

Report 71-13

May 1971

NATIONAL HAIL RESEARCH EXPERIMENT -
ARMORED AIRCRAFT WORK PLANS - 1971

By: D. J. Musil

Prepared for:

National Center for Atmospheric Research
P. O. Box 1470
Boulder, Colorado 80302

Institute of Atmospheric Sciences

South Dakota School of Mines and Technology

Rapid City, South Dakota 57701

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1. INTRODUCTION

1.1 Background and Objectives

The South Dakota School of Mines and Technology (SDSM&T) armored T-28 will be participating in the 1971 National Hail Research Experiment (NHRE) Project under Subcontract No. NCAR 182-71, along with various other university groups and government agencies. The project is sponsored by the National Science Foundation (NSF) under the direction of the National Center for Atmospheric Research (NCAR).

These work plans are intended to be a supplement to the NHRE OPERATION PLAN - Summer 1971 prepared by NCAR. They should provide an elaboration of the T-28's participation in the 1971 NHRE Project as given in the above document.

The objectives of this study have been outlined in Research Proposal 70-5, October 1970. Briefly, the primary mission of the T-28 will be to make measurements of updraft strength and composition of high radar reflectivity regions of hailstorms. A secondary mission will be to evaluate the T-28 as a possible seeding platform.

1.2 Personnel

Overall direction for the project will be provided by Dr. Richard A. Schleusener, who is also principal investigator for the study. The field observation phase of the project will be carried out by a pilot, technician, and a project meteorologist.

These individuals are:

| <u>NAME</u> | <u>TITLE</u> |
|-------------------|-----------------------|
| Dennis J. Musil | Project Meteorologist |
| Wayne R. Sand | Pilot |
| Kenneth E. Jasper | Technician |

In addition, William G. Myers, Research Engineer, will be responsible for the installation and calibration of the meteorological instrumentation aboard the T-28, including supervision of electronic technicians involved with maintenance of the equipment. John H. Hirsch and James H. Boardman will be responsible for the reduction of the meteorological data on the PDP-8 computer and will assist in the interpretation of the data.

2. OPERATIONAL PROCEDURES

The primary mission of cloud penetration will be carried out by the pilot under the direction of the project meteorologist within the general framework of the overall NHRE Project. Decisions on flights to be undertaken will be the responsibility of the project meteorologist, who will be located at the radar site at Grover during research missions. The remainder of the crew will be on standby status at the Cheyenne Airport. Telephone communications will be maintained between Grover and Cheyenne to provide notification of an impending launch. It is expected that several phone calls may be necessary on a potential "Go" day, in order to keep the T-28 crew abreast of activities at Grover.

2.1 Cloud Penetrations

A flight will be initiated when conditions in the cloud are such that Phase III is imminent. As defined by NCAR, this occurs when the mature thunderstorm attains tops greater than 35 K ft and radar reflectivities greater than 40 dBz. The pilot will be given general information to direct him to the vicinity of the storm, following which the project meteorologist will relay IP information to aircraft control located at Greeley. After takeoff, climbout to 23.5K ft should be made while flying to the project area and Greeley should be contacted for specific flight path instructions for penetrations. It is also possible to have radio communication between the T-28 and Grover via frequency 123.05 at this time.

The T-28 will be directed to make repeated passes beginning at 23.5K and progressing at 2K ft intervals to lower altitudes for each successive pass until the 0C isotherm or cloud base is reached. Continual coordination will be maintained between the project meteorologist and Greeley to provide updated information concerning correct flight paths.

Upon entry and exit for each penetration, the pilot will transmit information concerning the penetration directly to the project meteorologist at Grover via radio frequency 123.05. This will be done by use of a STAH code developed by IAS personnel during 1970 and use of the event code channel on the DL-620A system. The scheme is given as follows:

LINEUP

S - Start recorder and switch to event code 8.
T - Time
A - Altitude
H - Heading

ENTRY

Switch to event code 7 at time of entry.

EXIT

Switch to event code 8 at the time of exit.

T - Time

A - Altitude

H - Heading

H - Hail encountered (yes or no)

I - Ice crystals (yes or no)

R - Rain (yes or no)

T - Turbulence remarks

R - General remarks

S - Stop recorder and switch to event code 9.

The above information, which will be recorded by the project meteorologist as well as on the voice recorder in the T-28, will provide valuable information necessary for an after-the-fact reconstruction of the mission. A copy of the recording form to be used at Grover is included as Appendix A. Pertinent information considered important by the pilot can be placed on the voice recorder at any time by operating it independently of the system described above.

The event code channel on the DL-620 system must be used to provide information required for computer reduction of the data. The meaning of the codes is given as follows:

| <u>DIGIT</u> | <u>EVENT</u> |
|--------------|--|
| 9 | Out of cloud, recorder in 1-min mode. Use during climb and descent. |
| 8 | Use during lineup prior to cloud penetration and upon exit from a cloud. Recorder switches to continuous mode and Kyle device is turned on. A yellow button has been installed to switch to this code. |
| 7 | In cloud, continuous mode. A white button has been installed to switch to this code. |

Other digits are available for other events; however, it is felt that time restrictions on the pilot will be such that only the simple scheme shown above can be maintained.

When the OC isotherm has been reached, a climbout will be made to 23.5K ft and further penetrations will be made provided enough fuel is available. It is recognized that it may be necessary to delay successive penetrations at any point to allow for the melting of structural ice, even though this did not constitute a major problem during 1970. Naturally, the pilot will have the final decision on any matters dealing with flight safety.

Top priority for flights of the T-28 will be within the project area of NHRE. On days with no thunderstorm activity in the NHRE area, the project meteorologist may order additional flights into neighboring areas.

2.2 Seeding Operations

As of the date of these work plans, the latest information concerning seeding operations is given in a letter to Dr. Guy Goyer (NCAR) from Dr. Richard A. Schleusener, dated 20 May 1971. A copy of that letter is included as Appendix B.

3. DAILY BRIEFING AND DATA REVIEW SESSION

Although NCAR plans no regular daily briefing session, it is planned for IAS personnel to have a daily briefing and data review session. In addition to providing a weather forecast and a review of the previous day's activities, it is intended that this meeting identify various problems affecting the project and seek possible solutions for them.

3.1 Location and Type of Briefing

If the T-28 has flown on the preceding day, the pilot and project meteorologist will travel to Grover and review the operations of the previous day using the computer display system. Other members of NHRE will be urged to participate in this review if they desire. Furthermore, the pilot will be able to attend the daily weather forecast provided by NCAR at Grover before departing for Cheyenne to prepare for the new day's mission.

If the preceding day was a "No Go" day, the briefing will be held in Cheyenne at a point to be specified by the project meteorologist, prior to his daily departure for Grover. Information for a weather forecast is available at Cheyenne, but is intended for guidance purposes only, since NCAR will be providing a daily forecast at Grover. Data gathered by the T-28 will be reviewed at these sessions. A tape recorder will be made available to the pilot to obtain a record of his comments following each flight. The project meteorologist will use a second recorder to provide a record of his activities at Grover and to prepare summary of the day's operations. Other members of the IAS crew will provide daily summaries of their activities also. These items will not be available in written form at the briefing session but they will provide a written record of activities for the project.

3.2 Telephone Call to Rapid City

Initially it is planned that the project meteorologist make a daily phone call at 0800 to Dr. Schleusener at Rapid City to discuss any problems which might be appropriate and to make a status report on IAS equipment and certain NCAR equipment at Grover. A copy of the status form showing the various items requiring a report is included as Appendix C. The conversation will be recorded at Rapid City and typed to become a part of the permanent record for the project.

4. DATA SYSTEM

4.1 T-28

The data system on the T-28 includes sensors to measure meteorological and aircraft parameters. These parameters are sampled and recorded at a rate of 2.4 records per second with each record containing 20 channels of data from the various sensors.

The data recording system on the aircraft is centered around a Metrodata Systems DL-620A digital magnetic tape recorder. Meteorological and aircraft data in analog form are used as inputs to the recorder. These data are processed with a self-contained analog-to-digital converter and multiplexer, then recorded on 1/4 in four-track magnetic tape cartridges for computer reduction and analysis.

Some of the parameters available from the system are: altitude, air speed, rate of climb, vertical acceleration, temperature, liquid water content, raindrop sizing, aircraft position, and time.

Plans have been made to ship the recorded data to Rapid City for preliminary reduction and analysis on the PDP-8 computer. A proposed shipping schedule for these data has been presented in memorandum for the record, dated 25 May 1971, and is included in this paper as Appendix D. A reasonably fast turnaround time will result in data for use by project personnel located at Cheyenne, as well as ascertaining that the aircraft instrumentation system is functioning properly. Reduced data returned to Cheyenne includes photographs of a computer-generated display of selected parameters and a hard copy (teletype form paper) printout, in engineering units, of any or all of the data recorded by the instrumentation system.

4.2 Radar

The radar system, including the computer display system, being provided by NCAR has been outlined in detail in the NHRE OPERATION PLAN and will not be reproduced in this paper. Since the data available from this system is uncertain at this time, specific data to be obtained is not presented. Instead, a memorandum which outlines radar data support required for T-28 operation is included as Appendix E. These data are requirements if the computer display system is operational. If it is not, other requirements will have to be identified.

APPENDIX A

National Hail Research Experiment
(Armored Aircraft)

Date _____

STAH CODE FORM

APPENDIX B

20 May 1971

AIR MAIL

Dr. Guy Goyer, Program Scientist
Laboratory of atmospheric sciences
National Center for Atmospheric Research
P. O. Box 1470
Boulder, Colorado 80301

Dear Dr. Goyer:

Enclosed is a suggested revised draft of the operational procedures for the T-28 missions. The changes suggested are intended to clarify notification and communication channels, and also to indicate that the measurement procedures would follow the normal routine once the seeding run(s) was completed.

I have strong reservations on the probability of success in hail suppression if seeding is initiated after the reflectivity reaches 55 dbZ. For this reason, I encourage you to give at least equal emphasis to the seeding of the feeder clouds mentioned in the second-to- last paragraph of the draft document.

We look forward to an interesting summer.

Sincerely yours,



Richard A. Schleusener
Director

RAS:ry
Enclosure
cc: D. J. Musil
W. R. Sand
bcc: A. S. Dennis

D

R

A

F

T

CLOUD SEEDING

In summer 1971, the SDSM armored T-28 will be tested as a platform for injecting nucleant in the volume of cloud and at the time considered best for optimum effects. The maneuverability of the aircraft in delivering nucleating agents at a specified time and place will be evaluated.

The T-28 will carry 24 pyrotechnic flares on wing racks. Each flare carries 50 g AgI and burns in 20 seconds with an efficiency of about 10^{12} nuclei per gram AgI at -10°C . The objective is to deliver the nuclei at an altitude where the cloud temperature is -2.0°C and in the major updraft.

A decision whether or not to attempt to seed will be made by the NHRE Operations Director each day prior to 1100 MDT. The decision will be relayed to the IAS project meteorologist at Grover, who will, in turn, inform the T-28 pilot at Cheyenne, so that seeding devices can be attached to the T-28 prior to takeoff. The seeding experiment will be incorporated within the observation of the severe storm.

When the maximum radar reflectivity reaches 40 dBZ, the T-28 will be scrambled by the IAS project meteorologist and directed towards the test storm. Grover radar will monitor the maximum reflectivity in the storm and the maximum reflectivity at the 30,000 ft. level. (The 30,000 ft. level is selected because it is believed that new hail bearing cells are detectable by radar at this level.) At the same time, the Wyoming C-45 will locate the major updraft and measure its variables at cloud base. Grover will track both the max Z at 30,000 ft. and the major updraft.

After the T-28 is launched from Cheyenne, the pilot may give reports of his visual observations of clouds to the IAS project meteorologist at Grover via 123.05 mhz.

When the maximum reflectivity in the storm reaches 55 dbZ, and the probability of the test case being a hailer is high, the T-28 will be requested to make a seeding pass through the cloud at an altitude corresponding to a temperature of -20. (This will be estimated by adjusting the altitude of the T-28 to a temperature of -5C ambient air temperature outside the cloud.) An attempt will be made to vector the T-28 through the major updraft below the max Z at 30,000 ft; and perpendicular to the direction of storm motion. The coordinates of the max Z at 30,000 ft. and the track bearing will be given by the IAS meteorologist at Grover to the aircraft controller at Greeley to enable the Greeley controller to vector the T-28 into the desired position of the storm.

After the cloud penetration is begun, the pilot will begin to seed as soon as he encounters updrafts exceeding 1000 feet per minute. The F-101 will make simultaneous penetrations at cloud top.

After completion of the seeding run, the T-28 will resume its primary mission of making measurements in the cloud, following the normal procedure for such measurements. (As specified on page 16 of the preliminary work plans of the aircraft observational program.)

Initially the T-28 will not be requested to penetrate storms exhibiting a maximum radar reflectivity greater than 60 dbZ. As experience is gained, this limitation may be removed if it becomes obvious that the aircraft can safely penetrate storms of higher reflectivities.

Initially 20 flares (1 kg AgI) will be burned on one pass in order to increase the probability of observing effects on radars and aircraft, through one large pulse of freezing nuclei. Other treatment rates may be used later in the season.

After the seeding pass, the T-28 and the F-101 will make measurement passes, using their normal procedures, in an effort to detect changes (resulting from seeding) in the cloud variables. The C-45 will continue investigating the updraft at cloud base.

The ground teams will be informed of the time and location of seeding and will be requested to take precipitation samples downwind for silver iodide analysis.

This procedure for seeding applies to mature front feeding storms expected to propagate east of the mountains in the western half of the experimental area. Occasionally one observes back feeding storms with the main updraft in the right rear quadrant (usually the south side) of the storm. If the occasion arises, these new towers will be seeded in the same manner as the front feeding storms. Some seeding runs may also be made below the base of the clouds. Visual navigation is expected to be necessary when the new towers do not exhibit a radar echo.

Since this seeding system has not yet been tested, the outlined procedure will remain flexible enough to permit optimization of the procedure from flight to flight.

Richard A. Schleusener
20 May 1971

APPENDIX C

EQUIPMENT STATUS

NATIONAL HAIL RESEARCH EXPERIMENT
(ARMORED AIRCRAFT)

DATE _____

| EQUIPMENT | STATUS | REMARKS |
|----------------------------------|------------|---------|
| Radars and Communications | | |
| M-33 track (X-band) | Go Lim Out | _____ |
| M-33 Acq (S-band) | Go Lim Out | _____ |
| NCAR-CP1 (S-band) | Go Lim Out | _____ |
| NCAR-CP2 (S-band) | Go Lim Out | _____ |
| Computer Display System | Go Lim Out | _____ |
| 123.05 Radio | Go Lim Out | _____ |
| Other _____ | Go Lim Out | _____ |
| Aircraft | | |
| T-28 (510 MH) | Go Lim Out | _____ |
| NAV/COM | Go Lim Out | _____ |
| DL 620 | Go Lim Out | _____ |
| Hail Camera System | Go Lim Out | _____ |
| Kyle Device | Go Lim Out | _____ |
| Other _____ | Go Lim Out | _____ |
| _____ | Go Lim Out | _____ |
| _____ | Go Lim Out | _____ |

APPENDIX D

25 May 1971

MEMORANDUM FOR THE RECORD

FROM: Dennis J. Musil

SUBJECT: Proposed Shipping Schedule for Data Between Rapid City and Cheyenne

REMARKS:

Following the routine established during 1970, data gathered by the T-28 on Metrodats DL-620 digital data tape will be shipped via commercial airlines to Rapid City for analysis, with reduced data being returned to Cheyenne for use by IAS personnel located there for the 1971 NHRE Project. The proposed shipping schedule is based on current flight schedules from Rapid City and Cheyenne.

Since the last flight departs Cheyenne at 1715 MDT, data gathered on any given NHRE Project day will likely be too late for shipment on that flight. Therefore, the tape will have to be sent from Cheyenne on the 0813 MDT flight and will arrive in Rapid City at 1202 MDT.

In order for reduced data to be back in Cheyenne with an approximate 24-hour turn around time, the data would have to be processed prior to 1645 MDT on the same day it arrives in Rapid City. It appears that this would present a conflict with Project Cloud Catcher for use of the PDP-8. A more realistic return time would be on the Frontier flight departing Rapid City at 0645 MDT on the following day. In this way, reduced data would reach Cheyenne approximately 48 hours after the time it was gathered.

Tape shipments from Cheyenne will be made on Tuesday, Wednesday, Thursday, and Friday mornings, whenever data has been gathered on the preceding day. Data gathered on Fridays will be hand carried to Rapid City by returning project personnel. In the event the trip cannot be made, this tape will be shipped on Saturday morning.

Processed data being returned to Cheyenne should be shipped on Monday, Tuesday, and Wednesday only. Data ready for shipment on Thursday and Friday should be held in Rapid City for pickup by IAS personnel returning to Rapid City on weekends.

DJM:jms

cc: R. A. Schleusener
J. H. Hirsch
J. H. Boardman
G. Peterson

APPENDIX E

M E M O R A N D U M

24 March 1971

TO: R. A. Schleusener

FROM: D. J. Musil

SUBJECT: Outline of Support Required for T-28 Operation in Colorado

REMARKS:

Following is a description of the support requirements now known for the T-28 operation in Colorado in connection with the NHRE 1971 field project.

Transportation, Logistics, and Communication

1. Transportation for the project meteorologist from Cheyenne to Grover in the morning and return in the evening.
2. Continuously upgraded information from the NHRE project director in Grover specifically designating the test case; launch of the T-28 will be ordered by IAS project meteorologist after coordination with the NHRE project director.
3. Access to the hot line from our project meteorologist to the aircraft coordinator at Greeley and a 123.05 mc communication link for the IAS project meteorologist to the T-28. (We will plan to provide this transceiver at Grover.)
4. Access to a display console and computer I/O keyboard giving various radar and aircraft position data as outlined below. These requirements are given below in terms of "real time" and "post-analysis" data.

Type of Displays Desired in "Real Time"

1. Continuously upgraded S-band CAPPI displays of radar reflectivity with contours in 10 dBz intervals from 30 dBz at 1,000 ft intervals from 10,000 ft MSL to storm top, which are controllable by the IAS project meteorologist.
2. The path of the T-28 should be shown on the map for the last five minutes, or for a longer time period if specified.
3. A 3-dimensional position report of the maximum reflectivity in the test case upgraded at least every 3 minutes. The position of the maximum reflectivity should be shown in alphanumeric characters in terms of direction and distance from the present position of the aircraft and bearing and distance from the Gill VOR. Thus the position of the maximum reflectivity should be specified on

the display console with reference to magnetic north and nautical miles from the aircraft and from the Gill VOR. For example: "140° 15 n mi FR A/C - 120° 40 n mi FR GILL." All altitudes should be given in FT MSL.

4. An RHI section of radar reflectivity on any section and at any orientation on request of the operator.
5. The past position of the most intense radar reflectivity by showing successive positions of the most intense reflectivity contour at time 0, 0 minus 10 minutes, and 0 minus 20 minutes.
6. Magnetic north should be shown on the computer display with true north being vertically upward.
7. Display on call the position and altitude of other project aircraft with respect to the test case, showing the position for the most recent five-minute time period, expandable to 15-minute periods on request.
8. The actual clock time in digital format should be visible from the console position. Also, the data presented on the console should indicate how old the data are, either in terms of presenting the actual clock time at which the (radar and aircraft) data were obtained, or the time lapsed since the observations were taken.
9. Display a 10x "blowup" of the radar reflectivity data for a smaller portion of the storm being studied.
10. ANY of the above displays to be photographed on demand from display console.

Information Desired to be Recorded on 35-mm Film at the Close of an Operational Day for "Post-Analysis"

1. CARPI displays at 5,000 ft intervals from 10,000 ft to the top of the echo at the time of exit from each pass.
2. RHI slices along and at right angles to the T-28 path at the time of each pass. There should be additional RHI slices available, these are parallel to the RHI slice along the T-28 path, at the discretion of the project meteorologist.
3. Reconstruction of the scope displays with the T-28 position and track for the past 10 minutes from the time of exit from each pass.
4. Scope overlays which include radar reflectivities with the position and track of each of the other airplanes matched to the position and track of the T-28 airplane to show the correspondence in time and space of the various aircraft. The tracks of these aircraft should be shown for the 15 minutes preceding the time of exit of the T-28 from its pass.