMF health research and also has a program on exposure, field assessment, and management. For the latter, the chief aim is to investigate means of reducing 60-hertz magnetic fields from utilities and customer-owned facilities. ESEERCO and EPRI jointly sponsor research. ESEERCO, on behalf of its member utilities, is also contributing to the RAPID Program.

State and International Programs

Many states, particularly California and New York, have active EMF research and public education and information programs. Others such as Maryland, Texas, Connecticut, and Virginia have sponsored reviews of the available information on EMF research and policy developments. The Conference of Radiation Control Program Directors (CRCPD) is an organization of state government officials concerned with radiation matters, including electric and magnetic fields. CRCPD has a committee that is specially charged with keeping CRCPD members abreast of EMF issues.

International EMF research spans the full spectrum from epidemiology and laboratory studies to exposure assessment and EMF mitigation projects. Many foreign governments have sponsored EMF research for a number of years. Sweden and Canada, in particular, have a long history of extensive EMF research efforts with epidemiology and exposure assessment being the focus of Swedish research. Research in Sweden is mainly supported by the Swedish State Power Board and state utilities.

The focus of the Canadian efforts is on occupational safety. Major sponsors are Ontario Hydro, Hydro Québec, British Columbia Hydro (electric utilities), and Health & Welfare Canada (government agency). Some national coordination is accomplished through the Canadian Electric Association. In addition, the major utilities have joint or cooperative programs within and outside of Canada.

Other countries actively engaged in EMF research include Australia, Austria, Denmark, France, Germany, Italy, Japan, Russia, and the United Kingdom. In 1989, an International EMF Research Coordinators Group was officially organized. Over 20 international organizations belong to the group and provide support for its activities of information gathering and dissemination to members.
APPENDIX H:

EMF RAPID PROGRAM
RESEARCH AGENDA AND
COMMUNICATION PLAN*

* Published separately by the U.S. Department of Energy as DOE/EE-0021.

December 1995
Research Agenda and Communication Plan

May 1994

EMF
RAPID
PROGRAM

Electric and Magnetic Fields (EMF)
Research and Public Information Dissemination (RAPID)

EMF RAPID Program Interagency Committee
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EMF RAPID PROGRAM
RESEARCH AGENDA AND
COMMUNICATION PLAN

Introduction

The driving force behind the Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program, established by Section 2118 of the Energy Policy Act of 1992, is the "sense of the Congress that remedial action taken by the Government on electric and magnetic fields, if and as necessary, should be based on, and consistent with, scientifically valid research . . .".

Specifically, the legislation requires the development of a comprehensive program to:

- determine whether or not exposure to electric and magnetic fields produced by the generation, transmission, and use of electric energy affects human health;
- carry out research, development, and demonstration with respect to technologies to mitigate any adverse human health effects; and
- provide for the collection, compilation, publication, and dissemination of scientifically valid information to the public on the following subjects:
  a) possible human health effects of electric and magnetic fields;
  b) the types and extent of human exposure to electric and magnetic fields in various occupational and residential settings;
  c) technologies to measure and characterize electric and magnetic fields; and
  d) methods to assess and manage exposure to electric and magnetic fields.

Program Organization

The Department of Energy (DOE) is responsible for the overall administration of the 5-year, $65 million EMF RAPID Program. The program will be jointly funded by both Federal and non-Federal sources with non-Federal contributions accounting for at least 50% of the total funding. A nine-member Interagency Committee is responsible for developing a research agenda, making recommendations for coordinating Federal research activities, making recommendations for the communication of research results to the public, and monitoring and evaluating the overall program. The Committee is composed of representatives from
DOE, the National Institute of Environmental Health Sciences (NIEHS), the Environmental Protection Agency (EPA), the Department of Defense (DOD), the Occupational Safety and Health Administration (OSHA), the National Institute of Standards and Technology (NIST), the Department of Transportation (DOT), the Rural Electrification Administration (REA), and the Federal Energy Regulatory Commission (FERC). The Interagency Committee, established by the President of the United States, must also prepare two reports to Congress: an interim report in 1995 and a final report in 1997.

An Advisory Committee, whose members are drawn from representative constituencies including public interest groups, organized labor, state governments, academia, and industry, advises DOE and NIEHS on the design and implementation of the program. The Advisory Committee also provides recommendations to the Interagency Committee to assist them in performing their duties.

In accordance with its responsibility to develop the EMF RAPID Research Agenda and Communication Plan, the Interagency Committee produced this document to provide the strategic direction for the RAPID Program. It is the expectation of the Interagency Committee that both DOE and NIEHS will develop detailed plans for implementing each component of the RAPID Program in a manner that is consistent with the strategic direction provided by this document.

**Program Focus**

The RAPID Program has the central goal of determining if electric and magnetic fields associated with the generation, transmission, and use of electrical energy pose a risk to human health. The fact that twenty years of research have not answered that question is clear evidence that health effects of EMF are not obvious and that risk relationships, if risk is identified, are not simple. Because epidemiologic studies have raised concerns regarding the connection between certain serious human health effects and exposure to electromagnetic fields, the program adopts the hypothesis that exposure to electric or magnetic fields under some conditions may lead to unacceptable risk to human health. The focus of the program is not only to test, as far as possible within the statutory time limits, that hypothesis for those serious health effects already identified, but to identify as far as possible the special conditions that lead to elevated risk and to recommend measures to manage risk. The RAPID Program complements other Federal and non-Federal EMF research, and the results of these other programs will be considered in light of the new data obtained from the RAPID Program.

An important feature of the RAPID Program that distinguishes it from previous programs is its focus on a risk assessment framework for decision making. This includes the specific task of developing a detailed risk assessment model for potential human health effects of fields as well as adopting an overall risk assessment approach for all activities funded. The risk assessment approach during the early phases of the program will be useful in reviewing the evidence of existing research to determine gaps and areas where resources should be
focused. In the later phases of the program, risk assessment research will form the basis for
decision-makers’ interpretation of the health effects research and suggest directions for
assessing the nature and extent of any risk. We further expect risk assessment research to
assist program managers with systematic identification of key issues related to potential
health effects. Consequently, it will be an invaluable tool in directing the communication
cOMPONENT of the program.

The risk assessment framework is an important cornerstone of the entire RAPID research
program. The framework provides a context for making funding decisions and should not
be confused with the formal, risk assessment model, which will be independently developed
for the program. Since research funded under the RAPID Program must be oriented
toward testing the overall hypothesis, some methodology must be employed to ensure that
all research incrementally addresses the hypothesis in the context of the specific human
endpoints selected. Thus, the hazard identification process must be employed to determine
what additional information is needed to test the hypothesis. This approach will ensure that
all research is policy focused. Specific steps for implementing the risk assessment framework
will be developed by NIEHS.

Essential to the RAPID Program strategy is a continual application of the risk assessment
approach. Evaluation of research conducted through the program, and independent of the
program, will be ongoing and will be used to refine program activities by redirecting,
expanding or concentrating the areas of research. Such refinements should result in
narrowing the focus to those health effects and areas of research that will maximize the
chance of being able to answer the statutory questions within the program time frame.
**Program Components**

The RAPID Program has four major components: (1) health effects research with an emphasis on establishing quantitative relationships for field effects on living systems; (2) research on technologies to characterize and mitigate the effects of power frequency fields; (3) assessment of the risk, if any, to human health posed by 60 hertz electric and magnetic fields; and (4) dissemination of information on possible human health effects of electric and magnetic fields, the type and extent of exposures encountered, technologies to measure fields, and methods to manage exposure. NIEHS is responsible for the first and third components, DOE is responsible for the second component, and both agencies share responsibility for the fourth. Figure 1 shows the expected division of program funds for the first year. Because the program embodies a dynamic strategy with continuing evaluation that may result in redirection, detailed allocation of resources cannot be fixed in advance.

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**Figure 1. Anticipated Division of Total Funds for the First Year**

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2subject to modification
Program Review and Evaluation

A distinguishing characteristic of this program is the policy focus of the research and establishment of formal program review and evaluation criteria necessary to develop realistic measures of success. The policy focus embodies two fundamental principles: targeting and priority setting. The first criterion is achieved through the a priori selection of a few important human endpoints as part of the research focus, thereby building a knowledge base to use in answering the overall question of whether or not there are health effects. The second essential criterion responds to the overall time-limited nature of this program. Therefore, all funded research must be able to contribute to the final report (December 1997). This requires that the research have reportable findings pertaining to the selected human endpoints prior to the final report.

A major responsibility of the Interagency Committee will be to conduct an annual evaluation of the RAPID Program, based upon the risk assessment approach outlined in the program plan and upon performance indicators, paying particular attention to health effects research funding and consistency with overall goals.
Health Effects Research

The key questions for health effects research are:

- Are there robust bioeffects?  
- What are the relevant biological measures of an effect?  
- What are the relevant dose measures?  
- Are the observed bioeffects related to human health effects?

NIEHS will implement a multi-disciplinary program of applied and basic biomedical research complemented by appropriate expertise in engineering and the physical sciences to address these questions. Due to the RAPID Program’s financial and time constraints, initial research will be directed toward health effects already identified in human studies that are the focus of the public concern. Research efforts will therefore be focused on childhood leukemia, brain cancer, breast cancer, and certain adverse neurological and reproductive effects. Outcomes of health effects research experimentation cannot be predicted, so no research plan can be written to forecast the direction of research beyond its initial phase. Therefore, the principles established in the Program Focus to redirect, expand or concentrate the areas of research and research priorities must be employed to continually refine the funded research.

Health Effects Plan

This plan is organized according to scientific disciplines that are generally included among the environmental health sciences. All of the initial health effects research proposals will compete for funding through the peer review mechanisms established by the National Institutes of Health. Beyond the peer review for "good science," proposed research projects will be ranked in priority according to how well the application of the risk analysis indicates they will fill gaps in hazard identification within the program time frame and will contribute to the program final report. Finally, all health effects research to be conducted or supported under this program must include, wherever appropriate, the substantive participation of scientists with relevant expertise in engineering and physics.

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3 As used here, the term *robust bioeffects* refers to any change in living tissue or in animals, related to exposure to electric and/or magnetic fields, that can be replicated in other laboratories.

4 In most cases it is not feasible to conduct experiments with human beings to determine directly a relationship between electric or magnetic fields and human health. Rather, the relationship, if any, will be established by showing that the bioeffect can be made to occur under laboratory conditions that can be extrapolated to human beings exposed to fields of the type and strength that might explain the epidemiologic findings.
Funding Approach

Health effects research will be funded through research grants to non-Federal scientists, research and development contracts, and support to Federal scientists for studies conducted in government laboratories and clinical research facilities. In the first year, 70 to 80 percent of RAPID funds for health effects research (65 percent of the total budget) will support research grants. Because grants are customarily for multi-year research, in succeeding years other funding mechanisms may also be employed that can better target funding to address specific research needs or recognize the time-limited nature of the program. Grant funding is likely to remain a large proportion of total program expenditures. Scientists participating in the RAPID Program will be required to share their findings in a timely manner. Evaluation of grant research progress and expected findings, using the risk assessment framework, will determine the composition of the research program in later years.

Mechanisms Research (Cellular)

One of the problems associated with interpreting epidemiological studies that suggest an association between EMF and human health effects is the inability to identify a plausible biological mechanism that explains adverse effects on human health. Since risk assessment models ultimately depend upon a clear definition of dose, this research is critical to the ultimate assessment of risk from EMF exposure. Scientists have experimental evidence that EMF may interact with biological systems, but replication and interpretation of these phenomena are problematic. High priority will be given to basic biological research proposals that offer experimental approaches to understanding the direct or indirect mechanisms by which EMF may cause human disease or dysfunction.

Likely candidates include studies aimed at identifying whether or how EMF directly affects or modulates cell growth by affecting cell replication or cell proliferation and studies of the interactions between EMF and the genes involved in apoptosis. Similarly, studies of the impact of EMF on calcium flux across cell membranes and on free radicals are also viewed as important. In designing experiments of direct mechanisms, there will be a need to select model systems (cells, etc.) that have the potential to yield biologically meaningful data that have plausible implications for human health. Indirect mechanisms of health effects, including the reported links between EMF and melatonin, and EMF and magnetite, merit attention. Investigations of novel mechanisms for EMF-induced effects may be supported if plausible and scientifically tenable hypotheses are presented. NIEHS will encourage multidisciplinary research projects that maximize the shared use of resources for exposure facilities where feasible. Cellular studies are expected to receive 25 percent of the first year funding; funding in subsequent years will depend on the progress evaluation.

Mechanisms Research (Animal)

Research using animal models can help us to understand and better evaluate inconsistent findings from epidemiologic research studies. Toxicologic research using transgenic animals
and other advanced techniques will provide critically needed information on potential mechanisms by which EMF may affect organ systems and biological function in the whole animal. In addition, cooperation and collaboration among toxicologic researchers are encouraged, particularly the use of identical regional exposure facilities, animal strains, and other shared resources when feasible. This will improve the quality and replicability of research and reduce costs.

Areas of toxicologic investigation of high interest include EMF-induced cancer in rodents (particularly leukemia, brain, and breast cancer), mechanistic studies of biological effects in rodents, and neurological and reproductive toxicology. Animal studies are expected to receive 25 percent of the first-year funding.

**Directed Research**

A portion of funds available each year will be set aside to support opportunistic research. It is anticipated that investigators with innovative ideas for studies with direct relevance to the program goals can be given limited funding outside of the formal grant process to conduct such experiments. This will provide the flexibility to quickly address gaps in the research program, follow-up intriguing results, and round out the overall health effects research program, especially where formal research proposals are not forthcoming. The first-year set-aside will be 5 percent.

**Replication of Research Findings**

Regional laboratory facilities will be established for the use of scientists conducting basic research, to assure that exposure conditions are uniform and reproducible. These facilities will also be used to independently confirm and replicate critical studies already in the literature and those initiated under this program. These facilities will help offset criticism of the lack of standardization in some past EMF-related research. Direct support for replication research is expected to be 10 percent of first-year funding.

**Engineering Research**

The Department of Energy has responsibility for research, development, and demonstration with respect to technologies to improve the measurement and characterization of electric and magnetic fields and with respect to techniques for assessing and managing exposure to electric and magnetic fields. Many of the activities described below will be performed by means of competitively bid contracts. Additional work will be performed by DOE’s national laboratories and other Federal agencies.
Exposure Assessment and Source Characterization

The planned activities will initially seek to improve exposure assessment through standardization of measurement protocols and characterization of fields in various settings. Since it is not known which aspects of fields are relevant to human biology, measurements will be made of multiple field parameters. Activities will include developing protocols, studying personal exposure and demographics, analyzing source/use patterns, and developing an exposure information database. Additional projects may include improved measurement instrumentation if necessary.

Exposure assessment research enables us to choose appropriate laboratory exposures, to relate them to the body's internal fields (see Dosimetry), to determine if people are exposed to biologically significant fields, and to develop appropriate field management options. Considerable work has already been done on characterizing the types and strengths of fields associated with the generation, transmission, and use of electric power. No major field measurement activities are initially planned, although if standardized measurement equipment and protocols are developed, it may be desirable to verify earlier measurements. As the program progresses and the characteristics of fields that may present a health hazard become identified, extensive field measurements to delineate the population at risk would be made.

Quality Assurance

Although not strictly research, quality assurance is a vital part of any defensible research program. For research to be credible, investigators must be able to demonstrate that their experiments have been properly designed and conducted. Quality assurance is also a mechanism for the exchange of information and assistance between disciplines, as in the example of engineers providing suggestions to biologists on improving exposure procedures in the laboratory. The EMF RAPID Program will begin at once to support a variety of quality assurance activities including a laboratory quality control team, peer reviews, and standards development.

Field Management

Whether people are making field management decisions now or in the future, the environmental, safety, and cost impacts of various options must be considered. The purpose of field management research is to better inform decision-makers of approaches and techniques that could be used, if remedial actions become necessary to reduce exposures that result in health risks. The design and implementation of field management research focuses on those field characteristics that are found to have the greatest relevance to health. Exposure information will be used in field management research to determine those environments in which control measures and techniques need to be applied. The EMF RAPID Program will provide data on field management strategies and techniques.
Dosimetry

Electric and magnetic field dosimetry research is aimed at discerning the connection between the body’s internal currents and exposure to external electric and magnetic fields. This connection is an important one in the series of steps required to describe how exposure relates to any given biological effect. Information from dosimetry studies will not only help to focus and refine biological research and exposure assessment work, but will be directly applicable to the risk assessment activities. Projects will include mathematical modeling and developing techniques for measuring internal fields.

Risk Assessment Research

A multi-disciplinary team will be charged with collaborating with toxicologists and basic scientists to develop a hazard identification/risk assessment model for EMF. This model is the core of the entire program since it is critical to determining whether EMF exposure is a health risk. The fundamental process of risk assessment will be applied from the start as a means of identifying gaps in the information needed for hazard identification. Data from current literature will be evaluated to identify gaps, and these data will assist in establishing priorities for new research under this plan.

The risk assessment research component will use data from all relevant and reproducible health effects research, including that resulting from work under this plan, in testing hazard assessment models and estimates of uncertainties. If data are generated that suggest a health hazard exists from EMF, additional efforts will be made to quantify the magnitude of the risk to human health and to identify and reduce uncertainties associated with the risk estimations.

Communication

The RAPID Program will provide information to the public about possible human health effects of EMF, the types and extent of human exposure, technologies for measuring and characterizing fields, methods for assessing and managing exposure, and other topics specified in the legislation. The program will strive to provide the public and other scientists with useful, targeted information based upon risk communication principles. The communication program will candidly address the issue of scientific uncertainty regarding EMF health effects and overall complexity of the EMF issue, while providing information appropriate for a variety of audiences.

DOE and NIEHS will jointly develop a communication plan and oversee its implementation. Both the EMF Interagency Committee and the National EMF Advisory Committee will review public information materials developed under this program.
APPENDIX I:

EMF RAPID PROGRAM IMPLEMENTATION PLAN FOR HEALTH EFFECTS RESEARCH AND RISK COMMUNICATIONS*

* Published separately by the U.S. Department of Energy as DOE/EE-0038.

December 1995
EMFRAPID

Electric and Magnetic Fields
Research and Public Information
Dissemination Program

Implementation Plan for
Health Effects Research and
Risk Communications

October 1994

The National Institute of Environmental
Health Sciences
IMPLEMENTATION PLAN FOR HEALTH EFFECTS RESEARCH
AND RISK COMMUNICATIONS

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1. BACKGROUND

The National Energy Policy Act of 1992 established "The Electric and Magnetic Fields Research and Public Information Program ("RAPID"). The Act assigns overall program management to the Department of Energy (DOE) but the National Institute of Environmental Health Sciences (NIEHS) is given sole responsibility for research into the possible health effects conducted under this new program.

The Act establishes two goals for NIEHS:

1. Determine whether or not exposure to electric and magnetic fields (EMF) produced by the generation, transmission, and use of electric energy affects human health and biological systems; and

2. Disseminate the latest information on electric and magnetic fields (including relative risk assessments) to the public in a form that is appropriate and useful to people who are not experts.

This EMF Health Effects Research Plan was drafted by staff at the NIEHS. In preparing the Plan, NIEHS reviewed several earlier efforts to collect the pertinent scientific literature regarding the biologic and health effects of EMF and making recommendations for further scientific investigation. This Health Effects Plan describes the program of biomedical studies and related activities to be conducted and supported by the NIEHS to test the hypothesis that exposure to magnetic fields associated with the generation, transport, and use of 60 Hz electric power may present a potential hazard to human health. And, if such a hazard exists, the research studies are intended to produce data that will help determine whether exposures to these fields presents a risk to human health. If data from the NIEHS health effects research program indicate that effects reported in some key epidemiologic studies cannot be confirmed, the level of public concern should be significantly reduced. Alternatively, if the NIEHS studies provide solid scientific evidence of plausible biological mechanism(s) and/or animal models of the human illness or dysfunction associated with magnetic field exposures in epidemiologic studies, policies and actions can be formulated by appropriate public and private entities to protect public health.

The Research Agenda and Communications Plan states: "Because epidemiologic studies have raised concerns regarding the connections between certain serious human health effects and exposure to electromagnetic fields, the [RAPID] program adopts the hypothesis that exposure to electromagnetic fields under some conditions may lead to unacceptable risk to human health. The focus of the program is not only to test, as far as possible within the statutory time limits, that hypothesis for those serious health effects already identified, but to identify as far as possible, the special conditions that lead to elevated risk and to make recommendations to manage risk."

The Health Effects Research Plan outlines a program of biomedical research and risk determination activities to be conducted and supported by the NIEHS to test the hypothesis that exposure to magnetic fields associated with the generation, transport, and use of 60 Hz electric power may present a potential hazard to human health. And, if such a hazard exists, the research studies are intended to produce data that will help determine whether exposures to these fields presents a risk to human health. If data from the NIEHS health effects research program indicate that effects reported in some key epidemiologic studies cannot be confirmed, the level of public concern should be significantly reduced. Alternatively, if the NIEHS studies provide solid scientific evidence of plausible biological mechanism(s) and/or animal models of the human illness or dysfunction associated with magnetic field exposures in epidemiologic studies, policies and actions can be formulated by appropriate public and private entities to protect public health.

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The outcome of biomedical research experimentation cannot be predicted and no research plan can be devised to precisely forecast the direction of any research program beyond its initial phases. NIEHS therefore, reserves the option to redirect, reduce, or expand the areas of research priority envisioned in this Plan. Any revisions will be discussed with the federal Interagency Committee and the NEMFAC.

The key questions to be addressed in the NIEHS health effects research are noted in the Research Agenda and Communications Plan: These are:

1. Are there robust bioeffects associated with magnetic fields?
2. What are the relevant biological measures of an effect?
3. What are the relevant dose measures?
4. Are the observed bioeffects related to human health effects?

To answer these questions, NIEHS will initiate a multi-disciplinary program of applied and basic biomedical research complemented by appropriate expertise in engineering and the physical sciences. Initially the research program will be directed toward the adverse health effects reported in epidemiologic studies to be positively associated with exposures to magnetic fields and that have become the focus of intense public concern. These effects are: childhood leukemia, brain cancer, breast cancer, and certain neurological and reproductive effects. As the program matures and additional scientific data are produced from research conducted under this program and elsewhere, research may be redirected, expanded, or reduced and other priorities may be established.

The Health Effects Research Plan gives highest priority to studies aimed at identifying and characterizing any biologic mechanisms that might lead to adverse health effects in animal models (in vivo studies of mechanisms.) And in vitro (cellular) studies to identify significant changes in normal biological function caused by magnetic fields that may be plausibly involved in the processes leading to leukemia, breast and brain cancer, and reproductive and neurologic dysfunctions. Validation (and to the extent possible, replication) of bioeffects reported in the peer-reviewed literature as plausibly related to the mechanisms underlying these diseases will be stressed in the early phase of the program.

Epidemiologic research studies are not given priority in this Plan. Rather, laboratory-based research to identify and characterize the specific physical characteristics of EMF that might be biologically active is assigned high priority. Likewise, the development and evaluation of biologically-based methods and test systems for use in evaluating human exposure to EMF and as biological markers of effects and/or susceptibility are high priority.

An important element distinguishing this EMF Health Effects Research Plan is the inclusion of a risk assessment research component. Its purposes are: 1. to establish scientifically sound criteria for determining whether EMF is a potential human health hazard; and 2. the weight and strength of the scientific evidence required to determine whether EMF presents a risk to human health under the kinds of exposures commonly experienced in public buildings, residential settings, and/or occupationally. It is critical to identify, prioritize, and test the hazard identification criteria concurrently with the onset of the research program. This will help to assure that the priorities for health effects research are consistent with the ultimate goal of the RAPID Program and will assist in planning the risk determination and risk
communications activities anticipated for the last years of the RAPID Program.

2. HEALTH EFFECTS RESEARCH

1. Mechanisms Research: Cellular Bioeffects

NIEHS will publish and distribute a Requests for Applications (RFAs) and Program Announcements (PAs) for grants to support basic biomedical research into the biological mechanisms by which EMF might interrupt normal sub-cellular, cellular, intercellular signaling, tissue and organ system functions. This research is needed to establish the biologic plausibility of the diseases and conditions associated with EMF exposure in human studies. These experiments will be performed using in vitro test systems and be directed initially toward mechanisms already reported in the research literature as being potentially responsive to perturbation by electric and/or magnetic fields. This RFA solicits applications from scientists for the study of plausible direct and indirect biological mechanisms that are believed to be involved in the development of the diseases and conditions associated with EMF exposure in some epidemiologic studies. All applications received in response to this RFA will be reviewed for scientific excellence and for relevance to the key questions cited above and the goals established for NIEHS in the authorizing legislation. It is anticipated that NIEHS will receive at least 50 applications in response to this RFA. It is estimated that at least 10 will be given very high priority for funding. NIEHS will award funds to support 4 to 6 and may award funds to support as many as 6 to 8 of these grants depending on the actual negotiated cost per grant and funds available.

2. Mechanisms Research: Animal Studies

NIEHS will publish and distribute a Request for Applications (RFA) for grants to support research using animal models to help better understand and evaluate inconsistent (in vivo) findings from epidemiologic research studies. The RFA calls for toxicologic research using transgenic and other advanced techniques and will provide additional information on the mechanisms by which EMF may adversely affect organ systems and biologic function in the whole animal. It is estimated that NIEHS will receive at least 50 applications in response to this RFA. It is estimated that at least 10 will be given very high priority for funding. NIEHS will award funds to support 4 to 6 and may award funds to support as many as 6 to 8 of these grants depending on the actual negotiated cost per grant and funds available.

3. NIEHS Intramural Interdisciplinary EMF Research

NIEHS will set aside a portion of funds available each year to support NIEHS scientists with innovative ideas for experiments that are directly relevant to the key health effects research questions. Limited funding will be used to support these experiments. This activity will take advantage of an unique opportunity for NIEHS staff scientists conducting research in the fields of cell membrane function and signal transduction, molecular genetics, environmental carcinogenesis, neuro-endocrine- and immunobiology, and reproductive toxicology to add EMF exposure increments to their experiments as a contribution to the overall body of science related to EMF hazard identification. NIEHS will also augment the EMF toxicologic study being conducted under the auspices of the National Toxicology Program.
In each of the first three years of the program, the NIEHS Scientific Director will solicit research proposals from teams of intramural scientists wishing to participate in the EMF program. These proposals must be consistent with the priorities of the Health Effects Research Plan (e.g., be focused on mechanisms of toxic effects, rather than on epidemiology or clinical studies) and must represent a significant extra level of research effort on the part of the investigators. The proposals will be reviewed for scientific merit and relevance by an independent peer review group appointed by the Scientific Director. Final decisions on projects to be funded will be made by the NIEHS Director on the advice of the Scientific Director and the NIEHS EMF Program Managers.

Experiments to be conducted in the first year of the program include:

a. Additional mechanistic research will be done under the direction of NIEHS scientists as a part of the ongoing National Toxicology Program/NIEHS toxicologic study to include: 1. investigation of the effects of exposure to magnetic fields on the amplitude and duration of exposure affects nocturnal melatonin levels in mice; and 2. study of the effects of 60 Hz sine wave magnetic fields without transients on multiple parameters of immune function in mice; 3. and study of the leukemogenic effects of 60 Hz sine wave magnetic fields without transients in two strains of transgenic mice (PIM mice and p53 knockout mice.)

b. Melatonin-related research: Studies characterizing the antiproliferative effects in normal and neoplastic epithelial cells; signal transduction pathways responsible for the oncostatic properties of melatonin; and the role of melatonin in the biologic effects of magnetic fields.

c. Calcium Flux: Studies of ion changes in apoptosis as a possible mechanism of EMF effects and effects on calcium signaling in cells of the immune system.


e. Central Nervous System Alterations: Studies of EMF on proto-oncogene DNA binding activity during brain development; effects on brain cell cultures; alterations in astrocyte function and regulation of cytokine mRNA during perinatal exposure; and effects on immune function mediated by the rodent brain.

4. Validation (and Replication) of Research Findings

NIEHS, working in collaboration with DOE, will coordinate the establishment of two regional EMF laboratory facilities for the use of scientists conducting cellular research to assure the exposure conditions are uniform and reproducible among the investigators. These facilities will also serve to independently validate (and as far as is scientifically possible, replicate) critically important in vitro studies already reported in the research literature and as well as those initiated under this and other research programs. In the first year of the program, NIEHS will work with DOE and the National Institute for Occupational Safety and Health (NIOSH) and the Food and Drug Administration (FDA) to establish the regional laboratory facilities and to provide EMF exposure chambers with carefully monitored and controlled parameters for use by scientists engaged in EMF related mechanistic studies. The exposure equipment will be designed and provided by DOE, whose scientists and engineers will also provide quality control and quality assurance monitoring.
The creation of these exposure facilities is an unique contribution of the EMF health effects research program. These facilities will allow highly regarded biomedical research scientists who have not had experience in conducting experiments under carefully controlled EMF exposure systems to have access to a facility where excellence in quality control and quality assurance is assured. These facilities will also permit scientists who have an established reputation in the field of bioeffects of EMF exposures to replicate their previous work and conduct follow-up studies under standardized conditions.

The NIOSH facility will be in Cincinnati and will use the same exposure equipment under the same collaborative arrangement with DOE as the FDA laboratory. The principle research focus at the NIOSH regional laboratory will be on cell signal transduction (e.g. calcium transport, protein kinase C activity, and ornithine decarboxylase production.) The research objective of the effort at NIOSH will be to validate experiments demonstrating spontaneous induction of calcium oscillations in cell lines such as Jurkat, HL-60 or HeLa and to validate experiments demonstrating that EMF modulates the calcium response to mitogens. If previously reported effects are successfully repeated in these cell lines they will be investigated further in primary and secondary cell culture models such as rat hepatocyte or human keratinocytes.

The FDA will establish a regional in vitro magnetic field exposure facility in its laboratories in Rockville, MD. The main objectives will be to provide carefully controlled and reproducible exposure facilities and exposure conditions such as media, nutrients, temperature, humidity, etc. In addition, FDA will attempt to validate important new findings reported by scientists conducting cellular research. Emphasis will be placed on attempts to precisely replicate the original work. The principle focus will be on reported alterations in the expression of specific genes (c-myc, b-actin, and histone) when a promyelogenous leukemia cell line (HL-60) is exposed to various ELF magnetic field conditions. This is crucial since reported alterations in cellular transcription and translation lend plausibility to the reported associations between higher cancer rates and residences close to power transmission and distribution systems.

All work proposed by NIOSH and FDA will be reviewed by an interagency "Regional EMF Facilities Steering Committee" composed of scientists from NIEHS, DOE, NIOSH, and FDA. This committee will meet at least every six months to review the progress, to provide direction and oversight, and to alter the research course as necessary. The work scope for each regional facility, research directions, and results will also be reviewed by selected experts on an ad hoc basis.

3. EXPOSURE/DOSE RESEARCH

Each of the exposure variables generally evaluated in toxicologic and cellular studies of chemicals must be considered in EMF health effects research (e.g. dose, duration, and number of exposures.) However, electric and magnetic fields have additional physical characteristics (e.g. harmonics, transients, intermittency, etc.) that make them more complex than chemicals to test for health effects. This presents a major challenge to biological scientists in designing, conducting, and interpreting the results of health effect research. At present, there is no scientific consensus on which of the exposure variables or physical characteristics or combinations (if any) of EMF that might be related to bioeffects or health effects. NIEHS will support experiments to identify any biologically important variables. One approach will
be to select a well-understood, normal, human biological function that is sensitive to environmental perturbation and easily reproducible in an in vitro experiment. The experiment will be performed systematically under carefully controlled EMF exposure variables. If the expected results of the experiment are altered substantially under the EMF exposure conditions, that variable will be given high priority for more extensive investigation in the health effects research studies. In addition, data from these exposure experiments should be used to further refine the exposure components of new epidemiologic studies and to re-evaluate the exposure components of epidemiologic studies already completed.

The results of the exposure research activity must be interpreted with caution, since experience in chemical toxicology suggests that effects seen in a cellular system often do not translate into effects in either the tissue, organ, organ system, or whole organism. None the less, this experimental approach could contribute significantly to narrowing the vast number of possible dose considerations for EMF health research studies.

In addition to these experiments, NIEHS also will give high priority to health effects research aimed at developing biological tests of the internal dose of EMF received under various exposure settings and of biological markers of effects or susceptibility to the effects of exposures to EMF.

The exposure research activities will begin in the second and succeeding years of the program and will be closely coordinated with the DOE exposure research program.

4. HAZARD IDENTIFICATION AND RISK RESEARCH

The goal of this activity is to create and gather broad public support for a framework to be used by the NIEHS Director in selecting and interpreting data generated by the Health Effects Research Program and elsewhere in making a determination of whether electric and magnetic fields are a potential health hazard and, if so, whether EMF presents a risk to human health under exposure conditions typically experienced in the U.S. The objectives are to 1. Establish the scientific criteria upon which to base a determination of health hazard; and if a hazard exists, 2. Establish a scientifically credible process to define the magnitude of the risk to human health presented by EMF. This must be done in a public forum and carried out in close association with both the health effects research, engineering research and public communications components of the National RAPID Program. In addition to interpreting the results of biomedical and exposure research in terms of the risks of disease and dysfunction that may result from exposure to EMF, the framework is envisioned as a principal management tool for selecting health effects research priorities and monitoring the progress of the health effects research program. Thus, the activity must begin in parallel with the onset of the health effects research program.

Most of the work will be done under contract but NIEHS will manage the entire process. A senior NIEHS staff scientist with internationally-recognized expertise in mechanistically based risk assessment will provide scientific direction in developing recommendations for the health risk framework. To assist in this effort, NIEHS will identify approximately 10 persons to serve as a
multi-disciplinary group of biologic scientists, epidemiologists, risk analysts, biomathematicians and biostatisticians, and physicists and engineers (the EMF Risk Working Group) to develop a mechanistically-based, scientifically rigorous, EMF risk determination framework. The Risk Working Group will not include scientists conducting research under the RAPID Program but they will be thoroughly briefed on the broad Program goal and the details of the health effects and engineering research activities.

The key elements of this activity include:

a. NIEHS scientists will draft proposed hazard identification criteria and an outline of options for risk determination. These drafts will be given to the Risk Working Group for review and comment. The Working Group will meet in open session to discuss the drafts and to make specific recommendations for the criteria and the risk determination process. NIEHS will revise the drafts to incorporate the recommendations as necessary. This work will begin immediately upon receipt of funding for the NIEHS activities under the RAPID Program.

b. Working in collaboration with DOE in the creation of an information clearinghouse for the RAPID Program, NIEHS will provide for the collection of scientific literature on the biological and related effects of EMF and creation of a database which will be made available to scientists, organizations, and selected individuals involved in the RAPID Program. (NIEHS recognizes that there have been several recent literature reviews compiled and analyzed by panels of scientists convened by various organizations, agencies, and State agencies. There are also commercially available EMF bioeffects database(s). These will be used as the initial data to be included in the Program database.)

c. NIEHS will gather, analyze and assess, interpret, and disseminate scientific data from biomedical and related research (e.g. engineering and exposure studies) on the biologic and health effects of exposure to electric and magnetic fields. Scientific data and analyses will be made available to research scientists to facilitate communication, to foster research collaboration and to reduce unnecessary duplication. NIEHS will organize the scientific reports in the database chronologically by scientific discipline (e.g. epidemiology, toxicology, biology, human exposure measurement, etc.) and by useful sub-categories (e.g. EMF and disease end-point or EMF and signal transduction, melatonin, magnetite, etc.) These reports will be subjectively evaluated for relevance to the health effects of EMF generated at 60Hz and for quality (e.g., published v. non-published or peer-reviewed v. non-peer-reviewed.)

d. In addition to collecting existing research reports and creating a database, the database will be augmented with information on scientific research in progress inside and outside of government. This will be accomplished by collecting information on scientific studies currently being conducted on the biological and related effects of EMF. NIEHS will:

0 Identify and gather summaries of research studies conducted and supported by Federal Interagency Working Group and other Federal agencies. (Possible sources include information from surveys by Working Group members of their agency research activities and searches of PHS and NIH grants and contracts electronic databases.)

0 Identify and gather summaries of research studies conducted or supported by non-Federal
agencies. Possible sources include surveys of EPRI, and of BEMS and other selected professional societies, and interviews of key scientists in the field.

e. When the hazard identification criteria are in final draft form (a process anticipate to require 3-4 months,) NIEHS will test the criteria using existing health effects research and exposure data. If application of the hazard identification criteria suggest some hazard exists, efforts will accelerated in developing and testing a risk determination framework. These evaluations are intended to learn whether the criteria and framework can actually be applied and the if results appear to be useful in the decision making process. Any proposed revisions in these drafts will be made in an iterative process involving the Working Group and the Advisory Committees established for the RAPID Program.

f. The first draft and subsequent drafts of the criteria and framework will be given to the managers of the NIEHS health effects research grants and intramural program, to the managers of the DOE RAPID Program, to the managers of the federal EMF regional laboratories, and to the extramural scientists conducting EMF health effects studies. They will be encouraged to use the drafts as guidance for setting program and research priorities and to solicit preliminary results of research that might be particularly useful to the identification and characterization of health risks from EMF exposures.

g. NIEHS will provide a description of the activities and products of the risk research activity in its first progress report on the program due in May 1995.

5. RESEARCH PROGRAM PLANNING

NIEHS will seek consultation, advice, and guidance from the Federal Interagency Committee and the National EMF Advisory Committee in formulation a plan for health effects research funded under the National Energy Policy Act. NIEHS will brief members of these committees on all aspects of the health effects research program and solicit their advice and recommendations before key decisions are made with respect to program priorities and direction. Specifically, with respect to grant-supported research, NIEHS will seek the opinions of the NEMFAC and the IAC on program relevance and priorities of mechanistic research grants before final funding decisions are made. To the extent permitted by the applicable sections of the Public Health Service Act and the regulations, guidelines and procedures established for NIEHS by the Department of Health and Human Services, the Public Health Service, and the National Institutes of Health for the management of grants, NIEHS will request assistance in the preparation of RFAs for the program, will inform the IAC and NEMFAC of the findings of the peer review for scientific quality, and provide opportunity for discussion by representatives of the NEMFAC and IAC at the meetings of the National Advisory Environmental Health Sciences Council (NAEHSC) where decisions on program relevance of research grant applications are made.

NIEHS will regularly brief DOE program officials by telephone and in meetings on the status of research program planning and implementation.

In the second and succeeding years, research directions will be influenced heavily by research initiated in the first year of this program and by EMF health effects and biomedical research.
conducted outside the RAPID Program. In addition, NIEHS also has responsibility for the framework by which risk to human health from exposure to EMF will be identified and characterized. It is anticipated that priorities among research proposals may be made by the relevance of the research study to strengthening the identification and characterization of possible human health risk.

6. REPORTING RESEARCH FINDINGS

Within the established laws, rules and guidelines established by and for NIH, NIEHS will assure the timely release of data from health effects research supported under this agreement. NIEHS will make provisions for scientists supported under this program to attend professional meetings and briefings as necessary to assure collaboration, communication, and to prevent any unnecessary duplication.

During the period that research is ongoing under this program, NIEHS will assign qualified scientist-managers to monitor all health effects research and provide briefings and status reports on the progress of research as necessary to DOE or other relevant bodies (e.g. the NEMFAC and the IAC, the National Academy of Sciences and Members of Congress and staff with jurisdiction over the Program.)

7. COMMUNICATIONS: HEALTH EFFECTS RESEARCH AND RISK

NIEHS will not engage in any health risk communications activities in the first year of the RAPID Program. It is premature. However, NIEHS will work in collaboration with DOE in the development of a health risk communications plan for consideration by the Federal EMF Interagency Committee and the National EMF Advisory Committee. Some components of the health effects portion of the risk communication plan that NIEHS will contribute to in the first year of the program will include:

- A description of the NIEHS Health Effects Research Plan written for distribution to the general public. This overview will be consistent with the concept of conducting research intended to provide data needed to determine whether EMF can be identified as a human health hazard and what minimum level of scientific evidence is necessary to perform a health risk assessment for EMF.

- Review and evaluation of the health effects components of existing fact-sheets, pamphlets, brochures, videos, and other similar documents on the health effects of EMF for accuracy, balance, and clarity.

- Drafts of background information related to health effects research activities outside the RAPID Program effort for their potential to contribute to the understanding of any health risks of EMF.

NIEHS will inform the general public about the goals, objectives, and methods of the health effects research program and to interpret and communicate the results of the program to the public in a manner that is timely, useful, and understandable. NIEHS will begin this process in the first year by establishing dialog among the many parties interested in the status of health effects research efforts and the findings of such research. This dialog will help determine the structure of the risk communication program and identify specific information needs of the these parties and the most efficient means of disseminating information to them. To the extent
possible and practical, existing communications skills, networks, and health effects information already established by the many parties involved in addressing concerns about possible health effects from EMF should be identified and used in the communications program.

A number of organizations and entities have been identified that have both an interest in the outcome of health effects research related to EMF and a capacity to communicate the findings from such research. These organizations will be invited to participate:

- Department of Energy
- Environmental Protection Agency
- National EMF Program Federal Interagency Working Group
- HHS Agencies Conducting EMF Health Effects Research (FDA Center for Devices and Radiologic Health)
- NIH Institutes including the National Cancer Institute
- National Institute for Occupational Safety and Health
- State and local health agencies
- State and local electric utility regulatory agencies
- University-based communications and information experts
- Medical care providers (Physicians, nurses, etc.)
- Electric utilities
- Private, non-profit research organizations
- Industry and trade associations
- Labor organizations
- News media
- Community groups (interested citizens/civic organizations)
- Environmental groups
- Scientists and their professional associations
- National Academy of Sciences
- Elected officials (local, state, and federal)

8. PROGRAM ADMINISTRATION

1. Program Management

The NIEHS EMF Health Effects and Risk Communications program will be managed by existing senior management and scientific staff. The senior managers of the NIEHS Program will work directly with DOE staff to support the overall goals and objectives of the RAPID Program and provide support and assistance when required in all administrative, scientific, and communications activities.

Under the direction of the senior staff, NIEHS will establish an internal EMF scientific steering committee of scientists with differing training and experience from throughout the Institute to assist with the development of draft research plans; draft conceptual documents for Requests for Applications (RFAs), Program Announcements (PAs), and for Requests for Proposals (RFPs) for research and development contracts. The NIEHS steering committee will include scientists with experience in the design and conduct of biomedical research into the possible health effects of non-ionizing, ELF radiation.

NIEHS will convene a liaison group of scientists from agencies within the Public Health Services that have technical and research expertise in EMF research. At minimum, these will include the Food and Drug Administration, the Centers for Disease Control, and the National Institutes of Health.

2. Assistance to DOE for Program Administration

The DOE has overall management responsibility for the National RAPID Program. In order to successfully administer this Program, DOE will need assistance and support from NIEHS in a number of areas. Accordingly, NIEHS
will collaborate and coordinate with DOE Program managers to:

0 Meet with organizations and individuals included among the non-federal contributors to the RAPID Program to provide information on the status of the NIEHS health effects and risk communications activities.

0 Assist DOE in preparation and justification of annual budget and budget narratives for the RAPID program.

0 Attend and participate in meetings of the Federal Interagency Committee and the NEMFAC and the National Academy of Sciences.

0 Provide briefings, drafts and reports of progress and accomplishments to DOE as required.

3. Participation in Scientific Meetings

NIEHS staff will attend and participate in scientific meetings when appropriate and will provide support for scientific meetings that address the health effects of exposure to EMF. NIEHS will participate in the annual DOE contractor review meeting and meetings of the Bioelectromagnetics Society. NIEHS will encourage and support attendance and participation of NIEHS grantees and contractors at appropriate scientific meetings.

4. Assurance of Peer Review of Science

NIEHS will use the systems established and already in place at the National Institutes of Health for the scientific peer review of all grants, research and development contracts, and intramural studies funded under this agreement. In those instances where pre-existing peer review committees are not entirely adequate to assure full and complete review of multi-disciplinary research proposal, NIEHS will provide for the augmentation of peer review group(s) to include unbiased, independent scientists with the education, experience and demonstrated expertise to assure thorough and rigorous peer review.

To the extent permitted by law and regulation, NIEHS will facilitate monitoring of the peer review process by the senior EMF program manager and/or his/her designee.

9. OTHER CONSIDERATIONS

Several Federal agencies and non-governmental organizations and investigators will independently and apart from the NIEHS program, conduct or support health effects research related to the question posed in the first goal stated above. This is entirely appropriate and is encouraged. NIEHS will make every effort to keep current on these studies, avoid any unnecessary duplication of such efforts, and foster and support mechanisms for all scientists in the field to interact professionally.

The mandate for this national program is derived from a need to know whether 60 Hz-generated EMF presents or does not present a risk to human health. While it is not reasonable to believe that science can prove the absence of any such risk, NIEHS believes that rigorous scientific research studies that do not show an effect must be reported and given the same level of consideration in responding to public concern and in making public policy as "positive" studies. NIEHS will make every effort to assure that both "negative" and "positive" studies are reported and will encourage and support annual meetings of scientists engaged in EMF-related research at which all findings are reported and discussed.
NIEHS is committed to following established NIH procedures for solicitation, peer review, and funding decisions for studies conducted and supported in this program. NIEHS intends to solicit research proposals from the broadest range of researchers possible. These include scientists in academic institutions and other private research agencies and in federal agencies including the NIEHS intramural research program. NIEHS will use the most appropriate funding mechanism to support research conducted under the program. Such mechanisms include grants and cooperative agreements, contracts, and interagency agreements. Procedures for peer review and funding decisions differ by mechanism but NIEHS will make every effort to assure consistency and fairness in the peer review processes.

NIEHS anticipates convening a series of workshops for prospective researchers. The workshops will include both discussions of the proposed Research Plan; specific priority research areas (e.g. role of animal studies, gene transcription/translation, calcium transport across cell membranes, toxicology and epidemiologic research); and the funding mechanisms and procedures for the Program. To the extent feasible, these meetings and workshops will be schedule in conjunction with other major meetings of the EMF research community and will include scientist and engineers active in the National RAPID Program.
**NIEHS EMF HEALTH EFFECTS RESEARCH PROGRAM TIMETABLE**

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1. NIEHS EMF Program Announcement Issued
2. NIEHS Program Announcement Grants Begin
3. RAPID Program Enacted
4. NIEHS/NTP EMF Toxicology Study Begins
5. Congress Appropriates Funding for RAPID
6. NIEHS EMF Requests for Grant Applications (RFA) #1 and #2 Issued
7. NIEHS/NTP EMF Toxicology Study Add-on Research Begins
8. IAC Rapid Program Plan Issued
9. DOE-HHS EMF Memorandum of Understanding (MOU) Released
10. NIEHS Intramural Research Studies (1st Round) Begin
11. Funding Transferred to NIEHS from DOE for Section 2118
12. NIEHS RFA (#1 & #2) Research Grants Begin
13. NIEHS/DOE/FDA/NIOSH Regional Exposure Facilities Open
14. Risk Assessment Research Begins
15. NIEHS EMF Requests for Grant Applications (RFA) #3 Issued
16. NIEHS Intramural Research Studies (2nd round) Begin
17. NIEHS Interim Report Due
18. NIEHS RFA (#3) Research Grants Begin
19. Section 2118 Program Interim Report Due
20. NIEHS/NTP EMF Toxicology Study Ends
21. NIEHS/NTP EMF Toxicology Study Results Available
22. NIEHS Final EMF Report Due
23. Section 2118 Program Final Report Due/RAPID Program Ends

**Bold** = Data will be available from these projects for use in interim EMF reports. Additional data will be available from DOE-sponsored research and from other NIH EMF studies.
EXPLANATION OF TIMETABLE

1. and 2. NIEHS EMF Program Announcement-

Program Announcements are issued by National Institutes of Health (NIH) to notify the biomedical research community that a specific area of study is of high interest. Program Announcements encourage scientist from outside the NIH to apply for grants for research in priority areas. In December 1991, after sponsoring a scientific meeting on research needs and gaps, NIEHS issued Program Announcement seeking grant applications for EMF studies in was issued in December 1991. Applications were peer-reviewed and the most scientifically meritorious were funded beginning in September 1992. (The Environmental Protection Agency transferred $1.2 million to NIEHS to help fund the first year costs of some of these research grants.) These grants support research studies that continue for 3 to 5 years.

NIEHS was funding 12 grants related to health effects of EMF in 1994. These include:

- Cancer and Gene Expression (3)
- Epidemiology (1)
- Cellular and Mechanistic Studies (5)
- Effects on Reproduction (1)
- Organ and Organ System Effects Studies (2)

The Program Announcement was issued before the National RAPID Program was enacted. It remained open through 1993 and 1994 and it is anticipated that it will continue in effect in 1995 and beyond. Funds transferred to NIEHS from DOE for the RAPID Program will not be used to fund grant applications submitted in response to the Program Announcement unless the application is clearly and directly related to a health research priority established under the RAPID Program. However, the data from these grants will be analyzed and used in by NIEHS in the determination of any potential EMF health hazard or risk to human health.

3. RAPID Program Enacted-

Section 2118 of the National Energy Policy Act was signed by the President in October 1992. The NIEHS EMF Health Effects Research and Risk Communication Program was authorized in this Act. NIEHS began planning for the implementation of these new responsibilities began immediately.

4. NIEHS/National Toxicology Program (NTP) Study Begins-

In 1989, the Department of Energy requested that the National Toxicology Program (a program in the Public Health Service managed by the NIEHS and established to coordinate Federal toxicologic research and testing) to conduct a thorough toxicologic evaluation of the health effects of EMF exposure in animals. NIEHS worked with experts in and outside government to design an state-of-the-art, rodent bioassay. This study, estimated to cost over $5.0 million and span the lifetime of the animals, began in March 1993. The study is being conducted under contract with constant supervision be NIEHS scientists. No Section 2118 funds will be used for the NTP study but NIEHS will use about $500,000 to augment the contract to take advantage of unique opportunities for experiments directly related to the priorities established for health effects research under the RAPID Program. Data from these additional studies will start coming available in late 1994 and continue to be generated over the next 18 to 24 months. The full study will be completed in 1997.

October 1994

Health Effects Research and Risk Communications
5. Congress appropriates funding for the RAPID Program.

The federal fiscal year begins on October 1 and ends on the following September 30. Funding for the Program must be made available to DOE by Congress before the Program can actually begin. Funds were appropriated by Congress for the RAPID Program in October 1993, one year after it had been enacted. As a consequence, no new RAPID Program activities beyond planning were carried out by NIEHS in the 1992-93 fiscal year. Section 2118 specifies that no funding can be used until 50 percent of the amount appropriated is matched by contributions from non-federal sources. Thus, NIEHS could not begin to operate its new program until funds were appropriated, matched, and transferred from DOE.

6. NIEHS issues Requests for Applications (RFAs) for EMF Research Grants (first solicitation).

Requests for Applications (RFAs) are issued by NIH to stimulate additional studies in a particularly important area of biomedical research. RFAs differ from Program Announcements in that the Institute that released the RFA must set aside funds and commit to support research grant applications that are deemed scientifically meritorious by special peer review panels. NIEHS anticipated a need for additional studies to investigate plausible biological mechanisms that could help provide molecular or cellular explanation and animal models for the health effects reported in epidemiologic studies as associated with EMF exposures. In order to expedite the National RAPID Program, NIEHS issued two RFA's in November 1993, to solicit grant applications for such mechanistic studies, citing the need for both cellular and animal research. NIEHS further specified that the researchers follow-up on hypotheses for mechanisms that had been reported in the scientific literature. Applications were received February and peer reviewed in May 1994.

7. NIEHS/NTP EMF Toxicology Study Add-on Studies Begin.

As noted in item 4, NIEHS scientists are taking advantage of unique opportunities presented by the long-term toxicological study to conduct several experiments using existing animals and exposure facilities available under the NTP contract. The first of these studies, evaluating EMF exposure effects on melatonin, began in April 1994. Data from these experiments were being analyzed in the summer and reports will be available from NIEHS in the fall of 1994.

8. The Federal EMF Interagency Committee (IAC) releases its Research Agenda and Communications Plan for the RAPID Program.

The law requires the IAC to develop a comprehensive research agenda for the Program. The agenda was issued in May 1994. While the law give NIEHS sole responsibility for the health effects research component of the Program, the Institute was concerned that its plan for health effects research was consistent with the IAC’s agenda since it represents a broad Federal perspective and recommendations for the National RAPID Program. the NIEHS Plan does reflect the priorities identified by the IAC.

9. DOE-HHS Memorandum of Understanding Released.

The Memorandum of Understanding (MOU) is the document that delineates the responsibilities of the Department of Health and Human Services (HHS,) the NIEHS parent organization, under the National RAPID Program. The MOU
must be signed by the Secretary of Energy and the Secretary of Health and Human Services to permit the transfer of funding to NIEHS for the Program. The effective date of the MOU was January 13, 1994 and it was officially released in June 1994. It will remain in effect for the duration of the RAPID Program.

10. NIEHS Intramural Research Studies Begin-

The NIEHS employs approximately 400 research scientists, many of whom are conducting basic research in the fields of biological mechanisms of carcinogenicity, signal transduction, molecular genetics, etc. NIEHS will use this resource to expand the number of scientists conducting studies in the priority research areas in the Health Effects Research Plan. The first of these studies began in June 1994. They average 2 years in duration and are described in the NIEHS Plan. Additional studies will be ready to begin as soon as funds are available each fiscal year for the second and third years of the Program. Studies initiated in the second and third years will allow flexibility to follow-up on key findings from other EMF research, fill any gaps in the Program research priorities, and test the hazard identification criteria.

11. Funds Transferred to NIEHS from DOE for RAPID Program.

The first interagency agreement between DOE and NIEHS transferring funding for the NIEHS EMF health effects research and risk communication program was initiated in August 1994.

12. NIEHS RFA Research Grants (first RFA solicitation) Begin-

The approved applications for EMF studies received in response to the RFAs issued in November 1993 and the Program Announcement that are consistent with the priorities contained in the EMF Health Effects Research Plan will be funded in December 1994 and research will begin at this time. These studies will be conducted over a 3 to 4 year period.

13. NIEHS/DOE/FDA/NIOSH Regional Exposure Facilities Open-

These facilities will be described in the NIEHS Health Effects Research Plan. They will begin operation in October 1994 and continue for the duration of the Program.

14. Risk Assessment Research Begins-

This activity is described in the NIEHS Health Effects Research Plan. It will begin in October 1994 and continue at an intensive level for approximately one year and continue for the duration of the Program.

15. NIEHS issues RFAs for EMF Research Grants (second solicitation)-

NIEHS will expand the research grants in the priority areas contained in the Health Effects Research Plan will additional funding anticipated to be available for fiscal year 1995. Grant applications for new studies in the areas of gene expression, cell signaling, and hormonal effects will be sought. In addition, plans call for the solicitation of innovative studies to determine which of the magnetic field dose parameters or variables are biologically relevant. These second round of RFAs (or Program Announcements, if more appropriate for the purpose) may be released periodically during fiscal year 1995 to allow for applications that are needed to fill research needs identified in the process of developing the hazard identification and health risk determination framework. These grants will be limited to 2 to 3 years to assure data are available before the RAPID Program ends.

October 1994

Health Effects Research and Risk Communications
16. NIEHS Intramural Research (second round) Begin-

See item 10. NIEHS will initiate a second group of intramural research studies beginning in November 1994.

17. NIEHS Interim Report Due.

The Director of the NIEHS will issue an interim report in May 1995 on the status of the health effects research program to the Federal EMF Interagency Committee (IAC) and the National EMF Advisory Committee (NEMFAC) for use by these Committees in preparing the IAC Report to Secretary of Energy and to Congress due on December 31, 1995.

18. NIEHS Research Grants Begin-

See item 14. NIEHS will make funds available in to begin the extramural research grants that are received in response to the RFAs issued in November 1994 that have passed peer review and are selected for funding.

19. Section 2118 Report Due-

See item 16. A report from the IAC to Secretary of Energy and to Congress summarizing the progress of the RAPID Program is due December 31, 1995.

20. NIEHS/NTP Toxicology Study Ends-

See item 4. The long-term EMF toxicology study conducted by NTP under NIEHS supervision is scheduled to end in September 1996. All surviving animals in the study will have lived their expected life spans and sufficient time will have elapsed for any adverse health effects to appear.

21. NIEHS/NTP Toxicology Study Results Available-

See items 4 and 19. All pathology studies will be complete and health effects data analyzed from the NIEHS/NTP toxicology study. The final report of data from the study will be available in February 1996.

22. NIEHS Final EMF Report Due-

NIEHS will submit a report in March 1997 to the IAC and to the NEMFAC summarizing the results of the health effects research program, interpreting the findings, and making finding about health hazard and health risk.
APPENDIX J:

EMF RAPID PROGRAM IMPLEMENTATION PLAN FOR ENGINEERING RESEARCH, DEVELOPMENT AND DEMONSTRATION*

* Published separately by the U.S. Department of Energy as DOE/EE-0036.

December 1995
Implementation Plan for Engineering Research, Development and Demonstration

October 1994

U.S. Department of Energy
1.0 INTRODUCTION

1.1 BACKGROUND

Increasing public concern about the question of possible harmful health effects from exposure to power frequency electric and magnetic fields (EMF) led the U.S. Congress to address this issue in the Energy Policy Act of 1992 (P.L. 102-486). Specifically, Section 2118, under Subtitle B, Title XXI, (42 USC 13478) authorizes the Secretary of Energy to establish a jointly funded (Federal and non-Federal sources) comprehensive program to:

- determine if exposure to electric and magnetic fields produced by the generation, transmission, and use of electric energy affects human health;
- carry out research, development, and demonstration of technologies to mitigate any adverse human health effects; and
- provide for the dissemination of EMF information to the public.

In order to fulfill these legislated responsibilities, the EMF Research and Public Information Dissemination Program (RAPID) was established. Under the EMF RAPID Program, the Department of Energy (DOE) is responsible for exposure assessment and source characterization studies (including field measurement), dosimetry, and field management research, development, and demonstration activities. The National Institute for Environmental Health Sciences (NIEHS) is responsible for research on the possible human health effects of electric and magnetic fields. This scientific research includes, but is not limited to, health effects studies, basic biological mechanisms research, and the development of a risk assessment model for EMF.

Both DOE and NIEHS have major responsibilities for electric and magnetic fields research and communication under this program. The Research Agenda and Communication Plan for the RAPID Program was developed by the EMF Interagency Committee, consisting of representatives from nine Federal agencies, and established by the President. The purpose of this Committee is to make recommendations to the two lead agencies (DOE and NIEHS) regarding the direction of the research, coordination of activities of other Federal agencies involved in EMF research, and the communication of the results of the program to the public and to the Congress. The National EMF Advisory Committee provides guidance to the Interagency Committee and advice on program design and implementation to DOE and NIEHS. The research projects presented in this implementation plan are consistent with the agenda developed by the Interagency Committee and the guidance provided by the Advisory Committee.

In addition to the RAPID Program, the Department of Energy through its National Laboratories, continues to conduct a program of research into the effects of EMF on biological systems. This program of research has come to be known as the DOE EMF Biological Mechanisms Research Program. The activities of this program complement RAPID Program activities, and are an important part of the national effort to address this issue.

1.2 ENGINEERING PLAN OVERVIEW

This document contains information on the planned implementation of the EMF RAPID Program's engineering activities.
It describes the approach and specific projects required to achieve the goals laid out in the EMF Engineering Research component of the Research Agenda and Communication Plan. In addition to efforts funded by the RAPID Program, ongoing quality assurance and dosimetry research currently funded by the DOE EMF Biological Mechanisms Research Program are considered essential to achieving the goals of the RAPID Program.

EMF engineering research activities outside of the RAPID Program are currently underway at a number of government agencies, including DOE, as well as at privately funded institutions. A major objective of the EMF RAPID Program is to promote coordination of these research activities in such a way as to encourage information exchange, cooperative planning where appropriate, and the efficient use of resources. The projects outlined in this plan will typically be performed through competitively bid contracts. Close coordination between health effects researchers and engineering researchers is both essential and planned for. DOE and NIEHS will facilitate cooperative efforts among these groups to ensure that accurate and meaningful research results are obtained.

The Research Agenda and Communication Plan identifies the need for engineering research in four broad areas:

- Exposure Assessment and Source Characterization, including
  - standard measurement methods
  - exposure assessment
  - analysis of source/use patterns
  - development of a database

- Quality Assurance, including
  - laboratory quality control teams
  - peer reviews
  - establishment of quality control standards

- Dosimetry, including
  - mathematical modeling
  - development of techniques for measuring internal fields

Projects in the areas of engineering research specified by the EMF Interagency Committee in the Research Agenda and Communication Plan (with the exception of Dosimetry) will be presented in Section 2. Dosimetry research is being conducted under the DOE EMF Biological Mechanisms Research Program and is, therefore, not a part of this plan. Dosimetry research will, however, be targeted to meet EMF RAPID Program objectives, and is critical to the success of both programs.
2.0 ENGINEERING RESEARCH ACTIVITIES

2.1 EXPOSURE ASSESSMENT AND SOURCE CHARACTERIZATION

2.1.1 Objectives

To determine the range and typical characteristics of the electric and magnetic fields to which the general population and subgroups, such as occupational groups, are exposed.

To evaluate information about electric and magnetic field characteristics including field strength, frequency components, intermittency, coherence, transients and phase, as well as spatial and temporal distribution in relevant residential, workplace, and other environments.

To identify significant sources of extremely low frequency (ELF) and ELF-modulated EMF exposure, and use this information as input to support exposure assessment, risk assessment, communication, and the development of future field management strategies.

To evaluate instrumentation, and to develop techniques for measuring various types of electric and magnetic fields and techniques for assessing personal exposure.

2.1.2 Rationale

Human exposure assessment and source or environmental field characterization information is important for a variety of reasons. Laboratory researchers need this information to enable them to choose relevant laboratory exposures, and epidemiologists need exposure information to enable them to investigate associations between disease and exposure to EMF. Exposure assessment information is required if there is to be any meaningful assessment of risk. Exposure and source information is also needed in order to evaluate or develop field management options.

Human exposure to EMF is not constant and can be difficult to assess. Not only do fields vary in time and over very short distances, but people move in and out of fields throughout their normal daily routines. Exposure assessment is further complicated by the fact that we do not yet understand which attributes of fields may constitute dose for biological effects or possible adverse health effects. It is important that the full range of potentially relevant exposure parameters be investigated until we have a better understanding of how fields interact with biological systems.

An important function of the EMF RAPID Program will be to make significant contributions to the understanding of what kind of fields people are commonly exposed to in a variety of environments and from a variety of sources. Providing a forum for reporting exposure and measurement data in a standard format will help to make previously collected data more accessible and more useful. Another function of the program will be to assist the EMF research community, technicians, and instrument manufacturers in communicating about the latest instruments, techniques, and hypotheses concerning relevant field attributes.

2.1.3 Background

A number of exposure assessment studies have been conducted in recent years following the development of personal exposure monitors by the Electric Power Research Institute (EPRI) and Hydro Quebec. These devices are sometimes referred to as "dosimeters."
important to recognize however that, as yet, no particular field parameter has been identified that can be expressed in terms of "dose," so the term "dosimeter" is imprecise. Currently available personal exposure monitors are typically capable of measuring and recording the magnitude of a 60 Hz magnetic field at regular intervals. Some versions also record higher frequency signals or transients occurring during specified time intervals. Electric field measurements are far more difficult to take using a personal exposure monitor because the body is electrically conductive and distorts the electric field. Personal exposure monitors provide an accurate picture of an individual's exposure to certain magnetic field parameters when the magnetic field is relatively uniform over large areas. For example, magnetic fields produced by a transmission line vary little over distances of several feet, and aside from distortions of the field due to magnetic materials, a personal exposure monitor should provide a reasonable measure of an individual's exposure. Appliance fields, in contrast, vary significantly over short distances, and a monitor worn at waist level, on a belt for example, may provide a poor measure of the magnetic fields found near the head while a hair dryer is in use.

A study of EMF in nearly 1,000 homes, conducted by EPRI, includes measurements obtained from personal exposure monitors in conjunction with area measurements and follows an earlier study conducted by Geomet, which used personal monitors to evaluate the exposures of school children. Ontario Hydro, the Canadian Electrical Association (CEA), and EPRI together sponsored an exposure assessment study of 52 children in 31 households. EPRI, CEA, and Health and Welfare of Canada are also conducting a 48-hour personal exposure monitor assessment study.

A number of utilities and utility organizations have conducted studies of residential and occupational exposures resulting from power generation and distribution. Fewer studies have been performed to characterize exposures resulting from industry-specific occupational sources such as aluminum smelting operations. Research in EMF exposure assessment will focus on helping to collate existing data from previous and ongoing studies, and gathering additional data where needed. Exposed populations in utility, industrial, commercial, residential, and transportation environments will be considered, and further attention will be focused on identified high-exposure situations.

In the past decade, source characterization efforts have been focused on the electric power grid, mainly transmission and distribution equipment. Fields from these power lines, however, constitute only a subset of the total electromagnetic environment to which most individuals are exposed.

Utilities and utility organizations continue to support many studies to characterize the fields from the sources related to electric power generation and distribution. Examples of major studies include the Geomet study, which included 28 residences, and the 1,000-home study, both funded by EPRI. Studies have also been conducted by the Empire State Electric Energy Research Corporation (ESEERCO) to characterize transmission line fields and validate computer models for predicting those fields. DOE sponsored a study by the Tennessee Valley Authority (TVA) to measure and analyze electric and magnetic fields near 500 kV transmission lines in 1983, and later sponsored work at the University of South Carolina to develop models of the fields for comparison with the measured data.
EPRI is continuing its analysis of power line fields and ground currents in residences at the High Voltage Transmission Research Center (HVTRC). The Bonneville Power Administration (BPA), and others, have developed models for predicting fields from various configurations of conductors. Wiring codes have been used as a surrogate for magnetic fields in a number of epidemiological studies, and DOE, EPRI, and ESEERCO have sponsored research to investigate how well these codes predict field levels.

Several studies have been conducted to evaluate magnetic fields from appliances in the home. The EPRI 1,000-home study includes appliance measurements, and the U.S. Navy sponsored an earlier study by the Illinois Institute of Technology Research Institute (IITRI) to measure fields around 25 different appliances. Ontario Hydro used the IITRI data to develop models of the field levels. The U.S. Department of Energy is currently conducting a study of motor-driven appliances at Pacific Northwest Laboratory (PNL). The U.S. Food and Drug Administration (FDA), EPRI, and DOE/Pacific Northwest Laboratory have completed studies of fields produced by electric blankets. These studies evaluated a number of different blanket designs as well as information about the waveforms and temporal characteristics of the fields.

Fewer studies have been conducted of fields in commercial settings. EPRI sponsored a study of fields and field characteristics in 28 commercial areas conducted by General Electric Corporation. An Italian study evaluated the fields produced by five different types of office equipment using spot measurements. This same study included measurements of fields near 12 types of industrial machinery. EPRI has also sponsored a study of substation fields conducted by Ohio State University.

The U.S. Department of Transportation is currently investigating fields produced by electric rail and magnetic levitation (MAGLEV) systems. This research is being conducted by ERM, Inc., and includes complete characterization of amplitude and frequency as well as spatial and temporal characteristics of the fields. ESEERCO is sponsoring a literature review of the information available on electric transit system fields. The study is broad in scope and includes additional industrial and commercial sources of fields.

2.1.4 Projects

A. Develop Recommendations for Guidelines for Personal Exposure Measurement

Objective: To develop and test a set of guidelines and procedures for performing and reporting personal exposure measurement.

This project will entail identifying examples of different subjects and their environments, and developing a set of suggested guidelines for measuring EMF exposure for different subject categories. The project will produce a manual of guidelines for personal exposure measurement. These guidelines will include information on which field parameters to measure, applicable devices and their correct positioning relative to the body, measurement procedures, and data reporting.

Milestones

12/95 Recommendations for guidelines
06/96 Guidelines issued
06/98 Guidelines updated
B. Conduct Human Exposure Assessment Projects

Objective: To obtain detailed information about personal exposures.

Some of the projects will emphasize characterizing the exposure of groups experiencing atypical exposures. Candidate occupational groups include welders, electric rail workers, health care workers, and aluminum smelting operations workers. Some projects will focus on general population groups or subgroups of interest, such as children, who are not expected to have atypical field exposures. Information from these studies will be formatted for inclusion in the EMF Measurement Database, and made available for epidemiological studies, risk assessments, and evaluation of field management options. Wherever possible, studies will be conducted as add-ons to existing epidemiological studies in order to maximize the amount of information obtained from the data. This is the case with an analysis of residential EMF exposures being carried out by the University of Bristol.

C. Develop Exposure Prediction Model

Objective: To develop a method for predicting exposures by combining source field data with an individual's activity patterns.

This method will be used to estimate exposures in given environments using source characteristics and activity patterns. Analysis of the relative positions and motions of sources will be a component of this project. For example, the proximity of an electric razor to the head, and the duration of its use, may be information of importance for biological studies. Office workers stationed near a building transformer may receive long-term, low-level exposures, while those using a copy machine may experience higher fields over shorter periods of time. An approach to gathering, analyzing, and applying activity data to source field data will be developed, and the model's validity will be tested by comparing the predicted results with those obtained from personal exposure monitors.

Estimated Costs

Milestones

12/96 Assessment model complete
12/97 Analysis of validity complete

D. Develop Recommendations for Guidelines for Environment-Specific Field Measurement

Objective: To develop and test widely applicable guidelines and procedures for performing and reporting environment-specific field measurements.

Estimated Costs
This project will consider given environments as a whole and investigate the field exposures that people might experience within each environment. The project will produce a manual of recommended guidelines for characterizing field environments. These guidelines will address such factors as instrumentation requirements, measurement procedures, modifications in approach based on activity and use patterns, temporal and spatial variations, methods for describing sources and environments, and methods for reporting data and associated statistics.

Milestones

12/95 Recommendations for guidelines
06/96 Guidelines issued
06/98 Guidelines updated

Estimated Costs

$125,000 FY 94
$ 75,000 FY 97

E. Conduct Environmental Field Surveys

Objective: To conduct a series of preliminary surveys of fields in various environments in order to collect information on field levels and the contributions of individual sources to the total field level in the surveyed environments.

The project will produce descriptions of survey methods in each environment as well as complete survey results, including data analysis of environmental fields, major field sources in each environment, and cross-environment comparisons of field sources. Also, options for statistically validating the survey results will be presented. A portion of the field surveys will be performed by the National Institute of Occupational Safety and Health. Their expertise and experience in this area is expected to be a valuable component of this program.

Milestones

12/95 Preliminary environments characterized
12/98 Final combined report

Estimated Costs

$250,000 FY 94
$500,000 FY 95
$500,000 FY 96
$500,000 FY 97
$500,000 FY 98

F. Develop Recommendations for Guidelines for Field Source Measurement

Objective: To develop and test guidelines and procedures for performing and reporting field source measurements.

This project specifically addresses the measurement of fields associated with individual sources and will produce a manual of recommended guidelines for measuring those sources. The guidelines will provide measurement personnel with all the information necessary to perform measurements in a standardized way, including instrumentation requirements, measurement procedures, and formats for reporting data and summary statistics.

Milestones

12/95 Recommendations for guidelines
06/96 Guidelines issued
06/98 Guidelines updated

Estimated Costs

$125,000 FY 94
$ 75,000 FY 97
G. Conduct Source Characterization Projects

Objective: To develop complete information on specific sources, such as appliances and equipment, and source groups for use in exposure assessment and field management projects.

Milestones
12/96  Interim report
12/98  Final report

Estimated Costs
$100,000 FY 95
$50,000 FY 96
$50,000 FY 97

H. Conduct Source Modeling

Objective: To develop a model for predicting fields associated with sources.

The procedure will entail developing mathematical models of a source, and then performing measurements to verify the models. Once verified, the models can then be quickly and economically applied to similar sources. Modeling offers the ability to predict field levels at any desired location during analysis without performing further measurements. Models can also be used to predict the effects of design changes without incurring the costs of constructing prototypes. Computer models of transmission lines, substations, and distribution lines are currently available or being developed, so this program will focus more on modeling of fields from appliances and commercial and industrial sources.

Milestones
02/95  Decisions about which sources to model
06/95  Requests for proposals published

I. Develop EMF Measurement Database

Objective: To establish an EMF Measurement Database.

This project is an initial effort to make available original exposure assessment and measurement data and to set standards for new field measurement data to be included in the database. This project will produce a preliminary EMF Measurement Database and a document outlining the contents and format of that database, information on accessing the database, and instructions on how information can be submitted for inclusion in the database. The database will be one component of the EMF information clearinghouse being developed by NIEHS in cooperation with DOE. The database will include existing EMF data and measurement information. Every attempt will be made to coordinate this work with EMF researchers, so that the new database will be compatible with existing databases, and include relevant measurement information.

Milestones
12/95  Database operational

Estimated Costs
$100,000 FY 94
$100,000 FY 95
$100,000 FY 96
$100,000 FY 97
$100,000 FY 98
**J. Develop Instrumentation Evaluation Procedures**

Objective: To establish an interagency agreement between DOE and the National Institute of Standards and Technology (NIST) for the development of a set of protocols and procedures for the evaluation of EMF measuring instrumentation.

The product will be a complete set of instructions that will enable independent testing laboratories and equipment manufacturers to evaluate the relevant instrumentation parameters.

**Milestones**

- 06/96 Draft report format
- 12/96 Final report forms and instruction packet distributed
- 12/97 Program effectiveness evaluated

**Estimated Costs**

- $50,000 FY 95
- $50,000 FY 97

**K. Develop Instrumentation Specifications and an Evaluation Report Format**

Objective: To develop a reporting format for instrument and exposure system manufacturers who have had independent evaluation of their systems, allowing information about their systems to be voluntarily reported through the clearinghouse.

This will assist researchers planning exposure assessments and epidemiological studies in obtaining up-to-date information about the instruments most suited for their purposes.
2.2 FIELD MANAGEMENT

2.2.1 Objectives

To evaluate the costs, benefits, and effectiveness of options for managing EMF exposures from a variety of sources, such as transmission and distribution lines, electric wiring in buildings, appliances, commercial and industrial equipment, and transportation systems.

If needed, to develop new techniques for field management including engineering changes to reduce, avoid, or eliminate certain fields or field characteristics.

2.2.2 Rationale

The public, many utilities, some industries, some state and local governments, and others are interested in finding ways to minimize field exposures now, rather than waiting for the outcome of the scientific research. Some maintain that it is an appropriate conservative approach in the face of uncertainty regarding health effects from EMF exposure. Questions about the relative importance of various sources must be addressed, but there is considerable interest in methods that could be used for reducing fields from appliances, power lines, house wiring, and industrial sources.

The costs and risks to health and/or the environment associated with various field management options must be considered along with effectiveness, safety, and reliability. This information is especially important to policy makers and will help identify the most appropriate approaches to field management. In some cases, reductions in fields may be achieved with little additional cost as a by-product of more efficient design. The initial assessment of existing field management options in 1995 will provide a basis for determining if support for projects to develop field management options is appropriate for this program. All development projects undertaken in this area will be closely coordinated with industrial and utility participants to maximize project usefulness, to minimize overlap with other projects, and to seek co-funding of projects where feasible.

2.2.3 Background

There are three basic approaches to field management. They are cancellation, avoidance, and shielding. The first approach involves the use of cancellation techniques, including the design and use of source and/or auxiliary conductors to produce opposing fields that tend to cancel each other out. Reducing the separation between transmission line conductors will also lead to a cancellation effect, thereby reducing the field. Cancellation techniques may be passive (as in the case of reduced conductor spacing) or active. In Sweden, transmission line fields are actively reduced over short distances by sending currents on additional conductors that run parallel to the power conductors. The level of current in these additional conductors is adjusted to produce opposing fields, which then cancel the fields produced by the power conductor. EPRI is researching active and passive techniques at HVTRC. DOE, along with EPRI, ESEERCO, and others, sponsored construction of a prototype high-phase-order transmission line that transfers more power. A secondary benefit of this configuration is that it produces lower magnetic fields at the edge of the right-of-way as a by-product of line configuration.

The Tennessee Valley Authority (TVA), the State of Florida, the Bonneville Power Administration (BPA), EPRI, and ESEERCO have conducted studies to evaluate various transmission line conductor configurations and other
options, including both active and passive field reduction techniques. These studies resulted in the identification of several design and engineering options for field management. From the results of these studies, and others, additional research needs have been identified. EPRI and TVA are developing field computation software as a tool for designing reduced field configurations. EPRI is also funding research at Ohio State University into possible options for reducing fields from substations.

Magnetic fields in the home are produced by a variety of sources, and field management techniques will vary according to the type of source. A number of studies have indicated that ground currents flowing through pipes and other conductors are a major source of magnetic fields in the home. ESEERCO and EPRI recently completed a study investigating such fields as well as the effects of various wiring practices and codes, and considered methods for field reduction. EPRI is also investigating ground current field reduction techniques at the HVTRC. Present grounding practices are determined by the shock and fire safety guidelines of the National Electric Code, and also by the National Electrical Safety Code.

The second approach to field management, avoidance, simply involves increasing the distance between the EMF source and people. An example of this is siting new electrical facilities in remote areas and/or away from population centers whenever practical.

The third approach to managing fields utilizes materials with high magnetic permeabilities to shield or attenuate the source fields. Shielding of magnetic fields requires the use of high permeability ferromagnetic or superconducting materials. High-temperature superconducting materials are under development for specialized applications, but are not suitable for most shielding applications, except possibly in the case of advanced rail systems. As presently fabricated and used, non-superconducting ferromagnetic shielding materials require special forming and annealing processes. In use, their shielding properties may be degraded by shock and deformation. The processing required makes these materials relatively expensive, which limits their use in many retrofit shielding applications.

There may be a need for new classes of shielding materials that are more flexible than presently available materials for shielding of low flux density local magnetic field sources and/or their targets. If demonstrated to be cost effective, the new materials would find application in shielding of magnetic field sources, such as electrical cables, small-scale electrical equipment in industry, and electrical devices in the home. An example of such an application would be the vacuum deposition coating of such materials on the interior of existing small appliance casings in order to reduce their stray magnetic fields. Proposed approaches to the development of materials for passive shielding include multi-layer thin film composites (DOE/PNL) and high permeability metal impregnated polymers. Research to develop shielding materials, if conducted under the RAPID Program, will not replace or duplicate work already being performed by the private sector.
2.2.4 Projects

A. Evaluate the Effectiveness, Costs and Environmental Impacts of Field Management Options

Objective: To fully analyze the effectiveness, safety, reliability, environmental impacts, and associated costs of various field management options.

There are many different kinds of field sources and each one may require its own field management strategy. Even the same source may require different strategies depending upon where the source is located in relation to people. For example, field management strategies for power transformers and switchgear that are located in large commercial buildings would probably be different from strategies for substations located along a powerline corridor. Field-producing sources that may need to be managed include electric power generation, transmission, and distribution systems, appliances, house and building wiring, and commercial and industrial equipment. DOE will work closely with concerned industries when evaluating field management options.

For each source category, a list of approaches to field management will be developed, cost data will be gathered, possible environmental or safety concerns will be analyzed, and expected exposure reductions quantified. Additional projects will explore the implementation of field management options and non-technological approaches by State and local governments and industries. As all projects are implemented, relevant industries and research bodies will be solicited for advice and input. Information will be made available to decision makers through the EMF clearinghouse and other communication vehicles. Workshops for various decision makers, such as state regulators, will be held to exchange information about current approaches to field management, how these approaches are working, and to determine what still needs to be done. With information gathered from these assessment activities, future field management activities will be planned.

Milestones

12/96 Initial assessment of field management options and needs

Estimated Costs

$250,000 FY 95
$ TBD FY 96 and beyond

B. Develop New Field Management Strategies (If Justified)

Objective: To develop new field management strategies in response to identified and documented needs.

These projects may include the development of new technologies, innovative adaptation of existing technologies, or non-technical strategies, such as policy or voluntary actions. Projects will typically include a pilot test and demonstration phase involving an actual application of the new strategy. Advice from the EMF Interagency Committee and the National EMF Advisory Committee will be sought before field management development activities are initiated.

Milestones

$ TBD

Estimated Costs

$ TBD FY 96 and beyond
2.3 QUALITY ASSURANCE

2.3.1 Objective

To ensure that the studies supported under the EMF RAPID Program are conducted in a manner that assures that they are of excellent quality in terms of design, execution, and documentation.

2.3.2 Rationale

In order for results from EMF studies carried out under the RAPID Program to be fully credible to the scientific community as a whole and to be useful in guiding policy decisions, investigators conducting such studies will need to demonstrate that experiments have been designed and conducted in accordance with generally accepted scientific practices. Quality assurance issues for EMF experiments fall into two categories: laboratory guidelines that apply to all biology and health studies, and which include the generally accepted criteria for all scientific experiments; and those activities that ensure that the exposure conditions for experiments are carefully understood, controlled, measured, and documented. Studies of possible EMF biological or health effects require expertise in a number of disciplines. Life scientists may not be familiar with all of the subtleties associated with EMF exposure systems nor the opportunities for inadvertent exposures from sources in the proximity of the experimental apparatus.

2.3.3 Background

The U.S. Department of Energy has conducted an EMF quality assurance program for over a decade. This program is implemented by a team consisting of physicists, engineers, life scientists, and consultants who regularly visit laboratories conducting EMF research. The team evaluates exposure systems and experimental procedures and makes recommendations for improvements. Oak Ridge National Laboratory, a DOE facility, organizes and manages the team. Measurement standards support is provided by a physicist from the National Institute of Standards and Technology. The services of this team are sometimes offered to EMF research groups besides those sponsored by DOE and NIEHS. Such collaboration and cooperation between research-sponsoring agencies helps to coordinate research activities and disseminate information about the best available approaches to exposure and, also, the best experimental techniques.

2.3.4 Projects

A. Expand Quality Control Team Duties

Duties will include site visits and reviews of NIEHS-supported researchers in addition to DOE-supported researchers. Quality assurance activities provided for the new projects will have the same goals as those of the existing program. These goals are:

Present research results in an open manner and implement a peer review process. The Annual EMF Research Review Meeting will be continued as an open forum for presentation and discussion of results.

Ensure that EMF research is conducted with multi-disciplinary scientific teams, including biologists, engineers, and, as appropriate, other specialists. Experience has shown that EMF research conducted by either engineers or biologists alone can lack either relevance to public health or quality in exposure assessment and dosimetry. The concept of multi-disciplinary teaming to obtain the best quality EMF research is not new, but it
should be expanded to include all projects.

**Review instrumentation and analytical tools continually to assure the very best quality results.** In recent years, some EMF laboratories have found their analysis of results limited by the lack of high-quality instrumentation and other analytical tools. A careful analysis should be made on a regular basis to determine the adequacy of these most important tools.

Ensure strict and complete documentation of all results and support independent interlaboratory replication of important findings. To replicate adequately, detailed information must be reported by the researchers. For example, all research teams should validate, at the beginning and throughout the life of the project, the exact characterization of all fields in the vicinity of the experiment. This is especially critical for all imposed intermittent and/or varying fields. Every project has the potential to uncover unique and important findings. Strict documentation of the conditions leading to new findings will allow others to replicate the research.

**Estimated Costs**

- $80,000 FY 95
- $120,000 FY 96
- $120,000 FY 97
- $80,000 FY 98
## APPENDIX I

### EMF RAPID Program Engineering Projects

<table>
<thead>
<tr>
<th>Exposure Assessment &amp; Source Characterization Projects</th>
<th>FY 94</th>
<th>FY 95</th>
<th>FY 96</th>
<th>FY 97</th>
<th>FY 98</th>
<th>Project TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Develop Recommendations for Guidelines for Personal Exposure Measurement</td>
<td>125</td>
<td>75</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>B. Conduct Human Exposure Assessment Projects</td>
<td>150</td>
<td>750</td>
<td>750</td>
<td>750</td>
<td>500</td>
<td>2,900</td>
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<td>C. Develop Exposure Prediction Model</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Develop Recommendations for Guidelines for Environment-Specific Field Measurement</td>
<td>125</td>
<td>75</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Conduct Environmental Field Surveys</td>
<td>250</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>2,250</td>
</tr>
<tr>
<td>F. Develop Recommendations for Guidelines for Field Source Measurement</td>
<td>125</td>
<td>75</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Conduct Source Characterization Projects</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Conduct Source Modeling</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Develop EMF Measurement Database</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>500</td>
<td></td>
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<td>J. Develop Instrument Evaluation Procedure</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K. Develop Instrumentation Specifications and Evaluation Report Format</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>875</strong></td>
<td><strong>1700</strong></td>
<td><strong>1650</strong></td>
<td><strong>1875</strong></td>
<td><strong>1100</strong></td>
<td><strong>7,200</strong></td>
</tr>
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</table>

### Field Management Projects

| A. Evaluate the Effectiveness, Costs and Environmental Impacts of Field Management Options | 250 | TBD | TBD | TBD | 250 + TBD |
| B. Develop Novel Field Management Strategies (If Justified) | TBD | TBD | TBD | TBD |
| **Subtotal** | **250** | TBD | TBD | TBD | **250 + TBD** |

### Quality Assurance Projects

| A. Expand Quality Control Team Duties | 80 | 120 | 120 | 80 | 400 |
| **TOTAL** | **875** | **2030** | **1770** | **1995** | **1180** | **9,600 + TBD** |

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October 1994

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APPENDIX II

ANTICIPATED DIVISION OF TOTAL FUNDS FOR THE FIRST YEAR

RAPID Program Funding Distribution

Health Effects Research 65%
Cellular Studies 25%
Animal Studies 25%
Replication Research 10%
Directed Research 5%
Engineering Research 15%
Risk Assessment 10%
Communication 5%
Administration, Review, and Monitoring 5%
APPENDIX III

SUPPORTING DOCUMENTS


2. Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program Research Agenda and Communication Plan; The EMF Interagency Committee; May 1994.


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APPENDIX K:

EMF RAPID PROGRAM IMPLEMENTATION PLAN FOR COMMUNICATION*

* Published separately by the U.S. Department of Energy as DOE/EE-0037

December 1995
EMFRAPID

Electric and Magnetic Fields
Research and Public Information Dissemination Program

Implementation Plan for Communication

October 1994

A joint project of the National Institute of Environmental Health Sciences and the U.S. Department of Energy
1.0 INTRODUCTION

The Electric and Magnetic Fields (EMF) Research and Public Information Dissemination Program (RAPID) is required by law [Section 2118 of Public Law 102-486] to provide information to the public regarding four aspects of the EMF issue: possible human health effects; the types and extent of human exposure; technologies for measuring and characterizing fields; and methods for assessing and managing exposure.

Under this program, the Department of Energy (DOE) and the National Institute of Environmental Health Sciences (NIEHS) share responsibilities for developing and distributing this information. DOE and NIEHS will coordinate public information activities to meet the needs of both technical and general audiences. Both agencies recognize that this program is not without precedent. Public information efforts regarding various aspects of the EMF issue have been initiated by several federal and state agencies as well as by the private sector.

This plan assumes that effective and timely communication of information about EMF requires the utilization of communications skills and information dissemination networks already established. All appropriate networks will be identified and engaged in communication of credible and understandable information.

The EMF Interagency Committee, which includes representatives from nine federal agencies, including DOE and NIEHS, is responsible for setting the research agenda for the EMF RAPID Program. In May 1994 the Interagency Committee published the EMF RAPID Program Research Agenda and Communication Plan, a document which provides strategic direction for the program. The National EMF Advisory Committee provided guidance to the EMF Interagency Committee and continues to advise NIEHS and DOE regarding implementation of the program. The plan presented here describes how the communication component of the EMF RAPID Program will be implemented. This plan is consistent with the Interagency Committee's strategy and with the guidance provided by the Advisory Committee.

[Note: In addition to DOE and NIEHS, the law requires that the EMF Interagency Committee include representatives of the following federal agencies: Environmental Protection Agency (EPA), Department of Defense (DOD), Occupational Safety and Health Administration (OSHA), National Institute of Standards and Technology (NIST), Department of Transportation (DOT), Rural Electrification Administration (REA), and Federal Energy Regulatory Commission (FERC). Although not an official member, a representative from the U.S. Department of the Interior attends the regular committee meetings as well.]

2.0 BASIC ASSUMPTIONS

This strategy is based on the following assumptions:

1. The EMF issue is of very high public concern. A series of random polls by Cambridge Report/Research International, shows that familiarity with the issue, concerns over health impacts, and public willingness to take strong action to reduce exposures have been increasing steadily over the last five
years. Everyone who uses electricity has a stake in this issue.

2. **Information is needed now.**
   Decisions about EMF are being made now by businesses, private individuals, public utility commissions, state and local governments, and many others. Although current science is uncertain about the possible health consequences of EMF exposure, useful information does exist and can be communicated to the public to help inform these decisions. It is not the purpose of the EMF RAPID Program communication component to reach premature conclusions about the health effects of EMF. Rather, the program will provide as complete a picture as possible of what is currently known about EMF. Initially, the message will reflect the uncertainty and complexity of the state of the science, and will report on what the federal government is doing to reduce that uncertainty. It is important to note at the outset that the main goal of the RAPID program--and the principal responsibility of NIEHS under this program--is to acquire the scientific data necessary to learn whether EMF exposure presents a hazard to human health. If it is determined that such a hazard exists, then the magnitude of the risk must be quantified. Ultimately, this information is the message to be communicated to the public and to Congress. In the event that the scientific data suggest that no hazard to human health exists, then this message must be effectively communicated. The pursuit of the ultimate "answer" to the EMF question does not negate the RAPID program's responsibility in the meantime to provide the best information it can.

3. **The public can understand and accept uncertainty.** Decisions often have to be made with incomplete information. Continued uncertainty cannot be used as an excuse for inaction or avoidance of responsibility, nor can it be used as an excuse for official silence on the EMF issue. The provision of accurate information to the public is most difficult, yet perhaps most crucial, when an issue is emerging, when questions give rise to more questions, and when every policy option, including inaction, entails risk. A sincere effort to offer information to the public as the information becomes available allows everyone, the scientific community and the general public as well, a better understanding of the issue and an opportunity to influence public policy.

Thomas Jefferson put it this way:

> I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion.

4. **The messenger matters.** Many current sources of information about EMF are perceived by the public to be lacking. People question the objectivity of industry sources and the accuracy of media reports. The EMF RAPID Program public information effort is intended to help fill this gap. NIEHS and DOE will work together, soliciting participation from a broad range of interested groups, both public and private, to develop informational materials that meet both agencies' standards of accuracy and objectivity and that address the questions people really ask. During the development process, DOE and NIEHS will solicit advice from
both the EMF Interagency Committee and National EMF Advisory Committee. In addition, federal agencies that serve on the EMF Interagency Committee will have the opportunity to endorse informational materials.

NIEHS and DOE will make full use of existing channels to distribute EMF information. Federal hotlines already in operation at the U.S. Environmental Protection Agency (EPA) and at the National Institute of Occupational Safety and Health (NIOSH), will be given materials developed by the EMF RAPID Program for distribution. Materials will also be provided to other groups with public information networks and constituencies already established. Groups such as the American Public Health Association, state associations of attorneys general, state and local health departments, the Conference of (State) Radiation Control Program Directors, the National Governors' Association, the American Cancer Society, and grassroots citizens' organizations will be enlisted to help the EMF RAPID Program design, review, and distribute informational materials. A preliminary list of organizations that may be involved in the EMF RAPID Program public information effort is found in Appendix I on page 8.

Both NIEHS and DOE assume their public information responsibilities with certain limitations that stem from their primary missions. As the agency responsible for carrying out health-related EMF research, NIEHS must not appear to jump to conclusions in any of the public information materials produced, until research results warrant a conclusion. Interim public information development tends to pull toward simplification, distillation, and drawing conclusions where possible. The tension here is obvious, but not insurmountable, and is likely to yield products which are held to high standards of accuracy as well as readability.

Some people wonder how the U.S. Department of Energy, the agency responsible for ensuring the nation's energy supply, can be objective about whether EMF exposure has consequences for human health. On the other hand, DOE is viewed as the government expert on many aspects of the EMF issue, such as how to assess EMF exposure and what practical options are available to reduce exposure. Public information materials which combine DOE technical expertise with NIEHS experience and responsibility for public health issues are likely to have enhanced credibility with the public.

5. Communication is a two-way process. The government must be able to hear what people are asking about EMF and not just answer what is most easily answered. At present, neither DOE nor NIEHS are necessarily the first government agencies people turn to with their EMF-related questions. To have a better grasp of what is most on the minds of the public regarding EMF, DOE and NIEHS need to tap into other networks regularly, such as utilities' public liaison offices, government agencies such as the U.S. EPA, state and local health agencies, public utility commissions, public officials' offices, labor organizations, environmental groups, and civic organizations.

The EMF RAPID Program will cofund the U.S. EPA's "EMF Infoline," which began operating in May 1994. The infoline will respond to general public inquiries about EMF and will also give feedback to the EMF RAPID Program about what aspects of the EMF issue are of most concern to people. Both NIEHS
and DOE plan to have a designated ombudsman for the EMF program who can convey the complexities of the issue to lay audiences, and disseminate information from the public for federal program managers.

6. Technical information on EMF must be better organized and quickly shared with those who need it. To address this need, NIEHS and DOE will establish a Biomedical Science and Engineering Information Clearinghouse to collect and distribute scientific and technical information on EMF. The clearinghouse and its databases will be as comprehensive as possible, including not only information about current research and development funded under the new national EMF program but also information from the various literature reviews that have been compiled and reviewed by scientific panels in recent years, information about all federally funded EMF-related research, and privately funded research as well, to the extent that such information is available.

7. The potential audience for EMF public information materials is as diverse as the American public. People with widely varying technical abilities, educational backgrounds, and financial resources have questions and concerns about EMF. In accord with our commitment to environmental equity, the RAPID Program seeks to make information available and accessible to everyone.

Information must be presented in different formats and varying degrees of detail, depending on the audience. Among the first public information materials to be developed by the EMF RAPID Program will be a general public information booklet, available in both English and Spanish, which presents detailed responses to questions people often ask about EMF. The audience for the general public information booklet is presumed to be educated but not necessarily technically-oriented. In addition to the general booklet, public information materials will be designed for specific audiences such as: workers in various occupations; state and local health officials; students; parents, teachers and school officials; the news media; home buyers and tenants; measurement and control technicians; and policymakers.

3.0 COMMUNICATION PROJECTS

A. EMF Biomedical Science and Engineering Information Clearinghouse

Headquartered at NIEHS but closely coordinated with DOE, the EMF Biomedical Science and Engineering Information Clearinghouse will provide computerized databases and reports containing EMF technical information, scientific literature, descriptions of research in progress, and research reviews for researchers and anyone else who has an interest. This clearinghouse will serve as the central repository for technical and scientific and regulatory information about EMF. It will be accessible through the Internet.

There have been several recent reviews of the scientific literature regarding EMF, compiled and analyzed by panels of scientists convened by various organizations and state agencies. There is also a commercially-available EMF bioeffects database. These will be employed as appropriate for this element of the communications program.
It is anticipated that this activity will be carried out under contract, with close supervision by NIEHS. Decisions about what to include in the database will be made by NIEHS. The EMF Clearinghouse will provide for the review and aggregation of existing literature chronologically by scientific discipline (e.g., epidemiology, toxicology, biology, human exposure measurement, etc.) and by useful sub-categories (e.g. disease end-point, signal transduction, melatonin, magnetite, etc.) This literature will be evaluated for its relevance and potential value (e.g., published v. non-published or peer-reviewed v. non-peer-reviewed), as part of the peer review process.

The database will be augmented with information on scientific research in progress inside and outside the federal government. In support of the EMF Clearinghouse, initiatives will be funded to:

- Identify and gather summaries of research studies conducted and supported by state and federal government agencies. Possible sources include information from members of the EMF Interagency Committee about their respective agencies' research activities, searches of Public Health Service and National Institutes of Health grants and contracts, and electronic databases.

- Identify and gather summaries of research studies conducted or supported by other groups. Possible sources include the Electric Power Research Institute (EPRI), professional societies such as the Bioelectromagnetics Society (BEMS), and key scientists in the field.

- Create a database of current research (including summary of hypothesis, methods, and specialized equipment and techniques) by scientific discipline, investigator, and timeline for completion.

- Integrate the Current Studies database into the Literature database.

The EMF Clearinghouse will include in the database each of the health effects research studies specifically initiated as a part of the EMF RAPID Program.

Also as part of this effort, articles and periodic newsletters will be provided to the research community and others regarding such topics as:

- achieving laboratory exposures at environmental levels;
- protocols for creating laboratory exposures and assessing environmental exposures;
- controlling for ancillary EMF exposure;
- subject exposure scaling; and
- extrapolating from sources to exposure.

**Milestones**

- 12/94 Contract awarded
- 12/95 Clearinghouse operational
Estimated Costs

<table>
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<th>FY</th>
<th>Cost</th>
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B. EMF Infoline

Available through a toll-free number [1-800-363-2383], the EMF Infoline provides information for the general public in response to basic questions about EMF. The Infoline is not intended to answer specific technical questions; operators refer such questions to the appropriate agency. The U.S. EPA manages the Infoline, with support from and in consultation with the RAPID Program.

The EMF Infoline will distribute up-to-date information generated by the RAPID Program and other federal EMF programs. Information from the EMF Biomedical Science and Engineering Information Clearinghouse will feed the Infoline as well.

Infoline operators will collect information about calls they receive, providing feedback for the RAPID Program about public concerns and information needs. A Spanish-speaking operator will be available.

Milestones

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>5/94</td>
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Estimated Costs

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C. General Public Information Booklet

This booklet will provide background information for the general public about what we know and don’t know about EMF. It will be developed jointly by DOE and NIEHS, reviewed by the EMF Interagency Committee and the National EMF Advisory Committee, and will be widely distributed. A Spanish language version will also be developed.

Two revisions are planned—one in 1996 and one in 1998. Revisions will reflect latest research findings as well as feedback from the public and communication experts.

Milestones

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<td>9/95</td>
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Estimated Costs

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D. EMF Information Materials for Specific Public Audiences

Information drawn from the general public information booklet will be presented in formats suited to various audiences including: workers in various occupations; students and school personnel; and home buyers and tenants. As with the general public information.

October 1994
booklet, these materials will be reviewed by the EMF Interagency Committee and the National EMF Advisory Committee and distributed through various networks. A brief brochure designed to inform potential contributors and participants about the background and goals of the EMF RAPID Program has been prepared and will be updated when necessary.

**Milestones**

- **5/94** Draft program brochure developed
- **8/94** Program brochure published and distributed
- **6/95** Brochure for workers drafted, reviewed
- **6/95** Brochure for home buyers and tenants drafted
- **12/95** Final brochure for workers published
- **12/95** Final brochure for home buyers and tenants published
- **12/95** Materials for students, teachers drafted
- **6/96** Final student/teacher materials published
- **9/97** Materials updated
- **9/98** Materials updated

**Estimated Costs**

- $25,000  FY 94
- $50,000  FY 95
- $50,000  FY 96
- $50,000  FY 97
- $50,000  FY 98

**E. EMF Sourcebook for Public Information Resource People**

For staff of DOE, NIEHS, and other federal and state agencies who are often asked to address the public about EMF-related issues, DOE and NIEHS will develop an EMF Sourcebook, patterned after one developed by the EPA, containing key EMF reference materials: a listing of public information documents and information about how to order them; a list of knowledgeable EMF contacts in government, industry, and private organizations; research reviews; Section 2118 of the 1992 Energy Policy Act; summaries of state legislation on EMF; and a generic background briefing on EMF. The EMF Sourcebook can also be distributed to libraries, schools, county extension offices, utilities, manufacturers, employers, unions, and other groups with an interest in EMF-related issues.

**Milestones**

- **8/95** Review draft
- **12/95** Document finalized
- **4/96** Publish and distribute

**Estimated Costs**

- $25,000  FY 94
- $25,000  FY 95
- $25,000  FY 96

**F. Handbooks for State and Local Health Officials**

Health officials need detailed information regarding such issues as: field measurement techniques and equipment, exposure metrics, and practical methods for avoiding or reducing exposures. NIEHS and DOE will develop this information together, with input from state health officials and the Centers for Disease Control. A looseleaf format for the handbook will enable its users to update it periodically, as new research information becomes available.
Milestones

8/95 Handbook published
8/96 Handbook evaluated
8/97 Update information published
8/98 Update information published

Estimated Costs

$25,000 FY 94
$25,000 FY 95
$25,000 FY 96
$25,000 FY 97
$25,000 FY 98

G. Information for Policymakers

Many state legislators, public utility commissioners, and other public officials are faced with decisions about powerline sitings and other EMF-related controversies and urgently need better information on which to base their decisions. Concise fact sheets will be prepared, highlighting research results and summarizing current knowledge about such topics as:

- typical magnetic field strengths and how these are used in epidemiological studies to differentiate between exposure groups;

- comparing powerline exposures with EMF exposures from other sources;

- options for reducing EMF exposures from transmission and distribution lines and other sources;

- costs, safety, and reliability of various EMF reduction technologies;

- what exposure to EMF means since relevant parameters are unclear; and

- EMF-related policies being considered by state and foreign governments.

DOE and NIEHS will work together to develop these fact sheets and update them periodically.

Milestones

9/95 Review drafts of first products
2/96 First products distributed

Estimated Costs

$25,000 FY 95
$25,000 FY 96
$25,000 FY 97
$25,000 FY 98

H. Information for Measurement and Control Technicians

DOE will develop information for the growing EMF measurement and control industry regarding issues such as:

- specifications for measurement equipment;

- methods and materials for managing or mitigating fields;

- making a distinction between sources and exposure;

- advice about what to measure, what to control, and how to communicate effectively with the public.

Developing and disseminating this type of information will be an ongoing effort, closely tied to the DOE engineering research program.
Milestones

7/96 1st edition of manual
7/98 2nd edition of manual

Estimated Costs

$50,000 FY 95
$50,000 FY 98

I. Information for the News Media

Information will be designed specifically for use by print and broadcast news media. Products will include background information packets, reports on current research and program developments (via computer bulletin board and press releases), and lists of key contacts inside and outside of government.

Milestones

12/95 Media packets available.
Information updated throughout the program

Estimated Costs

$50,000 FY 95
$50,000 FY 96
$50,000 FY 97
$50,000 FY 98

APPENDIX I

Listing of Organizations Expected to Participate in the EMF Public Information Dissemination Program:

* Federal government agencies
* State and local health agencies
* State and local electric utility regulatory agencies
* University-based communications and information experts
* Health care providers
* Electric utilities
* Private, non-profit research organizations
* Industry and trade associations
* Labor organizations
* News media
* Community groups
* Environmental groups
* Scientists and their professional associations
* Elected officials (local, state, federal)
* Standards setting bodies
* Engineers and EMF Measurement experts

Note: The EMF RAPID Program welcomes the participation of organizations that have an interest in public information about EMF. To be included on this list, please contact: Lynne Gillette, EMF Research Program Manager, U.S. Department of Energy, 1000 Independence Avenue, SW (EE-141), Washington, DC 20585.
## APPENDIX II

### EMF RAPID Program Communication Projects

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APPENDIX III

RAPID Program Funding Distribution

Health Effects Research 65%
Cellular Studies 25%
Animal Studies 25%
Replication Research 10%
Directed Research 5%
Engineering Research 15%
Risk Assessment 10%
Communication 5%
Administration, Review, and Monitoring 5%
APPENDIX IV

SUPPORTING DOCUMENTS


2. Electric and Magnetic Fields (EMF) Research and Public Information Dissemination (RAPID) Program Research Agenda and Communication Plan; The EMF Interagency Committee; May 1994.


APPENDIX L: EMF RAPID PROGRAM DOCUMENTS CURRENTLY AVAILABLE


D. EMF RAPID Program: Implementation Plan for Health Effects Research and Risk Communications (DOE/EE-0038), National Institute of Environmental Health Sciences (NIEHS), October 1994.


H. Questions and Answers About Electric and Magnetic Fields Associated with the Use of Electric Power (DOE/EE-0040), DOE and NIEHS, January 1995. A Spanish version of this document is also available, (DOE/EE-0050), March 1995.
