THE AEROSPACE CORPORATION

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November 13, 1981

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. Brian Grimes
U. S. Nuclear Regulatory Commission
Division of Inspection and Enforcement
Washington, DC 20555

Dear Brian:

In accordance with our previous conversations, I have enclosed a draft program description to investigate the "Influence of Meteorology on Emergency Response Options". The program reflects an effort to evaluate the benefits (from a planner's point of view) to be obtained from implementing weather-dependent plans for protective actions to reduce public risks from unlikely, but potentially severe nuclear power plant accidents. We realize that it is occasionally necessary to iterate a time or two before a work statement fits a customer's needs exactly and accordingly you may wish to suggest modifications in the program task descriptions. We will be happy to receive your comments and suggestions on changes that you think might be useful in the approach, if you should see any.

In accordance with our earlier discussions, we have configured the program to about a one man-year level of effort. A good engineering estimate of the overall program costs is about $100,000, to be expended over a period of about one year. As a breakdown, the total costs would include about $85,000 of direct labor and $15,000 of other direct costs (including computer, travel, publications, etc.). The "other direct costs" would be weighted heavily toward computer charges on the Aerospace Corporation's CDC 7600.

You may recall that we mentioned the possibility of using an Interagency Transfer of Funds mechanism for funding such an effort. Recent conversations with Denny Ross, Ron Scroggins, and Marty Hayes of NRC/RES have reconfirmed that this mechanism is currently a viable pathway for funding between Aerospace and the NRC. If you need further information on the mechanics of implementing this funding method, either Ron or Marty should be able to tell you about their recent experiences with it.

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I thank you for your interest in the concept of developing a weather-dependent approach to emergency planning. We would be very pleased to perform the study for you, and welcome your review and comments on the program description.

Sincerely yours,

Fred C. Finlayson

Fred C. Finlayson, Manager
Nuclear and Geothermal Systems

FCF:jmf

Enclosure

THE INFLUENCE OF METEOROLOGY UPON NUCLEAR EMERGENCY RESPONSE OPTIONS

1.0 ABSTRACT

Several studies have indicated that relatively uncommon combinations of weather conditions are associated with the calculated cases leading to the most adverse consequences in risk analyses of nuclear power plant accidents. When the onset of rainfall is calculated to occur over a populated area simultaneously with the arrival of the radioactive cloud from a severe reactor core-melt accident, doses to the exposed populace are substantially amplified above normally expected levels. On the other hand, calculations of accidents occurring under steady high velocity wind conditions (without precipitation) have been shown to result in substantial reductions in the ordinary distribution patterns for close-in doses to the exposed population. Emergency planners may be able to use available meteorological forecasts to aid in decision making for protective actions to be taken to mitigate potential consequences to the public, if the planners recognize the implications of weather with respect to their risk reduction options.

In the program outlined below, the relative risks of pursuing weather-independent accident response plans will be compared with the implementation of weather-dependent responses. The potential benefits of implementing "flexible" emergency response plans in accordance with forecasted weather conditions will be assessed. The risk analyses for this study will be performed using the NRC's new CRAC2 (Calculation of Reactor Accident Consequences-2) risk analysis code with its improved meteorological and evacuation procedures models. The results of the risk analyses will be disaggregated in terms of the consequences of individual contributing accident calculations. The discrete calculational results will then be assessed in terms of the effectiveness of various protective action strategies as a function of weather conditions, accident categories and population distributions, etc.

Though the analysis will be run for specific sites, with real population distributions and actual, historical weather data, generalizable results for planning options are anticipated from the study. (The actual sites studies need not be identified in the final documentation.) Idealized models will be developed of weather and accident-dependent emergency plan implementation scenarios from the generalized results of the study. These models will be the basis for the comparisons that will be made of the potential for risk reducing benefits of using flexible, weather-dependent plans for implementing protective action options in nuclear emergencies.

2.0 OBJECTIVES AND SCOPE

The feasibility of developing flexible nuclear emergency response plans for protective actions that can account for weather-dependent influences on public risks will be investigated in this study. Idealized models of weather-dependent response procedures for reducing risks of nuclear power plant accidents will be developed. The idealized procedural models will be based upon an assessment of the risk reduction potential of alternative protective actions strategies under various accident and weather conditions. An assessment will be made of the relative effectiveness of implementing weather-related strategic plans as opposed to the implementation of hypothetical fixed-response procedures. The comparison will be based upon an analysis of the overall risk reduction potential of the two types of strategies as well as the specific effectiveness of the approaches under particularly high-risk accident and weather conditions.

3.0 BACKGROUND

In risk assessments conducted for each of the State of California's four nuclear plart sites (Reference 1) and in a separate study performed independently by the Aerospace Corporation some significant observations became apparent. Statistical data sets for early fatalities (deaths occurring within 60 days of exposure to large doses of radioactivity) that were developed from a large number of calculated severe reactor accident events were found to be very sparsely populated. The set of results generally contained a very small number of isolated early fatality events (frequently only one calculated accident sequence). These few events were generally associated with a relatively large number of early deaths, rather than being an assemblage of a large number of calculated events involving a substantial spread in the number of deaths. A comparison of the mean and maximum early fatality columns of Table 1 will show the basis for these observations. (The statistical analysis from which the results of Table 1 were derived contains the equivalent of approximately 5000 separate calculations in the data base for each of the mean values shown in the table.) For example, the Rancho Seco results imply that the maximum early fatality value shown was the only non-zero result in the set of calculated values. A similarly small number of non-zero early fatality values were evidently associated with the results for all the other sites presented in Table 1.

Conversely, a similar comparison of the latent fatality results shown in Table 1 gives evidence that cases involving latent fatalities are more uniformly distributed within the calculated runs included in the statistical data. The data contained a larger number of events that produced latent fatalities because the calculations were performed using the so-called "linear hypothesis" for predicting the effects of low level radiation on cancer induction. This method of calculating the effects of low-level radiation doses was adopted in the numerical analyses for the sake of conservatism. (It was recognized that most biological experts acknowledge that the linear approach exaggerates the apparent effects of low-level irradiation, reference 2.) Unlike the linear model for estimating latent cancer effects from low-level radiation, the accepted model for early fatalities requires exposure to high irradiation levels before death is probable and has an effective limiting dose (of about 400 rem) below which

TABLE 1. STATISTICAL ANALYSIS OF CALCULATED CONSEQUENCES OF EXTREMELY SEVERE (MAJOR CONTAINMENT FAILURE) REACTOR ACCIDENTS

FACILITY	EARLY FATALITIES		LATENT (CANCER) FATALITIES	
	MEAN	MAXIMUM	MEAN	MAXIMUM
DIABLO CANYON	19	27,000	190	2,500
RANCHO SECO	11	77,000	530	11,000
SAN ONOFRE 1	0	55	660	20,000
SAN ONOFRE 2, 3	1	4,800	1,200	46,000
HUMBOLDT BAY	0	23	27	1,900

the probability of death occurring within a short period of time approaches negligible values (cf, Reference 3).

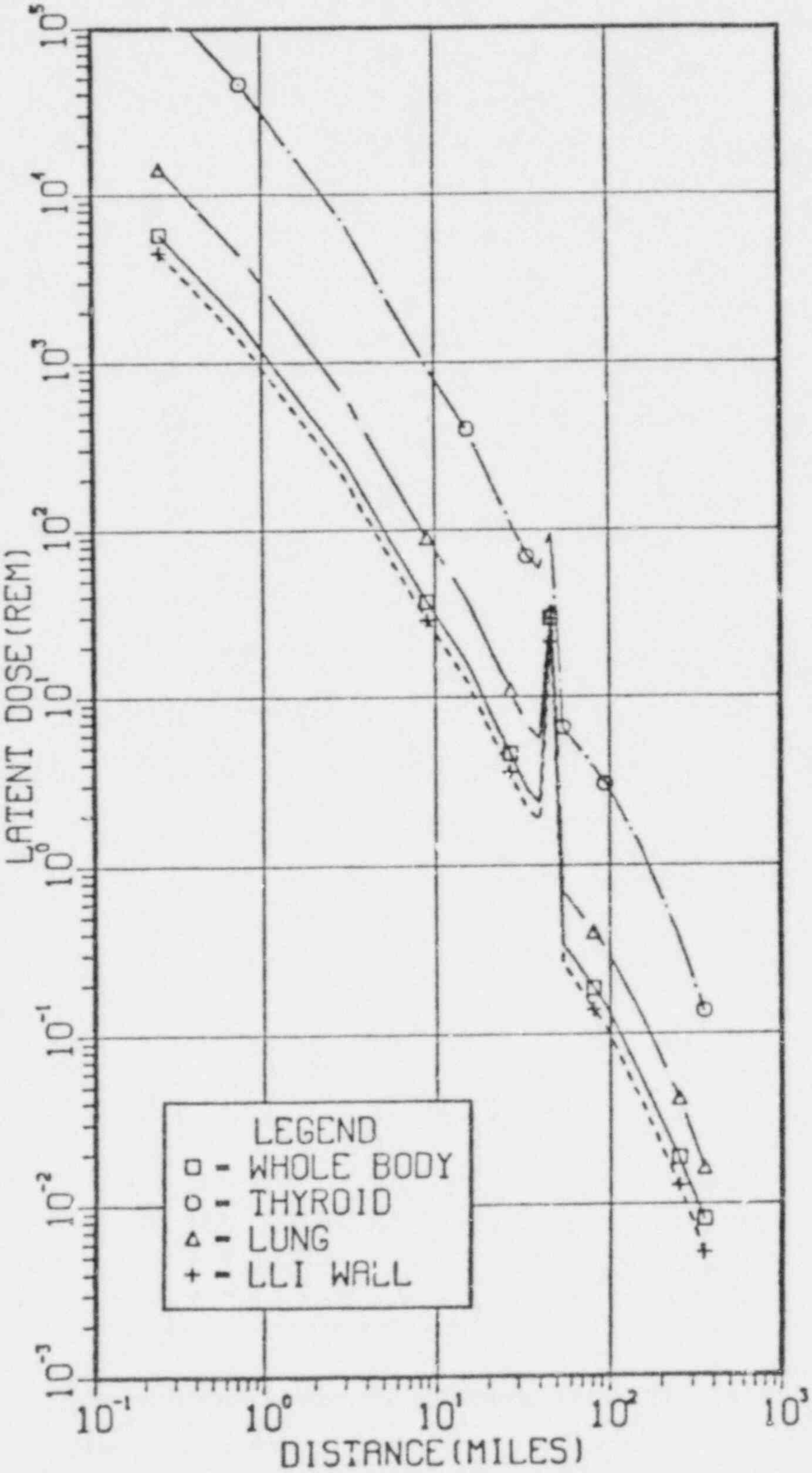
Thus, early fatalities from severe nuclear plant accidents are found to be limited to small geographical locales that are potentially associated with high dose levels. Latent fatalities, on the other hand, were found to be potentially distributed over much broader areas from the same event since no calculational limits were prescribed to the impacts of low dose levels. Thus, in general, most calculated accident sequences lead to development of some latent fatalities at distances where large numbers of people are located. At such distances, doses may reach levels that are sufficiently low so that individual risks of cancer induction approach relatively insignificant levels. However, if the exposed population density is high enough, the linear dose-effects relationships may lead to relatively large projections for overall latent fatalities.

The individual calculational runs from the California study were examined in detail to determine the factors that induced the singular early fatality results. The examination showed that calculational cases with large numbers of early fatalities were limited to events in which either the onset of rainfall occurred precisely as the radioactive cloud front arrived over a densely populated sector, or to circumstances in which high velocity winds decreased to much lower values as the cloud passed overhead.

In Figure 1, an example is presented of dose-distance curves calculated for a particular event. In this event, a clear demonstration of the impact of rainfall on dose distribution from an accident can be seen. In the example, latent dose results are presented. Similar results could be shown for acute doses. In Figure 1, the latent whole-body dose can be seen to be increased by over a factor of 10 when rainfall occurred as the cloud front passed over the terrain about 40 miles from the site of the reactor. It can be seen that subsequent doses (beyond a distance of about 50 miles) fall beneath the extrapolated initial dose-distance trend line by nearly a

Figure 1

SAN ONOFRE CASE 6 (LATENT DOSE CURVES)



factor of ten for regions beyond the rainfall initiation zone. When rainfall occurs over a populated zone while the radioactive cloud is within a relatively short distance of the reactor, such amplification effects could cause doses to reach lethal levels for early fatalities. Dose-distance curves for calculated events associated with substantial slow-downs of winds can also be shown to lead to similar localized dose amplification effects.

The computer model used in the California study to derive the data underlying Table 1 and Figure 1 was a version of the calculation of Reactor Accident Consequences (CRAC) Code. A potentially more efficient method for handling meteorological data in the investigation of the low frequency-high magnitude tail of the statistical fatality curves has been developed in a newly modified version of the CRAC Code, CRAC2. The CRAC2 Code, which is already available at Aerospace, would be adapted for use in the proposed study.

4.0 PROGRAM PLAN

4.1 Task Descriptions

Task 1: Analysis of the Risks for Hypothetical Weather-Independent Procedures for Implementing Emergency Preparedness Plans

A parametric analysis will be made of public health risks for hypothetical, predetermined, singular implementation procedures for nuclear power plant emergencies. The analysis of this task will consider two basic alternative approaches to protective action strategy: implementation of either evacuation or sheltering/relocation procedures irrespective of accident categorical types or weather conditions. The sizes of protected zones and timing of operational procedures for the two protective action strategies will be considered parametrically in the risk analyses. The study will be based upon historical weather conditions and actual population distributions for three California sites; Rancho Seco, Diablo

Canyon, and San Onofre. The sites are useful because they have broadly significant differences in population distribution for close-in, intermediate, and distant ranges (in excess of 50 miles), as well as substantial differences in meteorological conditions. Data for population distributions and multi-year weather conditions are available from a previous study.

Task 2: Analysis of the Effectiveness of Response Procedures by Accident and Weather Categories

Discrete results of individual calculational runs performed in the risk analyses of Task 1 will be analyzed in terms of the relative effectiveness of various protective action strategies under given accident and weather conditions. Results for the several sites will be used to derive generalized observations concerning the strengths and/or weaknesses of the several protective action strategies under consideration for various population distribution conditions, evacuation requirements, etc.

Task 3: Development of an Idealized Model of Weather and Accident Dependent Plan Implementation Scenarios

Simplified models will be derived of "idealized" emergency plan implementation procedures for broad categories of nuclear power plant accidents and weather conditions. The implications of population distributions and dominant (potentially site-dependent) weather characteristics on the procedural models will be assessed.

Task 4: Analysis of the Effectiveness of "Ideal" Plan Implementation Scenarios With Respect To Reduction of Risks For Hypothetical Inflexible Procedures.

Using the "idealized" models of plan implementation procedures developed in Task 3, the public health risks will be reevaluated for the three sites previously analyzed in Task 1. Results of the analysis will be compared with those of Task 1 to determine the potential benefits of applying the "idealized" weather-dependent procedures instead of following a hypothetical, pre-selected, inflexible procedure that does not account for meteorological conditions at the time of the accident. A preliminary assessment will be made of the potential impact of uncertainties in weather forecasting accuracy and prediction of accident types and status on the benefits to be expected from application of weather-dependent procedures.

4.2 Deliverables

The product of this study will be a final report that will address the following topics: (a) an analysis of projected risks for hypothetical inflexible implementation procedures for emergency response plans; (b) results of an analysis of the discrete results contributing to the risk analysis above in terms of the implications of weather and accident categories on potential accident consequences; (c) a presentation of "idealized" models of procedures for implementation of emergency plans in terms of accident and weather categories; (d) an assessment of the benefits and/or disbenefits to be expected from utilizing such idealized, weather-related methods of plan implementation. The results will be analyzed to evaluate features that are generalizable for weather-related plan implementation procedures as opposed to those that are site-specific for this study. A first-order estimate of the effects of uncertainties in weather forecasting and accident projection on the relative effectiveness of idealized or hypothetical fixed implementation procedures will also be provided.

4.3 Staffing

The program will be conducted under the direction of Dr. Fred C. Finlayson, Manager of the Nuclear and Geothermal Systems Office within the

Energy Systems Directorate. Dr. Finlayson, a licensed professional nuclear engineer, has broad experience in the field of assessment of the safety and risks of nuclear power reactors. In his most recent work, he provided technical direction of the probabilistic risk analyses conducted for the State of California's evaluation of Emergency Planning Zone (EPZ) requirements for the nuclear power reactors located within the State's boundaries (e.g., References 1, 4, and 5). Dr. Finlayson was also the Aerospace Corporation's program manager in their technical management support role for the California Energy Commission's study of underground nuclear power plant design and safety. In this program, he directed the extensive studies that were made of both above and underground plant design requirements, costs, and the relative consequence implications of severe accidents (e.g., References 6 and 7). He was also the principal investigator and program manager on the NRC sponsored investigation of the adequacy of human engineering under severe accident conditions in nuclear power plant control rooms. In this study, he supervised a detailed investigation of power plant control systems for Engineered Safety Features (ESF) which involved analyses of ESF fault trees for their interrelationships with operator actions both inside and outside of the control room (e.g., References 8, 9). Dr. Finlayson was also a consultant to the NRC's Rogovin Special Inquiry Group in their investigation of human engineering factors associated with the Three Mile Island incident (Reference 10). He has conducted and directed extensive assessments of the design and effectiveness of ECCS for LWRs, including the analysis performed by the American Physical Society's Review Committee (1975) on Light Water Reactor Safety (e.g., References 11 and 12). In addition, Dr. Finlayson has been a consultant to the NRC and other federal and state governmental agencies on a wide variety of nuclear safety related issues such as site-specific risk analyses, sabotage, waste transport hazards, major reactor test program design and effectiveness and a wide variety of other related topics, including a recent assignment to the NRC's 1980/1981 LOFT Special Review Group. Dr. Finlayson will bring an extensive background in nuclear safety and risk analysis, systems management, and emergency response planning to the program.

In the conduct of the program, Dr. Finlayson will report directly to Dr. Mason B. Watson, Principal Director of the Energy Systems Directorate at Aerospace. Dr. Watson is a licensed professional nuclear engineer. He has been the principal investigator and program manager for many of the nuclear programs conducted at Aerospace (cf, Reference 13 and 14). In addition, he has provided overall supervision to nearly all of the nuclear safety investigations conducted at Aerospace as essentially all of these programs have originated within the Energy Systems Directorate.

The Energy Systems Directorate of the Energy and Resources Division will assume lead responsibility for the conduct of this study. In the performance of the program, Dr. Finlayson will also have a large number of Aerospace technical staff members available for support who have extensive backgrounds in nuclear reactor design and operation, risk and safety analysis, and emergency planning for nuclear power plant accidents. These staff members will be provided from among the over 2200 available support personnel on the technical staff at Aerospace.

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APPENDIX A

1.0 CORPORATE BACKGROUND AND STRUCTURE

The Aerospace Corporation was created in 1960 at the instigation of the U.S. Congress. Its founders designed and dedicated the organization to the resolution of high priority technical problems involving the national security. Throughout the two decades of its existence, Aerospace has contributed its expertise to America's military missile and space activities. In performing its functions (which have been likened to those of a systems architect and engineer) Aerospace provides the technical know-how to support the development of space systems from their conception to completion. As the federal government has increased its technical efforts in order to meet changing national needs and priorities, the scope of Aerospace activities has been broadened to include support of national security related non-defense programs. Included among these needs are advanced and innovative energy systems, energy conservation programs, domestic energy resource development, and environmental technology.

Objective in character, the Corporation is an independent, not-for-profit, public service company, chartered under the laws of the State of California. Aerospace does not engage in manufacturing, have stockholders, or distribute dividends. Earnings are applied to strengthen Corporate scientific and technical capabilities. Aerospace maintains major offices in Los Angeles (El Segundo), California; Washington, D.C.; Germantown, Maryland; New Orleans, Louisiana; Vandenberg AFB, California; Kennedy Space Center, Florida; and Sunnyvale, California. Corporate headquarters are located in its El Segundo offices.

2.0 CORPORATE FUNCTIONS

The Aerospace Corporation has broad experience in planning, systems analysis, systems engineering, and technical management on major programs of national significance. The depth and breadth of its skills in these areas have been thoroughly demonstrated in the many programs where the Corporation has been an active participant during the years since its founding.

Aerospace performs systems level architect-engineer services exclusively for governmental agencies in programs essential to national security. The Corporation directs its activities toward programs that entail high technical content. Most of its efforts are applied to advanced systems involving new technologies; high risk, high payoff, large systems incorporating advanced technologies; the architecture of complex systems; and tasks associated with the planning and conduct of long range research and development programs.

The principal functions performed by the Corporation are: General Systems Engineering and Integration, program planning and technology evaluation, and applied research. General Systems Engineering and Integration has been defined as the application of systems engineering to the overall integration of a system development program. This concept includes the performance of technical analyses and cost tradeoffs needed to define program objectives, articulate system requirements, and set priorities; the synthesis and assessment of complex systems into design concepts in which balanced compromises are made among requirements, costs, technical factors, socioeconomic, and institutional impacts; development of system and subsystem criteria and specifications; definition of interfaces; analysis of system and subsystem design and performance characteristics; assessment of the progress of design and quality of production; supervision of system testing; and certification of the completion of the development process in connection with operational readiness -- all to the extent necessary to ensure economical and timely achievement of program objectives.

The degree to which Aerospace participates in any particular program depends upon the program's nature, time phasing, risk level, technical complexity, the competence of the development contractors and the requirements of the customer. These are the same factors that determine the participation of independent architects and engineers in any major system project.

3.0 STATUS WITH GOVERNMENT

Since its inception, The Aerospace Corporation has been sponsored by the U.S. Air Force to provide its planning and systems engineering services on a long term and privileged basis. Accordingly, the Corporation has been categorized by the Department of Defense (DOD) as a systems engineering Federal Contract Research Center (FCRC). The National Science Foundation has additionally categorized Aerospace as a Federally Funded Research and Development Center (FFRDC). Thus, the operational constraints upon Aerospace's contractual relationships are similar in many ways to those applied to other FFRDC's such as the DOE National Energy Laboratories, etc.

The relationship between Aerospace and the Air Force Space Division is codified in Air Force SAMSO Regulation 800-8, "Policies and Procedures Relating to The Aerospace Corporation Technical Support." This regulation establishes and defines all areas of Air Force/Aerospace interaction.

Aerospace provides technical services in support of programs for which the Air Force is currently expending approximately $3 billion annually. The Corporation's activities for the Air Force are performed under an annually negotiated contract.

4.0 NON-DEFENSE, NATIONAL SECURITY RELATED PROGRAMS

During the past decade, with the expressed encouragement and concurrence of the Federal Government, Aerospace has expanded its activities to include efforts in the civil sector, supporting a variety of non-defense agencies. The scope of the Corporation's continuing activities in support of non-defense agencies has been formalized in a Memorandum of Understanding (MOU) with the Air Force which reflects the Corporation's special status as an FCRC and establishes that its non-DOD work will be consistent with the Corporation's overall commitment to national security. Non-defense efforts contemplated by the Corporation are coordinated with the Air Force consistent with the provisions of the MOU. The MOU with the Air Force has focused the Corporation's attention on issues that are directly related to, or supportive of, national security goals.

Assurance of energy supplies has become a major national security goal. Accordingly, The Aerospace Corporation's national security support of energy-related problems has addressed four major areas of national need:

- o Energy systems
- o Energy conservation programs
- o Domestic energy resource development
- o Environmental technology.

Service to the Department of Energy (DOE) has been by far the largest element of Aerospace's non-defense activities during the past several years. Aerospace work for DOE has involved a spectrum of activities pertaining to electric energy systems, solar thermal, photovoltaic, geothermal, wind, energy storage, ocean, and fossil energy technologies and systems, as well as energy conservation. This work also includes planning and evaluation support to DOE's Office of the Assistant Secretary for Environment, as well as General Systems Engineering and Integration support to the Strategic Petroleum Reserve and the MX Renewable Energy Systems Projects. In addition to work for DOE, Aerospace non-defense activites also include support to selected projects of: the federal Departments of the Interior, Transportation, Treasury, and Agriculture; the Nuclear Regulatory Commission; the Environmental Protection Agency; National Aeronautics and Space Administration; and National Science Foundation. A more complete listing of non-defense program clients is provided in Table A-1.

Table A1

NON-DEFENSE PROGRAM CLIENTS

(PARTIAL LISTING)

- EXECUTIVE OFFICE OF THE PRESIDENT
- CABINET LEVEL DEPARTMENTS
  - DEPARTMENT OF AGRICULTURE
    - FOREST SERVICE
    - SOIL CONSERVATION SERVICE
  - DEPARTMENT OF COMMERCE
    - MARITIME ADMINISTRATION
    - NATIONAL BUREAU OF STANDARDS
    - NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
    - NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
  - DEPARTMENT OF ENERGY
    - HEADQUARTERS, WASHINGTON D.C.
    - ALBUQUERQUE OPERATIONS
    - CHICAGO OPERATIONS
    - IDAHO FALLS OPERATIONS
    - LAS VEGAS OPERATIONS
    - NEW ORLEANS OPERATIONS
    - OAKLAND OPERATIONS
    - OAK RIDGE OPERATIONS
    - OKLAHOMA OPERATIONS
    - PITTSBURGH OPERATIONS
    - RICHMOND, VIRGINIA OPERATIONS
    - SAVANNAH OPERATIONS
    - WYOMMING OPERATIONS
    - BARTLESVILLE ENERGY TECHNOLOGY CENTER
    - CARBONDALE MINING TECHNOLOGY CENTER
    - LARAMIE ENERGY TECHNOLOGY CENTER
    - MORGANTOWN ENERGY TECHNOLOGY CENTER
    - BONNEVILLE POWER ADMINISTRATION
  - DEPARTMENT OF THE INTERIOR
    - BUREAU OF LAND MANAGEMENT
    - BUREAU OF MINES
    - FISH AND WILDLIFE SERVICE
    - GEOLOGICAL SURVEY
    - OFFICE OF MINERALS POLICY AND RESEARCH ANALYSIS
    - OFFICE OF WATER AND RESEARCH AND TECHNOLOGY
    - WATER AND POWER RESOURCES SERVICE
  - DEPARTMENT OF JUSTICE
    - DRUG ENFORCEMENT ADMINISTRATION
    - FEDERAL BUREAU OF INVESTIGATION
    - IMMIGRATION AND NATURALIZATION SERVICE
  - DEPARTMENT OF TRANSPORTATION
    - OFFICE OF THE SECRETARY
    - FEDERAL AVIATION ADMINISTRATION
    - FEDERAL HIGHWAY ADMINISTRATION
    - FEDERAL RAILROAD ADMINISTRATION
    - OFFICE OF PIPELINE SAFETY REGULATION
    - TRANSPORTATION SYSTEMS CENTER
    - URBAN MASS TRANSPORTATION ADMINISTRATION
    - U.S. COAST GUARD
  - DEPARTMENT OF THE TREASURY
    - BUREAU OF ALCOHOL, TOBACCO AND FIREARMS
    - U.S. CUSTOMS SERVICE
- INDEPENDENT FEDERAL AGENCIES
  - ENVIRONMENTAL PROTECTION AGENCY
  - FEDERAL EMERGENCY MANAGEMENT AGENCY
  - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
  - NATIONAL SCIENCE FOUNDATION
  - NUCLEAR REGULATORY COMMISSION
- STATE GOVERNMENTS AND REGIONAL ORGANIZATIONS
  - STATE OF ALASKA
  - STATE OF CALIFORNIA
  - STATE OF IDAHO
  - CALIFORNIA AIR RESOURCES BOARD
  - CALIFORNIA ENERGY COMMISSION
  - SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS
- UNIVERSITIES AND COLLEGES
  - CALIFORNIA INSTITUTE OF TECHNOLOGY
  - CALIFORNIA STATE UNIVERSITY NORTHRIDGE
- OTHER ORGANIZATIONS
  - AMERICAN PUBLIC GAS ASSOCIATION
  - ARGONNE NATIONAL LABORATORY
  - BROOKHAVEN NATIONAL LABORATORY
  - ELECTRIC POWER RESEARCH INSTITUTE
  - JET PROPULSION LABORATORY
  - LAWRENCE BERKELEY LABORATORY
  - LAWRENCE LIVERMORE NATIONAL LABORATORY
  - LINCOLN LABORATORY
  - LOS ALAMOS NATIONAL LABORATORY
  - NATIONAL ACADEMY OF SCIENCES
  - OAK RIDGE NATIONAL LABORATORY
  - SOLAR ENERGY RESEARCH INSTITUTE

In its non-defense work, as in its support to the Air Force, whenever possible Aerospace seeks to establish long term, durable working relationships with the agencies it serves. Long-term programs, as contrasted with intermittent or temporary relationships, benefit both the Corporation and its clients. Such long-term relationships provide stability, continuity of effort through the various phases of a project from planning to implementation, and a "corporate memory" which provides an effective mechanism for transfer of knowledge and experience from one project to another.

In its work for non-DOD agencies, Aerospace performs only R&D programs that are similar to and compatible with those it performs for the Air Force -- specifically, tasks requiring the objectivity and freedom from conflicts-of-interest. The concentration of its work in national security-related areas (e.g., energy) and activities generally requiring the same technical disciplines required for its Air Force work has facilitated effective and efficient use of its professional staff. Approximately 10 percent of The Aerospace Corporation's work is concerned with non-defense activities.

5.0 POLICY AND DIRECTION

The Aerospace Corporation maintains a unique position in its service to government, which is its only client. By its charter, organization, and operation, Aerospace has established a relationship whereby it has characteristically worked more at the side of government, rather than simply for government. In exercising that relationship, Aerospace developed and maintains a Corporate posture that assures:

- Freedom from bias due to predilection for particular concept designs or specific hardware elements
- Access to government planning information
- Access to industry proprietary information

- Access to industry proposals
- Continuity of effort.

To maintain its objectivity and avoid conflicts of interest, Aerospace has a non-profit structure, does not accept contracts with private industry, nor does it engage in any product development or commercial hardware manufacturing. This posture is vital to its relations with industry and the government and, therefore, to its ability to marshal all available technology for the solution of its customer's problems.

In order to maintain the Corporation's unique and privileged position with its customers, and preserve its independence and objectivity, Aerospace requires that no employee or consultant be compromised by any relationship, direct or indirect, which might constitute (or appear to constitute) a conflict of interest. Corporate policy and practice rigidly maintain this condition.

A major portion of the Corporation's work involves the review, evaluation, and technical direction of the activities of industrial contractors participating in government-sponsored development programs. To be thoroughly effective in this role, Aerospace must have ready access to the technical data of these firms. Such access would not be possible if there was concern that Aerospace would use these data to gain a competitive advantage over the firms whose work was being assessed.

As a consequence, Aerospace cannot respond to formal competive requests for proposals that might involve industrial contractors. Its services are made available to government agencies when one or both of the following conditions exist:

- When a contract is awarded on a single source basis (this is the primary way in which Aerospace contracts with the government have been negotiated).

- o When the competition leading to contractor selection is restricted to not-for-profit organizations such as the FCRC's or FFRDC's.

6.0 PROFESSIONAL STAFF

The Aerospace Corporation prides itself on its technical excellence. To meet its commitments to research and technological programs important to national security, it has been essential to maintain an organization of the highest professional competence and a staff that performs at the forefront of the relevant areas of science and technology. The people which comprise the Corporation are its preeminent resource and total approximately 4000. This staff includes more than 2200 scientists and engineers with highly diverse backgrounds covering a broad range of technical areas. A large percentage of the technical staff holds advanced degrees, as shown in Figure A-1.

The Corporation's diverse role in planning, performing policy studies, systems engineering, and technical management has required support by a staff who, by virtue of their extensive experience and accomplishments, warrant the respect of the governmental agencies and industrial contractors with whom they work. Figure A-2 shows the distribution of Corporate technical staff experience. As indicated, the average Aerospace staff member has more than 20 years of professional experience.

7.0 CORPORATE STRUCTURE

The organizational structure of the Corporation has been designed to provide both quick response and/or long-term support to the large number and wide variety of government programs typically in process at any one time. The Aerospace organization has been divided into four major "Groups"

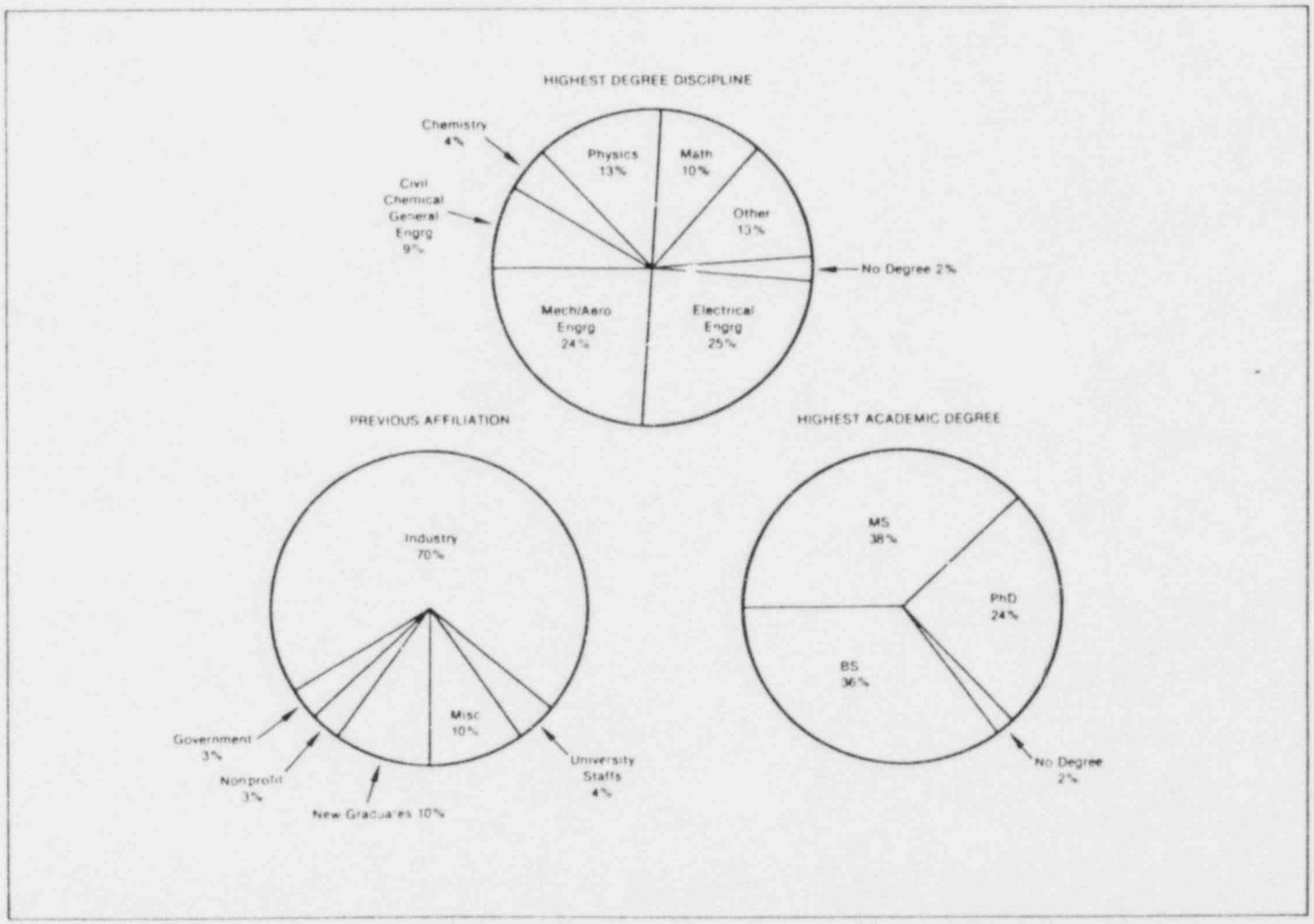


Figure A1 Characterization of the Technical Staff

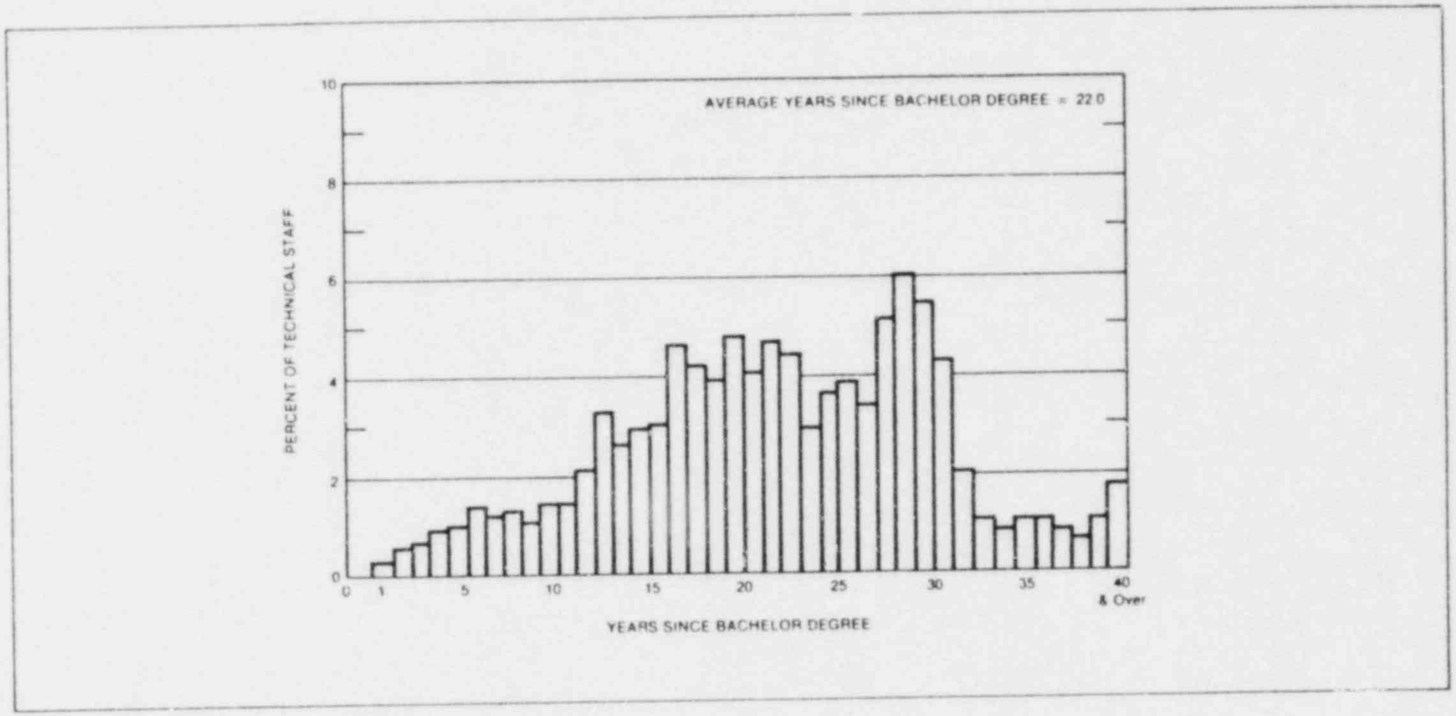
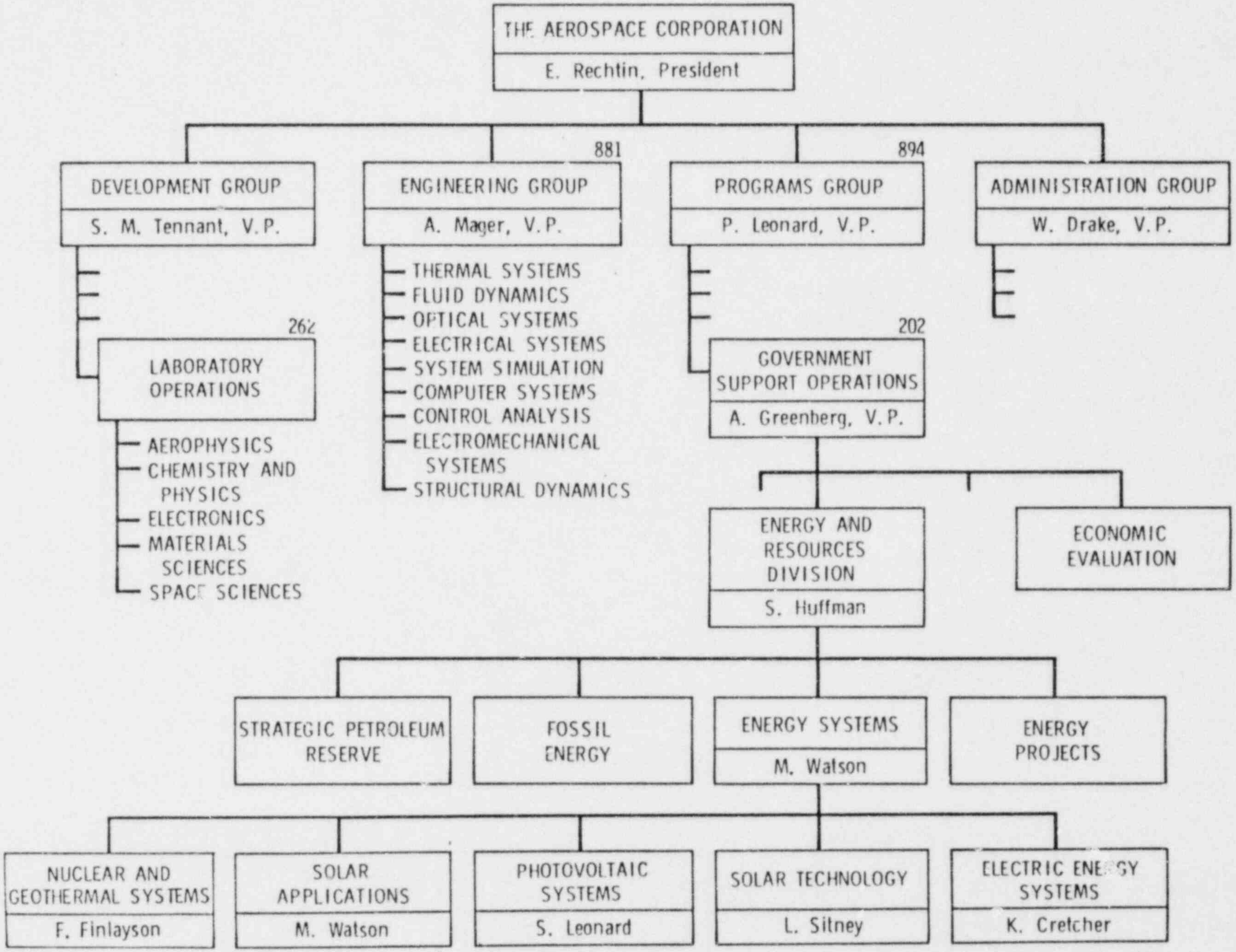


Figure A2 A Representative Distribution of Technical Staff Experience as illustrated in Figure A-3. Three of these (the Programs, Engineering, and Development Groups) are technical in nature and the fourth is administrative. The Programs Group is responsible for the direction of most of the military and civil programs supported by the Corporation. The Engineering Group has a functional organization; and is staffed by technical specialists who support both military and civil programs providing a matrix type of organizational overlay with respect to the program offices. In addition to advanced concept development activities, the Development Group contains the Ivan A. Getting Laboratories where physical research is conducted in support of both civil and military programs.

7.1 Government Support Operations: Non-Defense Programs

The Corporation's activities in civil fields have been consolidated into a single top-level organizational element: Government Support Operations, under the leadership of Vice President and General Manager, Dr. Arthur B. Greenberg. Civil programs are conducted under two division within the Government Support Operations: The Energy and Resources Division, operating under Mr. Shay D. Huffman, has its primary base of operation at the El Segundo Corporate Headquarters; and the Eastern Technical Division (not shown) that operates primarily out of Washington, D.C. The Energy and Resources Division has the responsibility for activities at the federal, regional, and state levels for programs in areas such as energy resources assessments, energy systems analysis, and natural resource development, related technologies evaluation, and environmental impact assessment.

Through the organizational structure described above, the Energy and Resources Division draws, as needed, on the capabilities of over 1100 scientists and engineers in the Engineering Group and the Laboratory Operations to support its programs. These organizational relationships permit flexibility in personnel assignments and allow a program office to adjust the mix of capabilities to meet its changing program requirements as



Figue A3 Aerospace Corporate Structure

the work evolves. This mode of operation has proved to be both efficient and effective, particularly in providing specialized expertise for quick response to program needs.

7.2 Engineering Group

The Engineering Group is staffed by about 900 professional personnel. As shown in Figure A-3, the Group is organized along engineering discipline lines so that individuals from the organization may, at any given time, be providing support in their engineering specialities to more than one program. Within the Engineering Group, technical capabilities exist in practically all technology and engineering disciplines. Separate departments exist for structures, fluid mechanics, dynamics, thermodynamics and heat transfer, reliability, automatic controls, and so on. In all, over 30 distinct technical disciplines are represented within the Group. Specialists with many years of experience staff each department.

The Engineering Group also provides digital and analog computation services for the entire Corporation. This service is of particular importance in most energy related programs and is outlined below in more detail. Specialized Engineering Testing Laboratories are also maintained within the Engineering Group. The functions of these applications-oriented laboratories are also described below.

7.3 Laboratory Operations

The major responsibility for scientific R&D and the associated laboratory support to the Corporation's many faceted programs rests with Laboratory Operations. This responsibility has necessitated developing expertise in a remarkably broad range of scientific and technology areas reflecting the breadth of corporate program requirements.

As indicated in Figure A-3, Laboratory Operations is a division within the Development Group. It has been organized with two main objectives: to conduct applied research in areas appropriate to the overall mission of the Corporation, and to provide both quick response and highly specialized, state-of-the-art support to corporate programs. Research activities underway in the laboratories, most of which are interdisciplinary, span a broad portion of the technological/scientific spectrum -- from studies of very basic scientific questions to those whose results may have immediate impact on operational systems or new programs. Experimental facilities assembled in support of these activities are extensive, representing a significant capital investment in laboratory test equipment.

Laboratory Operations is presently organized into five laboratories:

- The Electronics Research Laboratory is performing research and experimentation in the following areas: microwave and semiconductor devices and integrated circuits; communication sciences, gallium arsenide, and superconducting device physics; lasers; millimeter and far-IR technology; radar; and electromagnetic propagation.

- The Aerophysics Laboratory is primarily involved with all aspects of high-energy chemical laser research including: laser physics and laser resonator optics, chemical kinetics, aerodynamics, laser effects, and countermeasures. In addition, this laboratory has expertise in engineering mechanics, flight dynamics, and heat transfer.

- The Materials Sciences Laboratory is working in many fields including: composite materials, graphite, and ceramics; polymers; stress corrosion; metallurgy microstructure; materials for electronic devices; weapons effects; and chemical and structural analysis.

- The Space Sciences Laboratory performs laboratory and space experiments in the following research areas: magnetospheric, ionospheric, and atmospheric physics; optical and IR background radiation; charged particles in space and their effects on spacecraft; and density and composition of the atmosphere.

- The Chemistry and Physics Laboratory programs include: chemical thermodynamics, laser chemistry, IR sensor materials and optics, surface chemistry, cathode materials, contamination of spacecraft materials, lubrication, chemical reaction rates, electrochemistry and batteries, and pollution and trace element monitoring.

7.4 Computer Cabability

The Information Processing Division of the Engineering Group operates the Corporate computing facility; provides software analysis; and numerical analysis support to the various engineering and administrative functions of the Company. The Corporation operates a large scale computer center to support the extensive engineering and administrative computing requirements attendant with the performance of its mission. The facility contains a CDC 7600 computer (and associated CDC CYBER 172 and CDC 6400 computers) for scientific computing and an IBM 3033 computer which is used for interactive computing, administrative data processing, flight test data reduction, and engineering applications that require reduction of large volumes of data as well as extensive computation. A laser printer (IBM 3800) provides high volume printing support to all of the Aerospace computers. The computers are interconnected by a data network that provides for transfer of data files among computer systems.

Time-shared access to both CDC and IBM computers is provided by many interactive terminals (either cathode-ray-tube or typewriter-like units) distributed at Aerospace locations throughout the country. These terminals provide access to a wide variety of programming systems and special computational capability. Remote computer job entry terminals (consisting of medium speed card readers and line printers) are located at several sites.

High speed plotting capability is provided by a variety of different devices, including:

- o CalComp 835 Cathode Ray Tube Plotter (attached to the CDC Computer Systems)
- o Two CalComp High Speed Incremental Plotters (driven by magnetic tapes written on either IBM or CDC computers)
- o Three High Density Electrostatic Plotter/Printers (attached to both CDC and IBM Systems)

Interactive graphics capability is also available using a minicomputer based display system (IMLAC PDS-4) and a variety of smaller graphic display devices (Tektronic 4013, Hewlett-Packard 2648A and 2647A).

7.5 Engineering Testing Laboratories

Engineering testing at Aerospace is conducted at the component and subsystems level. Its scope varies from quick reaction studies needed to isolate the cause of problems requiring immediate action to the more extensive studies required to obtain engineering data with broad applications to many programs. The following specialized testing laboratories are located in the Engineering Group:

- The Failure Analysis Laboratory provides technical support to virtually all hardware development programs in the areas of electronic, electrical, and electromechanical part technology. It seeks to improve the reliability of electronic piece-parts through component evaluation, failure mode investigations, and the development of improved test methods.

- The Microprocessor Laboratory performs computer-aided design and design verification of LSI circuits and the testing of such devices in cooperation with the Aerospace research laboratories.

- The Real-Time Simulation Laboratory provides a capability to test the functioning of control electronics, programmed controllers, and human operators under simulated operational conditions. This capability has been applied to system simulations as diverse as operational satellites and highway traffic flow patterns.

- The Communications Laboratory provides the capability to evaluate new microwave and digital components, low-noise receivers, multibeam antennas, and other communications susbystems.

- The Digital Image Processing Laboratory evaluates, develops, and demonstrates imaging processing concepts.

- The Electro-Optics Laboratory tests and evaluates optical and IR photoelectric and solid-state sensors and components.

8.0 SUMMARY OF CORPORATE CAPABILITIES AND CHARACTERISTICS

Aerospace has capabilities and characteristics that are specifically designed to provide its governmental customers with the highest levels of technical expertise and objectivity in systems management programs or other research and development projects. The organizational structure of the Corporation is designed to operate efficiently and effectively on both quick response and long-term support programs. The matrix type of organizational structure combines program office control and continuity with the essential support of diverse technical specialists. This organizational structure provides cost-effective programmatic flexibility through its capacity to focus continuous attention on the customer's project, while providing highly expert technical assistance to the program when it is specifically required.

The personnel of The Aerospace Corporation are its most highly prized element. The technical staff includes more than 2200 engineers and scientists whose mature backgrounds span essentially all areas of science, technology, and policy development. With an average of more than 20 years of professional experience, the staff members represent the Corporation's collective memory and technical competence.

Thus Aerospace is prepared to work side-by-side with its government customers in performing all kinds of research and development programs related to national security problems. Potential programs include support in planning, systems analysis, systems engineering, and technical management on major programs or direct R&D support to smaller individual projects of technical significance and national need. Whatever the project, Aerospace pledges to bring to its customers independence from conflict of interest; objectivity in its analyses and assessments; and cost-effective performance on its programs. Over twenty years of successful Aerospace Corporate service to its government customers have demonstrated its capability to support this pledge.