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T-28 SUMMARY OF OPERATIONS  
1972 NHRE FIELD SEASON

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## 1. INTRODUCTION

### 1.1 Background and Objectives

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 measurements of vertical motion and composition of high radar reflectivity regions of hailstorms during the 1972 field season.

Personnel involved with the field phase of the project included a pilot, an electronics technician, and an aircraft mechanic, who were located in Cheyenne with the aircraft; plus a project meteorologist located at field headquarters in Grover.

The overall objective of the proposed research was to use the armored T-28 to obtain data within and in the immediate vicinity of hailstorms. The specific objectives include:

- 1) Obtaining measurements of updrafts in regions of hail formation;
- 2) Determining the composition of high radar reflectivity zones;
- 3) Obtaining a "first look" at ice-water budgets in hailstorms;
- 4) Using the data gathered by the T-28 as input to numerical models of hailstone and hailstorm growth being developed under other sponsorship; and
- 5) Evaluate the use of and data obtained from two prototype devices designed by Dr. Tom Kyle of NHRE; one to obtain bulk liquid water contents (Kyle evaporator) and the other to find drop-size distributions (Kyle spectrometer).

## 2. EVALUATION OF THE 1972 FIELD SEASON

### 2.1 Summary of Flight Operations

Appendix 1 is a summary of T-28 operations between 26 April, when the aircraft was released from the Naval Air Rework Facility, Pensacola, and 1 August 1972. It should be noted that during this period there were a total of 51 flights with 83 cloud penetrations and hail was encountered in flight on 7 different days during the season.

### 2.2 General Data Quality

Data gathered by the T-28 is recorded on a Metrodata Systems DL-620A magnetic tape recorder. A general data quality summary for each parameter recorded by this system is shown in Appendix 2.

### 2.3 Ranking of Research Days

An evaluation was made by IAS personnel to recommend priority days that might be used as complete research days for analysis purposes. This ranking of days is shown as Appendix 3.

The priority was established on the basis of the quality of the T-28 data tape, the voice/noise tape, the availability of M-33 radar track for aircraft position, plus a qualitative assessment of the day by the project meteorologist and the aircraft pilot.

### 3. SUMMARY

The operational experience of 1972 has shown that the armored T-28 is a satisfactory platform for penetrations of hailstorms with radar reflectivities  $\leq 55$  dBz. The 83 penetrations made have provided valuable information on the interior of such storms.

Although marked improvement was made during the season in the areas of presentation of aircraft track and real-time 10-cm radar data at Grover, the lack of such data still precludes the most effective use of the T-28 for penetration purposes.

The shortcomings of the T-28 data system have been better identified by the experience of the 1972 season. Work is now underway to alleviate the problems and make the T-28 a more effective instrument for 1973.

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APPENDIX 1

T-28 Flight and Operations Summary - 1972

Flight Number	Date	Purpose	Period of Flight*		Research Stop	Number of Penetrations	Hail	Data Tape	Voice Tape	Radar Track	Turbulence	Icing	Remarks
			Takeoff	Landing									
1	26 April	Aircraft test	1500	1610	--	--	--	--	--	--	--	--	Testing at MARF, Pensacola.
2	28 April	Aircraft test	1200	1235	--	--	--	--	--	--	--	--	
3	28 April	Aircraft test	1415	1505	--	--	--	--	--	--	--	--	
4	29 April	Build time	1330	1530	--	--	--	--	--	--	--	--	
5	30 April	Build time	1300	1500	--	--	--	--	--	--	--	--	
6	1 May	Cross country	1045	1221	--	--	--	--	--	--	--	--	Cross country, Pensacola to Rapid City.
7	1 May	Cross country	1305	1515	--	--	--	--	--	--	--	--	
8	1 May	Cross country	1750	1920	--	--	--	--	--	--	--	--	
9	2 May	Cross country	0830	0942	--	--	--	--	--	--	--	--	
10	2 May	Cross country	1015	1155	--	--	--	--	--	--	--	--	
11	15 May	Instrumentation test	1400	1418	--	--	--	42 min	No	--	--	--	Combined as one flight.
12	21 May	Instrumentation test	1530	1624	--	--	--	42 min	42 min	--	--	--	
13	23 May	Instrumentation test	1805	1853	--	--	--	20 min	20 min	--	--	--	Rapid City to Cheyenne.
14	24 May	Instrumentation test	1457	1547	--	--	--	20 min	--	--	--	--	
15	25 May	Research	0955	1117	--	--	--	--	--	No	No	No	Weak clouds, no track.
			1445	1645	1607	1623	No	Yes	Yes	No	No	No	
16	30 May	Aircraft test	1500	1530	--	--	--	No	20 min	--	--	--	General cloudiness. Data tape failure. Research canceled after takeoff.
17	2 June	Instrumentation test	1240	1315	--	--	--	45 min	45 min	mdt	mdt	mdt	
18	2 June	Research	1440	1652	1635	3	No	No	40 min	Yes	--	--	
19	3 June	Research	1445	1555	1547	4	No	No	40 min	Yes	--	--	
20	6 June	Research	1715	1740	--	--	--	--	--	--	--	--	
21	7 June	Cross country	0935	1010	--	--	--	--	--	--	--	--	Preparation for tower fly-by. (Cheyenne-Jefco-Cheyenne).
			1227	1301	--	--	--	--	--	--	--	--	
22	8 June	Tower fly-by	0640	0740	--	--	--	15 min	15 min	--	--	--	First hail encountered, fair research day. Intercomparison with NCAR, Buffalo.
23	8 June	Instrumentation test	0955	1035	--	--	--	No	No	--	--	--	
24	9 June	Research	1645	1835	1713	1811	Pea	Yes	Limited	Yes	mdt	mdt	
25	13 June	Intercomparison flight	0935	1210	--	--	--	40 min	40 min	--	--	--	

\*All times given in Mountain Daylight Time.

Flight Number	Date	Purpose	Period of Flight		Research Start	Research Stop	Number of Penetrations	Hail	Data Type	Voice Type	Radar Track	Turbulence	Icing	Remarks
			Takeoff	Landing										
26	15 June	Instrumentation test	1105	1145	--	--	--	No	60 min	--	Limited	lgt	--	Weak, but wet storms.
27	15 June	Research	1615	1755	1634	1733	6	No	60 min	--	Limited	lgt	hvy	Landed at Greeley, oil temp problems. Squall line penetration, rough. Installation of prop boots in DEN.
28	17 June	Research	1440	1605	1554	1558	1	No	30 min	No	Yes	?	No	
29	17 June	Research	1650	1805	1725	1737	2	No	30 min	30 min	Yes	svr	hvy	
30	17 June	Cross country	1915	1950	--	--	--	--	--	--	--	--	--	
31	20 June	Cross country	1545	1620	--	--	--	--	--	--	--	--	--	Return to CYS.
32	21 June	Research	1545	1628	--	--	--	--	--	--	--	--	--	Canceled, lack of clouds.
33	21 June	Research	1705	1835	1730	1753	3	Pea	30 min	20 min	Yes	mdt	hvy	Isolated cell, good analysis day.
34	5 July	Aircraft test	1630	1700	--	--	--	No	60 min	30 min	Limited	svr	--	Active storm, very turbulent.
35	6 July	Research	1620	1810	1641	1745	4	No	60 min	30 min	Limited	svr	hvy	
36	7 July	Research	1740	1935	1806	1856	4	Marble	45 min	45 min	Yes	svr	hvy	Excellent analysis day for T-28.
37	11 July	Instrumentation test	1240	1315	--	--	--	--	--	--	--	--	--	
38	11 July	Research	1610	1750	1636	1723	5	Pea	40 min	40 min	Yes	mdt	hvy	Good data for analysis.
39	14 July	Tower fly-by	0605	0710	--	--	--	--	15 min	15 min	--	--	--	
40	18 July	Instrumentation test	1820	1900	--	--	--	--	--	--	--	--	--	
41	19 July	Research	1605	1745	1628	1728	5	No	40 min	40 min	Limited	mdt	mdt	No hail encountered, data quality good.
42	22 July	Research	1540	1725	1603	1700	5	3/4"	45 min	45 min	Yes	mdt	mdt	One of best days for analysis, well defined storm, much hail.
43	24 July	Research	1535	1717	1606	1700	6	Pea	No	50 min	Yes	mdt	lgt	Data tape failure.
44	25 July	Research	1525	1725	1547	1658	6	No	50 min	No	Limited	mdt	lgt	Unorganized effort. Several clouds penetrated. Last 2 penetrations best.
45	25 July	Research	1810	1935	1852	1907	2	No	20 min	No	Yes	mdt	mdt	Penetrations followed dropsonde mission.

Flight Number	Date	Purpose	Period of Flight		Research Period		Number of Penetrations	Hail	Data		Voice Radar		Turbulence	Icing	Remarks
			Takeoff	Landing	Start	Stop			Tape	60 min	60 min	Tape			
46	26 July	Research	1630	1820	1704	1801	6	Marble	60 min	Yes	svr	mdt		Excellent day for analysis.	
47	27 July	Radar check	1025	1210	--	--	--	--	--	--	--	--		Test of track radar and display system.	
48	27 July	Research	1500	1655	1508	1632	5	No	45 min	Yes	svr	lgt		Fair day for analysis, some rough penetrations.	
49	29 July	Climb and sink tests	0830	1030	--	--	--	--	50 min	50 min	--	--		Flight made for measurements needed to refine updraft data.	
50	30 July	Cross country	0840	0950	--	--	--	--	--	--	--	--		End of project, return to RAP.	
51	1 August	Research	1745	1900	1758	1833	6	No	30 min	No	No	No		No track, storm too far away.	

TOTALS

Total Number of Flights	51 flights
Total Flight Hours	69.4
Total Number of Cloud Penetrations	83
Total Data Tape Time	15.5 hours
Total Voice Tape Time	12.7 hours



APPENDIX 2  
T-28 Data  
General Quality Summary

Channel	Parameter	Quality
1, 2	Time	Always good, synchronized daily with Grover.
3	Ball Altimeter	Generally good. Within 2 - 3 mb.
4	Indicated Air Speed	Very good.
5	VOR	Good early in the season. Unusable in the last half of the season.
6	WSI Altimeter	Generally good. Within 2 - 3 mb.
7	DME	Very good.
8	Manifold Pressure	Very good.
9	Rosemount Temperature	Unacceptable.
10	WSI Temperature	Good to within 1.5° C.
11	J.W. Liquid Water Content	Questionable. Flight and ground checks OK but numbers appear too low on cloud, 0.1 - 0.6 gm/m <sup>3</sup> .
12	Rate-of-climb	Good. Zero bad. Correction for manifold pressure altitude and airspeed required for actual updraft information.
13	Regulated 5 Volts	Very good.
14	Accelerometer	Equipment never acquired.
15, 16	Kyle Evaporator	See Dr. Kyle.
17	Spare	
18	Voice	Unused.
19	Event Code	Very good.
20	Spare	
21 - 24	RR - 40	Unacceptable.
25 - 28	Joss Hail Sensor	Unacceptable. Threshold too high. Icing problem.
29	Spare	
--	Kyle Spectrometer	See Dr. Kyle.

## APPENDIX 3

## T-28 Data

Recommended Priority for Complete Research Days  
(as of 8 September 1972)

NHRE Proposed Complete Research Days	Dates	Flight Number	Time Data Are Available	
*	22 July	42	1603:32 - 1659:04	
*	26 July	46	1704:37 - 1800:32	
*	19 July	41	1628:58 - 1727:51	
	7 July	36	1806:42 - 1855:05	
*	21 June	33	1730:26 - 1752:15	
	11 July	38	1636:19 - 1722:23	
	6 July	35	1641:14 - 1744:11	
*	25 July	44 & 45	1547:33 - 1657:43	1852:47 - 1906:36
	27 July	48	1508:39 - 1631:25	
*	15 June	27	1634:10 - 1732:46	
*	9 June	24	1713:08 - 1810:55	
	17 June	28 & 29	1554:47 - 1557:52	1725:34 - 1736:19
	2 June	18	1514:25 - 1634:45	
*	13 June	--	Aircraft Down	
*	24 July	43	Bad Data Tape	