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REPORT

APPLICATION OF AEROSPACE-GENERATED TECHNOLOGY TO WATER POLLUTION AND OTHER PUBLIC SECTOR PROBLEMS

QUARTERLY REPORT NO. 2
1 September - 30 November 1968

Contract No. NSR 26-002-083

MRI Project No. 3217-E(B,C)

For

National Aeronautics and Space Administration
Office of Technology Utilization
Technology Utilization Division
Washington, D. C. 20546

APPLICATION OF AEROSPACE-GENERATED TECHNOLOGY TO WATER POLLUTION AND OTHER PUBLIC SECTOR PROBLEMS

by

David Bendersky
Andrew J. Winfrey

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PREFACE

This report covers the activities, during the second quarter, on two tasks called for under NASA Contract No. NSR 28-002-083; the application of aerospace technology to (1) water pollution problems, and (2) other selected public sector problems.

This contract is under the technical direction of Roy Bivins, NASA Technology Utilization Division, Washington, D. C. At Midwest Research Institute, this project is under the technical management of Paul C. Constant, Jr., Assistant Director of the Engineering Sciences Division. The project leader is David Bendersky, Principal Engineer. Andrew J. Winfrey, Associate Environmental Engineer, Physical Sciences Division, conducted the water pollution study.

Approved for:

MIDWEST RESEARCH INSTITUTE

Harold L. Stout, Director
Engineering Sciences Division

13 December 1968

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I. INTRODUCTION

Contract No. NSR 26-002-083 calls for Midwest Research Institute's Biomedical Applications Team to conduct a program aimed at the transfer of applicable science and technology from the aerospace program to secondary applications. The definition of medical problems and the identification of potential solutions available in aerospace technology are primary objectives of this contract. Two supplementary tasks call for the MRI Biomedical Applications Team to:

1. Conduct a planning study to provide a framework for matching aerospace-generated technology to needs and problems in the area of water pollution. Based on the results of the planning study, a minimum of 12 specific problems in the area of water pollution are to be selected and the applicability of aerospace-generated technology as potential solutions to each of these problems is to be determined.

2. Provide five evaluation reports together with retrospective searches for selected public sector problems, solutions to which will be aided by the application of aerospace-generated technology.

This report covers the activities on the two supplementary tasks during the second quarter of the contract period.[1/]

II. ACTIVITIES ON WATER POLLUTION PROBLEMS

During this report period, the activities on the water pollution task were concerned with the first phase of this task, the planning study. The purpose of the planning study is to provide a framework for matching aerospace-generated technology to needs and problems in the area of water pollution. A preliminary literature search was performed to define water pollution and its boundary conditions. A description of the primary problem areas and the general research needs were outlined. The various research groups and their corresponding activities in water pollution control were studied.

1/ The activities on the medical problems are given in a separate report, "Biomedical Applications of Aerospace-Generated Technology," Quarterly Report No. 2, 1 September - 30 November 1968, Contract No. NSR 26-002-083, MRI Project No. 3217-E(A).

The results of the planning study are given in a report contained in Appendix I. Copies of this planning study report were submitted to Mr. R. Bivins, NASA Technology Utilization Division, Washington, D. C., on 31 October 1968.

In accordance with a meeting of representatives of NASA Technology Utilization Division, the Federal Water Pollution Control Administration and Midwest Research Institute held in Washington, D. C., on 28 August 1968, the specific problems to be pursued by MRI are to be selected from a list of problems to be submitted by FWPCA. However, formal approval from FWPCA to participate in this program was delayed until the latter part of November 1968, so that no problems have yet been submitted by FWPCA to MRI. Another meeting of representatives of NASA/TUD, FWPCA and MRI has been arranged for 19 December 1968 at which it is planned that action will be initiated on the submission of the problem list.

III. ACTIVITIES ON OTHER PUBLIC SECTOR PROBLEMS

It is proposed that the effort on Supplementary Task No. 2 of this contract, as described in Section I, be devoted to problems related to weather research. The Bureau of Reclamation of the Department of the Interior is engaged in a long-range research program on weather modification. Under a previous NASA contract, Midwest Research Institute initiated a program to assist the Bureau of Reclamation in the solution of problems in weather modification, through the application of aerospace-generated technology.[1] A number of computerized searches of the NASA literature tapes were made on subjects related to weather modification.

There are many problems in weather modification which may be solved through the application of aerospace technology. A list of areas which are of interest to the Bureau of Reclamation are given in Appendix II. With NASA/TUD approval, it is planned to select five of these areas which appear to be related to aerospace technology, conduct a thorough search of the aerospace technology in these areas, and prepare evaluation reports on the potential applications of aerospace technology to each of the five selected problem areas.

1/ "ASTRA Services for the Bureau of Reclamation," Paul C. Constant, Jr., Midwest Research Institute, Final Report, Contract No. NASr-63(14), 15 October 1967 - 15 October 1968.

IV. PLANS FOR THE NEXT QUARTER

1. A meeting of representatives of the NASA Technology Utilization Division, the Federal Water Pollution Control Administration and Midwest Research Institute will be held in Washington, D.C., on 9 December 1968. The purpose of this meeting will be to acquaint key personnel at FWPCA with this project and to solicit a list of problems in water pollution control.

2. Twelve problems in water pollution will be selected and searches of pertinent aerospace technology will be initiated.

3. With approval from NASA/TUD, and concurrence of the Bureau of Reclamation, five problems in weather control will be selected and searches of pertinent aerospace technology will be initiated.

APPENDIX I

PLANNING STUDY

APPLICATION OF AEROSPACE-GENERATED TECHNOLOGY TO WATER POLLUTION PROBLEMS

by

Andrew J. Winfrey
David Bendersky

PLANNING STUDY
October 31, 1968

Contract No. NSR 26-002-083
MRI Project No. 3217-E(B)

For

National Aeronautics and Space Administration
Office of Technology Utilization
Technology Utilization Division
Washington, D. C. 20546

PREFACE

One of the tasks in NASA Contract No. NSR 26-002-083 calls for the application of aerospace-generated technology to problems in water pollution. The first phase of this task was to conduct a planning study to lay the groundwork for this task. This report covers the results of the planning study.

Approved for:

MIDWEST RESEARCH INSTITUTE

Harold L. Stout, Director
Engineering Division

October 31, 1968

crs

I. INTRODUCTION

The U. S. Public Health Service states that 95 million people drink water that is below federal standards or of unknown quality.[1] In the last decade, many of the rivers, lakes and streams have changed from fairly acceptable recreational facilities to dirty, unsightly, and unacceptable waters. The Great Lakes are referred to as the "Great Cesspool," and the treatment and return of many polluted bodies of water to their natural state is termed impossible.

The casual methods that once appeared satisfactory for the disposal of wastes no longer seem acceptable. Man has the daily evidence of his eyes and nose to tell him that his planet cannot assimilate without limiting the untreated wastes of his civilization.

All available resources should be used to greatest effectiveness to understand and intelligently control our environment. The need for and research on new and improved water pollution control techniques are being intensified by the population growth, the increase in national wealth, advances in technological capabilities, and the awakening and concern of the people. It has often been stated, "How ironic it is that we can place a rocket on the moon, and we cannot solve our air and water pollution problems." As a matter of fact, the technological capabilities which have been developed in the space program may prove to be very valuable in the environmental pollution field. The measurement of contaminants, the effects of contaminants, waste treatment systems, sensing and transmitting systems, thermal pollution control, meteorological parameters, and the study of bodies of water as viewed from the spacecraft are just a few areas of common interest.

Midwest Research Institute (MRI) is under contract with the NASA Office of Technology Utilization to undertake a program aimed at the utilization of aerospace-derived technology to solve selected water pollution problems. The methodology to be used is to be patterned after that being used by the NASA Biomedical Applications Teams[2], which are concerned with the utilization of aerospace-derived technology for solving biomedical problems.

1/ "A Strategy for a Livable Environment," A Report to the Secretary of Health, Education and Welfare, by the Task Force on Environmental Health and Related Problems, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., June 1967.

2/ "Medical Applications of Aerospace Science and Technology," by David Bendersky, Midwest Research Institute, Final Report, 1 May 1967 - 31 May 1968, NASA Contract No. NASr-65(13).

The first task in this program has been to conduct a planning study to provide a framework for matching aerospace-generated technology to the needs and problems in the area of water pollution. This planning study included an investigation of the general problems of water pollution, the major technological problem areas, the federal, state and local agencies which are concerned with water pollution, the principal research institutions which are engaged in water pollution studies, the reference sources on water pollution, the methodology to be employed in this program, and a schedule for the project activities.

II. WATER POLLUTION

A. Definition and Problem Areas

Water pollution is the contamination or other alteration of the physical, chemical, and biological properties of water. This includes changes in temperatures, taste, color or odor of the waters; or the discharge into water of any liquid, gaseous, radioactive, solid, or other substance which may create a nuisance or render such waters harmful, detrimental, or injurious to public health, safety or welfare.

The sources, pollutants, and effects are the primary problem areas of water pollution. The primary problems and their control involve six basic research areas: (1) the identification and measurement of pollutants, (2) pollution effects on water quality and water use, (3) treatment of wastes and contaminated water, (4) disposal of waste effluents, (5) control of wastes at their source, and (6) water resource management. The quantity of available water, the sources of fresh water, the hydrologic cycle, and meteorology are important technical phases of water resource management.

General research needs described by the Federal Water Pollution Control Administration provide another indicator of problem areas.

1. Improved techniques for waste treatment, water purification and reuse.

   a. Advanced waste treatment research.

   b. Development of modifications to existing biological treatment systems.

   c. Effectiveness of water disinfectants.

d. Use of soils as a treatment medium.

2. Improved methods for handling, conditioning, treating and disposing of impurities removed from waste streams.

3. New methods to control nitrates and phosphates which cause fertilization of lakes; also included are procedures for treating and removing these nutrients from lakes, streams, and other water courses.

4. New treatment processes for industrial wastes to serve as models to industry and state regulatory authorities on how pollution can be reduced and controlled in an economical manner.

5. New instruments for surveillance and operational control.

6. New and improved methods for control of pollution caused by discharges from combined storm and/or sanitary sewers.

7. Control of irrigation return flows and acid mine drainage.

8. Methods for water conservation.

B. Research Groups and Activities

Various federal, state, and local agencies are actively involved in water pollution studies. The Federal Water Pollution Control Administration, Department of Interior, provides technical and monetary assistance to the majority of the state and local agencies and to educational and private organizations. A listing of the various groups and their corresponding activities illustrates the organizational aspects of water pollution control.

Federal Agencies	Major Activity
Federal Water Pollution Control Administration	All areas with the exception of some legal and enforcement actions of water quality control
Corps of Engineers	Flood control, navigation, or related projects
Bureau of Reclamation	Irrigation Projects
Tennessee Valley Authority	All areas of concern in the Tennessee Valley

Federal Agencies (Concluded)	Major Activity
Soil Conservation Service	Watershed projects and soil conservation
Public Health Service	Water quality inspectior and enforcement
Office of Water Resources Research	
Office of Saline Water	
Atomic Energy Commission	
U. S. Geological Survey	Stream surveys
Fish and Wildlife Service	
U. S. Weather Bureau	
Interstate Commerce Commission	Navigation
Migratory Bird Commission	
Bureau of Land Management	Non-forest land
St. Lawrence Seaway Development Corporation	
National Park Service	Recreation
Area Development Administration	Project benefits and economics
Forest Service	
Boundary Commissions	Rivers or waters at U. S. boundaries
Bureau of Indian Affairs	
House and Home Finance Agency	Home water supply

The state and local agencies usually have water pollution control programs and related activities similar to the federal program. A few non-federal interstate study groups are working on interstate water movement and its associated problems. Various mutual companies, public

utilities, land companies, research organizations, industry, and other private firms are conducting studies that may produce useful technology. The following list is some of the universities primarily concerned with data collection and analyses, and research.

University of Colorado

Stanford University

Massachusetts Institute of Technology

Harvard University

University of Kansas

University of Minnesota

University of Kentucky

Purdue University

University of Michigan

University of Florida

C. Water Pollution References

The major water pollution references are federal reports, university and research literature, and technical journals and magazines. Preprints, conference reports, and other sources offer valuable current information. The principal references concerning water pollution are as follows:

Technical Journals

Journal Water Pollution Control Federation

Water Works and Wastes Engineering

Water and Sewage Works

Industrial Water and Wastes

Journal of the Sanitary Engineering Division

Magazines

American County Government

Consulting Engineer

Public Works Magazine

Civil Engineering

American City

Engineering News Record

Chemical Engineering

Other Sources

Conferences

Division of Water Supply, U. S. Public Health Service

Federal Water Pollution Control Administration

Universities

Research Centers

Private and Industrial Organizations

III. METHODOLOGY

The methodology to be used in the transfer of aerospace technology to water pollution problems, which is patterned after the NASA Biomedical Application Team Program methodology, consists of four basic steps: (1) definition of the problems, (2) identification of applicable aerospace technology, (3) evaluation of the technology and (4) dissemination of the technology.

1. Definition of the problems: The first step in the procedure is to define specific problems of concern to those in the field of water pollution control. In accordance with instructions from NASA, 12 problems are to be undertaken under the present contract. The problems will be

obtained from one or more of the organizations listed in Section II, B. The Federal Water Pollution Control Administration will be asked to recommend the organizations from which the problems should be obtained. To allow a maximum of personal interviews and exchange of ideas, preference will be given to organizations within easy access of Midwest Research Institute.

The problems will be chosen on the basis of (1) their importance to water pollution control, (2) relevance of NASA technology sources, and (3) the originator's available talent, time, facilities and funding to evaluate and apply relevant technology brought to his attention.

Each problem will be prepared in written form, in non-disciplinary terms so that it will be meaningful to reviewers in other disciplines, and express the unique characteristics and functional requirements to be met.

2. Identification of applicable aerospace technology: Once the problems have been defined, diligent efforts will be made by MRI project personnel to identify aerospace-derived technology which represents potential solutions to the problems. Computerized literature searches of NASA document tapes will be conducted, utilizing the RDC computer services. Manual searches will also be made of the Scientific and Technical Aerospace Reports, International Aerospace Abstracts, NASA Tech Briefs, and other literature not normally abstracted. Descriptions of the water pollution problems will be distributed to appropriate NASA research centers and other appropriate groups to solicit suggestions. When appropriate, the problem originators and MRI project personnel will consult with NASA research center personnel and contractors.

3. Evaluation of identified potential solutions: Aerospace technology which are identified as potential solutions to the water pollution problems will be evaluated by both the MRI project personnel and by the problem originator. Preliminary evaluations will be made by the MRI project personnel. If the preliminary evaluation is affirmative, the technology will be furnished to the originator for his evaluation. The results of the literature searches, pertinent reports and other related references will be given to the problem originator for evaluation. In those cases where hardware is involved, attempts will be made to obtain the hardware from NASA for evaluation. If hardware is not available from NASA, the problem originator will be encouraged to obtain the hardware through other sources.

4. Dissemination of information: Information on potential and actual transfers of technology to water pollution control applications will be prepared and disseminated. Separate Technology Transfer Reports

will be prepared on each potential and actual transfer. These reports will include a description of the water pollution problem, the applicable aerospace-derived technology, how the transfer was accomplished and the status of the transfer.

When an item of aerospace technology has been evaluated by the problem originator and found to be successful, he will be encouraged to prepare a paper for presentation at appropriate professional meetings and publication in professional journals. Dissemination of information to the public news media (newspapers, magazines, TV, radio, etc.) will be coordinated with the NASA Office of Technology Utilization.

IV. SCHEDULE

The planned schedule of events in this program is graphically shown in Figure 1.

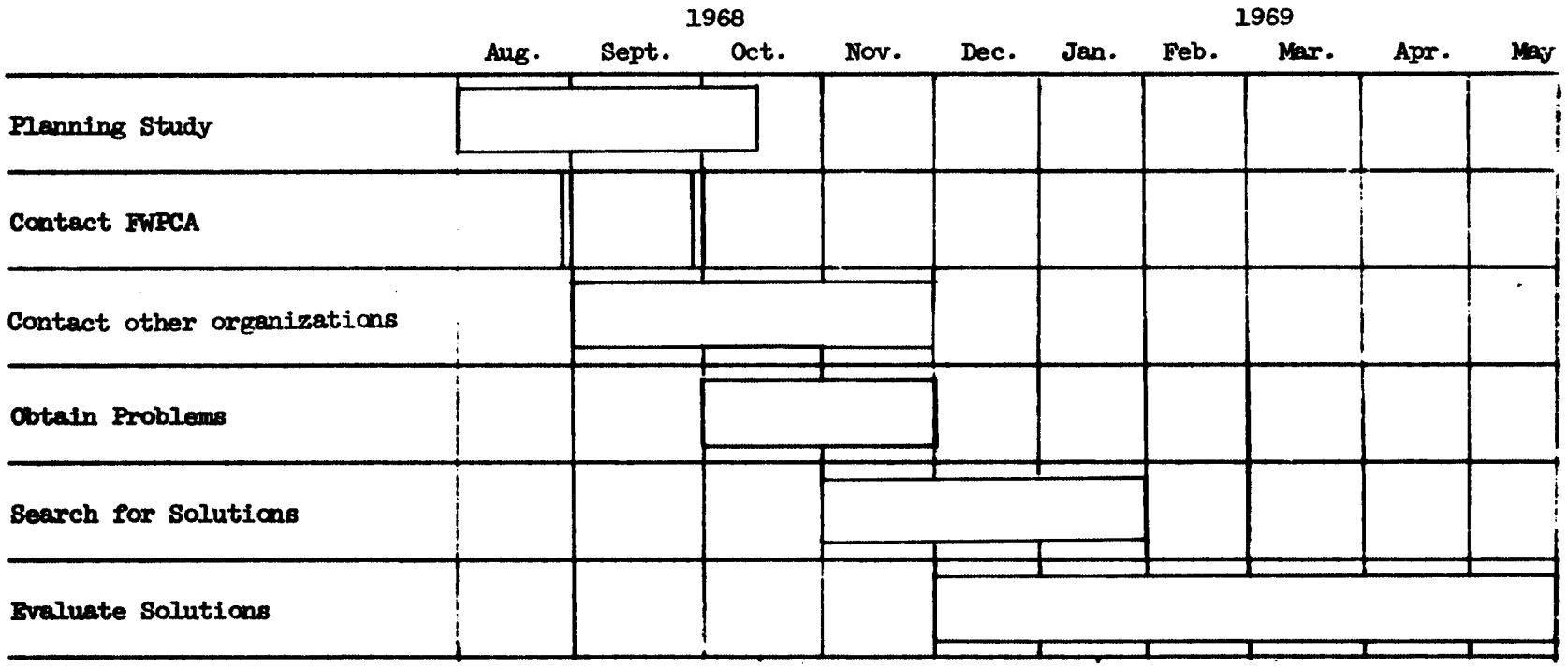

Figure 1 - Schedule: NASA-TU Water Pollution Program

APPENDIX II

AREAS OF INTEREST -- BUREAU OF RECLAMATION

1. Detection of trace elements in precipitation (rain, hail, snow).
2. Detection of iodides of silver or lead in precipitation.
3. Quantitative measurement of silver iodide in water in amounts of 10^{-11} to 10^{-12} grams per milliliter.
4. Detection and chemical analysis of organic material in precipitation.
5. Information on content of precipitation from various areas of the world.
6. Detection of moisture samples during the 15 sec. of flying time through a cloud.
7. Sequential sampling techniques for use by aircraft flying through the clouds.
8. The drawing of large water samples in very short times.
9. Vertical wind tunnels that suspend droplets or ice nuclei. Also static tunnels.
10. Historical information on phloroglucinol and AgI.
11. Information on the freezing and collision of droplets.
12. How can you detect weight change of a droplet with an accuracy of 1 percent?
13. Does the alternate wetting and drying of an ice crystal change the nucleate structure?
14. How can you control the distance of two aircraft flying through a cloud to 50 ft. without danger of collision in total overcast, and shear wind?
15. Information on wind path tracking.
16. Instrumentation, balloon flown, for telemetry and measurement of nuclei (0.02 to 0.05 micron), number of particles, etc.
17. Atmospheric temperature measurements.
18. Information on seeding by pollutants, i.e., nuclei.
19. Information on overseeding.
20. Information on supersaturation.
21. Information on thermal convection.
22. Information on local wind studies.
23. Information on surface energy of water droplet.
24. Numerical modeling.
25. Cloud dynamics.
26. Electrical effects of storms. Distribution of electrical effects in a cloud: charge, distribution, electrostatics, magnetics.
27. Finite difference in fluid flow and hydrodynamics.
28. Aircraft coordination out to 70 miles.
29. Infrared detection of water vapor.
30. Detection of water droplets from aircraft and ground.
31. Aerosol 10^{-8} to 10^{-12} Andersen sampler techniques.
32. Instruments for weather modification.
33. AEC diffusion techniques.
34. Replication of snow crystals.
35. Cloud chamber (cloud drying at 10°) vapor absorption.

36. Remote sensors, telemetry, precipitation, liquid water, aerosols of less than 50 microns, also hail.
37. Airborne environmental data: winds, temperature, water vapor.
38. Fuel cells, chemical reaction type generators.
39. Plasma applications, chemical reactions.
40. Photographic techniques.
41. Moisture flux measurement.
42. Shock wave.
43. Velocity profile measurement.
44. Pitot-static measurement.
45. Behavior of vapor over a snow melt.
46. Basic snow pack behavior, energy in and out, sublimation to the atmosphere (environmental).
47. Velocity measurements in fluid. Boundary layer flow. Mach I, 10 meters per second.
48. Photos of snow cover.
49. Aerial detection of ground water.
50. Infrared techniques, seepage, water in streams, temperature of water, inflow of ground water.
51. Ultrasonic techniques of measuring clouds, etc.
52. Biological techniques in weather measurements.
53. Analog to digital processor: Real time data processing (systems and hardware).
54. Aircraft tracking, balloon tracking, small tracking transponders (2 oz.).
55. Instrument development, salt particle detector, flame photometer.
56. Droplet detection size spectrum.
57. Weather modification (general); evaluation of experiments statistical: examples and criteria.
58. Hail, theories, statistics, records, suppression, radar detection (rain from hail) distinction.
59. Open end wind tunnel, 150 mph.
60. Camera for multiphotography, optical system, changing magnification.
61. Detection of humidity at -20°.
62. Ultra-violet light source that gives equivalence to sun's energy, IR and UV source for full range.
63. Many aircraft in the air at one time. Who is who? Solution is an L-Band transponder and IFF interrogator.
64. Solution in (63) works only with aircraft in the project. How do we locate other aircraft? Solution is "Moving Target Indication" MFT.
65. Pinpoint the seeding aircraft (Apache and Beech Baron). Solution might be an X-Band transponder and tracking equipment.
66. Sensing the meteorological data from the aircraft. Using a twin engine Apache:

    a. IR temperature looking down
    b. Altitude

c. True airspeed or indicated airspeed
d. Turbulence
e. Compass heading
f. Liquid water content
g. Rate of climb
h. Vertical acceleration
i. Lateral acceleration
j. Outside air temperature
k. Temperature (buoyancy)
l. Wet bulb depression
m. DME-Distance measuring equipment (from Vortac)
n. Potertial gradient
o. Radio emission (50 mc.)
p. Icing rate
q. Particle size
r. Voice
s. Manifold pressure
t. Event and condition and time
u. Camera pulses

67. Record as much meteorological data as possible in digital and analog forms and in real time.
68. Equip planes with remote-sensing capabilities.
69. Continuously monitor plane-data on ground-based computer, with control function returns to pilot.
70. An understanding of the mechanism by which seeding agents work would be very helpful.
71. Need to accurately measure cloud parameters and then seed with proper agent.
72. Need criterion and equipment to equate in-cloud data to ground rainfall.