

Report 73-14

October 1973

SUMMARY OF T-28 FIELD OPERATIONS - 1973

By: D. J. Musil, W. R. Sand, and
R. A. Schleusener

Prepared for:

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

Subcontract No. 182-71

Institute of Atmospheric Sciences
South Dakota School of Mines and Technology
Rapid City, South Dakota 57701

TABLE OF CONTENTS

	<u>Page</u>
1. BACKGROUND AND OBJECTIVES	1
2. FIELD OPERATIONS - 1973	2
2.1 Summary of Operations	2
2.2 Research Highlights	2
3. LIST OF PUBLICATIONS	4
4. CONCLUSIONS	5
ACKNOWLEDGMENT	5
APPENDIX 1: T-28 Flight and Operations Summary - 1973	6
APPENDIX 2: T-28 Data - General Quality Summary	7

1. BACKGROUND AND OBJECTIVES

The Institute of Atmospheric Sciences (IAS) of the South Dakota School of Mines and Technology contracted with the National Hail Research Experiment (NHRE) to provide an armored T-28 aircraft to obtain data within and in the immediate vicinity of hailstorms during the 1973 field season.

Field personnel involved with the project on a full-time basis included a pilot, an electronics technician, an aircraft mechanic, and two graduate students who were located in Cheyenne with the T-28, plus a project meteorologist located at the field headquarters at Grover. Other personnel in the IAS were used as necessary in the project.

The specific objectives for the project include:

- 1) Obtaining measurements of updrafts in regions of hail formation and growth;
- 2) Determining the composition of high radar reflectivity zones;
- 3) Studying ice-water budgets in hailstorms;
- 4) Comparison of data gathered by the T-28 and output from numerical models of hailstone and hailstorm growth being developed under other sponsorship;
- 5) Providing a measurement platform for the devices designed by Dr. Tom Kyle of NHRE; specifically, total liquid water contents (Kyle evaporator) and drop-size distributions (Kyle spectrometer); and
- 6) Use of the T-28 as a platform for other special measurements such as the Langer ice nuclei device.

2. FIELD OPERATIONS - 1973

2.1 Summary of Operations

A summary of T-28 operations between 11 April 1973 and 1 August 1973 is given in Appendix 1. These flights include all research and test flights, plus ferrying flights between Cheyenne and Rapid City. There were a total of 34 flights during this period with 27 cloud penetrations. Hail was encountered on 21 penetrations during the season.

Data gathered by the T-28 is recorded on a modified MetroData Systems DL 620 magnetic tape recorder. A general data quality summary for each parameter recorded by this system is shown in Appendix 2. In addition, a four-channel Hewlett-Packard tape recorder was carried on the T-28, on which hail noise, voice comments, radio conversations, and a duplicate copy of all data were recorded.

Inadequate time was available for preparation of all the meteorological instrumentation before the beginning of the 1973 season. Much effort was required during the first month of the field season to complete the installation and checkout of all this equipment.

A data transmission link was installed in 1973 to permit transmission of data from Cheyenne to Rapid City via telephone line for rapid computer processing. The reduced data were then transmitted via telephone facsimile to Cheyenne for checking prior to subsequent flights. This link was very valuable in identifying equipment malfunctions, and on several occasions prevented loss of data from subsequent flights.

There were numerous data tape recorder failures during the 1973 field season. A more reliable recorder is required for the future.

2.2 Research Highlights

Foil impactor - The foil impactor carried on the T-28 during 1973 made many measurements of rain and ice particles in the 250 μm -1 cm size category. Although the data must be reduced by hand it provides a very reliable and accurate means of counting and sizing particles and permits some distinction between solid and liquid hydrometeors. These are the first routine measurements of this type made in active thunderstorms/hailstorms.

Rosemount icing rate probe - This system has provided a reliable measurement of rate of icing during penetrations and should provide valuable information on liquid water contents found in thunderstorms.

Kyle evaporator - This total water content measuring device was developed by Dr. Tom Kyle of NHRE. Prior to the 1973 season Dr. Kyle modified the instrument and fitted it with a Lyman Alpha humidity device.

It now appears to provide more accurate data on total water content in thunderstorms.

Precipitation samples - A device was developed by NHRE personnel which permitted the capture of three precipitation samples on a given flight. Various scientists working under NHRE sponsorship are performing analyses on these samples.

Seeding experiment - On 29 July the T-28, which had been outfitted with flare racks, performed a seeding experiment. Two seeding runs were made with ten 100 gm ejectable flares fired on each pass for a total of 2000 gm of silver iodide released inside the cloud in extensive updrafts. While the results of this experiment are unknown at this time, an attempt will be made to observe seeding effects from detailed 10 cm radar data (CP-2) that were being gathered at the time of seeding.

3. LIST OF PUBLICATIONS

The following is a list of publications prepared since September 1972:

Kyle, T. G., and W. R. Sand, 1973: Water content in convective storm clouds. Science, 180, 1274-1276.

_____, and _____, 1973: A vertical velocity profile in thunderstorm updrafts. Proc. Eighth Conf. on Severe Local Storms, Denver, Colorado, September 15-17, 1973, 39.

Musil, D. J., W. R. Sand, and R. A. Schleusener, 1973: An interior view of a hailstorm near 20,000 feet. Proc. Eighth Conf. on Severe Local Storms, Denver, Colorado, September 15-17, 1973, 35-38.

_____, _____, and _____, 1973: Analysis of data from T-28 penetrating aircraft. Accepted for publication in J. Appl. Meteor., December 1973.

_____, _____, and _____, 1973: Analysis of data from T-28 penetrating aircraft. Submitted to NHRE for publication in NHRE Technical Report 73-1.

Sand, W. R., R. A. Schleusener, and D. J. Musil, 1973: Observed updrafts and hail inside a thunderstorm. J. Wea. Mod., 5, 24-29.

_____, _____, and _____, 1972: Final report of the T-28 armored aircraft during the period 1 May 1971 - 1 May 1972. Report 72-17, Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, Rapid City, South Dakota, 55 pp.

In addition to the above published articles, several studies are now being pursued as Master's theses topics by graduate students at the South Dakota School of Mines and Technology. They are:

- 1) Investigation of foil impactor data by E. L. May.
- 2) Comparison of radar reflectivities with T-28 observations by W. R. Sand.
- 3) Development of optical hail detector by W. S. Shaw.

4. CONCLUSIONS

The following conclusions related to the T-28 participation in the NHRE program can be made:

- 1) The T-28 provides a very reliable means of obtaining data inside active thunderstorms/hailstorms. Some unique accomplishments during the 1973 field season include:
 - a) Foil impactor impressions of hydrometeors were gathered.
 - b) Icing rate data were obtained.
 - c) Improved total water content data were obtained.
 - d) Precipitation samples were gathered during penetrations.
 - e) A large concentration of silver iodide was placed in the updraft of one storm at the -5 to -7C level.
- 2) The quality of data obtained during penetrations appears excellent in 1973, although the number of penetrations was fewer than in 1972 due to fewer thunderstorm occurrences and greater selectivity in choosing storms for study.
- 3) In preparation for future field seasons all equipment should be installed on the aircraft by 1 March so that test flights can be carried out prior to the beginning of the field season.
- 4) There is a necessity to upgrade or replace the magnetic tape recorder currently being used in the T-28.

ACKNOWLEDGMENT

This research was supported by the National Science Foundation, Prime Contract Number NSF-C460 (Subcontract Number NCAR 182-71).

APPENDIX 1
T-28 Flight and Operations Summary - 1973

Flight Number	Date	Purpose	Period of Flight		No. of Research Stop	Research Start	Research Stop	No. of Penetrations	Hail	Turbulence	Icing	Data Tape	Voice Tape	Radar Track	Remarks
			Takeoff	Landing											
58	11 Apr	A/C Test	1230	1320	-	-	-	-	-	-	-	-	-	-	Out of annual A/C test
59	18 Apr	Inst. Cal.	1110	1245	-	-	-	-	-	-	-	-	-	-	Altimeter & IAS cal. at Laramie & ret
60	20 Apr	Inst. Cal.	1550	1725	-	-	-	-	-	-	-	-	-	-	
61	27 Apr	Tower Fly By	0700	0915	-	-	-	-	-	-	-	-	-	-	Tower fly by; stop Cheyenne fuel
62	27 Apr		0945	1100	-	-	-	-	-	-	-	-	-	-	
63	7 May	X-C Ferry CYG	1500	1600	-	-	-	-	-	-	-	-	-	-	
64	17 May	Inst. Test	1415	1550	-	-	-	-	-	-	-	-	-	-	Hailstone area
65	23 May	Inst. Test	0940	1040	-	-	-	-	-	-	-	-	-	-	Test radios, cameras, transponders
66	30 May	Inst. Test	1900	1940	-	-	-	-	-	-	-	-	-	-	Test foil impactor, cloud camera
67	1 Jun	Inst. Test	1515	1605	-	-	-	-	-	-	-	-	-	-	
68	4 Jun	Inst. Test	1345	1440	-	-	-	-	-	-	-	-	-	-	
69	6 Jun	Inst. Test	1730	1855	-	-	-	-	-	-	-	-	-	-	
70	7 Jun	Inst. Test	1710	1815	-	-	-	-	-	-	-	-	-	-	
71	8 Jun	Tower Fly By	0700	0835	-	-	-	-	-	-	-	-	-	-	
72	12 Jun	X-C LAR Alt. Cal.	1135	1205	-	-	-	-	-	-	-	-	-	-	X-C Laramie for altimeter calibration
73	16 Jun	Tower Fly By	0640	0800	-	-	-	-	-	-	-	-	-	-	
74	20 Jun	Inst. Test	0840	1000	-	-	-	-	-	-	-	-	-	-	
75	25 Jun	Tower Fly By	0650	0800	-	-	-	-	-	-	-	-	-	-	
76	25 Jun	Inst. Test	1545	1635	-	-	-	-	-	-	-	-	-	-	Recorder test
77	28 Jun	A/C Intercomp.	0600	0615	-	-	-	-	-	-	-	-	-	-	T-28 down due to metal in oil
78	30 Jun	Research	1645	1820	1752	1710	1752	4	Marble	Mod	Lt	Yes	Yes	-	
79	4 Jul	Research	1440	1550	1530	1507	1530	1	Pea	Lt	Lt	Yes	Yes	-	
80	9 Jul	Research	1645	1835	1805	1721	1805	4	1/2"	Svr	Hvy	Yes	Yes	-	
81	21 Jul	Research	1710	1830	1800	1730	1800	1	Pea	Mod	Mod	Yes	Yes	-	
82	24 Jul	Inst. Test	1125	1150	-	-	-	-	-	-	-	-	-	-	Hail catcher test
83	24 Jul	Research	1615	1800	1730	1620	1730	3	3/4"	Svr	Hvy	Yes	Yes	-	
84	24 Jul	Flare Rack Test	2015	2050	-	-	-	-	-	-	-	-	-	-	Buffalo down so tower fly by
85	26 Jul	A/C Intercomp.	0715	0805	-	-	-	-	-	-	-	-	-	-	Recorder test
86	26 Jul	Inst. Test	1745	1830	-	-	-	-	-	-	-	-	-	-	A/C Intercomp. with 100W
87	28 Jul	Research	1615	1825	1805	1635	1805	4	Pea	Mod	Lt	Yes	Yes	-	Seeding test 2000 gms AgI
88	29 Jul	Research	1930	2035	2025	1940	2025	4	Pea	Mod	Mod	Marginal	Yes	-	
89	31 Jul	Research	1505	1630	1617	1526	1617	5	1"	Svr	Hvy	Yes	Yes	-	
90	31 Jul	Research	1710	1820	1745	1725	1745	1	None	Lt	None	Yes	Yes	-	Seeding attempt CNX airborne
91	1 Aug	X-C to RBP	0930	1050	-	-	-	-	-	-	-	-	-	-	Return Rapid City

TOTALS

Total Number of Flights	34
Total Aircraft Hours	44.9
Total Number of Cloud Penetrations	27

APPENDIX 2

T-28 Data

General Quality Summary

Channel	Parameter	Quality
1-2	Time	Always good, synchronized daily with Grover
3	Ball Altitude	Generally good, within 3-4 mb
4	Indicated Airspeed	Very good
5	VOR	Good, within 2°
6	Rosemount Ice Rate	Very good
7	DME	Very good, but breaks lock in cloud frequently
8	Manifold Pressure	Good, some spikes in data
9	Rosemount Temperature	Good, some spikes in data
10	WSI Temperature	Good
11	J. W. Liquid Water	Good
12	Rate-of-Climb	Good, zero bad, between ± 300 fpm it sticks at -300 fpm.
13	Regulated 5 volts	Very good
14	PRT-5 Temperature	Very noisy, requires filtering
15	Kyle Lyman-Alfa (Total Water)	Good, zero drift due to deposits on window
16	Kyle V _p (Total Water)	Good
17	Event Code	Very good
18	+G Accelerations	Unacceptable
19	-G Accelerations	Unacceptable
20	Spare	- -
21-24	Rain Rate 40	Unacceptable
25-33	Hail Sensor	Development not complete
34-49	Spare	- -