John E

Jim Fletcher & George Low prepared the enclosed in response to urgings some months ago from George & me. Fletcher wants to be sure you understand this background & don't jump to the conclusion NASA is undermining the Domestic Council effort.

There are only 8 copies of this, 4 here (you, us, Peter Flanigan + Ed David) and 4 left at NASA. You will note from the cover that you have what was George Low's copy.

Dan

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of the Administrator

July 21, 1971

Mr. Donald B. Rice
Assistant Director
Office of Management and Budget

Don:

Per our discussion, this is for John Ehrlichman.

James C. Fletcher
Administrator

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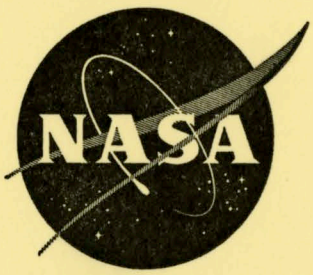
No. 2

~~G. M. Low~~

PRELIMINARY DRAFT

# APPLYING NASA CAPABILITIES TO NATIONAL GOALS

July 8, 1971




PRELIMINARY DRAFT

This document is an internal working paper for the attention of the Administrator and Deputy Administrator of the National Aeronautics and Space Administration only.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23365

July 8, 1971

REPLY TO
ATTN OF:

EYES ONLY

Dr. George M. Low
Deputy Administrator, Code AD
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Low:

Forwarded herewith is a report, "Applying NASA Capabilities to National Goals," in response to your request to me to conduct such a study. I would like to commend to you the efforts of the members of the study team, who are listed as recipients of copies of this transmittal.

We found this to be a stimulating experience --- and a somewhat sobering one. The enormity of the problems of the environment, transportation, power, housing, and public services, for example, led us to call them "superproblems." And while we can see possible lines of attack on these problems, we do not feel that the Nation has as yet mobilized its best human resources to solve them.

These human resources must include the top scientific and engineering talent of the country if there is to be any hope of success. Within the Federal government the bulk of this talent resides in the R&D laboratories of the DOD, NASA, and the AEC. Within the Nation, the aerospace and other defense related industries are the most technically sophisticated and the most experienced in large systems problems. But as yet these resources are largely untapped. To fail to use these talents when they are most needed would be a tragic waste of our national strength.

This study concludes that this existing capacity to organize and direct complex programs of high technological content constitutes the Nation's best hope for making rapid progress toward its goals and should be mobilized to this end. In this endeavor, NASA should play a key role.

Sincerely,

Edgar M. Cortright
Chairman

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# APPLYING NASA CAPABILITIES TO NATIONAL GOALS

This paper presents the results of a short study conducted in June 1971, to make a preliminary assessment of the capability of NASA to undertake assignments directed toward the achievement of national goals by the solution of critical domestic problems.

## Broad Observations and Conclusions

1. Failure to cope with such pressing national problems as pollution, energy, conservation of natural resources, transportation, housing, and health will have serious, if not catastrophic, consequences in the foreseeable future.

2. The magnitude and complexity of these "superproblems" will require the strongest possible leadership on the part of the Federal government to mobilize the resources of the nation toward their solution, including research and development in some areas that have historically been left to the private sector.

3. Although solutions to these problems will involve complex human, political, and economic considerations, the problems must be subjected to a concerted effort by the best scientific and engineering talent in the nation if there is to be any real hope of success.

4. The Federal research and development laboratories, the aerospace and other defense based industries, and the scientific community within the colleges and universities represent a largely untapped national resource which should be enlisted in an all-out attack on national problems of high technological content.

5. The prevailing attitude among these groups is that of a strong desire to help the nation solve its domestic problems, even at some expense to their current activities.

6. NASA, with its excellent systems management capability, its strong research and development centers, and its demonstrated ability "to get the job done," is a prime candidate for such assignments.

7. Space satellite systems will be powerful tools in the attack on these problems and multipurpose satellites will be able to serve the needs of several user agencies; development and operation by a single agency offers the potential of economy, efficiency, reliability, and flexibility.

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## Introduction

National problems in the domestic sector have been extensively studied by various review groups during the past several years. In assessing the results of this work, much of which was excellent, this study group was impressed with the magnitude and seriousness of the problems which face our society in such areas as the environment, transportation, energy, housing, and some of the public services bearing heavily on the quality of life.

That these problems are receiving high level attention is quite clear. The President, himself, has taken a lead in attempting to mobilize a national effort to solve them. In his budget message of January 29, 1971, President Nixon stated:

"Science and technology can make major contributions to the public by developing creative solutions to a wide range of national problems that will help us all enjoy a better life. I am proposing in this budget a substantial expansion in outlays for federally supported research and development.

"While a large portion of this increase is needed to strengthen our defense capabilities, I am also recommending substantial increases in civilian areas to:

--- make greater use of our scientific and engineering capabilities and resources to cope with major national problems such as pollution, crime, health, transportation, and other environmental and social problems;

--- strengthen research essential to the advancement of our technology and economic productivity; and

--- increase our investment in fundamental science which leads to the long-term progress of our society."

Thus a positive environment for the application of the nation's best scientific and technological skills has been well established. However, much remains to be done before such application becomes a reality. Accordingly, some strong recommendations are contained herein directed toward providing added muscle in support of the President's goals.

The bulk of the Federal government's technological strength is now being applied to defense, space, and nuclear activities. Similarly, the nation's highest industrial technology, as represented by the aerospace and nuclear industries, is similarly occupied. Yet it is

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precisely these skills that have the best hope of solving many of our "superproblems," which are collections of interacting subproblems resulting in a vast "system" of problems.

The organizations best equipped by training and experience to handle large systems problems are the DOD, NASA, the AEC, and their industrial and university counterparts. Yet this great national resource remains largely untapped insofar as our social and domestic problems are concerned. This study concludes that these teams must be enlisted in an all-out attack on these problems if the various national goals are to be met.

This paper concerns itself primarily with the possible role of NASA. Consideration of the DOD and the AEC was beyond the scope of the study. However, it must be recognized that the DOD constitutes the largest technological resource of the government. Directing some portion of this effort onto critical national problems of a non-defense nature would be effective and could enhance the peacetime roles of the armed services and their R&D laboratories. For example, an ideal role for the Navy might be to support NOAA in its oceanography program. At the same time, the AEC and its R&D laboratories might well assume major responsibilities for non-nuclear power.

Similarly, NASA represents a unique national asset with great potential for solving, or helping to solve, some of our most pressing national problems and thereby helping to achieve some of our most lofty national goals. This report recommends that NASA apply up to an additional 15 percent of its current scientific and engineering manpower on selected problems of the environment, transportation, energy, housing, and other problems of the society. These areas, and specific tasks therein, were selected from a longer list of problems on the basis of relative importance and a match with NASA capabilities.

About one-half of the proposed assignments are natural extensions of work already under way in NASA in aeronautics and space. The relevancy of this work is not surprising when one considers the obvious relationship of atmosphere physics to pollution, of earth resources satellites to global monitoring of the environment, of communication satellites to data retrieval and dissemination, and of aeronautical research to both transportation and environmental problems. On the other hand, some recommended work represents a significant departure from past assignments.

To absorb this amount of new work would have a significant impact on NASA's current program. How large an impact depends to a great extent on how NASA proceeds with the space shuttle.

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The recommendation that NASA displace some ongoing work to undertake these new problems should not be interpreted as a vote of no confidence for the space program. On the contrary, it is a vote of confidence that our aeronautical and space technology can help solve some national problems that must be solved if we are to have the privilege of exploring space in future years. It is also a vote of confidence for the NASA scientific and engineering team and its ability to get the job done.

The NASA team represents a national asset. It is a "can do" organization of high self-confidence and morale. NASA has demonstrated its ability to organize and execute complex programs of high technological content largely because of its system management ability. It also has a demonstrated capability to evolve new ideas and concepts within its nine R and D centers, and to back up its contracted effort with the aerospace industry with supporting R&D. It is the combination of the system approach, a technical understanding of the details, and the demonstrated ability to marshal the technical expertise of the industry which is required to successfully attack the national problems of today and of the future. These are capabilities that are urgently needed to handle the "superproblems" which confront the nation.

NASA's total strength goes far beyond its own in-house capabilities, however. During the past decade NASA has established a close and effective working relationship with the aerospace industry, the most technically sophisticated industry in the world. Similarly, the scientific and engineering communities from our colleges and universities have been enlisted in an effective working alliance. This total team has the capacity and desire to undertake the most difficult and complex of our national problems.

The following sections speak to the specific recommendations for work to be undertaken by NASA. Should these preliminary recommendations be of interest to the Administration, steps should be taken immediately to form the nuclei of task teams to more thoroughly assess them.

A brief discussion is provided on some of the organizational considerations and on the distribution of tasks among centers. In general, logical assignments can be identified in all cases and revising the organizational structure to handle the new assignments does not appear to present any major difficulties. The tentative task assignments indicated herein do not account for projected future workloads at the various centers. Depending upon the shuttle decision, MSFC and MSC might assume a substantially greater portion of the assignments.

The majority of the tasks recommended as the implementation required to achieve national goals can be initiated by the President within existing statutory authority. Agencies having primary responsibility

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already have the statutory power to cooperate with other agencies, including NASA, just as the Space Act empowers NASA to enter into agreements with other Federal agencies to accomplish its mission.

Either an OMB policy directive, or if the Administration thinks it suitable, an Executive Order can serve as interim authority pending legislative changes to the Space Act in FY 1973.

The required legislative measures enlarging the responsibilities of NASA present a significant and appropriate change in national policy.

No change in name is initially suggested. However, an eventual merger with the AEC and possibly the NSF is a possibility that would dictate a change in name to reflect continuing assignments in applied science and technology.

## National Goals and Objectives

The President has established broad national goals in each of the problem areas considered herein. The following objectives are offered in further support of these goals.

Environment: "Environmental problems have a unique global dimension, for they afflict every nation, irrespective of its political institutions, economic system, or state of development. The United States stands ready to work and cooperate with all nations, individually or through international institutions, in the great task of building a better environment for man." President Nixon, February 8, 1971.

- Develop, in cooperation with the world community of nations, an international program to monitor and understand the global environment; the U. S. to provide within five years, a satellite based data collection system in support of the effort.

- Complete, by the end of this decade, a series of regional projects designed to clean up the environment.

- Reduce, by the end of the decade, the total pollution from all stationary power plants to one-half of its present level, while meeting the demands for doubling the supply.

- Demonstrate, within five years, potential low pollution alternatives to the conventional internal combustion engine for automobiles.

Transportation: "We are now entering into a new era in transportation - an era in which our national mobility will demand the continued conquest of time and space, yet our national conscience will no longer permit

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irreparable damage to our land, our environment or the social fabric of our communities." "To meet that challenge, we will need a truly balanced transportation system." President Nixon, March 31, 1971.

- o Develop within five years, all of the essential elements, including V/STOL aircraft, high speed ground transportation vehicles, improved personal conveyances, and associated traffic control systems, to implement new and properly balanced transportation systems.

- o Implement by the end of the decade well-balanced air/land transportation systems in the nation's most congested regions in order to substantially relieve this congestion and point the way for the future.

Electric Power: "A sufficient supply of clean energy is essential if we are to sustain healthy economic growth and improve the quality of our national life. I am therefore announcing today a broad range of actions to ensure an adequate supply of clean energy in the years ahead." President Nixon, June 4, 1971.

- o Undertake a greatly expanded Federal R&D program on non-nuclear energy sources, and on electrical power generation, transmission, and storage so as to insure substantial improvements in our non-nuclear power systems during the coming decade of expansion.

Housing: The 1968 Housing and Urban Development Act established a national goal of building 25 million new homes by 1978. The prime thrust has been to make this goal economically feasible. An important consideration must also be to minimize the impact of these homes on the environments in which they are to be placed. "Even some of the newest suburban 'subdivisions,' planned and developed in a shortsighted, haphazard manner, are not prepared to provide essential public services to their growing populations." President Nixon, March 5, 1971.

- o Adapt space technology to housing within the next five years so as to minimize its impact on the environment and its needs for supporting services.

Health, Education, and Other Public Services: The increasing demands for more and better public service in the areas of medical care, education, law enforcement, and disaster warning require radically new approaches to these problems. In addition, as government services to its citizens increase, there is a growing need for direct communication between government officials and the populace. "Nineteen months ago I said that America's medical system faced a massive crisis. Since that statement was made, that crisis has deepened. All of us must now join together in a common effort to meet this crisis -- each doing his own part to mobilize more effectively the enormous potential of our health care system." President Nixon, February 18, 1971.

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- o Apply space technology to provide improved medical care to the remote and sparsely populated regions of this country within the next five years.

- o Undertake a major national effort during this decade to upgrade public service through the use of satellite based data relay and communications systems.

## Recommendations

The balance of this summary is concerned with specific tasks which are recommended for assignment to NASA. It is felt that these tasks would make significant contributions to solving some of the more pressing national problems and achieving national goals and objectives. In addition, this study concluded that present efforts in these specific areas are in need of a great deal of strengthening of the type NASA is ideally suited to provide.

Additional discussion of these recommendations is provided in the sections following this summary.

Environment: The problem of protecting our environment is the most serious of those considered. In short, it would appear that man may well be able to destroy his species by polluting his environment as surely as he can by blowing it up. The time scale is alarmingly short. At current rates of population and industrial growth, the effects of pollution could be catastrophic in less than a century.

This problem must be attacked on all fronts. Immediate improvement can be achieved by regulation and enforcement based on the current state-of-the-art. In the long run, however, much more must be done to understand the nature and effects of pollution on both a regional and a global basis. And more effective techniques must be developed to reduce pollution at its source.

NASA is ideally equipped to make significant contributions in several important areas that have been flagged by most studies as needing immediate attention. The first of these is in establishing a global baseline or point of departure which would define the current state of global pollution and observe trends as the situation develops in future years. Without this, it will be impossible to tell either how serious the pollution is becoming or how effective corrective measures are.

The problem then becomes one of instrumenting the waters and atmosphere of the earth and monitoring these pollutants on a regular basis. Such an effort will require the best of remote automated instrumentation, and the use of aircraft and satellite systems to collect and transmit data. Participation by many nations of the world will be required.

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This is a systems problem of major proportions, but one which NASA is well equipped to handle by virtue of its years of experience in developing meteorological and communications satellites and its lead role in prior years in the remote sensing of the earth and its atmosphere from space. In addition, NASA is well experienced in conducting cooperative programs with other nations in such areas as joint sounding rocket and satellite programs, and the operation of global communications networks.

Accordingly, it is recommended that:

1. NASA, IN CONJUNCTION WITH APPROPRIATE FEDERAL AGENCIES AND WITH PARTICIPATING NATIONS OF THE WORLD, DEVELOP AND PLACE INTO OPERATION A DATA ACQUISITION, COMMUNICATION, PROCESSING, AND DISTRIBUTION SYSTEM FOR MONITORING THE GLOBAL ENVIRONMENT.

In addition to collecting global data on pollution, much more scientific research must be conducted on the behavior of pollutants in the air and waters of the earth. NASA has since 1958 pioneered in the atmosphere sciences. In addition, NASA's strength in fluid mechanics is directly applicable to the theoretical and experimental modelling of the dispersion of pollutants by fluid flow on both a local and a global scale.

Accordingly, it is recommended that:

2. NASA EXPAND ITS RESEARCH PROGRAM IN THE ATMOSPHERIC AND EARTH SCIENCES TO BETTER UNDERSTAND THE BEHAVIOR OF POLLUTANTS IN THE AIR AND WATER OF THE EARTH; AND ACCELERATE ITS DEVELOPMENT OF THE INSTRUMENT TECHNOLOGY REQUIRED FOR THE DETECTION AND MONITORING OF POLLUTANTS.

While attempting to understand global pollution, it must simultaneously be attacked closer to its source. There is a need for regional demonstration projects on environmentally degraded bays, river basins, and cities where the thorough and systematic monitoring of the environment is a prerequisite to the identification, prediction, and corrective actions necessary to improve the environment. As demonstrated in its recent support of NOAA in the BOMEX project, NASA is ideally suited to provide a data collection and integration service on such regional projects, as well as to provide supporting systems analysis.

Accordingly, it is recommended that:

3. NASA PROVIDE SYSTEMS ANALYSIS AND OTHER TECHNICAL SUPPORT, IN A COOPERATIVE AGREEMENT WITH EPA, FOR A SERIES OF HIGH PRIORITY DEMONSTRATION PROJECTS TO MONITOR, UNDERSTAND, AND CLEAN UP SELECTED ENVIRONMENTALLY DEGRADED BAYS, RIVER BASINS, AND CITIES.

As a direct and immediate measure to curb pollution at its source, the President has taken steps to place severe emission controls on automobiles;

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to enforce adherence to these controls; and to produce an unconventionally powered, virtually pollution-free engine within five years. While the incentives for private industry to meet these goals are large, it would seem prudent for the government to back up these efforts with a broadly based research program and some high risk developments. This approach was eminently successful with the aircraft turbojet engine, where the NASA Lewis Research Center (formerly the NACA Lewis Flight Propulsion Center) pioneered such features as afterburners, transonic and supersonic compressors, high temperature materials, cooled turbine blades, advanced fuels and lubricants, and other features found in modern jet engines. Even now Lewis is assisting EPA on the automotive engine problem, but it seems clear to the study group that a much heavier involvement of NASA is highly desirable.

Accordingly, it is recommended that:

4. NASA, IN SUPPORT OF EPA, ACCEPT RESPONSIBILITY FOR THE RAPID DEVELOPMENT AND DEMONSTRATION OF ADVANCED LOW POLLUTION AUTOMOTIVE PROPULSION SYSTEMS.

Transportation: The people of the United States are the most mobile in the world by virtue of the phenomenal growth in ground and air transportation during the past decade. At the same time our economic and social structures have become highly dependent on this ability to move people and goods within and between population centers.

Today we see this transportation system facing the possibility of a serious breakdown of services during the coming decade of growth unless strong positive action is taken on the part of the Federal government. Already urban roads are congested, as are the major air terminals and the airways which feed them. We have come to realize that the nation needs an integrated transportation system and not merely a continued uncontrolled growth of the separate elements of such a system.

In order to achieve a well-balanced national transportation system, several positive steps must be taken. New ground and air vehicles must be developed, new control systems for these vehicles must be developed, new route structures must be developed, and the use of these new elements must be properly "traded off" in the total systems engineering. While this overall picture is becoming well appreciated, considerably more technical strength is required to achieve it.

NASA is in an excellent position to help realize these goals. One of the required new vehicles is the STOL or VTOL aircraft designed to off load major air terminals, reduce airspace congestion, and provide improved service to outlying communities. These aircraft face stringent requirements for reliable automatic, all-weather

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operations, including take-off and landing, and they must be clean and quiet. They must also achieve new levels of efficiency and performance in order to be economically attractive. NASA (and its predecessor, NACA) has pioneered aeronautical research and experimental airplane developments for over 50 years. It has developed effective working relationships with the DOT, as represented by the jointly published CARD study. And, within NASA, experimental STOL aircraft developments are already under way.

Accordingly, it is recommended that:

5. NASA ACCELERATE THE DEVELOPMENT AND FLIGHT TESTING OF STOL AND VTOL EXPERIMENTAL AIRCRAFT CAPABLE OF FULLY AUTOMATIC ALL-WEATHER TERMINAL AREA OPERATIONS; AND DEMONSTRATE THE APPLICABILITY OF SUCH AIRCRAFT TO VASTLY IMPROVED INTERURBAN AIR TRANSPORTATION SYSTEMS.

A new system of terminals and its supporting route structure will require new air traffic control systems for most efficient operation. New airborne avionics must be developed which make full use of the advanced guidance and control techniques pioneered by the space program. Compatibility with ground systems already under way will be important. In addition, new procedures for flying and operating aircraft in the terminal areas must be researched and developed.

Accordingly, it is recommended that:

6. NASA, IN CONJUNCTION WITH THE FAA, UNDERTAKE TO DEVELOP AND DEMONSTRATE EXPERIMENTAL AIR TRAFFIC CONTROL SYSTEMS, INCLUDING BOTH GROUND BASED AND AIRBORNE EQUIPMENT, FOR V/STOL AIRCRAFT.

The nation has already made a huge investment in air traffic control (ATC) systems and is committed to making an additional large investment to upgrade this system during this decade. It seems clear, however, that during the 1980's a more advanced system will be required to meet the needs of the projected traffic growth, and that such a system will involve the use of satellites. Navigation and traffic control satellites also have potential for application to ground transportation; for example, to keep track of the location of commercial vehicles. NASA has pioneered in the development of satellite systems applicable to the navigation and traffic control function.

Accordingly, it is recommended that:

7. NASA PLAN AND DEVELOP, AS AN AGENT OF THE DOT, A COMPREHENSIVE NAVIGATION AND TRAFFIC CONTROL SATELLITE SYSTEM FOR THE 1980's.

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The attempts which are under way in the government to accelerate new developments in ground transportation would benefit greatly by increased technical support in the form of in-house research and development and systems analysis. Much of the NASA experience with high speed air vehicles is applicable to their counterparts on the ground. All of the technical disciplines and most of the required equipment already exist at NASA Research Centers to support work of ground transportation systems of all types.

Accordingly, it is recommended that:

8. NASA, IN SUPPORT OF THE DOT, UNDERTAKE A COMPREHENSIVE R&D PROGRAM ON ALL FORMS OF ADVANCED GROUND TRANSPORTATION, WITH EMPHASIS ON SPEED, SAFETY, ECONOMY, AND COMPATIBILITY WITH THE ENVIRONMENT.

In the case of high speed ground transportation, there is an urgent need to accelerate the development and demonstration of advanced vehicles to make such systems attractive, safe, and economical.

Accordingly, it is recommended that:

9. NASA, AS AN AGENT OF THE DOT, DEVELOP AND DEMONSTRATE SEVERAL EXPERIMENTAL HIGH SPEED GROUND VEHICLES SUITABLE FOR EARLY INCORPORATION INTO A BALANCED URBAN TRANSPORTATION SYSTEM.

Electric Power: The United States is facing a long term power crisis. To meet the growing demand for electric power will require an expenditure of close to $400 billion on generation and transmission equipment in the next ten years alone. Within thirty years the use is expected to quadruple. At the same time, power generation plants contribute 50% of the sulfur oxide pollutants to the air. And by 1980 they may require as much as 1/6 of the fresh water runoff in this country to cool them. The President has stressed the need for R&D on all possible clean energy sources and systems, stressing such areas as sulfur dioxide control technology, coal gassification and liquification, nuclear fusion, MHD, underground electric transmission, solar energy, oil shale, geothermal energy, and the natural gas supply. In his message to the Congress, he requested additional funds for some of the programs relating to the above areas.

In order to effectively carry out the Federal energy program, the President has proposed, within his Departmental Reorganization Program, that all energy related R&D be the responsibility of the proposed Department of Natural Resources (DNR). He further stated that "The Atomic Energy Commission would still remain intact, in order to execute the nuclear programs and any related energy research which may be appropriate as part of the overall energy program of the Department of Natural Resources."

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Consideration should be given to extending the role of the AEC into non-nuclear power R&D. Their extensive background and related experience make them a logical choice to provide the government's technical leadership in the entire power field consistent with the DNR/AEC relationship outlined by the President.

It is also recognized that the task to be done is formidable and that NASA's background is directly applicable. For many years, NASA (NACA) has been engaged in research associated with fluid flow, combustion, fuels, thermodynamics, materials, etc. - all of the basic disciplines involved in the generation of electrical power. These efforts have been continued during the "space age," largely directed at space power and propulsion (airbreathing and rocket), including nuclear power.

Accordingly, it is recommended that:

10. NASA, IN CONJUNCTION WITH THE AEC, AND IN SUPPORT OF OTHER FEDERAL AGENCIES, UNDERTAKE AN R&D PROGRAM DIRECTED AT NON-NUCLEAR ENERGY GENERATION AND AT ENERGY TRANSMISSION AND STORAGE.

Housing: Although Americans are the best housed people of the world, they face a serious housing shortage brought on by an expanding population, old housing wearing out, antiquated construction techniques, and rising costs of new homes, and an increasing demand for supporting utilities and services. Like so many of our national problems, this one must be attacked from several directions.

The NASA/Aerospace team has unique capabilities in system engineering and spacecraft life support technology which are directly applicable to many urban problems. The utilization of space technologies to help solve the environmental and urban problems was recognized by President Nixon in his message to the Congress on environmental quality on February 10, 1970: "A great deal of our space research has been toward creating self-sustaining environments, in which people can live for long periods of time by reprocessing, recycling, and reusing the same materials. We need to apply this kind of thinking more consciously and more broadly to our patterns of use and disposal of materials here on earth." NASA has an experienced technical staff and the most up-to-date development and test facilities which can be used to fully evaluate contractor developed equipment. The combination of these resources and existing technology can be used to provide a fresh approach to the solution of many urban and housing problems.

Accordingly, it is recommended that:

11. NASA, IN CONJUNCTION WITH HUD, UNDERTAKE TO DEVELOP AND DEMONSTRATE NEW CONCEPTS IN HOME LIFE SUPPORT SYSTEMS WHICH WILL CONSERVE POWER AND WATER, TREAT WASTE ON SITE, MINIMIZE POLLUTION,

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IMPROVE FIRE SAFETY, AND OTHERWISE HAVE MINIMUM IMPACT ON THE ENVIRONMENT AND PLACE MINIMUM DEMANDS ON COMMUNITY SERVICES.

Health, Education, and Other Public Services: The areas of health, education, and human welfare are plagued with a host of problems, such as inadequate medical, teaching, and law enforcement personnel and services. The training and effectiveness in all three areas could be enhanced by a satellite based system for intercommunication and for the storage and retrieval of data and other reference material. Further, there is an increasing requirement for direct communications between government officials and the public at large. For example, of immediate importance would be the ability to broadcast directly into special home receivers warnings of impending disasters such as enemy attack, severe storms, floods, earthquakes, riots or insurrections, or blackouts and other breakdowns of supporting services. A satellite based system capable of either regional or national coverage would be ideal to meet this need. NASA's experience with communications satellites is directly applicable.

Accordingly, it is recommended that:

12. NASA DEVELOP A PUBLIC SERVICE SATELLITE BASED BROADCAST SYSTEM THAT CAN SUPPORT THE SPECIAL NEEDS OF HEALTH CARE, EDUCATION, LAW ENFORCEMENT, DISASTER WARNING, AND OTHER NATIONAL SERVICES.

In many areas of our country health care is woefully inadequate. The current methods used in providing health care must be modified and redirected to keep pace with medical technology, the expanding population, and to meet the national goal established by the President in the 1970 Public Health Service Act. Under the provisions of this act, HEW was authorized to pursue a vigorous and comprehensive research and development program to expand and demonstrate new health care techniques.

New multiphasic health screening tests are currently being developed which would allow paramedical personnel to conduct medical examinations and to provide a level of preventative medicine with removal of the seriously ill to a medical center. NASA is in a good position to accelerate the application of such techniques in remote areas.

A project could be implemented by modifying an existing advanced space station clinical and medical research system to meet the requirements for a remote area regional health care unit. (The existing design not only has the capability for bioinstrumentation measurements but also incorporates automatic method for blood and urine analysis, vision and auditory testing, automatic data retrieval, storage and processing.) A project team could be established to manage such a program using proven spacecraft development management techniques.

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Therefore, it is recommended that:

13. NASA UNDERTAKE A JOINT PROGRAM WITH HEW AND A SELECTED MEDICAL CENTER TO DEVELOP AND DEMONSTRATE A SEMI-AUTOMATED MOBILE HEALTH CARE UNIT THAT CAN BE OPERATED IN REMOTE AREAS BY PARAMEDICAL PERSONNEL.

Operational Satellite Systems: It is reasonable to expect that several new uses of space systems will be sought by the Federal government in time. Some of them have been discussed in this document. There is also a high probability that several agencies of the government will have needs for space systems and, furthermore, that several agencies will have an interest in the common output or services resulting from a single system.

It is logical to make use of the expertise developed in the space R&D programs to develop, establish, and operate all space systems and services required by the civilian agencies of the Federal government. This does not preclude the supplying of space capabilities and services by private enterprises on a leased basis where desirable. It would make use of the space agency's expertise to assess the adequacy of approach and the economy of the services proposed by industry based on a real and current knowledge of state-of-the-art and all alternatives available to both industry and the government. NASA is the logical agency to be assigned the operational space systems support function. NASA, a nonuser agency, can execute this function and respond to the requirements of the several user agencies without prejudice. The users are interested in the service or the information product derived from the system. Each user could take his required product from the system (which may be a common product or a unique product) and use it as appropriate. The results of all space R&D could be fed immediately and naturally into the operational systems considered.

Accordingly, it is recommended that:

14. NASA BE ASSIGNED RESPONSIBILITY TO DEVELOP AND OPERATE ALL SATELLITE SYSTEMS AND SERVICES REQUIRED BY USER AGENCIES OF THE FEDERAL GOVERNMENT FOR CIVIL APPLICATIONS.

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# SUMMARY OF RECOMMENDATIONS

## ENVIRONMENT

1. NASA, IN CONJUNCTION WITH APPROPRIATE FEDERAL AGENCIES AND WITH PARTICIPATING NATIONS OF THE WORLD, DEVELOP AND PLACE INTO OPERATION A DATA ACQUISITION, COMMUNICATION, PROCESSING, AND DISTRIBUTION SYSTEM FOR MONITORING THE GLOBAL ENVIRONMENT.

2. NASA EXPAND ITS RESEARCH PROGRAM IN THE ATMOSPHERIC AND EARTH SCIENCES TO BETTER UNDERSTAND THE BEHAVIOR OF POLLUTANTS IN THE AIR AND WATER OF THE EARTH; AND ACCELERATE ITS DEVELOPMENT OF THE INSTRUMENT TECHNOLOGY REQUIRED FOR THE DETECTION AND MONITORING OF POLLUTANTS.

3. NASA PROVIDE SYSTEMS ANALYSIS AND OTHER TECHNICAL SUPPORT, IN A COOPERATIVE AGREEMENT WITH EPA, FOR A SERIES OF HIGH PRIORITY DEMONSTRATION PROJECTS TO MONITOR, UNDERSTAND, AND CLEAN UP SELECTED ENVIRONMENTALLY DEGRADED BAYS, RIVER BASINS, AND CITIES.

4. NASA, IN SUPPORT OF EPA, ACCEPT RESPONSIBILITY FOR THE RAPID DEVELOPMENT AND DEMONSTRATION OF ADVANCED LOW POLLUTION AUTOMOTIVE PROPULSION SYSTEMS.

## TRANSPORTATION

5. NASA ACCELERATE THE DEVELOPMENT AND FLIGHT TESTING OF STOL AND VTOL EXPERIMENTAL AIRCRAFT CAPABLE OF FULLY AUTOMATIC ALL-WEATHER TERMINAL AREA OPERATIONS; AND DEMONSTRATE THE APPLICABILITY OF SUCH AIRCRAFT TO VASTLY IMPROVED INTERURBAN AIR TRANSPORTATION SYSTEMS.

6. NASA, IN CONJUNCTION WITH THE FAA, UNDERTAKE TO DEVELOP AND DEMONSTRATE EXPERIMENTAL AIR TRAFFIC CONTROL SYSTEMS, INCLUDING BOTH GROUND BASED AND AIRBORNE EQUIPMENT, FOR V/STOL AIRCRAFT.

7. NASA PLAN AND DEVELOP, AS AN AGENT OF THE DOT, A COMPREHENSIVE NAVIGATION AND TRAFFIC CONTROL SATELLITE SYSTEM FOR THE 1980'S.

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8. NASA, IN SUPPORT OF THE DOT, UNDERTAKE A COMPREHENSIVE R&D PROGRAM ON ALL FORMS OF ADVANCED GROUND TRANSPORTATION, WITH EMPHASIS ON SPEED, SAFETY, ECONOMY, AND COMPATIBILITY WITH THE ENVIRONMENT.

9. NASA, AS AN AGENT OF THE DOT, DEVELOP AND DEMONSTRATE SEVERAL EXPERIMENTAL HIGH SPEED GROUND VEHICLES SUITABLE FOR EARLY INCORPORATION INTO A BALANCED URBAN TRANSPORTATION SYSTEM.

## ELECTRIC POWER

10. NASA, IN CONJUNCTION WITH THE AEC, AND IN SUPPORT OF OTHER FEDERAL AGENCIES, UNDERTAKE AN R&D PROGRAM DIRECTED AT NON-NUCLEAR ENERGY GENERATION AND AT ENERGY TRANSMISSION AND STORAGE.

## HOUSING

11. NASA, IN CONJUNCTION WITH HUD, UNDERTAKE TO DEVELOP AND DEMONSTRATE NEW CONCEPTS IN HOME LIFE SUPPORT SYSTEMS WHICH WILL CONSERVE POWER AND WATER, TREAT WASTE ON SITE, MINIMIZE POLLUTION, IMPROVE FIRE SAFETY, AND OTHERWISE HAVE MINIMUM IMPACT ON THE ENVIRONMENT AND PLACE MINIMUM DEMANDS ON COMMUNITY SERVICES.

## HEALTH, EDUCATION, AND OTHER PUBLIC SERVICES

12. NASA DEVELOP A PUBLIC SERVICE SATELLITE BASED BROADCAST SYSTEM THAT CAN SUPPORT THE SPECIAL NEEDS OF HEALTH CARE, EDUCATION, LAW ENFORCEMENT, DISASTER WARNING, AND OTHER NATIONAL SERVICES.

13. NASA UNDERTAKE A JOINT PROGRAM WITH HEW AND A SELECTED MEDICAL CENTER TO DEVELOP AND DEMONSTRATE A SEMI-AUTOMATED MOBILE HEALTH CARE UNIT THAT CAN BE OPERATED IN REMOTE AREAS BY PARAMEDICAL PERSONNEL.

## OPERATIONAL SATELLITE SYSTEMS

14. NASA BE ASSIGNED RESPONSIBILITY TO DEVELOP AND OPERATE ALL SATELLITE SYSTEMS AND SERVICES REQUIRED BY USER AGENCIES OF THE FEDERAL GOVERNMENT FOR CIVIL APPLICATIONS.

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## Impact of the Recommendations

Within NASA, it will be necessary to make some organizational changes to assure that the new areas of responsibility recommended herein receive proper attention and visibility. It would seem appropriate to establish an Associate Administrator for Applied Science and Technology in NASA Headquarters, with a counterpart of Director for Applied Science and Technology in each center undertaking an appreciable workload in support of new efforts. Within the centers, the groups carrying out the new work should be given separate status and visibility rather than having the tasks merely "blended in" to existing divisions, branches, and sections. It will be important for user agencies to be able to clearly identify with the organizational entities doing work for them.

The utilization of NASA's in-house technical competence is a vital aspect of the proposed NASA attack on national problems. While it is true that relatively large teams of government, university and industrial scientists, engineers, and technicians must be organized to carry out these programs, the experience with the space program has conclusively shown that this is best done when locked up by a strong commitment of in-house research and development personnel.

In order to make a significant contribution to the solution of national problems, consistent with the recommendations summarized herein, a total of about 15 percent of NASA's 13,000 scientists and engineers should be applied as indicated in the attached table. The capabilities and experience of the various NASA field centers have been reviewed and correlated with the technical skills required for each of the 14 recommendations. No attempt has yet been made to determine the impact of the recommended actions on the current NASA program. It is clear, however, that some program redirections and modifications would be necessary; for example, the final plans for the shuttle would be a major driver on NASA's ability to proceed with all of the tasks, as recommended, and on the field center assignments for them.

The center responsibilities indicated in the attached table were based upon matching the skills required with the experience of the various field centers. No attempt has been made to determine the availability of manpower at the various centers consistent with their current and projected assignments. Depending on the shuttle decisions, MSC and MSFC might assume more of the new assignments than indicated.

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TABLE - SUMMARY ASSESSMENT OF RECOMMENDATIONS

| RECOMMENDATIONS (Key Words) | Within NASA Authority | NASA Legislation Desired | Option to use other funds | Recommended Funding Sources | Estimated S&E Manpower Reallocation | Possible Centers to Participate |
|---|---|---|---|---|---|---|
| 1. Global Environmental Monitoring System | YES | NO | YES | NASA | 250 | GSFC*, MSC |
| 2. Pollutant detection and behavior | YES | NO | YES | NASA | 100 | GSFC, MSC LaRC, ARC |
| 3. Regional environmental demonstrations | NO | YES | YES | EPA, Corps. of Engs. | 50 per Center | ARC, LeRC, LaRC, MSC, MSFC, WI |
| 4. Low pollution auto engines | NO | YES | YES | EPA & NASA | 200 | LeRC * |
| 5. Experimental aircraft | YES | NO | NO | NASA | 100 | ARC*, LaRC*, LeRC, FRC |
| 6. ATC FOR V/STOL | NO | NO | YES | DOT & NASA | 100 | LaRC *, ARC* MSC |
| 7. Navigation and ATC Satellite System | YES | NO | YES | DOT & NASA | 150 | ARC, LaRC, GSFC, MSC |
| 8. Advanced ground transportation R&D | NO | YES | YES | DOT | 200 | MSFC*, MSC, LaRC, LeRC |
| 9. High speed ground vehicles demonstration | NO | YES | YES | DOT | 250 | MSFC * |
| 10. Power | NO | YES | YES | NASA & DOI | 200 | LeRC *, MSFC |
| 11. Minimum impact housing system | NO | YES | YES | HUD & NASA | 200 | MSC *, MSFC |
| 12. Disaster warning & public service satellite system | YES | NO | NO | NASA | 150 | GSFC, MSC, MSFC, LeRC |
| 13. Health care unit | NO | YES | YES | HEW & NASA | 50 | MSC *, ARC |
| 14. Federally regulated operation satellites | NO | YES | YES | Users & NASA | ? | GSFC & others as appropriate |

*Possible lead center



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ENVIRONMENT

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# ENVIRONMENT

There are two major aspects to the control and preservation of our environment. The first concerns itself with understanding the environment and being able to monitor its changes and their causes. The second involves the elimination of environmental polluting or otherwise degrading practices and equipments. This paper discusses elements of both aspects.

## Environmental Monitoring

### Overview of the Problem

The problem of understanding and protecting our environment while efficiently using it to support our growing population's needs is one of the new "superproblems" of our time. It is a blend of many interacting subproblems, each difficult in its own right. Together they form a problem of monumental proportions, transcending the individual, community, state or even the nation.

Some problems are already upon us in a serious way; others are more distant, but potentially more far reaching in their dangers. In short, it would appear that man may well be able to destroy his species by polluting his environment as surely as he can by blowing it up.

It may be that the space program has helped man to appreciate this fact by expanding our view of the universe and our place in it, and by letting us literally stand off and see the earth, in all its fragile beauty, as a closed ecological system of which we are losing control.

It is clear that it will take a massive coordinated effort to even stay abreast of this problem, let alone roll it back. But the United States has no real alternative but to mount such a program. All indications are that piecemeal efforts will do little more than delay the day of reckoning. Responsible analyses indicate that unless major breakthroughs in controlling air and water pollution are achieved, and in monitoring and managing our natural and agricultural resources, life as we know it on this planet may be seriously jeopardized within the next century -- or sooner.

With a problem as serious as this, one might expect that the nature of the problem, and its possible solutions, would have received extensive attention and would be fairly well understood. The facts of the matter

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seem to indicate otherwise. While there exists a vast volume of literature on various facets of the environmental problem, the more subtle dangers, which bear on the ecology of the entire earth, have only recently begun to be appreciated, i.e., the buildup of carbon monoxide and particulates in the atmosphere with the attendant danger of major changes in the earth's climate; the buildup of CO, hydrocarbons, and the oxides of sulphur and nitrogen, with the dangers of adverse effects on the life of humans, animals, and vegetation; the buildup of pesticides and other chemicals in the ground and in the water, with the danger of disruption of ecology of our lakes, rivers, and oceans -- and with a threat to those who use this water or the life therein; the increased thermal pollution of both the air and the water with two distinctly different potential hazards -- the first to the life and ecology of the various bodies of water, and the second to the climate of the earth itself as total generated heat becomes a significant fraction of that received from the sun; and the increasing noise pollution with unknown effects on the mental and physical processes of humans.

Our society's needs have made necessary the use of the most productive variety of each principal agricultural product and has caused the interconnection of our services (i.e., power, water, transportation, and communications) to such an extent that we are dependent on the fault-free operation of a rather small number of "unisystems" for survival. The security provided by redundant or alternative sources and the high improbability of simultaneous loss of a number of species in an entire major food source is no longer available to us.

These factors will make more urgent the near real time monitoring of the status of our service systems, the health of our agriculture, the availability and quality of our water and air, and an understanding of the consequences of a stress anywhere in the system. Models and understanding of systems must be developed to intelligently design new systems as well as minimize effect of failure of the old systems. Many are required now as only relatively little is known about the effects of the urban environment on hydrologic pressures. Drainage is an anomalous urban water problem. Knowledge gathered from previous research in rural areas is not applicable to the cities where water and sewage problems are becoming acute and three-quarters of the U.S. population is concentrated.

There are many such ecosystems and biological systems (biomes) which need to be monitored and understanding developed regarding effects of change. Since these systems are interrelated, there will be a need for basing considerations and decisions on analyses derived from a data of comparable currency, reliability and accuracy if not from a common set of data. Insofar as remote sensing from space and aircraft can make this practically and economically attainable, it can serve as a common input to a large number of the environmental data interests.

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Areas Needing Technical Assistance

The areas requiring technical assistance today are:

1. The development of environmental models in conjunction with an understanding of how the environment itself can be monitored to provide information on status and change. The development of an ability to forecast change and consequences to be expected as a result of change. Models need to be developed for a number of biomes, drainage basins, streams, estuaries, urban centers, the atmosphere, and the oceans. It appears possible to also develop models of our earth structure and monitor it to provide certain disaster warnings such as earthquakes, volcanic eruptions, and tsunamis.

2. The development of data processing, dissemination, analysis, storage, and retrieval techniques and systems will require a sizeable R&D effort. The amount of data to be handled and the number of diverse sources that will need correlation for the total job will tax the current technology. The success of any global monitoring effort of this type will depend on the development of efficient machinery and analytic techniques.

Active Organizations

Leadership for our national program to protect the environment begins with the President, who has assumed an active role. In his message to Congress of February 8, 1971, on this subject he stated: "Environmental problems have a unique global dimension, for they afflict every nation, irrespective of its political institutions, economic system, or state of development. The United States stands ready to work and cooperate with all nations, individually or through international institutions, in the great task of building a better environment for man.

"I call upon all Americans to dedicate themselves during the decade of the seventies to the goal of restoring the environment and reclaiming the earth for ourselves and our posterity. And I invite all peoples everywhere to join us in this endeavor."

Resources Currently Being Applied

The President is advised on this subject by the Federal Council on Science and Technology, the Council on Environmental Quality, Water Resources Council and others. Major line responsibilities have been assigned to the newly created Environmental Protection Agency and the National Oceanic and Atmospheric Administration, but the total burden of this problem is shared by at least 14 Federal organizations, all of which conduct R&D programs which bear importantly on the

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environmental question. The cost of this R&D on environmental quality preservation alone exceeds $700 million in FY 1971. There are numerous other R&D programs (i.e. water resources R&D, agricultural R&D, etc.) which contribute to development of models, systems research and development to meet needs of individual interests. According to the FCST Ad Hoc Committee on Environmental Quality R&D, these organizations and their applicable R&D resources include NASA ($149), Environmental Protection Agency ($142M), United States Department of Agriculture ($94M), Department of Interior ($88M), Atomic Energy Commission ($72M), Department of Commerce ($56M), and Departments of Defense and Health, Education and Welfare, National Science Foundation, Department of Transportation, Corps of Engineers and the Smithsonian Institute.

The President's proposed departmental reorganization will consolidate some of the Federal effort on environmental control in the new Department of Natural Resources. However, the other proposed departments have vital interests and it will be necessary to maintain wide participation in this program in order to bring all of the necessary resources to bear. EPA (Environmental Protection Agency) will remain independent and must be relied upon to coordinate the needs for any protection measures. It seems likely that further clarification of roles and missions and of specific assignments will be likely during the next year or two. Some additional organizational changes may be forthcoming.

NASA Qualifications

As already mentioned, NASA is involved in a very active research program on the problems of our environment. This stems from the fact that NASA has played a lead role for the United States in the scientific investigation of earth as a planet.

For more than a decade, the Goddard Space Flight Center has explored the upper atmosphere and magnetosphere through the use of satellites and sounding rockets. The Wallops Station has supported this work. Goddard, in partnership with what is now NOAA (National Oceanic and Atmospheric Administration), has also developed all United States meteorological satellites, many for operational use by ESSA (Environmental Science Services Administration).

Goddard is also developing the Earth Resources Technology Satellite. This satellite is designed to develop instruments and techniques to observe the natural resources of the earth on a global scale. The program is supported by sensor development and research on data interpretation at the Manned Spacecraft Center and the Langley Research Center. Some sensors are designed to detect pollutants in both the water and the atmosphere; some may permit the detection of the effects of pollutants on crops and other vegetation.

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Goddard has also developed various communications and data gathering satellites, and operates a worldwide network of tracking and data acquisition stations. And to support the scientific and applications satellite activity, NASA has developed a broad expertise in unique automated remote instruments of all types to measure environmental parameters on this and other planets.

In essence then, the NASA capability to develop new instruments and to use them in conjunction with ships, aircraft, and spacecraft to gather vast amounts of information about the earth and its environs is without equal in the world. This is a highly significant statement for it bears importantly on one of the most critical and difficult problems facing those concerned with understanding and control of our global environment.

The problem is the instrumentation of the entire earth and the regular collection of data therefrom on the state of the environment and its natural and man-made perturbations. Virtually all other documents reviewed, stressed the critical importance of this task for the long range understanding and preservation of our environment and efficient management of our resources.

Current Activity

NASA is the developer of space technology. It has in operation systems for the support of space flight and the acquisition and communication of data on a global basis. It has operated systems for and has considerable capability to manage large data acquisition, processing, dissemination and storage and retrieval services. These systems have had to correlate information from numbers of diverse sources. Any system for adequately monitoring our environment would necessarily make use of aircraft and surface observations as well as space observations. NASA demonstrated the ability to provide such a data integration service for another agency in support it provided to NOAA in the recent BOMEX project. NASA's facilities and computer complex are particularly suited for this job.

It is probable that there will be a need for several space systems to support various aspects of environmental monitoring. A Meteorological Satellite System is in being today in low-altitude polar orbit. A synchronous (or stationary) orbit meteorological satellite system is currently being developed.

All of this argues for a multipurpose satellite (possibly with a single operating agency) for all space systems. This would permit the most economic deployment of specific observing instruments on optimum spacecraft regardless of principle purpose for the satellite. A meteorological requirement for a sensor in synchronous orbit might well be integrated into a satellite placed in that orbit for air traffic control purposes.

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NASA could most easily and efficiently design systems to meet total space needs with this in mind. NASA would also be in the best position to introduce desirable new technologies derived from the research program as well as incorporate the strengths of any manned space station capability into the operational system.

Disciplinary Skills

Few agencies of the government have had the experience required of designing, engineering, establishing and operating complete systems as large and as complex as that required for the assimulation of global environmental data. NASA's experience in this area is unique -- particularly in the area of insuring the reliability of large complex systems. Such a data system must be highly reliable if it is to serve its users well. If the ultimate in reliability is not employed, the system can fail because of its size and complexity.

NASA has learned to be responsive to user requirements for such suggested services without infringing on the authorities and responsibilities of the user agencies. Our experience in support of NOAA has proven that point. Each user agency would be the responsible agent for extracting the required data from the system and using it in the execution of its responsibilities or using the services supplied by the system in the execution of respective responsibilities. NASA would be responsive to the needs of all as required by the administration.

In support of some rather specifically needed research, NASA has physical systems expertise that could work on environmental model development. As an example, NASA's fluid mechanics and fluid flow experts can assist in the development of required hydrologic models. As a part of the regional activities in the Earth Resources Program, the NASA centers will be attacking a small number of local or regional environmental problems and determining the utility of remote sensing to the solution of these problems. Hydrologic modeling of the Chesapeake Bay and the James River by Wallops and Langley are examples. Ames is working with the University of California on the Feather River. Lewis Research Center is working with the Water Quality Administration in monitoring the quality of water in Lake Erie. The utilization of NASA instrumentation, physical science and systems engineering talents as well as our facilities close to regional problems represents an opportunity to accelerate understanding and potential solutions to some of our initial environmental problems. MSC,MTF, and MSFC are also developing regional efforts of this type.

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Recommendations

In view of the potential of pollution of the Earth's atmosphere, land and water to seriously alter or destroy life as we know it; and in view of the need to develop a better understanding of the effects of gaseous, chemical, particulate, and thermal pollution on a global as well as a regional basis; and recognizing the need of EPA, NOAA, and the scientific community for vastly more environmental data than can be collected by current techniques; it is recommended that:

NASA, IN CONJUNCTION WITH APPROPRIATE FEDERAL AGENCIES AND WITH PARTICIPATING NATIONS OF THE WORLD, DEVELOP AND PLACE INTO OPERATION A DATA ACQUISITION, COMMUNICATION, PROCESSING, AND DISTRIBUTION SYSTEM FOR MONITORING THE GLOBAL ENVIRONMENT.

NASA EXPAND ITS RESEARCH PROGRAM IN THE ATMOSPHERIC AND EARTH SCIENCES TO BETTER UNDERSTAND THE BEHAVIOR OF POLLUTANTS IN THE AIR AND WATER OF THE EARTH;AND ACCELERATE ITS DEVELOPMENT OF THE INSTRUMENT TECHNOLOGY REQUIRED FOR THE DETECTION AND MONITORING OF POLLUTANTS.

NASA PROVIDE SYSTEMS ANALYSIS AND OTHER TECHNICAL SUPPORT, IN A COOPERATIVE AGREEMENT WITH EPA, FOR A SERIES OF HIGH PRIORITY DEMONSTRATION PROJECTS TO MONITOR, UNDERSTAND, AND CLEAN UP SELECTED ENVIRONMENTALLY DEGRADED BAYS, RIVER BASINS, AND CITIES.

## Development of Clean Automobile Engines and Monitoring Systems

### Overview of the Problem

A major source of air pollution in our great urban areas is the internal combustion engine used in the automobiles and buses. The average automobile exhausts about 3/4 to 1-1/2 tons of pollutants per year. The emissions of primary concern have been hydrocarbons and carbon monoxide resulting from incomplete combustion in the internal-combustion engine and compounds of nitrogen with oxygen ($NO_2$) resulting from the reaction of these components of air at high combustion temperatures. In addition there is concern for particulates emitted by the engines, especially compounds of lead.

Beginning in about 1961, efforts have been made to reduce the emission output of the engines. Much of this activity has been stimulated by regulations imposed by the State of California, closely followed by the Federal Government. The President took the initiative on February 10, 1970, with a 37-point administrative and legislative program in which he said: "I hope the automobile industry's present determined effort to make the internal combustion engine sufficiently pollution-free succeeds. But if it does not, then unless motor vehicles with an alternative, low-pollution power source are available, vehicle-caused pollution will once again begin an inexorable increase.

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"Therefore, prudence dictates that we move now to ensure that such a vehicle will be available if needed.

"I am inaugurating a program to marshal both government and private research with the goal of producing an unconventionally powered, virtually pollution-free automobile within five years.

> --I have ordered the start of an extensive Federal research and development program in unconventional vehicles, to be conducted under the general direction of the Council on Environmental Quality.
>
> --As an incentive to private developers, I have ordered that the Federal Government should undertake the purchase of privately produced unconventional vehicles for testing and evaluation.

"The immediate task, however, is to see that an intensified program of research and development begins at once."

A major step was taken by the Federal Government with the passage of the Clean Air Amendments of 1970. This act requires that the carbon monoxide and hydrocarbon emissions in 1975 be only 10 percent of that allowed in 1970 and that the $NO_2$ emissions in 1976 be only 10 percent of those allowed in 1971. Congress has authorized substantial funds to the new Environmental Protection Agency (EPA) for R&D toward meeting these goals.

Active Organizations

EPA - Primary responsibility in the government rests with the Air Pollution Control Office (APCO), formerly a part of HEW and now an office in EPA. Before the passage of the Clean Air Amendments of 1970, APCO had supported work to improve the conventional internal-combustion engine. With the passage of the law, APCO took the view that the auto industry would probably put the needed resources against the problem to protect its huge investments in the internal combustion engine and thus APCO could concentrate on stimulating alternatives to that engine as was provided for in the law.

DOT - Under its Urban Mass Transit Authority, DOT is supporting improvements in bus and rail transportation and developing new urban transportation modes such as pneumatic tubes and air cushion vehicles. Some of these programs are aimed at reduction of pollution --e.g., the bus program includes the installation of unconventional engines into buses for tests in various cities.

The Auto Industry - Each auto company is spending large sums of money to solve the problem with the internal combustion engine. Much lesser sums are being spent on alternatives to that engine. The auto companies

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have collaborated in various ways to coordinate some of their efforts. One example is IIEC, Inter-Industry Emission Control Program, which is a cooperative group among Ford and five oil companies. Another is the Coordinating Research Council, Inc., which is a joint effort of Society of Automotive Engineers, SAE, and American Petroleum Institute. These groups are somewhat hampered by their concerns about the anti-trust laws. Apparently, as a result, the latter group seems to be limited to quite basic research.

Coordination - Coordination of a portion of this effort is achieved through the Advisory Committee on Advanced Automotive Systems under the President's Council on Environmental Quality. NASA (LeRC) has a staff member on that Committee.

Resources Being Applied

EPA - Their support of engines that may be low pollutant alternatives to the internal combustion engine is planned as follows: FY 72 $17.5M; FY 73 $18.2M; FY 74 $14.8M; FY 75 $7.9M. The reduction in funding after FY 73 results from the idea that the solution to the problem should be identified by that time if they are to provide a viable engine choice by production year 1975 or 1976. They apparently have substantial funding on monitoring systems as well. They cannot impose standards unless they can quickly, cheaply measure the important emissions from the vehicles.

EPA also has an Incentive Program wherein they will pay 1-1/2 to 2 times the cost of a conventional car to any company who comes up with a engine that will satisfactorily meet the standards. They will then produce a fleet of 5 to 10 cars and test them for the inventor. This program is to encourage anyone (even the backyard garage) who can come up with a good idea.

DOT - The total budget for Urban Mass Transit Authority (UMTA) is $45M with about $10M related to buses. A significant part of this latter sum is aimed at unconventional engines that would reduce pollution from these vehicles.

Industry - The resources being invested by the auto companies (mostly on the internal combustion engine) are not available although such information has been provided to EPA on a proprietary basis. The amounts are surely large. The program conducted by the Coordinating Research Council was at the rate of $7.5M per year. At one point DuPont was investing perhaps $4 to $8M per year to develop a thermal reactor that would clean up the exhaust from an I-C engine burning leaded fuel. (DuPont is a major producer of the lead additives.) With the new Federal controls on lead content of fuels, this program has been severely cut back.

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The solution to the problem for the internal combustion engine is not in hand. Major gains have been made in lowering CO and hydrocarbon emissions, minor gains in reduction of $NO_x$; yet the achievement of the goals of the Clean Air Act of 1970 are not yet in sight. Practical long-life, low-cost thermal reactors and/or catalytic converters almost certainly will be needed and have yet to be developed.

The development and introduction of an alternative engine into the production of some 10 million cars a year is indeed a challenge. Many alternatives are being considered and the final system may yet need to be invented. EPA is currently considering the gas turbine, the diesel, all-electric, heat engine-battery, heat engine-flywheel, Rankine and other new concepts. The successful development of these engines depends upon achieving improved component performance as well as development of new engines and complex systems where, for example, electric power is coupled to a heat engine with automatic shifting and division of the load.

For electric cars or electric hybrids, considerable improvements, generally beyond the potential of the lead-acid battery in regard to specific power, energy capability, and cyclic life are required.

In regard to monitoring systems, simple reliable diagnostic instrumentation is required to make regular vehicle inspection practical.

NASA Qualifications

NASA personnel were leaders in the development of reciprocating engines (the internal combustion engine) during the years prior to and during WW II as NACA. Since WW II we have been leaders in all aspects of research in gas turbine engines including every component and material in these engines as well as full-scale engines and control systems. Since creation of NASA we have had a large effort in Space Power Systems that utilize the Rankine and Brayton cycles. This effort has focused on high efficiency, once-through boilers, condenser, low pressure drop reliable heat exchanges, highly efficient small turbines and compressors, bearings and lubricants for high temperatures, controls, etc. Rankine and gas turbine (Brayton) systems are used to drive alternators and the systems are integrated with all the electronic controls. We have considerable research on improved performance batteries (Ag-Zn, NiCd, etc.) and fuel cells. The nickel-zinc battery using a NASA developed separator should be of great interest to the auto industry.

Current Activity

1. About three years ago Air Pollution Control Office (APCO) (then with HEW) came to LeRC to ask for help on the development of low cost high temperature materials to achieve a reliable thermal reactor for the

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internal combustion engine. They transferred $300K per year for two years to LeRC. This money has been used to define material requirements for such reactors, sponsor development of new metal alloys and coatings, develop new design concepts utilizing ceramics and to evaluate the materials in reactors on test engines. The fundamentals of the combustion kinetics related to the thermal reactor have been studied. Currently about five professionals are active in this program.

2. A few months ago, APCO again came to LeRC for help, this time on their programs to develop an alternate engine. (They were being criticized for the quality and depth of knowledge of their small staff on the program.) Lewis has helped by reviewing proposals, reviewing progress on contracts, etc. APCO has requested that Lewis take over the management of contracts (at least six) and suggested that one or more engines be brought in-house for evaluation and study. They have also sought help to date in combustors, working fluids, batteries, Rankine cycles and their components -- i.e., areas where they recognize Lewis has competence developed over many years.

Disciplinary Skills

Indicated above: -- engineering, component design and performance, heat transfer, turbine and compressor design, materials, lubrication, bearings, electrochemistry, systems integration, computers, instrumentation R&D, analytical chemists with research capability, etc.

Resources and Other Considerations

Active now -- roughly outlined above.

Needed - Depends on the responsibility assumed by NASA. A minimum of 60 people (maximum 200) and an additional $40M per year may be required for a combined contract and in-house effort that would effectively lead the way in this area. As opportunities are demonstrated, the industry would be expected to assume the burden.

Recommendation

It is clear that government must take the lead and play a major role if clean engines meeting the nation's needs are to be achieved. The auto industry, one of America's key industries, is profit motivated and is less responsive to this need. Their current investment in pollution control is largely a result of their fear that the present law dictates that cars may not be sold in 1975 (or 1976) if the goals are not met. If a new engine is required, innovation will be needed in many areas on a broad front -- more characteristic of the accomplishments of the high technology aerospace industry than the conservative auto industry but with the cost consciousness and mass production genius of the auto industry. The highly competitive auto industry is further hampered from truly cooperative effort (even if they chose to do so) by antitrust laws.

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NASA and the aerospace industry undoubtedly have the greatest and best combination of specialist and management talent coupled with R&D capability covering the skills required for advanced engine development. NASA is eminently qualified to take the lead role for government in the effort to achieve an alternate low-pollution auto engine.

In support of the President's goal and EPA it is, therefore, recommended that:

NASA, IN SUPPORT OF EPA, ACCEPT RESPONSIBILITY FOR THE RAPID DEVELOPMENT AND DEMONSTRATION OF ADVANCED LOW POLLUTION AUTOMOTIVE PROPULSION SYSTEMS.

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TRANSPORTATION

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# TRANSPORTATION

## Overview of the Problem

Modern society has become highly dependent upon an efficient transportation system for passengers and goods. (See Table 1.) This system comprises air and surface transportation together with the necessary interfaces between them. Each of these modes is economically viable, under different demographic conditions and under certain route structures, and we can anticipate a continuing demand for both forms of transportation in the future, recognizing the distributed nature of the centers of population and manufacturing industry in the United States.

Over the past 50 years, we have seen a phenomenal rise in the highway segment and in the air transportation segment due to the influence of modern technology in the form of the commercial aircraft and the automobile, and simultaneously a significant decrease in rail and water transportation due in part to the absence of modern technology. The resulting mix of transportation modes has not been achieved without some cost to society. The automobile, in addition to being a convenient form of transportation, particularly over short distances, is also a major source of pollution in large population centers (see figure 1), and similarly, the truck and the airplane are a major source of noise

During the next 10 years, the urban passenger traffic demand (primarily automobile and air travel) is expected to grow from the current 1000 billion passenger miles to approximately 1700 billion passenger miles and would more than double its present value if the current annual rate of increase of 4½% continues. Similarly, demand for interurban transportation of goods, primarily by rail and truck, is expected to increase from its current level of 1800 billion ton miles to approximately 2500 billion ton miles in the same period. Inland water transport of freight is a small but not negligible fraction of this total and is credited with an annual 230 billion ton miles in recent years.

Urban transit vehicles perform an annual eight billion passenger trips, of which approximately three-quarters are by bus and the remainder by rail. These modes have lost passengers to the automobile in recent years and are likely to continue this trend unless improvements are made to the mass transit systems. This will compound the highway congestion already experienced by all major centers of population and place further pressures on urban centers to build more freeways. It is estimated that for urban commuter traffic the automobile requires 17 times the land area taken by mass transit systems (per passenger).

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In view of the future importance of transportation in its various forms, both as a means of distribution of goods and as a means of relocating our densely populated urban areas, improvements in transportation are absolutely essential. If such improvements are to be achieved, new technology must be applied to all promising forms of transportation and applied in such a way that air and surface modes are developed in a balanced fashion, each contributing to an integrated transportation network without incurring unnecessary costs to the public.

Current Activities

The federal agencies most involved in the development of civil transportation are (1) the Department of Transportation (DOT), (2) the National Aeronautics and Space Administration (NASA), and (3) the Department of Commerce. The DOT is responsible for developing national transportation policies and programs, and its organization includes the Federal Aviation Administration (FAA), the Federal Highway Administration (FHWA), the Federal Railroad Administration (FRA), the Urban Mass Transportation Administration (UMTA), and the Transportation Systems Center, Cambridge, Mass.

The FAA is responsible for the regulation of air commerce to promote its safety and development, achieving efficient use of navigable air space, developing civil aviation, and developing and operating a system of air traffic control and navigation. It has two facilities: the Aeronautical Center, Oklahoma City, and the National Aviation Facilities Experimental Center, Atlantic City, N. J., which is responsible for the development of improved air traffic simulation and aircraft certification research.

The FHWA carries out the highway transportation programs of the DOT and is concerned primarily with the federal-state highway construction program, but it is also concerned with the total operation and environment of the highway systems. The FRA consolidates government support for rail transportation and conducts research and development activity in support of improved rail and ground transportation. Within the FRA, the Office of High Speed Ground Transportation plans and implements a program of research and development in high speed ground transportation.

The current R&D program of this Office consists primarily of systems studies (e.g., for automated highway systems, multi-modal vehicles, tube systems, and tracked systems using fluid and magnetic suspension); technology developments related to high speed railroad systems (for example, improved suspension and drive mechanisms, use of aircraft technology, fluid state control circuitry, improved acoustic insulation, etc.); and field test and demonstration programs using the rail research cars at the Pueblo, Colorado, test facility and in the Northeast corridor.

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The Urban Mass Transportation Administration was established to assist public and private mass transportation operators in the development of improved facilities, to encourage planning and establishment of areawide urban mass transportation systems, and to provide financial assistance to state and local governments. UMTA undertakes a R&D program through the administration of grants and contracts with public and private organizations.

The Transportation Systems Center, Cambridge, Mass. (formerly the Electronics Research Center, NASA) conducts studies and research for, and is funded by, the several administrations (as outlined above) within DOT; it also conducts research for, and is funded by, NASA's Office of Advanced Research and Technology. Its program is conducted primarily in-house but with some contracts and grants to universities, and is largely concentrated on avionics and instrumentation for improved air traffic control systems.

NASA is charged with the responsibility for aeronautical research and development and has the capabilities and facilities to carry out this function within its diversified laboratory complex. With NASA the emphasis in aeronautical R&D is on the development of new technology applicable to aeronautical vehicles and systems, but its program also includes the application of new technology to advanced air traffic control concepts. Current emphasis in civil aviation is on quiet STOL aircraft technology and improved subsonic transport technology.

The Department of Commerce, through its Maritime Administration, aids in the development and operation of the United States Merchant Marine and conducts research activities to improve its efficiency. In recent years it has been funded by the National Science Foundation in a sea grant program to pursue programs in maritime science and technology and in advanced ship engineering and development. Its R&D program currently includes: Development of heavy duty turbines, studies of coastal and ocean going tug-barge systems, study of power requirements for ships in rough seas, collision avoidance, and oil spillage prevention.

The resources currently being applied, and those estimated for FY 1971 and FY 1972, within the three agencies involved in transportation are shown in Table 2. The total expenditures estimated for FY 1971 exceed $11.2 billion and are almost totally expended through DOT. A breakdown of the DOT estimated expenditures for FY 1971 and FY 1972 is shown in Table 3. Major amounts are expended on the highway system for urban and interurban transportation, and on the operation of the air traffic control system and the airport.

The Urban Mass Transit Act of 1970 provided $3.1 billion, to be expended between 1971 and 1975, for high speed ground transportation, and substantial further investments are proposed, bringing the total to approximately $10 billion by 1980. Despite these major responsibilities for the expenditure of government funds on advanced transportation systems,

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DOT has virtually no in-house R&D capability that would permit it to determine the technical feasibility of these advanced systems. UMTA has 129 people, augmented by a small technical group at the Transportation Systems Center, with annual expenditures for R&D of approximately 20 million dollars.

Similarly, in air transportation, large annual expenditures are anticipated over the next decade for maintaining the present system, or for making modest changes to it. Small annual expenditures (50 million dollars) are planned for R&D programs on more advanced ATC systems, but here again the DOT has very limited in-house R&D capabilities to direct properly such programs.

Areas in Need of Technical Assistance

In view of the prime responsibility and concern within DOT for operational problems of the present transportation systems, and in view of the lack of in-house technical capability to formulate and evaluate properly alternative approaches to a future, more efficient transportation system, there is serious doubt that our long term transportation needs will be satisfied, despite the large expenditures proposed for the next 10 years. Questions relating to the best components for intermodal transportation require in-depth technical and economic evaluation followed by properly directed system research and development; and the present capabilities of DOT are insufficient to provide them.

More specifically, greater technical resources must be applied in the following areas:

1. Ground Transportation

a. Total Transportation System Studies

The future requirements and specifications for mass transportation in urban areas and between urban centers can be determined and defined only by broad transportation system studies. Such studies must take account of the most viable alternative modes of transportation, the vehicle characteristics, the modal interfaces, and the economics of development and subsequent operation. In these studies the impact of new technology on the operating characteristics and, therefore on the economics must be assessed in detail if new transportation systems are to be developed in a national way.

b. Urban and Interurban High Speed Ground Transportation

Transportation within urban centers and between urban areas is accomplished today primarily by automobile and, for larger distances, by airplane. As the airways and roads become more crowded, alternative means of public

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transportation must be given renewed consideration, particularly where existing rights-of-way can be used. A large number of imaginative vehicle concepts has been proposed over the past decade, but technical development of these vehicles has not been pursued to the extent that they can be properly evaluated. The current need is for the development of high speed ground transportation research vehicles which incorporate the best available technology; the modification of existing track or the development of new track systems; and the development of modern control systems to permit low cost operation of those vehicles and track systems that are subsequently pursued to operational status.

## 2. Air Transportation

### a. Aircraft Development

The past 40 years have seen a continued rapid growth in air transportation both domestically and internationally. While the past technical developments have, in large measure, benefited from related developments in military aviation, the future aircraft developments, particularly for short haul domestic needs, are unlikely to be so fortunate. The development of quiet, pollution-free STOL and VTOL aircraft, capable of a high degree of automated flight path control, will be a major contribution to solving the problem of congestion in terminal airspace. Such a development has no military counterpart, however, and will require initial development under the cognizance of a civilian agency having experience in the traditional areas of aeronautical engineering: aerodynamics, structures, propulsion, and guidance and control.

### b. Air Traffic Control Systems

The current Air Traffic Control System, operated by the FAA, comprises facilities, regulations, and personnel which provide services and procedures that control traffic in U. S. airspace. The ATC facilities include radar systems, control towers, and communications systems, and these work in conjunction with airborne navigation and communication equipment and with the pilot. The present system is gradually being improved in order to avoid increasing the controller workforce at a rate proportional to the growth of air traffic.

These improvements are not likely to keep pace with the increasing traffic levels anticipated for the late 1970's, however; a major R&D program is needed to bring about significant advances in the ATC system. More specifically, the following three areas require substantial efforts:

- o New traffic control concepts
- o Development of various system approaches
- o Development of new subsystem technology

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This need for R&D is particularly critical in view of the fact that a total government investment of some $40 billion is anticipated over the next 20 years for the development, procurement, and operation of the ATC system.

The R&D program over the next decade will require, as a minimum, the following:

- o System engineering, simulation, and trade-off studies of alternative concepts.
- o Research and development in ground and satellite based position determination for navigation and surveillance.
- o Research and communications techniques in a high density aircraft traffic environment.
- o Development of high capacity ground and airborne computer systems and data acquisition, processing, and directory methods.
- o Determination of influence of new aircraft, particularly STOL and VTOL, noise abatement, turbulence detection, etc., on ATC characteristics.

NASA Qualifications

1. Ground Transportation

The provision of a modern transportation system in the United States involves the development of an integrated network of air and surface modes incorporating the best available technology in order to insure an efficient, reliable, and clean service. The complexity of the system, the need for advanced vehicles, and the character of the required technical advances are all basically similar in nature to corresponding systems, vehicles, and technology that NASA has successfully developed in the past.

The system and vehicle development programs conducted by the manned space flight centers have involved design, prototype testing, and system integration of fundamentally new concepts and were carried out in a way that took maximum advantage of the development and production capabilities of the United States aerospace industry. It is exactly this combination of government and industry talents that is required to make significant advances in our ground transportation systems.

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The capabilities, for example, of the Marshall Space Flight Center are such that they encompass the following aspects relating to surface transportation: propulsion and thermal engineering, material research and engineering, electrical networks, structural analysis and design, power sources, plasma physics, formulation and assembly, processes, quality and reliability assurance, computation technology, systems and subsystems testing. These capabilities place the Center in a preferred position to manage aerospace contractor teams involved in ground transportation development.

The facilities of Marshall Space Flight Center include the following: acoustic test facility, plasma physics laboratory, pneumatic and cryogenic test facility, composite structures test facility, electrical systems integration laboratory, noise propagation and measurement laboratory, guidance and control systems development laboratory, hydraulics research facility, vibration test facility.

Similarly, the advanced aeronautical vehicle technology that is produced by NASA's Research Centers can be extended readily into corresponding areas of research applied to surface vehicles. The basic technology of structures and materials, propulsion, aerodynamics, guidance and control, human factors, avionics, and instrumentation are quickly transferable to all forms of high speed transportation.

The facilities of the NASA Ames, Langley, Lewis Research Centers include: instrument research laboratory, structural dynamics laboratory, motion simulator facilities, low-speed wind tunnels, fatigue research laboratories, dynamics research laboratories, impacting structures facility, noise research facilities, structures research laboratory, engine components research laboratory, energy conversion laboratory, fracture mechanics laboratory, materials and stress laboratory, propulsion component evaluation laboratories, fluid mechanics laboratory.

In the event that NASA takes a leading R&D role in ground transportation, it should be possible to modernize the entire transportation system in the United States over the next 10 years. While many of the problems to be solved will be nontechnical in nature, the opportunities for meeting institutional and other constraints are considerably broadened if alternative efficient modes of transportation are made feasible through technical development. Rail transportation, for example, which is currently labor-intensive, can achieve levels of efficiency through the approach of automated control technology that would permit it to contribute positively to the transportation system.

Much of the technology required for major advances in transportation resides within the aerospace industry and NASA's involvement would provide an important mechanism for encouraging the aerospace industry to broaden the scope of its business to cover surface transportation. Such an expanded scope with appropriate government funding, could do much to alleviate the currently depressed condition of the industry.

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## 2. Air Transportation

The expertise within NASA's Research Centers that has accelerated the growth of air transportation is well known and requires little elaboration. Much of NASA's experience relates to R&D for aeronautical vehicles, from conceptual design through wind tunnel testing and simulation, to the development and flight testing of experimental aircraft. Additionally, however, NASA's work in guidance and navigation, both for aircraft and spacecraft, has placed us in a strong technical position to make a major contribution to future developments in air traffic control systems, including the development of navigation and air traffic control satellites.

The current aeronautics program, conducted at the NASA Research Centers, covers a broad range of ground based investigation that are both discipline-oriented and vehicle oriented. The current vehicle-oriented work is being focused in part on experimental STOL research aircraft and on STOL avionics for automatic approach and landing. The developments of VTOL and ATOL Research aircraft is envisioned so that ground based research can be validated and operating modes and procedures can be acquired for future civil aircraft of these types.

In the area of air traffic control, simulation and modeling studies have been conducted at Ames and Langley Research Centers, and the interrelationship between advanced air traffic control procedures and aircraft maneuvering capabilities have been explored. Goddard Space Flight Center is currently involved in studies of navigation and traffic control satellites that are expected to be an important part of any advanced ATC system.

The disciplinary skills within the aerospace industry and at the NASA Research Centers are completely adequate to support an expanded program of experimental STOL and VTOL research aircraft. With respect to advanced Air Traffic Control, the necessary skills associated with the development of subsystems and systems, including Navigation and Air Traffic Control Satellites, are also available: avionics, guidance and control electronics, sensors, communications, human factors, flight simulation.

Furthermore the operational skills that have been developed at Manned Spacecraft Center and employed in the control of NASA's manned spacecraft missions are all extremely relevant to the formulation of advanced ATC systems (real time data handling and analysis; communications, processing and display of information for the pilot and the ground controller; automatic monitoring of multicomponent systems; formulation of special decision algorithems, etc.) and these competences can be used to accelerate the necessary system developments by the industry.

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The facilities at NASA research centers applicable to advanced ATC system R&D include: instrumentation laboratories, guidance and control laboratory, flight simulators, vehicle antenna test facility. The facilities at Manned Spacecraft Center include: electronic equipment development laboratory, radar development laboratory, antenna test range, communication laboratory, flight simulation and training facility, guidance and control laboratory, instrument and electronic systems laboratory, inertial and optical lab. radar range, large capacity digital computer. The facilities at Goddard Space Flight Center applicable to the development of Navigation Satellites include: Antenna control systems facilities, antenna test range, RF anechoic chamber.

With the application of NASA technical expertise to the development of experimental aircraft and to the development of advanced ATC systems, it should be possible to demonstrate new modes of air transportation and new methods of traffic control that will provide substantial relief from the congestion suffered by the nation's airways.

Recommendations

In view of the increasingly important role of interurban air transportation in the United States and the need for quiet advanced aircraft to reduce congestion of the airspace in urban areas, it is recommended that:

NASA ACCELERATE THE DEVELOPMENT AND FLIGHT TESTING OF STOL AND VTOL EXPERIMENTAL AIRCRAFT CAPABLE OF FULLY AUTOMATIC ALL-WEATHER TERMINAL AREA OPERATIONS; AND DEMONSTRATE THE APPLICABILITY OF SUCH AIRCRAFT TO VASTLY IMPROVED INTERURBAN AIR TRANSPORTATION SYSTEMS.

In view of the importance of a reliable air traffic control system to the safe and efficient operation of the nation's airways, and in view of the major government expenditures in areas of high technology that are required to modernize our ATC system, it is recommended that:

NASA, IN CONJUNCTION WITH THE FAA, UNDERTAKE TO DEVELOP AND DEMONSTRATE EXPERIMENTAL AIR TRAFFIC CONTROL SYSTEMS, INCLUDING BOTH GROUND BASED AND AIRBORNE EQUIPMENT, FOR V/STOL AIRCRAFT.

NASA PLAN AND DEVELOP, AS AN AGENT OF THE DOT, A COMPREHENSIVE NAVIGATION AND TRAFFIC CONTROL SATELLITE SYSTEM FOR THE 1980'S.

In view of the major government investment anticipated for the next decade in urban and interurban transportation, and the need for an integrated system development utilizing new vehicle concepts, it is recommended that:

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NASA, IN SUPPORT OF THE DOT, UNDERTAKE A COMPREHENSIVE R&D PROGRAM ON ALL FORMS OF ADVANCED GROUND TRANSPORTATION, WITH EMPHASIS ON SPEED, SAFETY, ECONOMY, AND COMPATIBILITY WITH THE ENVIRONMENT.

NASA, AS AN AGENT OF THE DOT, DEVELOP AND DEMONSTRATE SEVERAL EXPERIMENTAL HIGH SPEED GROUND VEHICLES SUITABLE FOR EARLY INCORPORATION INTO A BALANCED URBAN TRANSPORTATION SYSTEM.

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## TABLE I

Inter Urban Transportation 1965-1970

| Passenger Miles | Auto | Bus | Rail | Aircraft | Total |
|---|---|---|---|---|---|
| (Billions) | 940 | 20 | 10 | 80 | 1,050 |

| Freight ton-miles | Truck | Rail | Water/Pipeline | Aircraft | |
|---|---|---|---|---|---|
| (Billions) | 390 | 760 | 680 | 3 | 1,833 |

## TABLE II

Transportation Funding (Billions)

| | 1970 Actual | 1971 Estimate | 1972 Estimate |
|---|---|---|---|
| DOT | 8.685 | 11.169 | 8.448 |
| NASA | 0.100 | 0.102 | 0.116 |
| DOC | 0.012 | 0.023 | 0.025 |

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TABLE III

DOT Funding (Billions)

| | 1970 Actual | 1971 Estimate | 1972 Estimate |
|---|---|---|---|
| Urban Transportation | | | |
| Category Total | 2.483 | 5.511 | 2.376 |
| (Trust Funds) | (2.306) | (2.411) | (2.372) |
| Inter Urban Transportation | | | |
| Category Total | 5.090 | 5.083 | 5.124 |
| (Trust Funds) | (3.896) | (3.843) | (4.594) |
| *Other | | | |
| Category Total | 1.132 | 1.222 | 1.496 |
| (Trust Funds) | .216 | .289 | .450 |
| TOTAL | 8.705 | 11.816 | 8.992 |

*Includes: International transportation, General Transportation Safety, and General Support.

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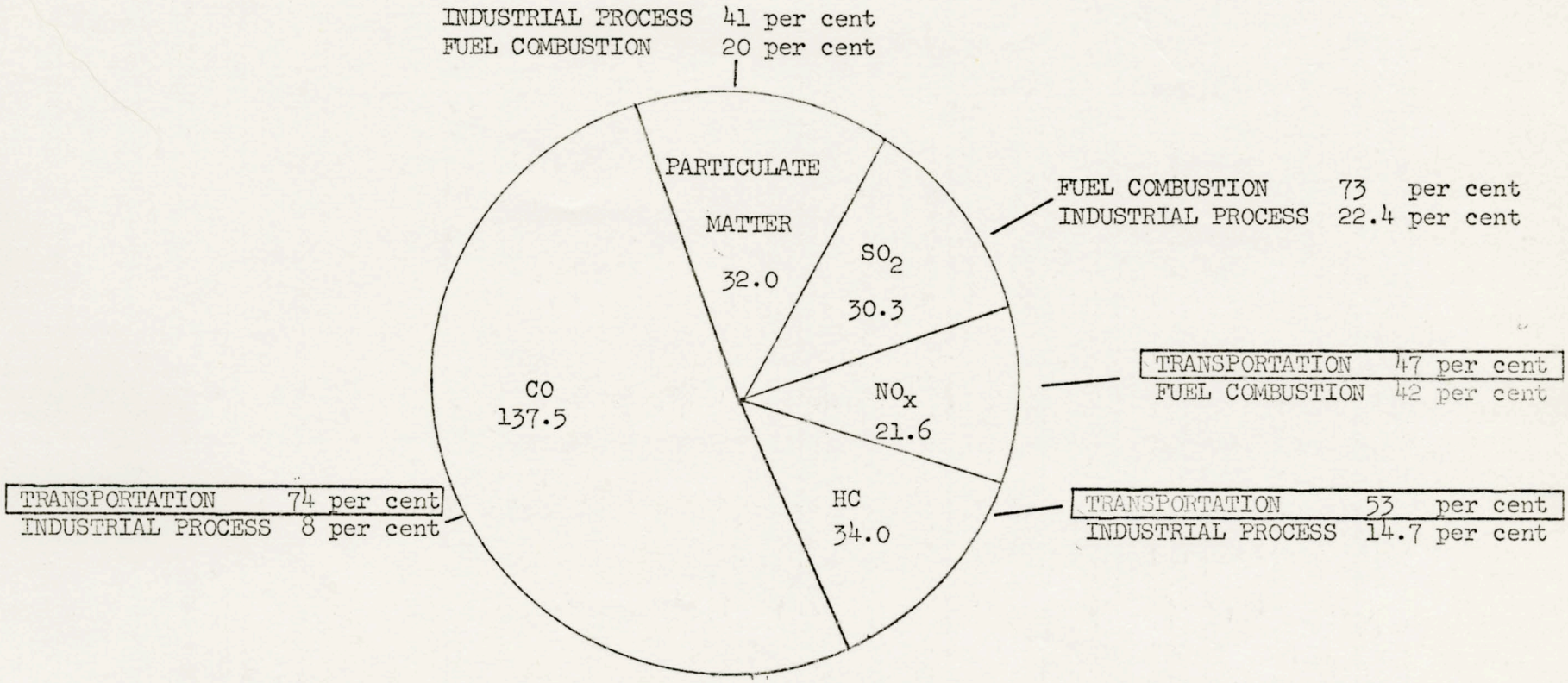
1969 U. S. EMISSIONS OF FIVE MAJOR POLLUTANTS




1969 EPA DATA

Figure 1. ALL UNITS ARE MILLIONS OF METRIC TONS

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POWER

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# ELECTRIC POWER

## Overview of the Problem

Although the use of electricity has doubled (and is expected to further quadruple in the next 20 to 30 years), the population has grown by 12 % in the last decade. To meet this demand, the Federal Power Commission has estimated that the electric power industry will expend close to $350 billion on generation and transmission equipment in the next 20 years.

The continuing problems faced by the industry are location and exploitation of fuel reserves, transportation and processing of the fuel, power generation, transmission, and distribution. These problems are aggravated by the major increase in electricity demand and the fact that generation of electrical power is a major polluter of the environment.

The extremely large increase in electric power consumption has resulted in fuel shortages; in the past few years we have been utilizing natural gas at a rate almost double that of the discovery of new reserves. While this trend is not expected to continue, the fact remains that we will consume all of our currently known natural gas resources in less than 10 years. In the case of our petroleum reserves, the situation is not quite as severe; current oil reserves will last for another 20 to 30 years. Coal, on the other hand, is in plentiful supply and known reserves will last for a century or more.

The major expansion of power generation capacity has introduced a host of problems at the generation plants. For example, generators are currently being operated in the 600 to 900 megawatt range compared to past practices of about 200 to 300 megawatts. Recent experience has indicated that the 10 to 15 percent reserve previously found to be acceptable to offset equipment failures now has to be increased to 15 to 20 percent.

About 10 percent of the energy generated by today's power plants is lost in transmission of the energy to the consumer. Improvements are achievable through the use of cryogenic transmission lines and superconductive materials. The industry today also faces public pressures to place transmission lines under ground. While this would permit the use of higher transmission voltages, thereby reducing the line losses, the major drivers are protection of the environment and more effective land utilization. However, the cost of underground transmission lines is substantially more than that associated with lines aboveground.

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The Northeast blackout of 1965, which affected some 30,000,000 persons, dramatically illustrated the interdependency of many electric power utilities serving a large area and indicates the need for increased reliability of transmission and distribution equipment as well as better overall system planning. Brownouts, due to inadequate generating reserves, are unfortunately becoming commonplace. Unless the reliability of distribution networking is improved, blackouts may also become commonplace.

For the past few years, preservation of the environment has become a major issue. The continuing major expansion in power generation raises the possibility of significant modifications to the Earth's thermal balance, atmosphere, water, and ecology.

Fossil fueled electric power plants discharge almost 50 percent of the sulfur oxide pollutants and about 20 percent of the particulate pollutants into the atmosphere. These pollutants represent 25 percent of the total pollutants discharged into our atmosphere, and are the two that require the greatest volumes of air to dilute them to the acceptable levels specified by the Environmental Protection Agency (EPA).

Thermal pollution from electric power plants poses a problem of increasing importance. Each kilowatt hour of electrical energy generated by a modern large fossil fueled plant requires the equivalent of slightly more than one kilowatt hour of heat to be rejected at the steam condenser. One-sixth of the fresh water runoff in the United States will be required by electric power plants by 1980. Most fossil fuel power plants now discharge cooling water back into their water source some 20° F above the ambient temperature of the water source (or 4 times the standard being considered by EPA.) While the ecological effects on marine life, marsh lands, and estuaries, are uncertain, they are of major concern.

What about nuclear power? Of the new generating capacity currently on order in the United States only about 1/3 will be nuclear fueled. Nevertheless, the Atomic Energy Commission has estimated that by the end of this century nuclear fission power will account for 60 percent to 70 percent of the electricity generated in the United States. Known resources of uranium required by modern power plants are not unlimited. However, upon development of the liquid metal fast breeder nuclear reactor, the life of our natural uranium fuel supplies would be extended to many centuries.

Nuclear power will markedly reduce the overall air pollution due to electric power generation. It does, however, introduce other environmental problems.

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The handling of vast quantities of nuclear fuels increases the danger of escaping radioactive materials from processing plants. Potentially of greater concern will be the emission of radioactive krypton-85 into the air and radioactive tritium into the primary coolant (which must be periodically purified.) In addition, the thermal pollution of cooling water from modern nuclear power plants is 50 percent higher than for fossil systems.

In addition to its improved fuel utilization, the breeder reactor will also reduce the emission and thermal pollution associated with modern nuclear systems. To quote President Nixon ... "Our best hope today for meeting the nation's growing demand for economical, clean energy lies with the fast breeder reactor."

The consumption characteristics of electrical power dictate that a combination of fuels and power generating techniques will continue to be employed for many years to come. For example, because of the electrical load cycle, 25 percent of the nation's generating capacity is needed to supply the peak 5 percent of the electrical energy required during a typical day. Thus, nuclear power will not become the sole means for electrical power generation and the problems associated with fossil fuels will continue to be important.

Because of the scope of the problems, fundamental new approaches must also be examined and their potential understood. For example, it is highly questionable that we should continue to depend solely on the use of the steam boiler cycle in generating plants, whether they be fossil fueled or nuclear fueled. Advanced techniques such as controlled thermo-nuclear fusion, Magnetohydrodynamic (MHD) power, solar energy, geothermal energy, fuel cells, synthetic fuel, and improvements to the basic thermodynamic cycle need to be explored. In addition, we need to exploit on our vast coal resources through improved energy conversion technology, such as development of fluidized bed combustion, and techniques to gassify coal so that it can be used as a "natural" gas with its low sulfur dioxide emission.

It is also clear that breakthroughs in electrical energy storage are needed to improve the economics of electrical power systems. When one recognizes the high capital investments required, it is economically wasteful to require 25 percent of our generating capacity to satisfy the 5 percent peak load requirements. Looking further into the future, the development of reliable, low-cost energy storage methods, fuel cells, and gassified coal may lead the way in providing energy to the home of the future where gassified coal would power fuel cells in each home which would, in turn, provide all of the electrical needs of the home.

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In the words of the Energy Policy Staff of the Office of Science Technology in August 1970, "A greatly expanded research and development effort is urgently needed if we are to make significant progress in meeting power needs with less damage to the environment."

Current Activities

Historically, the Federal Government's role in the electric power field has been regulatory (the role of the Federal Power Commission.) Significant exceptions include public power projects (such as the Tennessee Valley Authority), the research activities of the Atomic Energy Commission and the Department of the Interior, the mineral resources efforts of the Geological Survey, and pollution control work by the Environmental Protection Agency. Until the last few years, however, non-nuclear power R&D was concentrated in the private sector and was extremely limited. The majority of industrial R&D efforts are for "development" by the major petroleum corporations and the manufacturers of large electric power generating equipment. The electric utility companies are expending about 40 to 60 million dollars a year, mostly to improve present systems - not for research. Applied research in the industry is centered in the Edison Electric Institute (EEI), a trade association made up of 185 electric operating companies which provide funding for the activities of EEI (which include marketing and new products, as well as applied research.) The EEI research effort is thinly spread and is mostly under contract with industry and universities since EEI has limited in-house R&D capability.

In 1965, the Electric Research Council was formed to provide a means by which the various segments of the electric utility industry in the United States could cooperatively sponsor research of industry-wide importance. The Council includes representatives from the Department of Interior and the Tennessee Valley Authority but is largely made up of representatives from private industry. The Council organizes and coordinates research by members of the industry which is supported on a voluntary basis. It is not organizationally associated with EEI; EEI does co-sponsor some of the Council's research projects, however.

The International Electric Research Exchange was founded in 1969 to provide a mechanism to exchange R&D information of international interest. Membership includes representatives from the United States, Canada, Japan, and Western Europe. Their objectives include international financial support of joint projects; for example, Japan is now providing financial support to one of the Electric Research Council's projects.

Within the United States, the Federal Government's role in sponsoring and conducting electric power research has broadened in scope in the past few

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years. Civilian nuclear power R&D by the AEC has increased markedly; the AEC is now also becoming engaged in environmental problems, studies of plant siting, and a regional resource model as well. However, the major thrust of AEC's efforts continues to be directed at the development and demonstration (in cooperation with the industry) of a fast breeder reactor power plant.

For several years, the Bureau of Mines and other offices within the Department of Interior have been engaged in R&D on the utilization of coal. In addition, Interior has initiated an underground electric power transmission research project. The National Air Pollution Control Administration (now part of the Environmental Protection Agency) has been engaged in power plant emission control R&D for several years, its major effort being directed at the sulfur dioxide emission problem.

The changing nature of the government's role is best characterized by the Research Applied to National Needs Program (RANN) of the National Service Foundation (NSF) and President Nixon's June 4, 1971 Special Message on Energy Resources. Within RANN, NSF has requested $12 million in FY72 for "Energy Resource Research and Analysis" which is a continuation (at about double previous funding levels) of a number of NSF sponsored efforts on the entire problem from extraction of the fuel to consumption of the power.

The President in his recent message made it clear that the government must expand its R&D efforts in electric power. He highlighted the fast breeder reactor, sulfur dioxide control technology, and coal gassification. He also stressed the need for R&D efforts on nuclear fusion, coal liquification, MHD, underground electric transmission, solar energy, oil shale, geothermal energy, and the natural gas supply.

It is clearly his intent, under the Departmental Reorganization Program, to assign full responsibility for power (including R&D) to the Energy and Mineral Resources Administration of the proposed Department of Natural Resources (DNR). While the Atomic Energy Commission will be left basically intact and will continue to perform R&D on civilian nuclear power, responsibility for policy and funding of the civilian nuclear power R&D will be transferred to DNR. In the meantime, the President has designated the Secretary of the Interior to be the Government's "manager" of energy.

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Industry's funding of R&D (other than equipment engineering development) is approximately as follows:

| | |
|---|---|
| Edison Electric Institute | $8 to $9 million/year |
| Electric Research Council | $32 million (total for 1965-71) |
| Electric Utilities* | $40 to $60 million/year |

* (to improve present systems)

R&D funded by the Federal Government is increasing rapidly. Annual funding levels are about as follows:

| | |
|---|---|
| Environmental Protection Agency | $60-70 million |
| Department of the Interior | $35-40 million |
| National Science Foundation/RANN | $12 million |
| AEC (Civilian Nuclear Power) | About $200 million |

In addition to the AEC laboratories and the TVA, there are two other organizations within the Federal Government which have in-house technical R&D capability. These are the Bureau of Mines and the National Air Pollution Control Administration (now part of EPA).

Under the President's reorganization proposal, the focal point and prime agency for power R&D will be the Energy and Mineral Resources Administration of DNR. This organization will be composed of about 6,000 people, the majority of which will be from the Bureau of Mines. The Bureau has a total of about 1,000 R&D professionals in some 23 laboratories. Most of these field units are small and specialize in metallurgy, mining techniques and safety, and coal utilization. EPA has, within the past few years, opened an air pollution research facility in Raleigh, North Carolina with a total staff of about 1,000. Their efforts encompass air pollution from all sources, including electric power generation.

Areas in Need of Assistance

1. Advanced non-nuclear techniques such as MHD, solar energy, geothermal energy, fuel cells, synthetic fuels, and improvements to the basic thermodynamic cycle (Brayton and Rankine system.)

2. Methods to dispose of or use waste heat and materials emitted into the air and cooling water.

3. Transmission of electric power, including overall transmission and distribution networking system studies.

4. Improvements in fuel resource exploration techniques with emphasis on remote sensing.

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5. Energy storage systems; large capacity for power generating plants and low capacity for residential and industrial use.

6. Technological discipline support to the industry in materials, heat transfer, combustion, fluid mechanics, thermodynamics, overall system analysis and engineering, etc.

NASA Qualifications

For many years, NASA (and previously NACA) has been engaged in research associated with fluid flow, combustion, heat transfer, fuels, thermodynamics, materials, power cycles, etc., - all of the basic disciplines involved in the generation of electrical power. These efforts have been continued during the "space age"; largely directed at space power and propulsion (airbreathing and rocket), including nuclear power. In addition, NASA has demonstrated an ability to organize, manage, and successfully conduct complex technological projects. Its system engineering capability is one of the best in the Federal laboratory structure.

Within NASA's 13,000 scientists and engineers and its extensive facilities are the "problem solving" skills required to undertake many of the complex problems associated with this country's electric power crisis. In addition, the interest is high as evidenced by the 1968 Conference at the Lewis Research Center on "Selected Technology for the Electric Power Industry."

A very large fraction of the 1,700 scientists and engineers (S&E) at NASA's Lewis Research Center have many years of research experience in power and related fields. Lewis has a sizeable effort today on space electric power technology (about 300 S&E), materials (about 120), nuclear propulsion (50), to cite a few examples of applicable efforts. In addition, Lewis has extensive research laboratories and facilities which are directly applicable. The Marshall Space Flight Center has a similar background and experience. Again, the combination of skilled and experienced researchers and extensive facilities could be applied to the problems in the electric power field. There are also applicable skills at several of the other NASA centers.

NASA also has had a long and successful relationship with NSF and AEC which would be vital if NASA is to become a major contributor. It must be recognized, however, that NASA does not have extensive experience and working relationships with the private power sector. While "cost effectiveness" has been a factor in NASA's operations, NASA does not have experience in the social/economic factors associated with electric power generation and consumption, even though its field centers are, themselves, large electricity consumers.

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Recommendations

President Nixon in forwarding his message to the Congress on Energy Resources stated ..."A sufficient supply of clean energy is essential if we are to sustain healthy economic growth and improve the quality of our national life. I am therefore announcing today a broad range of actions to ensure an adequate supply of clean energy for the years ahead." The actions included ... "A commitment to complete the successful demonstration of the liquid metal fast breeder reactor by 1980."

The President also stressed the need for R&D on all possible clean energy sources and systems such as sulfur dioxide control technology, coal gassification and liquification, nuclear fusion, MHD, underground electric transmission, solar energy, oil shale, geothermal energy, and the natural gas supply. In his message, he requested additional funds for some of the current programs in the above areas.

In order to effectively carry out the Federal energy program, the President has proposed, within his Departmental Reorganization Program, that all energy related R&D be the responsibility of the proposed Department of Natural Resources (DNR). He further stated that ...."The Atomic Energy Commission would still remain intact, in order to execute the nuclear programs and any related energy research which may be appropriate as part of the overall energy program of the Department of Natural Resources.

It appears that the AEC role could be extended to include non-nuclear power R&D. Their extensive background and related experience make them a logical choice for the Government's technical leader in the entire power field consistent with the DNR/AEC relationship outlined by the President. It is also recognized that the task to be done is formidable and that NASA's background is directly applicable. Therefore, it is recommended that:

NASA, IN CONJUNCTION WITH THE AEC, AND IN SUPPORT OF OTHER FEDERAL AGENCIES, UNDERTAKE AN R&D PROGRAM DIRECTED AT NON-NUCLEAR ENERGY GENERATION AND AT ENERGY TRANSMISSION AND STORAGE.

The major NASA tasks would be:

1. Research on advanced non-nuclear power generation and sources; MHD, solar energy, geothermal energy, fuel cells, synthetic fuels, etc.

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2. Studies on methods to dispose of and utilize waste heat.

3. Research on energy storage techniques; large capacity for utility company use and low capacity for industrial and residential use.

4. Power transmission and networking system studies.

5. Technological discipline support to industry and government agencies in materials, heat transfer, rotating machinery, fluid mechanics, thermodynamics, combustion, fuel technology, power cycles, etc.

In order to provide a committment to meeting the President's broad objectives, goals in addition to the already announced fast breeder reactor demonstration could be considered. Possible candidates include:

1. By the end of this decade, reduce the total pollution from all stationary power plants to one-half the present level.

2. By the end of this decade, demonstrate electrical energy storage techniques to improve the economics of energy generation and to preclude brownouts.

3. Within five years, identify feasible alternatives to the conventional steam cycle for the generation of electricity and feasible uses for the waste heat resulting from the conventional steam cycle.

If any or all of these goals were established, the EPA, AEC, and NASA R&D would be provided a valuable focus.

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HOUSING

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# HOUSING AND URBAN PROBLEM

## Overview of the Problem

The expanding population, the decay of our cities, and the continued demand to increase the American standard of living have created a shortage of acceptable housing which can be afforded by all U. S. citizens (Senate Hearing HR-17548). The requirement for new housing during the next ten years exceeds our capacity to build and finance them.

Since we must house our people, the nation must step up to this problem and turn its productive genius to the task. Providing the number of new units (single and multiple dwellings) required should be considered an opportunity as well as a problem. This new generation of homes should not merely be as economical as possible but should be liveable and durable. Modern science and technology can make these requirements compatible.

The continued use of conventional housing materials and construction practices will not alleviate this housing shortage. New technological approaches in building materials and fabrication techniques can contribute to the solution of this problem. These materials will permit unique and novel approaches to be used in prefabrication of houses which will last longer than existing homes and will provide improved habitability. The cost of housing construction may be lowered by this approach which will permit the use of a higher percentage of lower skilled and cheaper labor. The home and its occupants when considered as a unit are major contributors to air pollution, solid waste accumulation, overloading of sewage capacity, and to the wasteful use of our natural resources, i.e., water and energy fuels. It has been estimated by the Department of Health, Education and Welfare (HEW) that home heating units contribute 3.4 million tons of CO and $SO_2$ annually. This pollution largely comes from household heating systems which have not been designed to reduce and/or eliminate pollutants. The processing of human wastes and sewage effluents high in phosphates from the residental home is a major contributor to the pollution of rivers, lakes, and underground water reserves. One-third of the residential homes in the United States have independent septic systems and are not coupled to an existing sewage treatment plant. Three percent of the homes with sewage connections dump raw sewage into streams or rivers. The appliances and plumbing fixtures used in the American home have not been designed to minimize the utilization of water, electrical power, or energy fuels. A totally new approach to household system design and operation can minimize the use of water and energy fuels and decrease the pollutants emitted from individual homes. Solid wastes from residential and commercial sources create another complex national problem. It has been estimated that better than 200 million tons of solid

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wastes are generated alone from the urban areas. The term "solid waste" defines unwanted residues of used natural or man-made resources handled in the solid state, such as tin cans, newspapers, etc.

Solid wastes are considered a pollutant; however, they must also be considered as a resource which can and should be reused. The utilization of solid wastes must be approached as a technology problem. The methods used in the collection and transport of solid wastes account for 80% of the 4.5 billion dollar annual costs for waste collection and disposal. From these problems, it is apparent that engineering development activities are required in the collection, transportation, conversion to useful products, and the disposal of solid wastes. One solution which could alleviate many of the current problems would be onsite residential treatment and utilization of solid wastes. If such a system could be devised, collection and transportation problems could be greatly reduced.

Active Organizations

The Department of Housing and Urban Development (HUD) is responsible for establishing and directing programs to improve low cost housing. "Operation Breakthrough" is the HUD research and development program being pursued to develop technology to modernize and improve the entire process of housing people. Specifically, materials and fabrication techniques are being developed for large volume production of high quality low cost housing. Twenty-two contractors are currently building prototype units which will be evaluated using test systems and criteria developed by the National Bureau of Standards (NBS) and the National Academies of Science and Engineering. Eleven prototype site planning contractors have been selected; 3,000 prototype homes will be built on these sites to fully evaluate these housing concepts. This program could be greatly enhanced through a systems analysis approach looking at the house itself as a system and also as a subsystem in a community system.

The Bureau of Solid Waste Management (BSWM) of the Environmental Protection Agency (EPA) has recently assumed the responsibility for implementing the Solid Waste Disposal Act of 1965. This Bureau is responsible for establishing in-house studies, contracts, and demonstration grant programs to devise improved methods for residential and industrial solid waste management and utilization and for the assurance of environmental quality. The Department of Interior (DI) was given responsibility under this Act for solid waste problems resulting from the extraction, processing, or utilization of minerals or fossil fuels. The Department of Interior Bureau of Mines has conducted a research program in secondary waste metals for more than 20 years; these studies have been generally concerned with high-value metallic wastes, such as scrap metal and residues from metallurgical processing.

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## Resources Currently Being Applied

| | (In Thousands) FY71 | FY72 |
|---|---|---|
| **Housing:** | | |
| HUD Operation Breakthrough | | 45,000 |
| National Bureau of Standards (1) | | 1,100 |
| **Solid Waste:** | | |
| Bureau of Solid Waste Management (2) | 10,771 | Not Available |
| Bureau of Mines | 648 | (3) 500 |

Notes:

(1) Funds to establish uniform nationwide building codes and regulations

(2) Health, Education, and Welfare budget transferred to EPA

(3) Included in conservation and development of mineral resources

## Areas Needing Technical Assistance

It would appear that the current housing programs which utilize conventional heating, plumbing, air-conditioning, and waste collection methods could be greatly improved with a completely new systems approach to household and urban area development. The objectives of this research would be to improve household system operation, to conserve consumable supplies, to reduce pollutants emitted and to process onsite solid waste materials. Additionally, the application of nonmetallic spacecraft materials to home construction could be investigated to eliminate and/or reduce the hazards from fire.

## NASA Qualifications

The NASA aerospace industry team has been responsible for the development of spacecraft systems which provide a viable atmosphere to support life and to collect and store human wastes. Advanced development programs have been conducted to develop closed ecological systems to support crewmen for long-term missions. The spacecraft for which these systems are being developed is in many respects a housing unit which must handle many of the ecological problems we face on earth today. For example, the waste

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management system in the next generation spacecraft must collect and treat these human wastes for reuse or to reduce the stowed volume to small biologically safe residues. Ongoing research has developed techniques to recover potable water from urine and human solid wastes. The atmosphere in the spacecraft must be treated to remove toxic or noxious products. This has required research and development efforts to establish an understanding of the chemical processes needed to build systems to control spacecraft pollution. Potable water systems have been developed which have required extensive development of equipment and standards to insure proper water quality. The treatment of solid waste for a long-term space station is another problem area in which NASA engineering personnel have been engaged.

In summary, NASA has been engaged in life support system research for the past 10 years. The combination of NASA's in-house skills and test facilities, its experience in successful project management involving many contractors and subcontractors throughout the United States, and its understanding in applying an integrated systems approach to the solution of complex problems represents a unique national capability which can help solve some of the national housing and urban problems.

Current Activity

The Manned Spacecraft Center has a two-year closed ecological life support system under development with an aerospace contractor. This system utilizes physiochemical techniques for the removal of $CO_2$ and the recovery of oxygen from the $CO_2$. Additionally, potable water is reclaimed from human waste products. Numerous smaller research programs are being conducted both in-house and through contract on waste management systems, methods of temperature and humidity control, fire proof materials and applications, toxicological studies and control, and atmospheric monitoring instrumentation.

The Langley Research Center is actively engaged in life support system component development and tests. This includes programs in waste management systems, trace gas analyzers, recovery of oxygen from $CO_2$ and water, toxic gas control, and other related activities.

The Ames Research Center conducts in-house housing and contract programs in bioregenerative life support systems.

The Marshall Space Flight Center has been responsible for the development of the orbital workshop life support system.

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Long-term manned chamber tests have been conducted to study closed ecological systems and human performance. These program results and conclusions drawn therefrom could very well initiate 21st century concepts well before their time.

Disciplinary Skills

Life support research requires a unique combination of many technical disciplines. These skills transcend from physicians to mechanical engineers working together as a team. The formation of such a group has required all members to acquire crosstraining in completely different technical areas. The major technical disciplines may be summarized as follows:

- Mechanical Engineers
- Electrical Engineers
- Chemical Engineers
- Physicists
- Biochemists
- Bacteriologists
- Chemists
- Physiologists
- Physicians
- Toxicologists
- Nutritionists

Resources

Laboratory facilities which are the most advanced in this nation and are specifically designed for life support research and evaluation are available at three NASA Centers. These facilities could provide in-house technology support for many urban and housing support tasks. These facilities include:

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- Environmental Test Chambers
- Development Laboratories and shops
- Instrumentation Laboratories
- Toxicology Laboratories
- Water Analysis Laboratories
- Materials Development and Test Laboratories
- Data Management Systems
- Waste Management System Laboratories

Recommended NASA Participation

The NASA expertise in life support system technology could be utilized in the development of a completely new minimum impact home concept. The objectives of this research and development effort would be the application of the "system engineering approach" to all heating, plumbing, major appliance, and waste disposal systems. Studies would be made to determine possible ways that these systems could be integrated into a house to provide increased operation efficiencies and the quality of life.

Using this unique technical approach, new housing units or developments would be built into an urban area with minimum impact on the environment and public utility systems. The development approaches may be summarized as follows:

1. Heating System - Current oil, gas, and coal furnaces are major contributors to air pollution. These heating plants have not been designed to minimize the emittance of pollutant gases. These units would be evaluated to understand the basic performance of each type and from these test programs research efforts would be initiated to develop home heating plants which would not emit air pollutant gases or particles. Research would also be conducted to develop systems which could filter the residual gas from existing units.

Additionally, home heating plants would be studied to develop methods to increase the efficiency of fuel consumption and energy transfer. Alternate methods of using heat from other sources in the home would also be investigated. The expertise NASA has developed in life support systems, aircraft fuel combustion and thermodynamic and heat transfer would be used in this program.

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2. Plumbing System - The existing designs of plumbing fixtures would be evaluated to determine methods to reduce the volume of potable water required for household use. Toilet fixtures may be redesigned to reduce the quantity of potable water required as a transport medium. The reuse of water from sinks or showers for other uses would also be investigated. Additionally, onsite treatment of sewage effluents and primary treatment of water for reuse would be investigated to decrease the burden on central sewage treatment plants.

Life support system personnel would be utilized to conduct research and evaluation programs and to apply space station waste management technology to the solution of these problems.

3. Material Utilization - The NASA has been engaged in an intensive study of fire prevention through the development and use of nonmetallic materials. This background can be used to improve the standards for household materials and fire safety. Projects are currently under way at two NASA centers to demonstrate the improvements in home fire protection by the use of spacecraft material technology. This effort should be expanded as a part of this program.

4. Electrical System - The household electrical power system would also be examined to determine ways to improve the effective utilization of this critical energy source. Research, both in-house and contractor, to improve electrical appliance efficiency would be initiated. Research would be conducted to determine whether a practical method of generating electrical power could be devised for a single house unit or for communities of houses and for apartments. Methods such as a solar cell, fuel cells, or thermal generation would be explored.

5. Solid Waste Treatment - Studies would be conducted in conjunction with programs carried out by the EPA Bureau of Solid Waste Management to attempt to provide methods for onsite utilization of solid waste materials. For example, combustible waste products could be used to augment the home heating system or hot water supply. Convenient and acceptable methods of trash separation and processsng in the home would be studied. If methods could be devised to treat and utilize solid waste at the home or community level, the cost, operation, and problems of trash disposal could be greatly alleviated.

6. Systems Integration - Systems studies would be made for household and community levels to determine performance requirements, interdependence of systems, possible methods of combinations of systems, and failure modes

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and effects. From the studies, a detailed development and evaluation program plan would be established. Intermediate milestone schedules would be established to provide a flow of systems level data into an integrated demonstration house and/or community project. This study and evaluation plan would parallel the approach used in spacecraft life support system research and development.

Implementation

This effort would be initiated by a project management team which would coordinate NASA in-house capability with one or more aerospace contractors with experience in systems analysis of life supporting systems. Subsystem engineers would conduct specialized research, development, and evaluation tasks, and the products of these efforts would be incorporated into the integrated minimum impact house. Specific development and test schedules would be established to insure completion of this research project by a target date.

The national housing shortage and the decaying cities are complex national problems; however, they do present a unique opportunity to provide a new housing concept for home replacement. The 1968 Housing and Urban Development Act established a national goal of building 25 million new homes by 1978. In order to minimize the environmental effects of these new homes in meeting this national goal, it is recommended that:

NASA, IN CONJUNCTION WITH HUD, UNDERTAKE TO DEVELOP AND DEMONSTRATE NEW CONCEPTS IN HOME LIFE SUPPORT SYSTEMS WHICH WILL CONSERVE POWER AND WATER, TREAT WASTE ON SITE, MINIMIZE POLLUTION, IMPROVE FIRE SAFETY, AND OTHERWISE HAVE MINIMUM IMPACT ON THE ENVIRONMENT AND PLACE MINIMUM DEMANDS ON COMMUNITY SERVICES.

The NASA/Aerospace team has unique capabilities in system engineering and spacecraft life support technology which are directly applicable to many urban problems. The utilization of space technologies to help solve the environmental and urban problems was recognized by President Nixon in his message to the Congress on Environmental Quality on February 10, 1970: "A great deal of our space research has been toward creating self-sustaining environments, in which people can live for long periods of time by reprocessing, recycling, and reusing the same materials. We need to apply this kind of thinking more consciously and more broadly to our patterns of use and disposal of materials here on earth." NASA has an experienced technical staff and the most up-to-date development and test facilities which can be used to fully evaluate contractor developed equipment. The combination of these resources and existing technology can be used to provide a fresh approach to the solution of many urban and housing problems.

July 2, 1971

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HEALTH, EDUCATION
AND OTHER PUBLIC SERVICES

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# HEALTH, EDUCATION, AND OTHER PUBLIC SERVICES

## Overview of the Problem

The areas of health, education, and welfare are plagued with numerous problems. The quality and level of health care and education of our citizens located in remote areas of the nation are some of the more serious problems. The growing need for methods of communication and information transfer to offset the shortage of professionals and to improve the quality of services in the fields of medicine, education, and law enforcement will be needed in the future.

The health care system employed in the United States largely relies on individual physicians or groups of physicians operating independently in the administration of health care. The rapidly expanding medical technology is providing new techniques and drugs for the treatment of patients. This expanded medical capability and the growth in population are mounting to a crisis level for the medical profession. In addition, individual physicians located across the nation in remote areas are faced with the difficult task of trying to keep pace with the latest available medical information. The general practitioner often has no means to obtain expert consultation on diagnosis and treatment. Additionally, many people are located in remote areas where physicians are not available to provide any medical care.

The current methods used in providing health care must be overhauled and redirected to meet the challenge of improving and expanding the medical care for all citizens of this nation. It is increasingly clear that the major health care problems of our nation lie in the area of high cost, insufficient manpower, and limited access to health care centers. The Department of Health, Education, and Welfare "Report on the Health of the Nation's Health System" dated July 10, 1969, states: "We see a massive crisis in (health care) and unless action is taken, both administratively and legislatively, to meet the crisis within the next two to three years, we will have a breakdown in our medical care system." The answer to these problems cannot necessarily be solved by increasing the number of physicians. It has been estimated that approximately 275,000 physicians (one physician per 740 of population) were actively engaged in medical practice in 1969. These physicians are not evenly distributed throughout the country, but rather are concentrated in the urban areas. Additionally, specialization contributes to this shortage of doctors. The present output of 9,000 physicians per year from medical schools and the normal rate of attrition in our existing physician supply will not greatly affect the number and distribution of doctors involved in health care.

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The cost of medical care continues to rise above the financial capabilities of a large number of citizens. In 1969 it was estimated that 60 billion dollars were expended for medical care and that by mid-1970 these costs would rise to 100 billion dollars per year. Technologies, which have been accelerated by the space program, have the potential for improving the quality of medical care, as well as greatly improving preventative medicine by automatic disease screening.

All medical practitioners have need for rapid access to medical libraries as well as to other expert consultation service. The requirements here range from the facsimile reproduction of some reference work in a remote library to a capability for visually conveying the evidence, symptoms, or a technique. There is also a need to provide an educational service for the professional. He must today return to a university or experimental hospital to learn the latest techniques, taking considerable time from his practice. Television could bring to the doctor's office or home the operating theater where new techniques are being demonstrated.

The conventional methods of communication used throughout the United States do not have the flexibility to respond to the ever increasing requirements of these new communication needs.

Disaster warning techniques employed in the United States today rely upon commercial radio and television to communicate warnings of impending storms or the need for evacuation or other such actions. This, of course, requires the general public to be listening to radio or television at the right times. Since warnings are not uniformly transmitted simultaneously, the chance always exists that many people may miss the warning broadcasts. A more effective method of disaster warning can be developed through the use of communication satellites which could broadcast warnings to inexpensive receivers which would be awakened by the satellite transmission. Such a system could be designed to selectively alert regional areas of the country or the entire nation at one time. While in a standby status, the system could be used to broadcast public service data to the public such as weather forecasts, health information, etc.

The quality and growth of our educational system is dependent on our communication capabilities. The retraining of teachers in the latest instructional techniques and educational materials is accomplished mainly through summer training programs, seminars, and educational journals. This approach is time consuming, costly, and does not provide uniform opportunities to all sectors of this nation to maintain the highest levels of teaching skills. Educational systems in remote and underprivileged areas of the United States are not of the same caliber as schools in the more advanced urban areas. Low cost methods must be

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devised to provide educational aids and the latest available information for these remote areas. Even with our highly developed commercial networks, many areas of the U. S., such as Alaska, have no access to educational television. This may be accomplished through the use of satellite communication systems.

The increasing crime rate in the United States has also created a communication problem for law enforcement officials. Conventional communication systems are now used to obtain fingerprint identifications and other pertinent information concerning criminal activities. The President's Commission on Law Enforcement and Administration of Justice Report, "The Challenge of Crime in a Free Society," dated February 1967, stressed the importance of improved communications at both the local and national level to provide an integrated national crime information system. Again, the use of satellite communications and data management techniques can be used to improve the transfer of data and thereby strengthen and improve law enforcement operations.

The expanding national population is overburdening the U. S. mail system. New techniques for transmitting information between individuals must be devised to decrease the cost and time required for these communications. Satellite communications is being actively considered by the Post Office to transmit the bulk of the mail of the future. Certain classes of mail can be conveyed via facsimile while others will continue in the conventional mode.

The need will also arise for agencies of the government and our political representatives to communicate in a more meaningful and current way with the public. The sophistication and size of government has made it more difficult for the public to be informed of the policies, purposes, and rationale of the various activities. The high cost of informing the public of political issues, particularly during election campaigns, is of deep concern to many today. A Public Service Broadcasting Satellite System which could reach the entire population could be shared for many of the aforementioned requirements and ultimately may prove to be the optimum way to provide the needed service.

Active Organizations

| | |
|---|---|
| Disaster Warning: | Office of Emergency Planning |
| | Department of Defense |
| | NOEA |
| Health Care: | Department of Health, Education, and Welfare |
| | Veterans Administration |

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Education: Department of Health, Education, and Welfare

Crime: Department of Justice

Mail: Post Office Department

The balance of this paper is divided into two areas: regional remote area health care and public service broadcast system.

## Regional Remote Area Health Care

### Current Activity

The Department of Health, Education, and Welfare is the responsible Federal agency for health care programs. The Public Health Service Act of October 30, 1970, established a charter for this agency to pursue a vigorous and comprehensive program to expand and demonstrate new health care techniques to improve the quality, expand the scope, and to lower costs for medical care in the United States. The act made provisions for research and demonstrations relating to health facilities and services. HEW was authorized to make grants and/or contracts to state, political subdivisions, universities, hospitals, and other public or non-profit agencies, institutions, or other organizations for projects for the conduct of research, experiments, or demonstrations relating to the development, utilization, quality, or new methods of health care delivery. In addition, the act specifically makes provisions for "projects for development and testing of new equipment and systems, including automated equipment, and other new technology systems or concepts for the delivery of health care." The bill authorized funding for these demonstration programs as follows:

| | |
|---|---|
| FY 1971 | $125 Million |
| FY 1972 | $150 Million |
| FY 1973 | $250 Million |

HEW has established numerous grants and contracts to medical centers and institutions for health care projects. A National Center for Health Services Research and Development was created under the Department of Health, Education, and Welfare. One of the objectives of this organization was to develop plans and programs to improve the technology of health care. Numerous programs have been established with medical schools and hospitals to improve the methods used to collect, manage, and analyze medical data, to develop new techniques for the detection of disease, and to study methods of providing health care to rural and remote areas.

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Areas in Need of Assistance

The development of new health care delivery systems is an area in which the NASA could make a significant contribution. NASA could establish for HEW a supporting technology program in conjunction with a designated medical center to design and develop a mobile health care system to be operated by a local medical center. The proposed support program would combine the aerospace developed bioinstrumentation, electronics, computer technology, communications network, and systems engineering approach to an integrated health care system for demonstration purposes.

An integrated medical research and clinical medicine system is being developed for potential use in long term manned space station flights. This system combines state-of-the-art bioelectric measuring techniques and newly developed approaches for conducting medical research and to assess the clinical status of crewmen. The heart of this integrated system is a computer based data management system which will be capable of data stowage and retrieval, data analysis, and the determination of trends in medical measurements which would indicate changes in the physiological condition of flight crewmen. This system is unique in approach to the detection and diagnosis of medical problems. The development of this system is currently being directed to a ground based unit suitable for detailed test and evaluation. Modules from this system could be combined into a unit suitable for use in a mobile remote care facility which could be operated by paramedical personnel. Data could be transmitted by hardline to the medical center for utilization by physicians. Through the use of this systems approach, a level of preventive medicine could be accomplished at the remote site, and more seriously ill patients would be transported to the medical center for treatment as required. This technique will allow a more effective utilization of physicians. The use of this health care system can be expanded through the use of a medical communication satellite system to greatly improve the exchange of medical data, diagnostic consultation, or to prescribe treatments.

NASA Qualifications

The NASA has had considerable experience with program oriented medical development and research projects. The development of miniaturized biomedical instrumentation was pioneered by the NASA/Aerospace Industry team. Techniques for the collection and transmittal of medical data were started in the Project Mercury Program and have been expanded to complex medical instrumentation developments for the Skylab in-flight medical research programs. The advanced in-flight clinical and medical research laboratory now under development represents a truly integrated medical laboratory which includes advanced medical instrumentation, automatic blood and urine analysis, vision and auditory testing, and data collection and processing. The system is being designed to perform most functions which are available only in a major medical center.

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NASA has a unique team of biomedical engineering talent which can provide a systems approach to the solution of this nation's health care problems.

Recommendation

The current methods used in providing health care should be modified and redirected to keep pace with medical technology and the expanding population and to meet the national goal established in the 1970 Public Health Service Act. Under the provisions of this act, HEW was authorized to pursue a vigorous and comprehensive research and development program to expand and demonstrate new health care techniques. To assist in meeting this goal, it is recommended that:

NASA UNDERTAKE A JOINT PROGRAM WITH HEW AND A SELECTED MEDICAL CENTER TO DEVELOP AND DEMONSTRATE A SEMI-AUTOMATED MOBILE HEALTH CARE UNIT THAT CAN BE OPERATED IN REMOTE AREAS BY PARAMEDICAL PERSONNEL.

New multiphasic health screening tests are currently being developed which would allow paramedical personnel to conduct medical examinations and to provide a level of preventative medicine with removal of the seriously ill to a medical center.

The NASA aerospace team has developed, over the past 12 years, an expertise in the development of remote bioinstrumentation monitoring techniques and has advanced system concepts under development which can be adapted to the nation's health care problems. Additionally, this team can provide its systems engineering talents in data transmission and management and in communication networks.

This project could be implemented by modifying an existing advanced space station clinical and medical research system to meet the requirements for a remote area regional health care unit. (The existing design not only has the capability for bioinstrumentation measurements but also incorporates an automatic method for blood and urine analysis, vision and auditory testing, and automatic data retrieval, storage, and processing.) A project team could be established to manage such a program using proven spacecraft development management techniques.

## Public Service Broadcast System

Current Activity

The NASA is currently engaged in preliminary discussion with user agencies on most of the problem areas covered in the earlier section of this paper. Specifically, the following activities are under way:

1. The NASA, NOEA, the Office of Emergency Planning, and the Department of Defense have had preliminary discussions concerning the potential use of a communication satellite for disaster warning. These agencies

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have all indicated interest in more detailed studies of this potential satellite application. The Lewis Research Center has completed a preliminary study for this satellite application.

2. The Department of Health, Education, and Welfare and the Lister Hill Medical Center have indicated an interest in pursuing more detailed studies on the utilization of communication satellites for health care problems. Prime interest has been shown in a medical information communication network to serve initially the Rocky Mountain areas and Alaska.

3. The use of communication satellites for educational purposes as outlined is being jointly considered with the Department of Health, Education, and Welfare and the Corporation for Public Broadcasting.

4. The Federal Bureau of Investigation has contacted NASA concerning the possible use of communication satellites as an aid to improve law enforcement by improving communications.

5. The U. S. Post Office has also contacted NASA to discuss the possible use of satellites to transmit messages in lieu of conventional letters.

Areas in Need of Assistance

NASA should maintain a continuing research program to advance satellite technology, to provide this nation the best possible communication capabilities, and to provide assistance to user agencies. The planned use of communication satellites can be summarized as follows:

1. Satellite based television systems can provide advanced medical and health care training to physicians, nurses, and paramedics. The general public can also become better educated as to health problems via educational TV. The same systems can make accessible to all who need it a vast automated library of medical information - including the latest developments in new drugs and treatments - thus providing a means to maintain currency in medical care. The consulting and diagnostic services of experts all over the world can be pulled together as needed. Paramedics and other semi-trained medical personnel can provide more difficult examinations and diagnoses with the aid of computerized analyses. Another area where great strides can be made is medical instrumentation and the systems design of hospitals to reduce the workload on the staff while actually improving the monitoring of patients.

2. The educational crisis can also be helped by improved communications. Teacher education, as well as child education, would be greatly enhanced by a dedicated educational TV system that could

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provide educational material and expert lecturers at both the teacher and student level on any subject. The potential is there for any teacher to either prepare himself for a difficult lecture or to electromagnetically provide an expert stand-in merely by dialing the proper code into a computer. Student requests for special information or lectures could be handled in a similar manner.

3. In the field of law enforcement, rapid communications and access to large data banks is essential. Local law enforcement systems must be more closely integrated if we are to halt the growth of crime syndicates that are national in scale and whose operations cross many local jurisdictions. Here again, a satellite based communication system is indicated.

4. A special human need is the requirement to be warned of impending disaster arising from war, severe storms, floods, earthquakes, riots, and insurrections, or blackouts and other breakdowns of supporting services. A synchronous orbit satellite could be placed over the United States to serve as relay communication point to the entire country or to regional areas. Inexpensive radio receivers would be provided to the population. When an emergency warning is given, the receivers would automatically turn on to acquire the message. Additionally, this system could be used by private citizens to acquire weather reports during routine periods of operation. Preliminary studies have been completed on this system.

NASA Qualifications

The NASA has been engaged in satellite research and development programs for over 10 years. Several of the NASA centers have a skilled staff, development laboratories, and test and evaluation facilities. These resources are currently unique in the Federal laboratory system. With this expertise NASA is qualified to perform a systems engineering function to communication satellite users both in and out of government. In carrying out these responsibilities, NASA could help user agencies to translate operational requirements into specifications and design, and could perform trade-off studies to determine multiple uses of satellite systems. This latter activity should, of course, be able to reduce overall satellite development and operational costs.

Recommendation

The areas of health, education, and welfare are plagued with a host of problems, such as inadequate medical, teaching, and law enforcement personnel and services. The training and effectiveness in all three areas could be enhanced by a satellite based system for intercommunication and for the storage and retrieval of data and other

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reference material. In view of the need for such an advanced system, it is recommended that:

NASA DEVELOP A PUBLIC SERVICE SATELLITE BASED BROADCAST SYSTEM THAT CAN SUPPORT THE SPECIAL NEEDS OF HEALTH CARE, EDUCATION, LAW ENFORCEMENT, DISASTER WARNING, AND OTHER NATIONAL SERVICES.

As a focal point for this study, NASA can assist user agencies in developing their requirements and can make the necessary trade-offs to achieve a practical multipurpose system.

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OPERATIONAL
SATELLITE SYSTEMS

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# OPERATIONAL SATELLITE SYSTEMS

## Overview of the Problem

It is reasonable to expect that several new uses of space systems will be sought by the Federal government with time. Some of them have been discussed in other sections of this document. There is also a high probability that several agencies of the government will have needs for space systems and furthermore, that several agencies will have an interest in the common output or services resulting from a single system.

It is logical to make use of the expertise developed in the space R&D programs to develop, establish, and operate all space systems and services required by the civilian agencies of the Federal government. This does not preclude the supplying of space capabilities and services by private enterprises on a leased basis where desirable. It would make use of the space agency's expertise to assess the adequacy of approach and the economy of the services proposed by industry based on a real and current knowledge of state-of-the-art and all alternatives available to both industry and the government. NASA is the logical agency to be assigned the operational space systems support function. NASA, a nonuser agency, can execute this function and respond to the requirements of the several user agencies without prejudice. The users are interested in the service or the information product derived from the system. Each user could take his required product from the system (which may be a common product or a unique product) and use it as appropriate. The results of all space R&D could be fed immediately and naturally into the operational systems considered.

Assignment of the function to a single agency would also make possible economics in approach through multiple or shared uses of individual satellites. It is quite practical for a communications satellite to carry a meteorological sensor or an earth resources sensor to the synchronous or stationary orbit and for low-orbit meteorological satellites to carry equipment required for global data collection and retrieval. Such shared use of satellites have been accomplished in the R&D programs, and this experience should carry over to produce operational systems optimization. Further economies are possible through shared use by both the R&D effort and operational systems of existing NASA facilities such as the Global Tracking and Data Acquisition Network, the Mississippi Test Facility, the Apollo Command Control computers, and the many environmental test facilities to name a few. Such shared use of facilities will become more practical as major projects such as Apollo are completed.

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Finally, assignment of the operational support function to NASA would assure the non-duplication of effort and facilities required for all space activities.

NASA Qualifications

NASA has the space expertise. It is thoroughly familiar with DOD contributory efforts, and DOD/NASA coordination mechanisms are established and working. NASA is capable of developing, operating, or contracting for all required space systems and services. It has the necessary supporting facilities as a result of its R&D program to support required developments, launchings, and data processing in many cases.

NASA has experience in supplying such a service in its long standing and successful support of the NOAA operational satellite systems. NASA not only launches the commercial satellites of COMSAT/INTELSAT, but it has experience with leasing the services of these satellites for use by NASA.

As a direct result of its R&D program in which NASA works with the user agencies of the government to develop the very applications of satellites that will eventually be called for operationally, NASA will have developed a fundamental understanding of the users' requirements and concerns as well as working relationships which can be used to advantage during the operational phase.

NASA has also had experience in making emergency use of the R&D satellites to support operational requirements should it be required, and it has long experience in handling and processing large quantities of data and preserving the integrity of this information throughout the process.

Method of Approach

The current NOAA/NASA arrangement can serve as a partial model. NASA funds the development of operational prototype systems, and NOAA funds the operational follow-on requirements. NOAA transfers funding to NASA for procurement and launching of operational satellites as well as for the development of supporting ground equipment. Currently the operational satellites are turned over to NOAA, once in orbit and working.

NASA should be assigned these same functions for all operational satellite systems and also retain the operational control of the satellites and supporting ground facilities to insure economy of the total operational

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support requirement. It may be desirable to provide the funding requirements for systems of interest to a number of agencies directly to NASA. In such cases, the agencies might, however, pay for the costs of processing the particular products they request of the system. These costs can vary from user to user depending on the volume and complexity of the product requested. Where services such as communications are required, the user should pay an appropriate share of the cost of sustaining the service based on the relative use of the system supplied. These measures would guard against requests being made without regard for cost.

Recommendation

To insure maximum economy, avoid duplication, and utilize the government's expertise in the operation of the nation's space systems, it is recommended that:

NASA BE ASSIGNED RESPONSIBILITY TO DEVELOP AND OPERATE ALL SATELLITE SYSTEMS AND SERVICES REQUIRED BY USER AGENCIES OF THE FEDERAL GOVERNMENT FOR CIVIL APPLICATIONS.

In fulfilling this function, NASA should operate all required ground support equipment directly involved in providing the satellite service except where services are procured on a leased basis.

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WATER RESOURCES
AND CONTROL

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# WATER RESOURCES & CONTROL

## Overview of the Problem

The availability of sufficient fresh water resources to meet the demands of domestic, industrial and agricultural needs is becoming an acute national problem. The sources of unpolluted water supplies are rapidly approaching a critical stage in certain parts of the nation. The major sources of water pollution are agricultural and industrial chemical and thermal wastes, effluents from municipal plants and ground runoff water from many sources. It has been predicted that water uses will increase two to six times the present level in the next 50 years. This increased water requirement coupled with the present marginal water supplies in some regions of the country would indicate that an expanded technology program or changes in water utilization are required to preclude a disaster stage in providing fresh water supplies for the nation.

## Current Activities

There are currently 11 Federal agencies involved in programs or demonstration projects for water quality research and development. The Federal Water Pollution Control Act of 1965 established a Water Resources Council as an independent agency. The functions of this council are: review Federal policy in water and related land resources and assess national needs, guide and review river basin planning efforts undertaken by Federal-State river basin commissions or by interagency committees, establish standards for carrying out river basin plans and for formulating and evaluating water resources projects, and to administer grants to the States for programs to improve water resources planning capabilities. The Council has a staff of 30 people and had a 3.7 million dollar budget in FY 1970. The Council is composed of the Secretaries of Interior, Agriculture, the Army, HEW and Transportation and the Chairman of the Federal Power Commission. The roles of the major agencies in water resources management as outlined by the President's Advisory Council on Executive Organization may be summarized as follows:

1. Bureau of Reclamation - Interior - Engaged in multipurpose development of water resources primarily in the 17 western states to meet economic, social and other needs of the country. The Bureau investigates, constructs and operates water resources projects in the Missouri Basin, Colorado Basin and the Pacific Southwest.

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2. Corps of Engineers - Conducts a variety of programs to investigate, plan, develop and manage water and related land resources. It constructs and maintains projects for flood control, navigation, water supply and irrigation and other uses. It carries out mapping and charting, research and related functions.

3. Soil Conservation Service - Agriculture - Provides technical assistance to landowners through conservation districts and other cooperative mechanisms. (Watershed Development)

4. Office of Saline Water - Conducts R&D programs for conversion of brines, brackish or sea waters into fresh water. Establishes grants and contract effort for demonstration test facilities.

5. Office of Water Resources Research - Stimulates a broad research in fields related to water resources and to assure an adequate supply of trained scientists. Provides grants to states for designated water resources research institutes.

In 1970, The Environmental Protection Agency was created to consolidate the management of all environmental programs. The functions of the Federal Water Quality Administration and activities carried on by the Department of Interior were transferred to EPA. The functions of the Bureau of Water Hygiene of the Department of Health, Education and Welfare were assumed by EPA. The chairmanship of the Water Pollution Control Advisory Board and the functions of this Board were transferred to EPA.

Current research activities on water pollution and control totaled $103 million in FY 1971 and may be summarized as follows: (Source - Draft of Federal Council for Science and Technology report on Environmental Quality Research and Development.)

1. Agriculture - Programs are underway to develop and demonstrate technology for effective control of water pollutants from agriculture, forrestry and logging operations, irrigation return flow, rural runoff of fertilizers, etc., and elimination of pollution from animal feed plots. Additionally, research is being conducted in the recovery and recycling of agricultural wastes.

2. Industrial Pollution Control Technology - R&D programs are being carried with the objective to develop economical methods for complete control of industrial wastes. New or improved systems are being developed to demonstrate various type industrial plant and mining effluent pollution control techniques. Pretreatment of industrial wastes to lower the burden on municipal sewage systems are also included in this program.

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3. Municipal Pollution Control Technology - Programs are being sponsored to develop more economical treatment methods and to develop techniques for the removal of phosphates, heavy metals, bacteria, viruses and organic wastes sewage plant effluents. Also being studied are onsite treatment of household wastes, the effects of urban storm water discharge, the behavior of heavy metals in fresh and sea water, and the control of pollutants from boats, oil spills and recreational activities.

4. Salinity - Research is being conducted on methods of converting salt or brine water to fresh water. Demonstration plant projects are being established. Additionally, studies are being made on the potential of using geothermal brines to produce fresh water.

5. Thermal Pollution - Studies are being made on the effects of thermal pollution from power plants, etc. on the ecology of rivers, lakes, etc. Math models are being developed to predict thermal distribution in rivers and other bodies of water.

6. Waste Treatment and Ultimate Disposal - Different methods of waste treatment and control are being studied for removal of nitrogen, iron and other metals, to handle sewage sludge, to use water, to control water acidity (pH), to improve disinfection, to develop tertiary treatment, and to reclaim photo-film wash water.

7. Water Quality - Research is being conducted on pollutant detection and identification methods for water quality control. Studies are also being made to establish a scientific basis for improving water quality standards.

Fiscal Year 1971 funding for this research can be identified as follows: $45 million for source pollution control technology, $35 million for water quality control technology and $23 million for water process technology, water quality requirements, thermal pollution studies, and salinity research.

Areas in Need of Assistance

The areas, identical in various water resources reports, as requiring additional research efforts may be summarized as follows:

1. A capability must be established for the prediction of water pollution problems before they reach a state of severity. (Recommendation No. 2 in this report proposes a role for NASA to provide research assistance in acquiring this data.)

2. Criteria should be established for the reuse of water. (This would appear to be a role that EPA and HEW will perform)

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3. Additional research should be conducted on waste treatment and/or recycling on closed loop techniques to provide new and innovative approaches to reduce water pollution. (Recommendation No. 11 proposes a role for NASA in developing sewage treatment techniques for home units or neighborhood systems.)

4. Innovative research is required in methods of utilizing thermal wastes. (Under Recommendation No. 10 in this paper NASA has proposed to study this potential use of waste heat.)

5. Studies need to be made on the effects of dumping thermal wastes in rivers, lakes, etc. on biological life. This effort should be accomplished by the cognizant Federal agency - not NASA.

6. A need was identified for using remote sensing to detect water pollution. (Recommendations number 1 & 2 proposed that NASA undertake this supporting role.)

7. It has been recommended that a more intensive use of a team effort using a systems approach should be utilized in the solution of water resources and pollution control problems. (This is strongly endorsed and should be assigned to a single Federal agency.)

8. The use of math modeling as a tool in predicting the behavior of rivers, lakes and other bodies of waters and the effects of pollutants on these bodies of waters should be pursued. (Under the effort covered by Recommendation No. 3 NASA has proposed the development of math models on regional projects.)

9. The development of shipboard waste management systems to reduce pollutants needs further research. (NASA technology from the spacecraft life support area could be applied to this problem area.)

NASA Qualifications

The NASA qualifications to support the program outlined in the section on "Areas in Need of Assistance" are covered in the detailed problem area section of this paper.

Conclusion

NASA can play a significant role in the solution of many problems facing the nation on water resources and pollution control. This support should be provided in a supportive role to cognizant regulatory federal agencies.

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