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REPORT TO THE CONGRESS

Need For A National Weather Modification Research Program

B-133202

Multiagency

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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AUG. 23, 1974

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-133202

To the Speaker of the House of Representatives
and the President pro tempore of the Senate

This is our report entitled "Need for a National Weather Modification Research Program." Weather modification research activities are administered by the Departments of Commerce and the Interior, the National Science Foundation, and other agencies.

Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Agriculture; the Secretary of Commerce; the Secretary of Defense; the Secretary of the Interior; the Secretary of Transportation; the Director, National Science Foundation; and the Administrator, National Aeronautics and Space Administration.

Elmer B. Staats

Comptroller General
of the United States

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ABBREVIATIONS

GAO	General Accounting Office
ICAS	Interdepartmental Committee for Atmospheric Sciences
NACOA	National Advisory Committee on Oceans and Atmosphere
NAS	National Academy of Sciences
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OMB	Office of Management and Budget

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COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NEED FOR A NATIONAL WEATHER MODIFICATION RESEARCH PROGRAM
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D I G E S T

WHY THE REVIEW WAS MADE

Weather modification research is part of an attempt to understand the atmosphere of the earth and other planets. Through this research, which is primarily federally supported, it may be possible to alleviate drought, reduce destructive forces of hurricanes, suppress lightning and damaging hail, and dissipate fog.

During fiscal year 1974 seven Federal departments and agencies--Agriculture, Commerce, Interior, Defense, Transportation, the National Science Foundation, and the National Aeronautics and Space Administration--conducted weather modification research.

Estimated cost for this research increased from about $3 million in fiscal year 1959 to about $17.4 million in fiscal year 1974.

Because of multiagency participation and increased Federal support, GAO reviewed the administration of weather modification research.

FINDINGS AND CONCLUSIONS

For nearly a decade, studies of the administration of Federal weather modification research have identified common problems hindering progress:

--No central authority to direct Federal departments efforts.

--Ineffective coordination.

--Insufficient resources to achieve timely, effective results.

Most studies proposed a national program to resolve the problems. (See pp. 7 to 15.)

4 The Interdepartmental Committee for Atmospheric Sciences, part of the Federal Council for Science and Technology, is responsible for identifying opportunities for improving atmospheric sciences programs. It, however, has no authority to direct Federal research programs. (See p. 4.) p. 1530

The Committee's efforts to establish a national weather modification research program have not been successful.

In 1966, the Committee recommended that a single agency assume responsibility for developing a national weather modification program. This suggestion was not implemented. (See p. 15.)

In 1971 the Committee recommended that national weather modification research projects be established to accelerate progress by bringing together resources of agencies performing similar research.

Seven major research areas, along with suggested lead and participating agencies, were identified. Each lead agency was to create a coordinating

committee of representatives from participating agencies which would develop plans and submit progress reports to the Committee. (See p. 15.)

GAO found, however, that the recommendations resulted in little change in multiagency participation or in general project administration. (See pp. 15 to 18.)

The National Hail Research Experiment, identified as a major research area in the 1971 Committee report, was already planned as a coordinated effort with the National Science Foundation as lead agency.

Even though the Experiment was well planned, requiring extensive interagency participation, GAO found, in comparing planned efforts with actual efforts that, for the most part, agencies could not and did not meet all their obligations.

For example, during the Experiment's first operational season (summer 1972):

--Agriculture planned to assess crop damage from hail and study the economic effects of hail suppression. The Foundation, however, had to subsequently fund the later study. Also, Agriculture could not coordinate and direct the Experiment's electrical studies as planned. (See p. 19.)

--Commerce did not furnish radars and all aircraft as planned and was able to provide technical ground work only with the Foundation's funding. The unanticipated Commerce request for funds caused the Foundation to cancel other items in the program plan. (See pp. 19 and 20.)

--Defense did not furnish helicopters as planned but did provide personnel (See p. 20.)

--The Atomic Energy Commission could not have provided technical assistance without the Foundation's funding. (See p. 20.)

--Transportation provided personnel as planned. (See p. 20.)

In the most recent operating season (summer 1973), the Foundation had similar problems obtaining support from the agencies participating in the Experiment. (See pp. 20, 27, and 28.)

A national weather modification research program, administered and maintained by a lead agency, is needed to effectively administrate fragmented Federal weather modification research activities. The program should include goals, priorities, and plans for allocating resources to meet priority objectives.

RECOMMENDATIONS

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GAO recommends that the Office of Management and Budget should, in cooperation with the Federal departments and agencies involved in weather modification research:

--Develop a national program with goals, objectives, priorities, and milestones, designating one of the agencies, which would have a major program responsibility, to administer and maintain the national program.

--Develop a plan to define and reassign, if appropriate, the

--responsibilities of Federal departments and agencies providing support or conducting weather modification research.

--Develop a plan to allocate resources to the national program elements.

AGENCY ACTIONS AND UNRESOLVED ISSUES

Most of the agencies acknowledged administrative and management problems in weather modification research but, except for Commerce, did not agree with GAO's recommendations for a national program.

The Office of Management and Budget believed some consolidation of weather modification research was desirable and that proposed legislation to establish a Department of Energy and Natural Resources would accomplish the appropriate degree of consolidation. (See p. 23.)

Commerce, although agreeing with GAO's recommendations, also commented that proposed legislation would bring together many of the widely scattered elements in Federal weather modification programs. (See p. 23.)

The legislation would transfer three agencies' weather modification activities to the proposed department. In GAO's opinion, problems of administration and management would continue because weather modification activities would still be fragmented. (See p. 23.)

Agriculture, Defense, Interior, and the Foundation generally supported the Committee's lead agency approach. Their comments on GAO's recommendations, which in some cases were shared by the Office of Management and Budget, and GAO's evaluation are on pages 24 to 29.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Because of longstanding problems caused by a fragmented Federal organization for carrying out weather modification research, a national program is necessary to effectively administer activities.

This report should be useful to the Congress in considering the proposed legislation creating a Department of Energy and Natural Resources, which would not totally consolidate Federal weather modification research.

CHAPTER 1

INTRODUCTION

Weather modification research is part of the atmospheric sciences which is devoted to understanding the composition and processes of the earth and other planets' atmospheres. The Federal Government supports atmospheric research in three program areas:

--The meterology area covers the lower atmosphere that extends from the surface of the earth to 100 kilometers, about 62 miles.

--The aeronomy area, which overlaps to some extent with meteorology, extends from outer space to approximately 50 kilometers, about 31 miles above the earth's surface.

--The planetary area is concerned with studies of other planets' atmospheres.

Weather modification research is primarily part of the meteorology area and includes:

--Precipitation modification	--to study and develop techniques to manage and control rain or snow.
--Fog and cloud modification	--to study and develop methods to dissipate cold and warm fogs.
--Hail suppression	--to develop techniques to eliminate hail or reduce the size of hailstones.
--Lightning modification	--to determine the basic characteristics of fire-setting lightning storms and develop techniques to suppress or modify lightning discharges.
--Hurricane and severe storm modification	--to determine the extent which hurricanes can be beneficially modified.
--Inadvertent modification	--to monitor atmospheric constituents and study their modifying influences on the weather.

Science lacks the knowledge to answer many of the questions on weather modification. For example, a thorough understanding of how clouds create rain and snow has not been obtained. In addition, it is not known with a satisfactory degree of confidence to what extent man is changing the climate of the earth. There is wide, though not universal, belief that weather modification has great potential for public good. If weather modification research, which is primarily federally supported,

proves successful, it may be possible in future years to alleviate drought, reduce the destructive forces of hurricanes, suppress lightning and damaging hail, and dissipate fog.

During fiscal year 1974, seven of the nine Federal departments and agencies conducting atmospheric sciences research were involved in weather modification research: the Departments of Agriculture, Commerce, Defense, Interior, and Transportation; the National Aeronautics and Space Administration; and the National Science Foundation (NSF).

Estimated costs for atmospheric sciences research as reported by the Interdepartmental Committee for Atmospheric Sciences (ICAS) increased from $36 million in 1959 to about $274.5 million in fiscal year 1974. During this period estimated costs classified as weather modification research increased from $3 million to about $17.4 million. NSF and the Office of Management and Budget (OMB) said much of the general research in atmospheric sciences is also applicable to weather modification.

SCOPE

Our review was directed primarily at obtaining information on Federal weather modification research and identifying opportunities for improvements in administration and management of research programs. It included an examination of records and scientific reports; interviews with officials of the various coordinating committees and Federal agencies, including OMB and the former Office of Science and Technology; and interviews with recognized authorities outside the Federal Government.

We did our work at agency offices and field locations listed below:

--Forest Service, Department of Agriculture.

--National Oceanic and Atmospheric Administration (NOAA), Department of Commerce.

--Defense Advanced Research Projects Agency, Department of Defense.

--Bureau of Reclamation, Department of the Interior.

--NSF.

--Federal Aviation Administration, Department of Transportation.

CHAPTER 2

NEED FOR A NATIONAL WEATHER MODIFICATION RESEARCH PROGRAM

The Federal Government's unsuccessful efforts to coordinate its many research programs in weather modification supports the comment often attributed to Mark Twain: "Everybody talks about the weather, but nobody does anything about it."

Our review of the Federal weather modification research activities supports the findings of nearly a decade of studies. These studies conducted by scientific panels, committees, and other groups all identified common problems--ineffective coordination, fragmented research, and research efforts that are subcritical (funded below the level necessary to produce timely, effective results). Most studies proposed a common solution. What was needed, in essence, was a national research program under a single Federal agency responsible for establishing plans and priorities, obtaining the needed funds from the Congress, managing research efforts, and accounting for the results its programs achieved.

To date, except for the establishment of several coordinating committees, subcommittees, and advisory panels--none of which have the authority to take action to correct problems already identified--an effective overall national weather modification research program has not been established.

We noted that research efforts to date have achieved some beneficial results. Individual agency programs have moved forward in several research areas, but panels, committees, and study groups have characterized results more as slow clarifications of concepts rather than as dramatic new discoveries.

There has also been some progress in developing better methods for coordinating weather modification research, although the results have been somewhat disappointing. A recent attempt to achieve a national effort in one research area--the National Hail Research Experiment--in which several agencies' talents and resources would be pulled together under the direction of a single organization has not been as effective as anticipated. Although several interested agencies initially expressed a desire to participate, they later withdrew or reduced participation due to limited funding or higher priority mission-oriented efforts. (See p. 18.)

If potential benefits of weather modification research are to be obtained, action should be taken now to establish an effective national program with all agencies involved required to work toward achieving national goals and objectives.

FEDERAL ACTIVITIES IN WEATHER MODIFICATION RESEARCH

In fiscal year 1974 seven departments and agencies were involved in weather modification research. Many of the research efforts were fragmented with as many as three or four departments and agencies funding research programs in precipitation modification, fog and cloud modification, lightning modification, and inadvertent modification.

Much of the fragmentation came about during the late 1940s and early 1950s when agencies were having little success in producing conclusive results in their weather modification programs. They believed that more basic research was needed to fill information gaps. At that same time, potential user agencies, specifically the Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Reclamation, were becoming interested in weather modification as a tool to help accomplish their missions. Eventually, these agencies, plus the others now involved, initiated their own mission-related weather modification programs.

Planned fiscal year 1974 expenditures for weather modification programs (about $17.4 million) are shown in figure 1. (See p. 6.) Program efforts are discussed in appendix I.

Since 1959 the following primary committees were established to coordinate the programs of agencies involved in atmospheric sciences. None of the committees have the authority, however, to direct these agencies' efforts.

Interdepartmental Committee for Atmospheric Sciences

On recommendation of the President's Science Advisory Committee, Executive Order 10807 established the Federal Council for Science and Technology in March 1959 which consists of policy-level officials from the Federal agencies principally involved in research and development activities. The Council's function is to provide for more effective planning and administration of scientific and technological programs, identification of research needs, use of resources, and international cooperation in science and technology.

In August 1959, ICAS was established as a committee of the Council to undertake studies and develop recommendations concerning the

--scope and balance of Federal agencies' present and future activities in the field of atmospheric research,

--needs and deficiencies of research programs,

--requirements for and use of specialized facilities,

--allocation of responsibilities among Federal agencies,

--effective coordination of agency programs,

--planning of future programs, and

--encouragement of nongovernmental participation in the field of atmospheric sciences.

Its members, scientist-administrators from the Federal agencies involved, meet monthly. They make recommendations to the Council which, when endorsed, serve as guidelines for participating agencies' budget submissions and as criteria for review by OMB and the Office of Science and Technology. 1/

Federal Committee for Meteorological Services and Supporting Research

In November 1963, OMB issued Circular A-62 entitled "Policies and Procedures for the Coordination of Federal Meteorological Services" which assigned to the Department of Commerce the responsibility to coordinate meteorological services and the research necessary to support them. Also, OMB directed Commerce to prepare a plan to integrate current and future services and research consistent with the effective and economical accomplishment of mission requirements. In response, Commerce established the Federal Committee for Meteorological Services and Supporting Research. The Committee, composed generally of members at the Assistant Secretary level representing the agencies comprising ICAS, meets annually to review and validate the Federal plan.

National Advisory Committee on Oceans and Atmosphere (NACOA)

Public Law 92-125, approved August 16, 1971 (85 Stat. 344), established NACOA which is made up of representatives appointed by the President from industry, science, and State and local governments. NACOA is required to assess the status of marine and atmospheric science programs and report annually to the President and the Congress.

OMB

OMB is responsible, by Executive Order 11541, issued July 1, 1970, for promoting the development of agencies' improved plans and organization; assisting in the development of better interagency cooperation; and

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1/ On January 26, 1973, the President transmitted to the Congress Reorganization Plan No. 1 of 1973, which transferred all functions of this Office to the Director, NSF. The reorganization, which abolished the Office, took effect July 1, 1973.

FIGURE 1

PLANNED FEDERAL RESEARCH EXPENDITURES IN WEATHER MODIFICATION DURING FISCAL YEAR 1974

----------(000 OMITTED)----------

Departments and agencies	Total	Precipitation modification	Hail suppression	Inadvertent modification
National Science Foundation	$ 6,600	$ 450	$3,250	$ 700
Commerce	4,233	840		908
Interior	3,250	2,400		
Defense	1,594			
Transportation	1,397			1,304
Agriculture	293			
National Aeronautics and Space Administration	[b]50			
Totals	$17,417	$3,690	$3,250	$2,912

[a]Other represents research efforts related to mathematical modeling; social, economic, legal, and ecological studies; and support and services.

[b]The administration in reporting its atmospheric science activities to ICAS did not classify any research as weather modification; however, the administration considers $50,000 of dynamic meteorology as applicable to weather modification.

Source: ICAS Report 17-FY74 (Issued May 1973)

Fog and cloud modification	Hurricane and severe storm modification	Lightning modification	Other (note a)
$ 800		$300	$1,100
	$1,548		937
			850
1,534		60	
93			
		293	
[b]50			
$2,477	$1,548	$653	$2,887

evaluating programs for the assessment of objectives, performance, and efficiency. An OMB representative sits as an official observer on ICAS and the Federal Committee for Meteorological Services and Supporting Research.

FEDERAL LEGISLATION ON WEATHER MODIFICATION ACTIVITIES

The spread of private weather modification activity in the United States in the late 1940s and early 1950s raised concern in the Congress about the usefulness and effectiveness of this new technology. The Congress, through Public Law 83-256, approved August 13, 1953, established an Advisory Committee on Weather Control. The Committee was required to study and evaluate public and private experiments in weather control and determine the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions. Its report, issued in 1957, was modestly favorable on the potentials of weather modification and recommended further research.

In following up on the report recommendations, the Congress enacted Public Law 85-510, approved July 11, 1958, which authorized and directed NSF to initiate and support a program of study, research, and evaluation in the field of weather modification, and to report annually to the President and the Congress. In addition to establishing weather modification as one of its research programs, NSF also required all commercial and private weather modifiers to maintain records and submit reports on their activities.

In 1968 NSF's authority under Public Law 85-510 was repealed, apparently on the assumption that it would be reassigned to some other agency during the same congressional session. However, no other authorizing law was passed until Public Law 92-205 was enacted on December 18, 1971. This law required that all nonfederally sponsored weather modification be reported to the Secretary of Commerce.

Since 1966 the Congress has considered several bills concerning the assignment of individual agency authority and responsibility for weather modification and one to prohibit weather modification anywhere in the Nation. None of these bills were passed.

INDEPENDENT STUDIES EVALUATING FEDERAL WEATHER MODIFICATION RESEARCH

For nearly a decade a number of scientific panels, committees, and other groups have reviewed, evaluated, and reported on the status of and problems associated with Government atmospheric sciences programs. In nearly every case the reports, including the most recent issued June 29, 1973, by NACOA have not only cited a need for a national program with centralized, single agency responsibility, authority, and control, but also highlighted problems in coordinating multiagency activities and the lack of progress because of fragmented and subcritical research programs. Several of these reports are discussed below.

"Government Weather Programs (Military and Civilian Operations and Research)"

This report, issued in 1965, was prepared by the Military Operations Subcommittee under the direction of the Chairman, House Committee on Government Operations. Its purpose was to inform the Congress, executive branch agencies, scientific and technical communities, and the general public about the scope and complexities of governmental programs related to weather services and research in the atmospheric sciences.

The report noted that the Congress is familiar with the difficulties of achieving efficient coordination of programs, but multiagency programs present special problems. It stated that:

> "Each agency that carries on only part of a Government research program has a difficult task to justify its own particular operations, but it is also hard put to avoid actual duplication of work due to overlapping or parallel activities of other participating agencies. The coordination which can be accomplished by each agency to avoid this is laborious and limited. And while the agencies may be conscientious in trying to avoid waste, they are charged with specific missions.
>
> "Coordination among agencies or bureaus of each executive department is difficult enough, but a field such as the one discussed in this report includes participation not only by several Cabinet departments, but by independent agencies and offices. The weather activities carried on by each may touch the major mission responsibilities of the agency, even though these activities are only a small part of its total effort. If missions are affected, the agency must strike a balance between insuring, as far as it can, that its work goes ahead successfully, and sharing the program area with other interested agencies.
>
> "Within the executive branch, the Bureau of the Budget [now OMB], the Office of Science and Technology, the Federal Council for Science and Technology, and similar groups may try to prepare a more unified 'program package' in an area such as weather research. But short of a Presidential directive to do so, these offices cannot continually monitor particular programs, and they obviously cannot give full-time attention to all programs at once.
>
> "The problem lies in finding economical means for continuous coordination among agencies. Committees, boards, panels, and groups may be formed, but a solution to policy problems, it is frequently said, is not found by forming a committee. Besides, what can be done to force agencies, particularly executive departments, to comply with committee recommendations, when departmental missions appear to conflict with generalized interdepartmentally agreed policy?"

The report noted a large Federal funding for atmospheric sciences research and meteorological services and that problems of administration, coordination, and financial control of the multiagency programs were becoming increasingly apparent. It raised a series of questions in 18 subject areas of potential congressional concern, such as national programs, Federal coordination, and fragmentation of atmospheric sciences research and meteorological services.

"Weather and Climate Modification - Report of the Special Commission on Weather Modification"

Also in 1965 a Special Commission on Weather Modification, authorized by the National Science Board, issued its report to the Director, NSF. The Commission, consisting of members primarily from the academic community, had been requested to examine the physical, biological, legal, social, and political aspects of weather modification and make recommendations for future policies and programs.

In commenting on how Federal weather modification activities are administered, the Commission identified duplication in research activities and coordination responsibilities as problem areas. The report stated that, with more agencies in weather modification research, there is a need to establish a Federal organization to accomplish what cannot be done by diverse research activities. The Commission said that, as long as weather modification activities were mainly basic research, duplication was not a major problem, but certain aspects had reached the applied research and operations phase and regulatory activity was not far away. It also said, because no single agency has been assigned the responsibility for developing the technology of weather modification, a definite need to do so existed.

The Commission recommended that the Office of Science and Technology establish

> "* * *a special mechanism for the coordination of weather and climate modification programs and for recommending such steps as may be appropriate for effecting a unity of governmental policy in this field."

Also, it recommended that the mission of developing and testing methods for modifying the weather should be assigned to one agency in the executive branch to correct overlap and lack of concerted effort among the various agencies.

"Weather and Climate Modification Problems and Prospects"

The Committee on Atmospheric Sciences published this report to the National Academy of Sciences (NAS), in 1966. It was the result of a 2-year study by a panel of the Committee which reviewed the present status and activities in this field and its potential and limits for the future.

The panel identified four problem areas in administration and management of weather modification activities.

1. The level of effort was not commensurate with the demonstrated opportunities for further research likely to have early practical implications.

2. The major portion of research resources (money and manpower) was being dissipated by supporting subcritical efforts.

3. Scientific groups were severely hampered by lack of a central management organization with authority and skill to consummate interagency negotiations and operations.

4. ICAS, which in principle has responsibility for coordinating efforts in weather modification, has no power to initiate action within any agency.

The panel concluded that:

--The present support and administrative mechanisms do not provide adequate means for setting priorities among the many large field experiments and projects that will eventually be needed.

--The present fragmentation of effort in weather modification research and development is unusual in that many of the fragments are below critical size or quality needed for effective work.

--Major responsibility for weather modification should be centered in a single agency.

"Weather-Modification Progress and the Need for Interactive Research"

This report, published in October 1968, was prepared by the Weather Modification Research Project Staff, Rand Corporation, under a contract with NSF. The report concluded:

"The structure of the national weather-modification program has not--in one vital respect--been strengthened since the time of our previous study in 1962. We referred to the specific weakness then as a lack of a 'cohesive' approach to weather modification. The NAS Panel on Weather and Climate Modification in 1966 called the same problem a 'fragmentation of effort.' We reiterate it now in terms of the need for more 'interactive research'."

* * * * *

"In 1962 we have concluded, and again in 1968 we are forced to conclude, that the subject of weather modification could

benefit, probably greatly, by a more directive program in which theoreticians as well as experimentalists are guided toward a common and mutually supporting set of goals * * *."

The report recommended establishing a weather modification research organization, either by creating a new organization or by strongly augmenting any of several existing groups, to apply all possible advances in atmospheric science and engineering competence to the design of research and experimental programs in weather modification.

"The Atmospheric Sciences and Man's Needs"

In 1971 the Committee on Atmospheric Sciences, NAS, issued another report which stated that:

"* * *determination of priorities for investment in atmospheric research and its application has become extremely difficult. Resources are not adequate to support all scientifically valid and useful programs. * * * Priorities will have to be determined."

* * * * *

"* * *FCST [Federal Council for Science and Technology] and ICAS have not been able to develop an integrated national program in weather modification. Individual agency programs have been subcritical in size and research capability. ICAS has no authority to consolidate or to modify agency programs; and, most important, ICAS is not able itself to mount research efforts, no matter how badly needed they may be. Agency initiatives at the scientist level, even though endorsed by ICAS, may not be approved by agency administrators; and agencies may launch major programs without ICAS endorsement. The result has been that in important respects the national effort in weather modification has been largely dissipated in submarginal projects, while crucial problems requiring large programs remain unsolved."

In considering how to best solve this problem, the report noted the following.

--Responsibility for research in weather modification must be closely associated with responsibility for research in the atmospheric sciences generally.

--National policy in weather modification must be based on full consideration of relevant economic, social, ecological, and legal factors, as well as scientific and technical factors.

The report concluded that a suitable administrative solution consistent with these requirements would be to make a single agency responsible for research in weather modification and for coordinating major field programs.

First and second annual reports--National Advisory Committee on Oceans and Atmosphere

NACOA's first annual report was issued on June 30, 1972. Concerning ongoing national projects in weather modification, such as the voluntary combinations of several Federal agencies' resources the report stated:

> "* * *Thorough agency funding for weather modification has lately been increased--in the last 2 years from $16 million (FY '71) to $20 million (FY '72 Estimate) to $25 million (FY '73 Budget)--the projects have characteristically been inadequately coordinated, underfunded through fragmentation, often not backed by basic research, and undertaken with obsolete equipment. This is not a criticism of any specific project, but of the lack of central planning and execution."
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> * * * * *
>
> "In almost every case the field programs are restricted by limited resources of one kind or another to the point where the programs are suboptimal and progress has been at a snail's pace."
>
> * * * * *
>
> "What is lacking is a central focus for the overall effort. * * *[There] is the need to have a single Federal agency responsible for taking the lead in development of the technology of the overall program. The present fragmented approach is moving the country ahead in weather modification in an erratic fashion."

NACOA's second annual report was issued on June 29, 1973. The report repeated its previous year's recommendation that the small weather modification research programs scattered widely through the Federal agencies be coordinated and provided with a central focus. The report stated:

> "* * *What NACOA found lacking is a central strategy for the overall research effort. * * * We had recommended increasing the NOAA lead role because it possessed the bulk of the capabilities required. We regret to note that this has not taken place, and further, that a step has been taken in the opposite direction--the assignment of lead responsibility for precipitation enhancement was transferred from NOAA in Commerce to the Bureau of Reclamation in Interior."
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> * * * * *
>
> "* * *the dispersive forces serving to fragment the program are strong. We feel that a formal lead agency assignment is desirable and that NOAA is the appropriate candidate. * * *"

The Committee's annual reports are submitted to the Secretary of Commerce who, within 90 days of receipt, transmits copies to the President and the Congress, with his comments and recommendations.

In his comments on the first annual report the Secretary agreed with the recommendation to establish a central focus in the Government for carrying out research and development in all phases of weather modification. However, he stated that it would be unwise to divorce the necessary supporting research, required for the application of weather modification techniques, from the agency responsible for such application. The Secretary, in commenting on the second annual report, said that Commerce interpreted the Committee's advice as not precluding agencies' need from carrying out operational and research activities closely related to their missions. He also commented that one of the benefits of establishing the proposed Department of Energy and Natural Resources will be to permit new opportunities for more effective planning and coordination and management of weather modification activities. See page 23 for our comments on the proposed new Department.

"Weather and Climate Modification Problems and Progress"

This 1973 NAS report was a followup of the 1966 NAS report to determine weather modification progress since the earlier study. The report reaffirmed the earlier conclusion that a single agency should be responsible for weather modification. It stated that:

> "* * *Finally there is a function to be provided by an agency that has the scientific and management competence, the dedication, and the resources to make the national goals cited earlier an integral part of its basic mission. It is precisely this function that has been conspicuously absent in the Federal government and is an important reason that progress has not been more rapid."
>
> * * * * *
>
> "* * *The responsibilities of these various agencies in the field of weather modification research need to be defined more carefully. A recent effort at defining these responsibilities was made by ICAS in proposing to the Federal Council of Science and Technology steps to 'accelerate progress in weather modification.' A more definitive specification is needed, combining both responsibility and authority to develop a national program in which basic, applied, and experimental efforts are carried out in an integrated manner.
>
> "With due consideration to the missions of the several agencies, their capabilities for supporting research in weather modification and their present activities in the field, we recommend that the National Oceanic and Atmospheric Administration be assigned

principal administrative responsibility for a national program in weather modification. * * *"

The report also stated that many weather modification projects still remain below critical size, which also was one of the conclusions of the 1966 report. The 1973 report stated:

"In 1966 the Panel on Weather and Climate Modification noted with concern that a major portion of the research resources in weather modification, both money and manpower, was being inefficiently used in the support of subcritical efforts. The same situation holds today. * * * No single agency has primary responsibility at the present time. The special role assigned to the NSF in this field has been removed from it as a result of legislation. The ICAS continues to provide communication among scientists and government. In principle, this body has the responsibility for coordinating efforts in weather modification. However, any agency can bypass the Committee if it so wishes, since no interdepartmental committee has the power to initiate action within a given agency."

ICAS EFFORTS TO ESTABLISH NATIONAL PROGRAMS

In 1966 and again in 1971, ICAS tried to establish national programs in weather modification. Both efforts were unsuccessful because ICAS lacked authority to direct agency involvement in coordinated programs and because mission-oriented agencies had higher priorities.

In March 1966, the Federal Council for Science and Technology asked ICAS to prepare a report on the division of weather modification research responsibilities. The resulting report entitled "A Recommended National Program in Weather Modification" was issued in November 1966.

This report evaluated weather modification program plans, budgets, schedules, staffing, facility construction, and operations of four agencies. Increased funding levels were recommended but never obtained by agencies. Recommendations that a single agency assume responsibility for developing a well rounded national weather modification program, that the Federal Coordinator be assigned the coordinating and reporting responsibility for weather modification, and that Interior and NOAA collaborate on a precipitation modification project were never carried out.

In 1969 the Council again asked ICAS to develop a national weather modification program. The resulting report entitled "A National Program for Accelerating Progress in Weather Modification" was issued in June 1971.

The report concluded that, although weather modification had progressed through the efforts of small and occasionally independent groups, progress could be accelerated by making it easier for these groups to bring together their skills, resources, and mutual interests under an interdisciplinary multiagency approach. It suggested that national projects be established, designating the agency currently performing the major effort in each project as lead agency; that is, the agency responsible for planning and managing the proposed project. Other agencies with similar programs or interests were to participate with the lead agency. Figure 2 on page 16 shows the projects proposed and the designated lead and participating agencies.

In addition, the report recommended that each lead agency create a coordinating committee composed of representatives from participating agencies which would develop action plans and submit periodic progress reports to ICAS.

Nearly a year after the June 1971 ICAS report we interviewed officials from several of the lead agencies and were advised that, with one exception, no plans had yet been made concerning coordinating committees. Consequently, no action plans, multiagency participation, or coordination of projects had been developed. The one exception, the National Hail Research Experiment, a project for which NSF was the lead agency, needed no further plans since it had an operating committee before the ICAS report was issued.

FIGURE 2

PROJECTS AND RECOMMENDED INTERAGENCY PARTICIPANTS IN THE ICAS NATIONAL PROGRAM FOR ACCELERATING PROGRESS IN WEATHER MODIFICATION

Project	Lead Agency	Other Federal participants								
		Agriculture	Atomic Energy Commission	Commerce	Defense	Housing and Urban Development	Interior	National Aeronautics & Space Administration	National Science Foundation	Transportation
Colorado River Basin Pilot Project	Interior, Bureau of Reclamation	X		X	X				X	X
National Hurricane Modification Project	Commerce, National Oceanic & Atmospheric Administration		X		X	X	X	X	X	X
National Project on Lightning Suppression	Agriculture, Forest Service			X	X		X	X	X	X
National Project on Precipitation Augmentation from Cumulus Clouds	Commerce, National Oceanic & Atmospheric Administration	X	X		X		X		X	
National Hail Research Experiment	National Science Foundation	X	X	X	X		X	X	X	X
National Great Lakes Project	Commerce, National Oceanic & Atmospheric Administration	X			X		X		X	
National Fog Modification Project	Transportation, Federal Aviation Administration	X	X	X	X			X	X	X

ICAS compiled the first progress reports in January 1973. Our review of these reports showed the following:

--The National Hurricane Modification Project was continuing with the Department of Defense and NOAA, although the ICAS report suggested a total of seven participating Federal agencies. The progress report noted that Defense had informed NOAA that, for fiscal year 1974 and beyond, it could support the project only as operational missions permitted. Since Defense plans included no budgeted funds for support, NOAA will be required to reimburse Defense (estimated at over $1 million in fiscal year 1974) for any costs incurred over those required for operational missions. The general outlook for accelerating progress appeared poor. (See app. III for additional NOAA comments.)

--The National Lightning Suppression Project continued to be carried out by the Department of Agriculture's Forest Service, although the ICAS report suggested six additional participants. No formal coordination committee had been established, nor had the Forest Service received funding to support the planning activities assigned. The progress report stated that the major problem was the amount of funds the lead agency received for the proper discharge of responsibilities assigned. No new funding was received in fiscal year 1973, although a major funding increment will be required to validate results of field experiments carried out in the mid-1960s.

--The ICAS report suggested participation of five other agencies in NOAA's National Project on Precipitation Augmentation from Cumulus Clouds. The progress report stated, however, that the project needed no formal interagency coordination since it had been solely an NOAA project.

--The National Fog Modification Project had not established a Project Coordinating Committee or set up a Project Action Plan. The National Great Lakes Snow Redistribution Project progress report stated formal interagency coordination has been unnecessary as only NOAA and non-Federal agencies have been involved. The National Colorado River Basin Pilot Project plans were reviewed in a 1969 conference, but a continuing project coordinating committee had not yet been formed.

In April 1974 the Executive Secretary for ICAS said that, except for the changes discussed below, the degree of interagency participation in the national lead agency projects had not changed since the January 1973 progress reports.

The Department of Agriculture representative to ICAS advised the Chairman, ICAS, on September 11, 1973, that it was withdrawing as lead agency for the National Lightning Suppression Project because it had not received enough funds to exercise the leadership responsibility. The

Director, Environmental Modification Office, NOAA, advised us in April 1974 that the National Great Lakes Snow Redistribution Project was terminated in fiscal year 1973 because anticipated benefits were not being realized, desirable weather to conduct the project did not develop, and the project was not considered as a high priority.

ICAS apparently has had little or no impact in increasing coordination and accelerating progress in weather modification research and there has been little change in the way projects have been carried out.

PROBLEMS IN COORDINATING A NATIONAL PROGRAM--NATIONAL HAIL RESEARCH EXPERIMENT

Since the Experiment was essentially organized to meet the objectives of a well coordinated lead agency project, we examined planning documents and agency participation in accomplishing the overall goals. This project was based on a plan prepared for NSF by the National Center for Atmospheric Research in Boulder, Colorado, operating under NSF sponsorship.

The Experiment which started in the summer of 1972, will be conducted in northeast Colorado over a 5-year period. The plan of operation involves the use of instrumented aircraft, specially designed radars, and other similar instrumentation. Storms will be monitored and those that show evidence of hail will be seeded randomly. The effect of seeding will be observed and related to mathematical models which have been proposed to explain hailstorm behavior. It is expected that these observations will provide the data for developing a realistic model which can be used to forecast hail and indicate how to suppress the growth of large hailstones.

ICAS recognized that such an experiment was too big for a single organization and that the effort should be a collaborative one. Therefore, it recommended NSF coordinate the expertise in various areas of hail research from universities, government agencies, and private sources. NSF authorized the National Center for Atmospheric Research for this management responsibility. The total cost to NSF was about $16.5 million.

The Experiment's program plan for 1972 to 1976 and related planning documents set out equipment and services required and planned to be provided by the National Center, universities and private research groups, and the five Federal agencies designated to participate with the National Center (the Departments of Agriculture, Commerce, Transportation, and Defense--Army, Navy, and Air Force--and the Atomic Energy Commission). The plans proposed that the activities of the universities and private research groups would be funded through the National Center's hail project office with NSF funds. Federal agencies' participation would be largely self-supporting.

Even though the Experiment was well planned, requiring extensive interagency participation, we found, in comparing the planned efforts

with the actual efforts that, for the most part, agencies could not and did not meet all their obligations.

Department of Agriculture

Plans called for contributions by Agriculture in the assessment of crop damage from hail, and economic effects of hail suppression.

An Agriculture representative informed Experiment officials that Agriculture intended to assess crop damage from hail but that there were no funds to study the economic effects of hail suppression. NSF subsequently furnished funds to Agriculture to carry out this study.

The Experiment's plan noted that, because electrical forces in the atmosphere influence precipitation formation, it was imperative that a scientist with experience in field research be appointed full time to direct and coordinate electrical studies. Although the Forest Service lightning suppression group had experience in lightning measurement and evaluation and had indicated a willingness to furnish such services, the Forest Service subsequently stated:

> "* * * our first obligation, the study of forest fires and the consideration of the needs of forest managers, is so great that we cannot accept with clear conscience the attractive offer to actively participate * * *."

Department of Commerce, NOAA

Initial plans called for NOAA to furnish aircraft and radars and establish and maintain a ground network of precipitation gauges, each essential in carrying out the project's objectives.

Aircraft

The plans called for use of three NOAA aircraft--a WB-57 and two DC-6's--for each summer during the 5-year period. The aircraft were to be used for observing the motion, temperature, and humidity fields environmental to the storms. However, during the field testing in 1971, the NOAA Administrator noted that, due to conflicts with other programs and limited funding, only one DC-6 could be made available at that time and that NOAA was reluctant to promise any improvement for 1972 and beyond until the funding and other requirements for aircraft were known.

Radars

Plans called for two 3-cm Doppler radars to be furnished to augment aircraft measurements of air motion below the cloud base. The only feasible means for obtaining this data was the dual Doppler radar system developed at NOAA. However, an Experiment official said both units had been committed to use by a NOAA laboratory on other programs and would probably not be available for the Experiment.

Ground network

NOAA initially agreed to supply the survey teams necessary to maintain and read the ground network stations. However, this could be accomplished only through NSF financial support. For the 1972 program NOAA submitted a proposal to NSF for about $100,000 to fund this work. Since NSF had planned to give only about $50,000, NSF had to cancel certain other items in the program plans.

Department of Defense

Helicopters

The Army was to provide two helicopters to maintain the extensive ground networks and collect hail samples. However, none were furnished. An Experiment official told us that the Army offered one helicopter for use during the 1972 operation but it was turned down because funding would have been too expensive.

Radiosonde stations

The plans called for four radiosonde stations to obtain data on temperature, humidity, and winds at frequent intervals in the atomosphere of the experimental area during the development and life of the storms. The Army and Air Force were to provide personnel and equipment necessary to man two stations each. However, because of a severe reduction in personnel, the Army was unable to support the 1972 operation. The Air Force subsequently furnished support for all the stations but advised officials that it was also experiencing personnel reductions which would likely eliminate its capability to support the program in 1973 and beyond.

Atomic Energy Commission

The Commission planned to conduct tracer studies and hailstone measurements, but its participation was conditional upon the availability of future funds. NSF funded the tracer studies, which were conducted during the 1972 summer project. The Experiment's Acting Deputy Director told us the Commission requested funding from the National Center for the 1973 summer project but, because the National Center did not have adequate funds, the tracer studies were not conducted.

Department of Transportation

The plans called for Transportation to provide flight control personnel. Three air traffic controllers participated in the 1972 field project.

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In most of the cases noted above, the Experiment's Director advised NSF of the problems in participation and funding. The ICAS chairman was asked to get firm commitments from respective departments and agencies. In nearly every case, the agencies cited personnel reductions, limited funding, or mission-oriented research as the primary reason for nonparticipation. The Deputy Director, citing NOAA as an example, stated that planning is very difficult because it is never known until the last minute whether agencies can participate during each project year. (See pages 27 and 28 for additional comments on the Experiment.)

CHAPTER 3

CONCLUSIONS, AGENCY COMMENTS, AND RECOMMENDATIONS

CONCLUSIONS

A national program in weather modification research is necessary to effectively control activities of the agencies involved. Although this need was recognized as early as 1966, the organizations established to coordinate these activities have not developed and implemented an effective overall national program. Although coordinating groups have tried to develop national programs, their implementation has not been successful. The present fragmentation of research efforts has made it extremely difficult for agencies to conduct effective field research which, in the case of weather modification, must precede operational activities.

If and when the results achieved from the weather modification research programs are ready to be applied on an operational basis, the various mission-oriented agencies will be responsible for making decisions. Procedures will be needed for insuring that operational programs conform to the public interest in every way--scientifically, socially, ecologically, economically, and legally. Before programs become operational agencies must insure that all effects of the operation are known within reasonable limits, all affected parties are represented in the decisionmaking process, and adequate provision is made for liability in case of damages. The state of the art with the present fragmented and subcritical programs spread throughout many agencies, each with its own mission-oriented research effort, has not progressed sufficiently to achieve these requirements.

AGENCY COMMENTS AND OUR EVALUATION

In making our findings available to several Federal agencies for review and comment, we suggested that OMB develop and maintain (1) a national weather modification research program with goals, objectives, priorities, and milestones, (2) appropriate plans to define responsibilities of all Federal agencies involved in weather modification research, and (3) plans to allocate resources to the national program elements.

While most agency comments acknowledged the administrative and management problems stated in our report, they were not consistent in agreeing on what actions, if any, should be taken to resolve the problems. Their specific agency comments on our findings and recommendations follow.

Consolidation of Research Efforts

Commerce

The Department agreed with our conclusions and recommendations and commented that a proposal to establish a Department of Energy and Natural Resources would bring together many of the widely scattered elements in Federal weather modification programs.

Transportation

"* * *We believe some consolidation of weather modification is desirable, but would not necessarily conclude that all such research should be concentrated, or that a lead agency approach for all generic weather modification is preferable."

OMB

"We view weather modification research not as a panacea but as an option, a possible means not as an end. * * *We believe the mission agencies rather than a single centralized agency should conduct the type of research activities they believe most suited to the national problems faced by them. Consequently, we believe that some consolidation of weather modification is desirable* * *the DENR [Department of Energy and Natural Resources] proposal will accomplish the appropriate degree of consolidation."

GAO evaluation

Regarding the consolidation of weather modification research activities, Senate bill 2135 and House bill 9090 would transfer to the proposed Department of Energy and Natural Resources the programs of the Bureau of Reclamation, Department of the Interior; NOAA; and the Forest Service, Department of Agriculture.

While the proposed reorganization plan should provide the opportunity for the new Department to more effectively manage the research efforts of these three agencies, we believe the problems in administration and management, such as funding competition and lack of interagency cooperation in participating projects, would continue because a national weather modification program would not exist.

Senate bill 2135 and House bill 9090 were introduced on July 10, 1973, and on June 29, 1973, respectively, and referred to their Committees on Government Operations. As of July 1, 1974, the bills were with the Committees and were not under active consideration.

A national program for weather modification

Agriculture

"* * *The difficulty with developing any overall national program direction is that the Federal agencies involved in weather modification have specific mission requirements that dictate particular research and development needs for weather modification technology. Agencies request their * * * funds, and Congress appropriates the money, on the basis that a specific mission requirement will be satisfied * * *. I would not wish to defend a budget request on the basis that it enabled us to participate in a national weather modification program. * * *"

Defense

"* * *Such a 'national program' could place an executive department or agency in the untenable position of being directed to allocate its resources to national program requirements. * * *executive departments can ill afford to have their programs directed by, or priorities established by, another government agency."

GAO evaluation

In our opinion, these comments highlight a major problem with the current fragmented Federal organization for weather modification research and the national projects established by ICAS--namely, weather modification activities must compete with an agency's mission priorities for funding and do not have the opportunity to compete against one another to establish national weather modification research priorities.

We would not expect that developing and implementing a national program would force agencies to carry out research totally unrelated to their missions. The agency designated to administer the national program should coordinate its funding requests for weather modification research with budget requests of other agencies and, when appropriate, could allocate its resources to other agencies for performing research.

In those instances where a major aspect of an agency's mission-related research is not consonant with the objectives and priorities of the national program, the agency would have the opportunity to justify its particular needs through OMB's budget process. We think that in most situations the need to do so would probably not happen since all agencies involved in weather modification would be involved with OMB in establishing the objectives and priorities of the national program.

Lead agency responsibility

Defense, Interior, and OMB

These agencies commented that, because weather modification research projects are significantly different in nature and technology, it would be difficult to proceed under the direction of a single agency.

For example, Interior said equipment and techniques, atmospheric data and models, decisionmaking processes, types of people and environment involved, and basic hypotheses are significantly different. In essence, this position supported ICAS' recommendation to continue with lead agencies for specific types of weather modification research.

GAO evaluation

ICAS recognized that an interdisciplinary multiagency approach would be necessary to accelerate progress in each project. As stated earlier, the designated lead agency has not always received agencies' participation and, in general, the national research projects showed little progress. One reason for the lack of multiagency participation in the projects is that weather modification research is not a high priority in an agency's mission. In our opinion, a national lead agency authorized to establish priorities and allocate resources would resolve the administration and management problems of national lead agency projects.

Regarding the differences in nature and technology of weather modification research projects, we assume a national lead agency would use the available expertise within Federal agencies in effectively managing a national program.

Status of weather modification research

NSF and OMB

These agencies commented that present weather modification activities are not sufficiently supported by scientific understanding and that a national weather modification research program would put undue emphasis on a technology that is mainly in the research stage.

GAO evaluation

We agree that weather modification activities should be supported by sound scientific understanding. However, a national program that would accelerate progress in weather modification research is not inconsistent with attaining greater knowledge.

NAS, in its 1973 report, "Weather & Climate Modification Problems and Progress," stated:

"* * *we still do not know, with a satisfactory degree of confidence, the precise meteorological conditions under

which it is possible to increase, decrease, or redistribute precipitation, what measures might be taken to mitigate the damaging effects of severe storms, or to what extent man is changing the climate of his cities and of his planet. This situation is likely to persist unless stronger and more unified federal programs are developed."

Weather modification coordination and priorities

Agriculture, Defense, and OMB

Defense and OMB commented that weather modification research is well coordinated by ICAS. It meets monthly and provides members and observers the opportunity to exchange information. Agriculture noted several examples of interagency cooperation in the exchange of computer models and equipment.

GAO evaluation

We agree that ICAS provides an excellent opportunity to meet and exchange information. However, lacking any type of directive authority, its efforts to coordinate weather modification research programs through interagency participation have had little success. For example, the ICAS recommendation to create a coordination committee for each of the national projects has, with one exception, never been implemented. The exception, the National Hail Research Experiment, already had a coordination committee. Effective coordination with positive results is very difficult to attain by only meeting and exchanging information. It also involves, as ICAS recommended, active interagency participation in the designated national projects.

Agriculture, Defense, Interior, and OMB

Agriculture further stated that its lightning research program had been underfunded for some time and that its funding was totally inadequate to discharge the leadership role suggested by ICAS. The major problem cited was the competition of funding priorities of weather modification research with other mission-oriented research.

Defense stated that its commitments to support cooperative pilot projects have always been contingent on the availability of resources. Resources and programs are mission-oriented, and funding is justified on that basis. It contended that, in allocating resources for cooperative national programs, it was evident such allocation had competed successfully with that of other Defense internal programs.

Interior stated that less than full interagency participation in ICAS efforts has been due primarily to financial and scientific reasons rather than a lack of organization or cooperation. It contended that implementation of ICAS recommendations primarily depends on adequate funding.

OMB stated that, to imply that project budgets are subcritical or to support citations to that effect, is a rather narrow view. It noted

that, where project budgets were reduced to accommodate other goals, weather modification research could be considered a lower priority.

GAO evaluation

The designation of lead and participating agencies on the national projects recommended by ICAS was a recognition that current programs were subcritical. The ICAS report noted that current projects consisted of small and occasionally independent groups and concluded that progress could be accelerated under a multiagency approach. Since both Agriculture and Commerce have labeled their own programs as subcritical we do not consider our support of these statements as a narrow view.

While Defense contends it has been successful in allocating resources to national programs, our report shows it limited its participation in the Experiment and withdrew support on the National Hurricane Modification Project.

In our opinion it is unrealistic to assume that adequate funding will solve the current problems in implementing a national program. Requirements still need to be recognized, priorities established, and resources allocated to the most beneficial programs.

Relative priority of weather modification

NSF

NSF said it was prepared to believe that developing weather modification is a valuable national asset; however, neither the report nor any of the studies cited were able to establish clearly the priority of this national need.

GAO evaluation

Our report and the other studies were not intended to assess the weather modification research priority status as it relates to other societal needs. However, we would expect that such assessment would be a major objective in developing a national program so that its priority could be realistically evaluated among competing national needs.

National Hail Research Experiment

NSF

NSF stated that the Experiment has achieved excellent progress. The project director reported cooperation among participating organizations. Many items discussed in the report were minor and have been overcome. The only impediment has been the lack of sufficient, suitable conditions which produce hail clouds. NSF commented that the report overlooked the basic fundamental mechanism for establishing coordination in multiagency programs--to centralize the flow of funds. Had NSF been given the funds to subcontract for essential

services to other agencies, coordination problems would not have occurred.

GAO evaluation

We subsequently contacted the Acting Deputy Director of the Experiment to determine the status of and participation of agencies in the most recent operating season (summer 1973) and found the following.

NOAA was able to furnish the Doppler radars for the first time, but could not furnish any aircraft in that period or for the remainder of the Experiment. Also, by mutual agreement, NOAA no longer participates in the operation of the ground network. It has requested funding from the Experiment for its Doppler radar participation in the 1974 season. Because of its importance to the program, the Experiment expects to fund this effort.

The Naval Electronics Laboratory Center took on the electrical studies in 1972 after Agriculture withdrew but advised that, for 1973, it could only fund projects that were directly oriented to purposes of the fleet. However, there would be no problem if outside support from the Experiment was obtained. The Experiment's Acting Deputy Director advised us that the Experiment was not able to furnish funding for 1973 and it is unlikely it could in future years.

Because of the foregoing, important segments of research were lost for 1973 and probably for the remainder of the Experiment. Initial plans designated NOAA's aircraft as critical for midlevel cloud exterior measurements. Also, the initial plans concluded that electrical effects were such an important part of the Experiment that it was imperative to make this a part of the program during the duration of the project.

In our opinion each operational season has had, and probably will continue to have, problems with commitments from participating agencies unless the organizational structure is changed. We agree that centralized funding would tend to eliminate problems and believe that, if a lead agency were managing a national program, such funding could be used.

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The agency comments, in our opinion, further support the need for a national program by their acknowledgment of limited scientific understanding of weather modification activities and the recognition that progress is being hampered by the current fragmented Federal organization structure. Although some agencies implied or stated that additional funding would accelerate progress, we believe that a national program would more effectively do so by clearly establishing national priorities and making more beneficial use of existing resources.

RECOMMENDATIONS

GAO recommends that OMB should, in cooperation with the Federal departments and agencies involved in weather modification research:

--Develop a national program with goals, objectives, priorities, and milestones, designating one of the agencies, which would have a major program responsibility, to administer and maintain the national program.

--Develop a plan to define and reassign, if appropriate, the responsibilities of Federal departments and agencies providing support or conducting weather modification research.

--Develop a plan to allocate resources to the national program elements.

WEATHER MODIFICATION PROGRAMS AND FEDERAL PARTICIPANTS IN FISCAL YEAR 1974

Most weather modification field research experiments are based on:

--Development and use of seeding material, such as silver iodide which is the most common.

--Acquisition and use of delivery systems to place the seeding material into the cloud.

--Development and use of measuring equipment and devices to determine the physical characteristics (temperature, pressure, humidity, wind velocity, etc.) in the cloud and atmosphere before, during, and after seeding.

--Evaluation of data over a period of several seedings or against a predetermined model to determine success or results.

PRECIPATION MODIFICATION

The general purpose of precipitation modification research is to study and develop techniques to manage and control rain or snow. Federal support for this research has been provided principally by the Interior, Commerce, and NSF. Planned expenditures for fiscal year 1974 for these three agencies total $3,690,000.

Department of the Interior--$2,400,000

Interior has supported precipitation modification research since 1962 under its Project Skywater which is administered by Interior's Bureau of Reclamation. Project Skywater's principal objective is to learn how to manage precipitation through cloud-seeding technology to help meet the growing water needs in the western mountains and the high plains regions of the United States.

Initially such seeding involved winter storm clouds only. On the basis of field experiments on winter-storm cloud seeding in the western United States, Interior has estimated that seasonal snowfall there can be increased by 10 to 30 percent. In fiscal year 1974, 11 such field experiments will be concluded for the purpose of performing a comprehensive analysis of current research before continuing future efforts.

Experiments involving seeding summer cumulus clouds under Project Skywater started in 1965 in various western states. During

fiscal year 1974 Interior plans to begin the High Plains Cooperative Program. This major program is intended to last 5 to 7 years and will require joint funding by local and State groups and other agencies. Program goals are to resolve remaining uncertainties in summer cumulus cloud seeding and to establish by 1980 a working technology capable of producing additional rain in the semiarid high plains region.

Fiscal year 1974 plans call for continuing a joint effort with the California Department of Water Resources for planning and ecological studies in the Central Sierra Mountains of California and Nevada to aid in evaluating the effects of cloud-seeding activities.

Department of Commerce--$840,000

Commerce, through NOAA, supports research aimed at increasing rainfall from tropical cumulus clouds. Experimental seedings were conducted initially over the Caribbean Sea in 1963 and 1965. Since 1968 such experiments have been conducted over Florida.

Experiments by NOAA's Experimental Meteorology Laboratory in seeding cumulus clouds in Southern Florida show a threefold increase in precipitation. Other experiments indicate the possibility of increased precipitation by stimulating the merger of two cumulus cloud systems. The ultimate objective is to achieve technology transfer of drought relief methods to the State of Florida and other regions with similar meteorological conditions.

Other activities involve the development of cloud models, including cloud merger models and feasibility studies of precipitation measurement by remote sensing techniques from existing satellites.

NSF--$450,000

NSF's research is focused on improving knowledge of precipitation mechanisms that are modified by artifical nucleation. Efforts will center on the scientific interpretation of the results of other agencies' seeding programs. Emphasis will be placed on nucleation mechanisms, nucleation efficiency, downwind effects, and the overall microphysical and dynamic mechanisms involved in cloud-seeding operations.

HAIL SUPPPRESSION

The purpose of hail suppression research is to develop techniques to eliminate or reduce the size of hailstones to reduce the damage potential.

ICAS recognized by 1969 that a large and long-term field experiment was needed to achieve results in this area. It also recognized that such an undertaking required more resources than would be

available to a single research group. It recommended establishing a centrally directed, collaborative effort of the groups involved in hail suppression research.

In 1971 the many organizations conducting hailstorm research were organized under the Experiment, a 5-year research program in northeastern Colorado. Its aims are to understand the physics of severe convective storms, assess the feasibility of suppressing hail damage to crops, and examine the effect on society of conducting an operational hail suppression program if an operational program proves to be possible.

The Experiment is directed by the National Center for Atmospheric Research, in Boulder, Colorado, with NSF providing substantially all of the funding. For fiscal year 1974, NSF estimates about $3,250,000 will be provided to the Center for conducting the third field year of the Experiment. The Experiment will continue its program to obtain more adequate information on the dynamics and microphysics of severe convective storms capable of generating damaging size hailstones. Its objective is to develop a mathematical model which can forecast hail growth conditions and indicate the most effective means for suppressing large hailstone growth.

INADVERTENT MODIFICATION

This research involves monitoring of atmospheric constituents and studies of their modifying influences on the weather. Federal support for inadvertent modification research is provided by Transportation, Commerce, and NSF. Planned expenditures for fiscal year 1974 total $2,912,000.

Department of Transportation--$1,304,000

Transportation is continuing the Climatic Impact Assessment Program to assess the environmental and meteorological effects of the projected world high-altitude aircraft fleet, including subsonic and supersonic vehicles. The program is considering the interactions between engine emissions exhausted into the upper atmosphere, the natural composition of the stratosphere, and the dynamic processes of the atmosphere. Transportation is also conducting studies to evaluate and develop transportation system air pollution models to describe the diffusion, transport, and chemical dynamics of air pollutants near transportation-related sources.

Department of Commerce--$908,000

NOAA's program called Global Monitoring of Climatic Change has the objectives of establishing a comprehensive air quality baseline monitoring network and being able to predict changes in climate resulting from man's activities. A baseline station at Pt. Barrow, Alaska, is planned for full operation in fiscal year 1974. Preliminary

monitoring is being done at American Samoa in cooperation with the National Center for Atmospheric Research.

During fiscal year 1974 limited solar radiation measurements are planned at Antarctica and systems will be designed for new trace-elements sampling along with oceanographic measurements of temperature and salinity for use off the coast of Hawaii.

NSF--$700,000

Inadvertent weather modification research continues to focus on project Metropolitan Meteorological Experiment in St. Louis which is aimed at assessing urban impact on local weather patterns and the identification of the responsible mechanisms. NSF will continue to support data-gathering elements required for Metropolitan Meteorological Experiment objectives in the St. Louis area, such as the Illinois State Water Survey, University of Chicago, and Stanford Research Institute.

The possibility that urban and industrial pollution may tend to deepen or prolong drought during times of atmospheric water deficiencies will also be explored.

FOG AND CLOUD MODIFICATION

The principal objective of research in this area is to study and develop methods to dissipate cold (under 0 degree Centigrade) and warm (over 0 degree Centigrade) fogs. Four agencies are carrying on research in this modification area with fiscal year 1974 planned expenditures totaling $2,477,000.

Department of Defense--$1,534,000

Defense's major point of attack is concentrated on warm fog due to its frequent effects on almost all military operations whether conducted in the air, on land, or at sea.

The Navy is intensifying its warm maritime fog investigations. The Air Force's plans for warm fog dispersal are concentrated on the heated plume technique which includes redesign of burners, studying the use of propane and natural gas, evaluating the first year's operational results of the French installation at Orly, and preparing for advanced development of a warm fog dissipation installation at Travis Air Force Base, California.

The Army is studying the warm fog life cycle to determine how it can be altered by helicopter downwash, hygroscopic materials, and heat.

Dissipation of cold fogs was performed as an operational program during the winter of 1970-71 at a number of air bases. These efforts

resulted in the successful completion of more than 500 takeoffs and landings during fog conditions which would formerly have caused suspension or curtailment of air operations.

NSF--$800,000

NSF's research in this area is related to the application of basic knowledge to explaining and predicting warm cloud precipitation processes and the role of ice nucleation in cold cloud systems. Emphasis is to be placed on more accurate detection and measurement of ice-forming nuclei involved in the atmospheric processes and the development of new nucleating materials using more inexpensive and available materials compatible with the balance of nature.

Department of Transportation--$93,000

The Federal Aviation Administration will continue its research to:

--Develop an economical operational ground based fog dispersal system.

--Test the efficiency of biodegradable glycerine for fog dispersal and develop treatment techniques.

--Monitor the development and operation of both foreign and U.S. fog dispersal systems and exchange information in this area.

National Aeronautics and Space Administration--$50,000

The agency supports fog modification studies for aeronautical safety applications. The objective is to study the life cycle and microphysical properties of fog in order to develop techniques to dissipate fog over and around airports and heliports.

HURRICANE AND SEVERE STORM MODIFICATIONS

The purpose of hurricane modification research is to determine the extent to which hurricanes can be benefically modified. Commerce has conducted hurricane research since 1956 and between 1962 and 1972 under Project Stormfury, a joint project with Defense.

Field experiments made on four hurricanes--all on the Atlantic Coast--between 1961 and 1971 indicated, in one case, that the destructive effects may be decreased. According to Commerce, a decrease in the wind velocity was noted after seeding Hurricane Debbie in 1969, but the level of the decrease was within the range of natural variability of hurricane winds and the results were therefore inconclusive.

On the basis of the scarcity of storms acceptable for seeding experiments in the Atlantic Ocean, the need for newer aircraft, and Defense's decision to participate only on a reimbursable basis, NOAA discontinued field experiments of Project Stormfury until safe, well instrumented aircraft are available for operations in the Pacific Ocean where storms acceptable for experimentation are more frequent. (See page 43 for additional comments on Project Stormfury.)

Meanwhile other research activities will continue. These include the possibility of moderating or modifying other types of severe storms, such as thunderstorms, tornadoes, and east coast storms.

Planned expenditures for fiscal year 1974 amount to $1,548,000.

LIGHTNING MODIFICATION

The purpose of lightning modification research is to determine the basic characteristics of fire-setting lightning storms and develop techniques to suppress or modify lightning discharges. Lightning research efforts are supported by Agriculture, Defense, and NSF.

Planned expenditures for fiscal year 1974 total $653,000.

NSF--$300,000

Most of NSF's research in the modification of cloud electricity is directed toward a study of the basic concepts, which relate cloud electricity to precipitation, and the possibility of inducing or augmenting rainfall by electrical charge modification. Observations and experiments are conducted from a mountain-top observatory and an extensive network of ground sensors and radars in the vicinity of the New Mexico Institute of Mining and Technology in New Mexico.

Department of Agriculture--$293,000

Agriculture's Forest Service lightning modification research was started in 1953. Designated as Project Skyfire, it is the United States' oldest continuously performed weather modification project. Objectives of the project, which is located at the Northern Forest Fire Laboratory, Missoula, Montana, is to test a hypothesis that the seeding of northern Rocky Mountain thunderstorms with silver iodide can significantly reduce cloud-to-ground lightning strokes which are responsible for the majority of forest fires in the intermountain West.

A major effort of the fiscal year 1974 program will be planning for full cooperation and participation in the lightning abatement experiment to be carried out by Interior's Bureau of Land Management over interior Alaska.

Department of Defense--$60,000

The Air Force will investigate electrical charges of cumulus clouds to determine when and where they are most easily susceptible to discharging.

OTHER

Other costs represent research efforts related to mathematical modeling; social, economic, legal, and ecological studies; and support and services. Planned expenditures for fiscal year 1974 total $2,887,000.

NSF--$1,100,000

Mathematical modeling research in cloud dynamics and microphysics is conducted in universities and at the National Center for Atmospheric Research to determine the mechanisms in severe storms which cause the formation of hail, severe winds, and lightning.

In most instances, actual experimental data from real storms is not available to critically test the validity of the devised models. Field observations made during the Experiment and additional laboratory data on microphysical and dynamic features of clouds will be used to refine the models and test their accuracy in forecasting the results of modification.

Studies involving the legal, social, and ecological aspects of weather modification will be continued at universities and nonprofit institutes. The social, legal, and economic studies of hail suppression will be incorporated into the Experiment's progress reports and will provide guidance to Federal, State, or municipal groups who plan to engage in hail suppression on an operational basis.

Department of Commerce--$937,000

The NOAA Research Flight Facility provides aircraft support, including seeding and airborne measurements, to all NOAA weather modification activities.

Department of the Interior--$850,000

General program support includes the continuation of the series of Skywater Conferences--seven have been held on specific problems--and field support, including snow surveys, steam gauging, and silver analyses.

Scientific and equipment assistance with access to the Bureau of Reclamation's Environmental Data Network will be provided to local- and State-sponsored projects.

Three principal ecological studies--San Juan Mountains of Colorado, Great Plains, and Sierra Mountains of California--will continue in 1974.

APPENDIX II

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Washington, D.C. 20250

4400
AUG 23 1973

Mr. Richard J. Woods, AD
Resources and Economics Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Woods:

We appreciate the opportunity to review and comment on the draft of your report to Congress entitled "The Need for a National Program in Weather Modification Research." In general, your report is a fair and accurate description of the past and present Federal activities in weather modification research. We noted, however, that your findings tended to rely heavily on the series of past studies and reports by various groups that were cited in your report. Most of these implied or concluded that weather modification research in the Federal Government was poorly coordinated, fragmented, and underfunded. In each instance the conclusions of the study were that a "national program" is needed and that more money ought to be spent in weather modification research.

None of the reports, including your own GAO study, appears to have identified any particular fault--lack of progress, for example--which could be traced directly to any of the defects which the report finds. Your report should provide more concrete evidence to substantiate the charges that it makes. What specific deficiency did you find in the output of the Nation's weather modification research program? Was the output too small; was it trivial or lacking in scientific merit? To label a program with terms such as "uncoordinated, fragmented, subcritical," without citing meaningful concrete evidence for these deficiencies raises questions regarding the validity of the findings.

Speaking for the Forest Service, I can agree that our lightning research program has for some time been underfunded in terms of the opportunities which our scientists see to advance the research at a faster pace and to validate the developed technology in comprehensive field experiments. Our funding is of course totally inadequate to discharge the leadership role in the National Lightning Suppression Project assigned to us by ICAS report 15-A. However, I cannot agree that our program is poorly coordinated as I understand the meaning of that term. Incidentally, there appears to be a tendency in your report to assign to "coordination"

a meaning which I associate with the words "integration, central control and direction." Our lightning research has been directed at meeting our responsibility for protecting forests from fire. We have not attempted to integrate our research with lightning research programs of other agencies (NOAA, NASA, or DoD, for example) whose missions and concerns regarding lightning phenomena are quite different from our own. We do collaborate and cooperate with sister agencies in weather modification research and experiments where it is of mutual benefit to do so. Recent examples of this cooperation are:

The Forest Service lightning research personnel joined with the Department of the Interior scientists in an experiment to evaluate the efficacy of cloud seeding in suppressing lightning fires over interior Alaska, from June to August, 1973.

Project Skyfire has made available its silver iodide generators to the Bureau of Reclamation for use in the Bureau's Skywater project.

Project Skywater has provided Skyfire with computer models for use in simulating cloud behavior and testing cloud seeding effects.

The Naval Weapons Center made available to Project Skyfire silver iodide flares for use in its cloud seeding work.

These are but a few examples of the interagency cooperation that has existed from time to time in the area of lightning research. I am told that similar collaboration exists between other Federal agencies involved in weather modification research.

Your report makes much of the failure of agencies to actively participate in the field program of the National Hail Research Experiment (NHRE). I agree that it is regretable that the Department of Agriculture and others were not able to participate in NHRE, but in our case, we had to decide whether the Forest Service weather modification scientists would conduct the electrical measurements required by the NHRE program in the experimental area in northeastern Colorado or go to Alaska to work with the Bureau of Land Management in its program for suppressing fire-starting lightning storms over Alaska wildlands. We concluded that our work in Alaska was more important to the mission of the Forest Service and directed that Skyfire undertake the Alaskan project in 1973. I feel that GAO could easily have criticized our doing otherwise.

In citing the lack of participation by some agencies in the National Hail Research Experiment, you have come across a real problem in

making your national program concept work. The difficulty with developing any overall national program direction is that the Federal agencies involved in weather modification have specific mission requirements that dictate particular research and development needs for weather modification technology. Agencies request their research and development funds, and Congress appropriates the money, on the basis that a specific agency mission requirement will be satisfied through the conduct of the proposed R&D. The Forest Service would not be able to present its budget requests before our congressional committees on any other basis. Certainly I would not wish to defend a budget request on the basis that it enabled us to participate in a national weather modification program. I doubt that many agency heads would be so inclined.

Our review of the ICAS record over the past 10 years indicates that that group has not been unmindful of the need to coordinate programs and has devoted a great deal of attention to weather modification research.

GAO note: Material has been deleted because of changes to the final report.

I have no basis for judgment on the adequacy of the Nation's overall weather modification research, or whether anything at all is wrong with the present program. In our research, the problem is one of funding priorities: Weather modification research in the Forest Service must compete for funds with research on such items as tree genetics, entomology, forest pathology and others. I am sure that other Federal agencies must make similar choices. It is not clear that the creation of a National program would relieve any of us of the need for making those difficult decisions on the allocation of research resources.

Sincerely,

John R. McGuire

JOHN R. McGUIRE
Chief

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

September 13, 1973

Mr. Donald C. Pullen
Assistant Director
General Government Division
U.S. General Accounting Office
441 G Street, N. W.
Washington, D. C. 20548

Dear Mr. Pullen:

This is in reply to your letter of August 8, 1973, requesting comments on the draft report on the review of weather modification research programs being conducted by various Federal departments and agencies.

We have reviewed the comments of the National Oceanic and Atmospheric Administration and believe they are appropriately responsive to the matters discussed in the draft report.

Sincerely yours,

Henry B. Turner
Assistant Secretary
for Administration

Enclosure

I. SUMMARY

In general, the Department of Commerce agrees with the conclusions and most of the recommendations contained in the GAO Draft Report.

The Department of Commerce believes that the President's proposal to establish a Department of Energy and Natural Resources (S. 2135) will bring together many of the widely scattered elements in Federal weather modification programs, and substantially resolve the issues raised in the GAO Draft Report. The new Department, for example, will include the weather modification programs of the Forest Service (Department of Agriculture), the Bureau of Reclamation (Department of the Interior), and the National Oceanic and Atmospheric Administration. The opportunity will be provided for developing a well-formulated, single, strong, national program in this increasingly important field.

II. COMMENTS ON SPECIFIC RECOMMENDATIONS

[See GAO note, p. 39.]

[See GAO note, p. 39.]

C. A national program for weather modification research, with goals, objectives, priorities, and milestones, conforming to identified needs.

The Department of Commerce supports this recommendation with the understanding that OMB will draw heavily upon the efforts of existing interagency coordination mechanisms to gain access to technical expertise and results achieved thus far in defining a national program.

D. A plan to define and reassign, if appropriate, the responsibilities of all Federal agencies that provide support or conduct weather modification research.

The Department of Commerce believes that this plan is an essential part of the national program discussed in the previous recommendation. Weather modification technology and supporting research should remain available for use by all agencies of the Federal government in the discharge of their mission responsibilities.

E. A plan to allocate resources to the national program elements.

The Department of Commerce supports this recommendation in the context of implementing a national program in weather modification. Carried to extremes, however, this directed use of resources does limit the flexibility of agency management.

[See GAO note, p. 39.]

GAO note: Page numbers referred to in these comments are those of our preliminary report, not this final report.

III. FURTHER COMMENTS

With reference to comments on pages 3 and 33 of the draft report concerning the National Hurricane Modification Project, NOAA has developed a program to modernize and instrument its Research Flight Facility aircraft in order to conduct the experimental field program. The technology to modify hurricanes must insure stringent safety standards, avoid endangering populated areas, and avoid reducing the essential, and substantial, contribution to annual water supplies these large tropical storms provide. The experimental field program necessary to verify our capability to produce predictable results, and to confirm the results to date, will require five modern turboprop aircraft capable of penetrating hurricanes and measuring accurately all meteorological parameters relevant to the program. NOAA developed a two-year plan to retire three out of the four aircraft which were obsolete, procure one new replacement aircraft, and install advanced airborne measurement systems in the two NOAA aircraft. A joint plan has been developed in which the Department of the Air Force will provide the use of three C-130 aircraft, and NOAA will procure and install the advanced instrumentation systems needed on these Air Force aircraft. NOAA will budget for the additional costs of operating Air Force and NOAA aircraft during the tropical storm season beginning in June 1976, designated Project STORMFURY-Pacific. The plan is based on operating the field experiment in the Pacific to take advantage of the larger number of occurrences of tropical storms in this area compared to the Atlantic-Gulf of Mexico area. By this plan, NOAA was able to obtain the aircraft support needed without the necessity of purchasing five new aircraft at a cost exceeding $36 million. The OMB has given this planning effort firm support.

The necessity of developing the aircraft and airborne instrumentation support needed for Project STORMFURY caused a delay in the field program until June, 1976. During this period, the National Hurricane Research Laboratory will be engaged in improvement of models, participation in the Atlantic Tropical Experiment of the Global Atmospheric Research Program and evaluation of the basic hypotheses in terms of data on hand.

The Department of Commerce experience in developing and funding the National Hurricane Modification Program is indicative of the problems caused by weather modification research programs which are funded at levels below the initial mass needed for expeditious and cost effective completion of the program. The uncertainties of inderdepartmental support have hampered the development of effective long-range plans. Delays were occasioned when the changing mission priorities and restriction of research goals led to the DOD withdrawal from joint sponsorship of Project STORMFURY and recommendation that NOAA assume the lead agency role. The requirements of the budget

cycle, instrumentation development cycle, and aircraft and instrumentation procurement cycles introduce further delays in this program. These long-lead time factors can be planned with minimum delays in the program when the critical mass for a successful program is available and continuity can be guaranteed. . . . [See GAO note, p. 39.]

APPENDIX IV

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

12 NOV 1973

Mr. R. W. Gutmann
Director
Procurement and Systems
Acquisition Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Gutmann:

This is in response to your letter of 10 August 1973 requesting DoD comments on the 31 July 1973 GAO Draft Report, "Need for a National Weather Modification Research Program."

The DoD research and development effort in weather modification is conducted because of two major defense interests: (1) protecting personnel and resources against weather hazards, thus improving our operational capabilities; and (2) guarding against technological surprise by increasing our understanding of the capabilities any potential adversary might possess in this area.

The GAO report concludes that a national program and a lead agency are needed "for the now fragmented federally-supported weather modification research activities." Such a "national program" could place an executive department or agency in the untenable position of being directed to allocate its resources to national program requirements. The DoD must retain the option to conduct RDT&E in those areas of atmospheric sciences, including weather modification, which offer the greatest potential contribution to solving problems associated with weapons systems and tactical and strategic operations. In the existing structure of our government, mission-oriented executive departments can ill afford to have their programs directed by, or priorities established by, another government agency.

The DoD has supported the Interdepartmental Committee for Atmospheric Sciences (ICAS) in recommending against a "national program" in weather modification. The Pilot Projects named in ICAS Report 15a constitute parts of programs which seek solutions to problems of national or near-national dimension. For example, the national problem is damage and destruction resulting from tropical storms: hurricane modification is but one approach to damage reduction; others include

better construction methods, improved land usage, better warning services, effective disaster assistance plans, etc. In short, weather modification techniques represent possible but not unique solutions to national problems.

The GAO report makes strong reference to "ineffective coordination." Weather modification research is well coordinated by the ICAS, which meets monthly and provides members and observers the opportunity to exchange information in a timely manner. Further, ICAS just completed sponsoring the 15th annual interagency conference on weather modification, which provides project managers and scientists a forum for exchanging ideas, resolving problems, and the potential for planning joint efforts. The purpose of coordination is to achieve a minimum of duplication, reduce interference, promote mutual assistance, and provide the impetus for cooperative projects. The effectiveness of coordination should not be judged on such criteria as an apparent failure to inspire larger programs.

[See GAO note, p. 39.]

Weather modification research involves projects which are separate and distinct because of the very problem being attacked. Federal agencies, in conjunction with OMB, have recognized these differences and have decided to concentrate their respective efforts in specific areas most relevant to their individual mission requirements; Commerce

in severe storms, Interior in precipitation, NSF in hail suppression, etc. Regarding duplication, there is invariably some overlap among the projects conducted because hailstorms, cumulus cloud development, and tropical storms do have some common meteorological characteristics. In basic research, some duplication is essential and does not constitute a significant problem. It should be recognized that the projects are significantly different to support having them conducted principally under the direction of a mutually agreed upon lead agency. Thus, we conclude that there are, in effect, recognized lead agencies for specific types of weather modification research, mission requirements and objectives having dictated who leads in what project.

The GAO report discusses the fact that support to weather modification projects by cooperating agencies has not always been forthcoming. DoD commitments to support cooperative pilot projects have always, of necessity, been contingent upon the availability of resources. DoD resources and programs are mission-oriented; funding for them is justified on that basis. In volunteering (allocating) DoD resources for support of cooperative "national" programs, it is evident that such allocation has competed successfully with other internal DoD programs; it must be recognized that this cannot always be the case due to stringent Congressional and budgetary constraints. One possible solution to the issue raised by the GAO is to identify an agency as the lead agency in a particular aspect of weather modification research, and then provide that agency the resources to conduct an adequate program. This means, for example, that the NSF in its conduct of the National Hail Research Experiment (NHRE), would have the means to reimburse other federal agencies for services rendered, or obtain the services from a contractor if mission requirements precluded other federal agency participation. A case in point in this regard is the Congressional designation of the Department of Transportation (DoT) as the lead agency in the conduct of the Climatic Impact Assessment Program (CIAP): CIAP is to assess by 1974, the impact of climatic changes on people, plants and animals, resulting from propulsion effluents of vehicles in the stratosphere, as projected to 1990; the DoT has been allocated by the Congress some $25 million over 4 fiscal years to get this job done.

We appreciate the opportunity to comment on your draft report.

Sincerely,

Malcolm R. Currie

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

SEP 18 1973

Mr. Philip Charam
Deputy Director
Resources and Economic
Development Division
General Accounting Office
Washington, D. C. 20548

Dear Mr. Charam:

The Department of the Interior's Bureau of Reclamation has reviewed your draft report, "Need for a National Weather Modification Research Program." Their comments in which I concur, state that less than full interagency participation in the ICAS efforts has been due primarily to financial and scientific reasons rather than a lack of organization or cooperation.

The ICAS position, concurred in by the Department through its representative, regarding the subject of an implied "national program" in weather modification has been stated formally several times, the most recent in its review of reports by the National Academy of Sciences Committee on Atmosphere Sciences (NAS/CAS) and the National Advisory Committee for the Oceans and Atmosphere (NACOA). This position has been summarized by Dr. Edward P. Todd, Chairman of ICAS as follows:

> "Assignment of a lead agency responsibility....would place the selection of priorities in weather modification R&D activity for all agencies in the hands of a single one. The ICAS feels, to the contrary, that for the foreseeable future there is a considerable tactical advantage in having a number of agencies making contributions to the R&D concepts underlying weather modification rather than....to reduce the diversity of intellectual and managerial inputs by relegating all but one agency to the role of potential users permitted to participate only in specifying 'requirements'."

Although grouped under the heading of weather modification, the equipment and technique, atmospheric data and models, decision-making processes, types of people and environment involved, and basic hypotheses are significantly different for each of the major forms of weather modification, such as: precipitation management, severe storm abatement, fog dissipation, lightning modification, or hail suppression.

These technical differences, difference in objectives, and diversity of problems in each area having differing priorities for solution argue for a separate lead agency for each major type of activity. Mission-oriented lead agencies would also be more responsive to public interest in each case.

We believe that the GAO erred in looking at weather modification as a single area of effort which could be defined as a program. It would have been more realistic to review the need, adequacy, and coordination of a "national program" in each of the specific areas listed above.

The apparent consistent recommendations cited by the GAO from "independent" advisory committees for a single lead agency can partially be attributed to a few individuals who have pressed for this concept in the face of a majority of agency recommendations against it. The science of weather modification is proving to be very complex, and making progress with limited resources is slower than earlier projections anticipated. This slower progress cannot, however, be blamed on improper organization or lack of coordination.

We believe that the ICAS is an adequate mechanism for coordination of Federal weather modification activities, and that implementation of many of its recommendations for a "national program" in weather modification is primarily dependent upon adequate funding of each of the activities included therein.

We appreciate the opportunity to comment on the report in draft form.

Sincerely yours,

A. L. Reynolds

Allan L. Reynolds
Director of Survey and Review

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
DIRECTOR

OCT 4 1973

Mr. Morton E. Henig
Associate Director
Manpower and Welfare Division
U. S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Henig:

Reference is made to your letter of August 6, 1973, requesting comments on the General Accounting Office draft report entitled "Need for a National Weather Modification Research Program."

Our comments on the draft report, presented in the following paragraphs, consist of (1) some general observations concerning the principal thrust of the report, (2) specific comments identified with pertinent sections of the draft report, and (3) some conclusions of our own.

First, we believe that the level of effort devoted to weather modification as described in the draft report may be misleading. The report states that weather modification research is but one part of atmospheric sciences research, and only briefly refers to total atmospheric sciences research expenditures. However, much of the research going on in the atmospheric sciences, other than that specifically identified as weather modification research, relates either directly or indirectly to the weather modification field. To obtain a really comprehensive understanding of the weather modification effort, it would be necessary to examine all such research, a lengthy and difficult task.

The GAO Report asserts that a national program is necessary. We are prepared to believe that development of weather modification is a valuable opportunity and potential national asset; however, the report does not show evidence that supports this assertion. Rather the GAO cites a number of studies that have previously been prepared by other groups. These studies, too, asserted a need for a national program in weather modification, but none of them were able to establish clearly the priority of this national need among competing societal problems. Assertions that current methods of coordination are not adequate do not justify the need for a lead Federal agency, but merely more effective methods of coordination.

The GAO Report specifically notes that we lack basic knowledge about the atmosphere. It is our opinion that seeking information about the fundamentals of this field is the first order of business. We also feel that a consistent pattern of basic research will provide the theoretical basis for a sound weather modification research program, the results of which will supply the Federal mission agencies and the national interest with additional alternative solutions which can be applied to national problems that exist or arise.

The following specific comments are identified with the comments in the draft report.

1. In several places in the GAO Report, comparisons of research expenditures between 1959 and 1973 are made. The rules for fund reporting in this area of research have changed several times over that time interval. It is possible to make comparisons of orders of magnitude but no comparisons should be made quantitatively.

[See GAO note, p. 39.]

4. Page 14 - Regarding the National Hail Research Experiment (NHRE), [See GAO note, p. 39.]

The NSF, through its executive agent, the National Center for Atmospheric Research (NCAR), has achieved excellent progress in the NHRE. The Project Director of NHRE has reported cooperation among the participating organizations. The design data are being

obtained in the fashion called for in the NHRE Plan. The only impediment to progress which has not been overcome, according to the Director, has been a lack of sufficient, suitable meterological situations which produce potential hail clouds.

5. Page 22 - The report states that the Special Commission on Weather Modification had taken the position that "... certain aspects had reached the applied research and operations phase." Current opinion in the scientific community generally is that present weather modification activities are not sufficiently supported by scientific understanding. Sound theory must precede operational application to insure that total consequences are known in advance. It should be noted that RANN/NSF is an agency which addresses itself to selected weather modification problems, and although it has no desire to do what the mission-oriented agencies can do, RANN has capabilities to bridge the gaps which exist between basic research and operational projects.

6. Page 28 - The report states that the Secretary of Commerce, commenting on the first annual report of the National Advisory Committee on Oceans and Atmosphere (NACOA), agreed with the NACOA recommendation for a central focus for weather modification activity in the Federal Government. This agreement did not reflect the position of all Federal agencies concerned. The NSF, for example, endorsed the National Pilot Project and Pilot Project Lead Agency mode as defined in Report 15A of the Interdepartmental Committee for Atmospheric Sciences (ICAS).

[See GAO note, p. 39.]

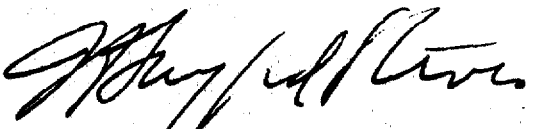
8. Pages 34-39 - The discussion of issues in NHRE are, in part, misleading. The heading "Current Problems" is inappropriate since many items discussed have been resolved and the project is on schedule. In addition, it is worth noting that a fundamental mechanism for establishing coordination in multi-agency programs has been overlooked. This mechanism is to centralize the flow of funds, that is, to "put all the money where the problem is." Had NSF been given the funds to subcontract for essential services to other agencies for their efforts in NHRE, it is unlikely that the coordination difficulties would be developed. Fortunately, the difficulties that did arise were minor and have been overcome.

[See GAO note, p. 39.]

Finally, we have concluded that the present scheme of National Pilot Research Projects, with assigned lead agencies, is a sound way in which to proceed and one which will produce viable alternatives through weather modification techniques for employment by the mission agencies of the Government in accomplishing their purposes. This mode of operation should, of course, be subject to periodic reexamination and appropriate adjustment if warranted by the existing circumstances.

We appreciate the opportunity to comment on the GAO draft report, and trust that the foregoing comments will be helpful.

Sincerely yours,



H. Guyford Stever
Director

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

September 12, 1973

Mr. Morton E. Henig
Associate Director
General Accounting Office
Manpower and Welfare Division
Washington, D. C. 20548

Dear Mr. Henig:

This is in response to your letter of August 6 requesting OMB comments on the draft report, "The Need for a National Weather Modification Research Program." OMB comments are made in relation to what we perceived to be the primary GAO findings and conclusions.

I. Main GAO Conclusion: That a national program (and a lead agency) are needed to pull together the fragmented, Federally supported weather modification research activities. This conclusion is based on the GAO investigation and studies by research groups who, over the last decade, have identified problems in the weather modification area as:

-- ineffective coordination

-- fragmented research

-- insufficient funds, inefficiently applied

-- lack of single agency responsibility

OMB Comment: The point on ineffective coordination of research projects is not supported by fact. Weather modification research is well coordinated by the Interdepartmental Committee on Atmospheric Sciences (ICAS). ICAS meets monthly and provides members and observers the opportunity to exchange information in a timely manner. Interdepartmental coordination of weather modification activities has been, in our opinion, achieved through the efforts of ICAS and the member agencies in an exemplary manner.

President Nixon has proposed a reorganization plan to form a Department of Energy and Natural Resources (DENR). The new Department will consolidate many Federal programs in atmospheric, oceanic and solid earth sciences - including elements of weather modification research from Agriculture - Forest Service, Commerce - NOAA, and Interior - Bureau of Reclamation. These agencies conduct weather modification research on precipitation, lightning, hurricanes and other severe storms, the socio-economic, environmental, and legal impact of weather modification and on inadvertent modification of the weather. This reorganization proposal will have many such salutary effects in the scientific areas dealing with air, oceans, and earth. In weather modification, it will be a primary focus for civilian research activities, although we will continue to support efforts by agencies to solve problems in their areas of interest with mission supporting research.

We view weather modification research not as a panacea but as an option, a possible means not as an end. A means in this sense is a technique that may achieve a particular objective. An example is the objective of mitigation of the impact of natural disasters. There are many techniques other than weather modification to attain this objective, for example, improved land use planning, community preparedness and stronger building codes. We believe the mission agencies rather than a single centralized agency should conduct the type of research activities they believe most suited to the national problems faced by them. Consequently, we believe that some consolidation of weather modification is desirable but would not necessarily conclude that all such research should be concentrated or that a lead agency approach for all generic weather modification research is preferable. In our opinion, the DENR proposal will accomplish the appropriate degree of consolidation.

Each weather modification research project is different because of the different nature and technologies of the various projects themselves. OMB has recognized this difference and has instructed particular agencies to concentrate their efforts in specific areas; Interior in precipitation, Commerce in severe storms, principally hurricanes, NSF in hail and so forth. There is inevitably some overlap, for example, in severe storms research between all projects because thunderstorms, tornadoes, and hailstorms have some common characteristics. The projects, however, are significantly different

to proceed under the direction of a single agency. In effect, therefore, there are lead agencies for specific types of weather modification research, related as stated earlier to mission objectives.

[See GAO note, p. 39.]

c. -- a national program with goals, objectives, priorities, and milestones conforming to identified needs.

-- a plan to define and reassign, if appropriate, the responsibilities of all Federal agencies that provides support or conduct weather modification research.

-- a plan to allocate resources to the national program elements.

OMB Comment: As stated earlier, in response to the main GAO conclusion, we believe a highly centralized program would be less effective than the alternative of permitting mission agencies to evaluate weather modification potentialities as one option in problem solving. Furthermore, the facilities and the technologies required to undertake the research vary greatly among problems and agencies. There does not appear to be sufficient evidence in our opinion to conclude that combining these assets, given the diverse informational

requirements and the relative priority for weather modification, would result in increased effectiveness. To the contrary, we believe such a combination would put undue emphasis on a technology that is, as yet, mainly in the research (versus operations) stage. This emphasis could detract from adequate consideration of operational techniques for achieving goals and objectives.

[See GAO note, p. 39.]

III. Other OMB Comments:

A. Level of funding

The funding level for research applicable to weather modification is understated in your draft. Due to the lack of understanding as to why certain events occur in weather modification, a great deal of general research in atmospheric sciences is applicable to weather modification. For example, much of the research in physical meteorology contributes directly to enhancing knowledge in weather modification. Your draft, however, leaves the impression that a summation of the weather modification project budgets will indicate the level of Federal funding in this field. It has been estimated that this limited view understates applicable research by at least $50 M.1/

As to the specific size of project budgets, we conducted a review of Federal weather modification programs prior to formulation of the 1973 budget. Our conclusion was that we should recommend the continuation of research in this field, accelerating in some areas, decreasing in others.

1/ Informal estimate from ICAS.

For example, we believe the hurricane modification research conducted by Commerce - NOAA, may, if feasible, have significant benefits. Accordingly, we recommended an increase in funding in this area in 1974 for capital equipment preparatory to conducting research experiments in the Pacific.

Because of this need for additional knowledge, however, we consider any decision regarding the Federal role in weather modification operations - especially in the suppression of severe storms - to be very premature at this time. If suppression proves feasible, given today's thinking and technology, the application of this knowledge would appear to be enormously expensive. This underscores our earlier statement that weather modification should not be viewed as a panacea in problem solving but should be developed, through research, as an option.

To imply that the project budgets are subcritical or to support citations to that effect is a rather narrow view. Our belief is that the adequacy of weather modification budgets must be viewed in context of the agencies' other priorities. To meet President Nixon's FY 1973 expenditure ceiling, many agencies were forced to make difficult management and budgetary decisions. Where project budgets were reduced to accommodate other agency goals, one must assume that weather modification research was a relatively lesser priority. The actual size of the budgets, therefore, should not be judged out of context with other programs conducted by the agencies.

B. Public vs. Private Role in Weather Modification Operations

Our position is that weather modification operations, as opposed to research, should be carried out by the private sector wherever possible. An exception to this may be hurricane or other severe storm modification. If such an activity proves feasible, the size of the investment required to modify these storms and their interstate impact seem to suggest Federal participation. In most other areas, however, the proper domain for operations seems to be the private sector - responding to local needs. In these cases, the Federal Government's primary role has been and should be as an advisor to State and local municipalities.

C. Public Reaction

State laws vary from regulation to prohibition of weather modification experiments and operations. It is noteworthy, however, that in a recent referendum in a farming community in southern Colorado on the question of weather modification the voters overwhelmingly rejected a proposal to modify the weather to benefit local barley growers. Because there is so much to be learned in weather modification research, one might conclude that widespread use and acceptance of operational weather modification may be more of a future rather than present concern.

There are, as mentioned earlier, in the private sector, entrepreneurs conducting rain-making operations principally in the western U. S. Their existence is proof of acceptance by certain segments of the population. These operations, however, should not be inferred as general societal acceptance of weather modification.

We appreciate the opportunity to comment on your draft report.

Sincerely,

John C. Sawhill
Associate Director

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY
FOR ADMINISTRATION

September 27, 1973

Mr. Richard W. Kelley
Associate Director, RED Division
U. S. General Accounting Office
400 7th Street, S.W.
Washington, D. C. 20590

Dear Mr. Kelley:

This is in response to your letter of August 29, 1973, requesting the Department of Transportation's comments on the General Accounting Office's draft report on weather modification research programs.

[See GAO note, p. 39.]

The General Accounting Office concludes that a national program (with a lead agency approach) is needed to pull together the fragmented Federally-supported weather modification research activities. We believe some consolidation of weather modification is desirable, but would not necessarily conclude that all such research should be concentrated, or that a lead agency approach for all generic weather modification is preferable.

Sincerely,

William S. Heffelfinger

APPENDIX IX

PRINCIPAL OFFICIALS OF THE DEPARTMENTS AND AGENCIES RESPONSIBLE FOR ADMINISTERING ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DEPARTMENT OF AGRICULTURE		
SECRETARY OF AGRICULTURE:		
Earl L. Butz	Dec. 1971	Present
Clifford M. Hardin	Jan. 1969	Nov. 1971
ASSISTANT SECRETARY, CONSERVATION, RESEARCH, AND EDUCATION (note a):		
Robert W. Long	Mar. 1973	Present
Thomas K. Cowden	May 1969	Mar. 1973
Vacant	Jan. 1969	May 1969
John A. Baker	Aug. 1962	Jan. 1969
CHIEF, FOREST SERVICE:		
John R. McGuire	Apr. 1972	Present
Edward P. Cliff	Mar. 1962	Apr. 1972
DEPARTMENT OF COMMERCE		
SECRETARY OF COMMERCE:		
Frederick B. Dent	Feb. 1973	Present
Peter G. Peterson	Feb. 1972	Feb. 1973
Maurice H. Stans	Jan. 1969	Feb. 1972
ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (note b):		
Robert M. White	Feb. 1971	Present
Robert M. White (acting)	Oct. 1970	Feb. 1971

a
Title changed from Assistant Secretary, Rural Development and Conservation, in January 1973.

b
NOAA was formed in October 1970 pursuant to Reorganization Plan Number 4, consolidating Environmental Sciences Services Administration with programs and elements from other Federal organizations pertaining to marine sciences.

	Tenure of office	
	From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
James R. Schlesinger	July 1973	Present
William P. Clements, Jr., (acting)	Apr. 1973	July 1973
Elliot R. Richardson	Jan. 1973	Apr. 1973
Melvin R. Laird	Jan. 1969	Jan. 1973
DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING:		
Malcolm R. Currie	June 1973	Present
John S. Foster, Jr.	Oct. 1965	June 1973
DIRECTOR OF ADVANCE RESEARCH PROJECTS AGENCY:		
Stephen J. Lukasik	Apr. 1971	Present
Everhardt Rechtin	Nov. 1967	Apr. 1971
DEPARTMENT OF THE INTERIOR		
SECRETARY OF THE INTERIOR:		
Rogers C. B. Morton	Jan. 1971	Present
Fred J. Russell (acting)	Nov. 1970	Jan. 1971
Walter J. Hickel	Jan. 1969	Nov. 1970
Steward L. Udall	Jan. 1961	Jan. 1969
ASSISTANT SECRETARY, LAND AND WATER RESOURCES:		
Jack O. Horton	Mar. 1973	Present
James R. Smith	Mar. 1969	Feb. 1973
Kenneth Holum	Jan. 1961	Mar. 1969
COMMISSIONER, BUREAU OF RECLAMATION:		
Gilbert G. Stamm	May 1973	Present
Gilbert G. Stamm (acting)	Apr. 1973	May 1973
Ellis L. Armstrong	Nov. 1969	Apr. 1973
Floyd E. Dominy	May 1959	Oct. 1969
DEPARTMENT OF TRANSPORTATION		
SECRETARY OF TRANSPORTATION :		
Claude S. Brinegar	Feb. 1973	Present
John A. Volpe	Jan. 1969	Feb. 1973
Alan S. Boyd	Jan. 1967	Jan. 1969

APPENDIX IX

	Tenure of office	
	From	To
ADMINISTRATOR, FEDERAL AVIATION ADMINISTRATION:		
Alexander P. Butterfield	Mar. 1973	Present
John H. Shaffer	Mar. 1969	Mar. 1973
David D. Thomas (acting)	Aug. 1968	Mar. 1969
Gen. William F. McKee	July 1965	July 1968
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION		
ADMINISTRATOR:		
James C. Fletcher	Apr. 1971	Present
George M. Low	Sept. 1970	Apr. 1971
Thomas O. Paine	Oct. 1968	Sept. 1970
NATIONAL SCIENCE FOUNDATION		
DIRECTOR:		
H. Guyford Stever	Feb. 1972	Present
Raymond L. Bisplinghoff (acting)	Jan. 1972	Feb. 1972
William D. McElroy	July 1969	Jan. 1972
Leland J. Haworth	July 1963	June 1969

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