Report SDSMT/IAS/R-92/02 February 1992

ANNUAL PROGRESS REPORT ON ARMORED T-28 AIRCRAFT FACILITY COOPERATIVE AGREEMENT (ATM-9104474)

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Prepared for:

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ABSTRACT

This is the annual progress report required under the terms of Cooperative Agreement No. ATM-9104474 between the National Science Foundation (NSF) and the South Dakota School of Mines and Technology (SDSM&T). The agreement provides for the operation of the SDSM&T armored T-28 meteorological research aircraft as a national facility for investigations into cloud, thunderstorm, and hailstorm processes. This report covers the period 16 February 1991 through 15 February 1992. During this period, the T-28 provided flight support to two field projects: COPS-91 in Oklahoma and CaPE in Florida. Much of the effort since completion of those two summer projects has been devoted to reduction and summarization of the data collected. Maintenance and development work has been carried out on the aircraft (inspection, brakes, propeller) and some of its instrumentation (electric field mills, reverse-flow temperature sensor, hail spectrometer, and foil impactor). A postdoctoral scientist joined the facility staff in January 1992 to augment the scientific capability, especially in the instrumentation area. Substantial scientific data analysis and reporting also took place during the period.

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1. INTRODUCTION

This annual progress report on T-28 research aircraft facility activities under Cooperative Agreement No. ATM-9104474 covers the period 16 February 1991 through 15 February 1992 (activities for the period 16 February - 15 May 1991 were carried out under the predecessor Agreement, No. ATM-8620145). During this period, the T-28 spent its busiest summer season since it commenced operations under cooperative agreements between the South Dakota School of Mines and Technology (SDSM&T) and the National Science Foundation (NSF) in 1987. Two field projects were supported during the spring/summer period, with more than ten weeks of flight activity.

The T-28 joined the first project, the Cooperative Oklahoma Profiler Studies (COPS-91) program, from 13 May (two days before the current agreement took effect) through 12 June 1991. It operated from Westheimer Field and the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma. Eight research flights were undertaken in support of multi-parameter radar studies and investigations of the electrical structure of thunderstorms.

Opening day for the Convection and Precipitation/Electrification (CaPE) field project in east-central Florida was 8 July. The T-28 was on-site in Melbourne, Florida, to begin six weeks of operations that eventually included 19 research flights in small to large thunderstorms. The flights supported multi-parameter radar studies and investigations of the microphysical and electrical structure of thunderstorms.

Both projects were major efforts involving many researchers and extensive coordination with ground-based, balloon-borne, and other aircraft platforms, as well as multiple radars; CaPE, at its peak, was five times larger than COPS-91 in terms of people and facilities. The role of the T-28 in both projects was to perform penetrations of the active regions of thunderstorms where turbulence, icing, lightning, and hail precluded penetrations by other available research aircraft.

Continuing support from the National Science Foundation and the State of South Dakota, combined with assistance from NSSL, the National Center for Atmospheric Research (NCAR), and the cloud physics group of the Atmospheric Environment Service (AES) of Canada, made it possible for the aircraft and crew to contribute to both projects with state-of-the-art measurements in hostile atmospheric environments. It is too early to assess the impact of these measurements, but early indications are that some of the T-28 data are extremely interesting and will be critical to several scientific investigations in the two projects.

Other facility activities during the year included the normal (and some abnormal) aircraft and instrumentation maintenance activities as well as further development of the electric field mill system and the imaging capability for the hail spectrometer. The analysis of data and reporting of results from past field projects supported by the T-28 also continued. Summaries of these and other facility activities are presented in the following section.

2. PROGRESS DURING THE YEAR

2.1 Project Support

2.1.1 COPS-91

The T-28 participated in COPS-91 at the request of Kultegin Aydin of The Pennsylvania State University. The field operations were funded through the NSF ATM facilities deployment pool. Professor Aydin's goal was to obtain multi-parameter data from the NSSL Cimarron radar and use *in-situ* aircraft microphysical data to verify microphysical retrievals based on the radar data. The T-28 was also able to supply data of use to storm dynamicists and electrical researchers, since the regions of the storms of most interest to Aydin were also of great interest to them. For its last flight of the COPS-91 program, the T-28 was used in the unusual role of measuring turbulent fluxes of heat through the boundary layer for comparison to surface-based microwave wind profiler data.

Table 1 gives a summary of all T-28 flights for the year. Those for COPS-91 were directed by radio from the NSSL facility at Norman, using radar data remoted in from Cimarron, FAA aircraft radar track information received via phone line, and GPS flight tracks and meteorological data telemetered from the aircraft. There were nine research flights, including the boundary layer flight, during COPS-91. Together with the ferry and test time, this resulted in utilizing 32 of the 40 flight hours authorized for COPS-91. In general, better and more extensive multi-parameter radar data were acquired as the project progressed, making data from the June flights the most important for comparison to radar observations. A large hailstorm complex was studied on the 5 June flight. There were two flights involving long traverses through stratiform regions behind decaying storms, and the remainder of the flights involved penetrations of smaller thunderstorms. Good coordination between ground-launched electric-field mill balloon packages, and T-28 and NOAA WP-3 airborne field mill measurements was achieved on the 2 June stratiform case.

In general, the T-28 instrumentation suite functioned well. More detailed discussion of equipment issues is given in section 2.2. Professor Aydin's letter critique of the support provided to COPS-91 is included as Appendix A. Reduced data have been furnished to Professor Aydin, who will be responsible for the detailed analysis and comparison with the radar observations.

TABLE 1: T-28 Flights - 1991

DATE	FLIGHT #	TIME	PURPOSE
23 Jan	534	1.5	Ferry to Bismarck Radio Shop
2 Feb	535	1.8	Ferry return to Rapid City
6 May	536	1.2	Ferry to Bismarck Radio Shop
	537	1.9	Ferry return to Rapid City
13 May	538	3.2	Ferry Rapid City to ICT
14 May	539	1.5	Ferry ICT OUN
17 May	540	1.7	Test
19 May	541	2.1	Research
21 May	542	2.3	Research
23 May	-	0.6	Ground Test
24 May	543	2.6	Research
30 May	544	2.8	Research
01 Jun	545	2.2	Research
02 Jun	546	1.4	Research
05 Jun	547	2.5	Research
08 Jun	548	2.1	Research
11 Jun	549	2.9	Research
12 Jun	550	1.7	Ferry OUN to HYS
12 Jun	551	2.1	Ferry HYS to Rapid City
05 Jul	552	2.6	Ferry Rapid City to DSM
06 Jul	553	2.3	Ferry DSM to MAW
06 Jul	554	2.5	Ferry MAW to CEW
07 Jul	555	2.4	Ferry CEW to MLB
11 Jul	556	1.7	Equipment Test
11 Jul	557	2.4	Research
12 Jul	558	2.7	Research
14 Jul	559	3.3	Research
16 Jul	560	2.4	Research
18 Jul	561	2.1	Research
19 Jul	562	2.5	Research
20 Jul	563	2.0	Research
28 Jul	564	2.5	Research
29 Jul	565	2.6	Research
31 Jul	566	2.0	Research
02 Aug	567	2.6	Research
03 Aug	568	2.1	Research
04 Aug	569	2.0	Test
07 Aug	570	2.8	Research
08 Aug	571	2.8	Research
09 Aug	572	2.5	Research
11 Aug	573	2.7	Research
13 Aug	574	2.5	Research
17 Aug	575	2.3	Research
18 Aug	576	2.0	Research
19 Aug	577	2.3	Ferry MLB to ABY
19 Aug	578	2.5	Ferry ABY to AWM
20 Aug	579	2.3	Ferry AWM to TOP
20 Aug	580	1.3	Ferry TOP to GRI
20 Aug	581	1.9	Ferry GRI to Rapid City

2.1.2 CaPE

T-28 participation in CaPE was at the request of V. Chandrasekar from Colorado State University, and a group of researchers from SDSM&T interested in cloud microphysics and electricity including Paul Smith, Dennis Musil and Andy Detwiler. The CaPE field operations were also funded through the ATM facilities deployment pool.

Thunderstorm activity in the region was above normal and mature storm targets drew the T-28 out for 19 research missions during five weeks of flying, accumulating 47 research flight hours. A crack in a propeller blade grounded the aircraft for six days while a replacement was being trucked in and installed, with the result that the aircraft was only available for five of the six planned weeks. (See section 2.2 for further discussion.) Nevertheless it completed 19 of the requested 20 research flights and accumulated 47 of the planned 50 research flight hours.

The T-28 flights were directed by radio from the Field Operations Center adjacent to the Melbourne airport. The T-28 was involved in coordinated missions with one or more of the seven other aircraft participating in CaPE (University of Wyoming and NCAR King Airs; NCAR sailplane; NASA Lear 25, T-39 and ER-2; and NOAA WP-3) on most of its flights. It was coordinated closely with the multiparameter CP-2 radar on most flights. High quality microphysical data sets accompanied by detailed mapping of the electrical characteristics of storm interiors were obtained on numerous occasions. Preliminary reduction of the data has been completed and an Abstract has been submitted for the program of the 11th International Conference on Clouds and Precipitation in August 1992. Researchers are now awaiting access to archived radar data and other observations in order to prioritize the data sets available and begin detailed analyses of the most promising data.

2.2 Equipment and Aircraft Maintenance

The equipment star of the field season was our newly-acquired GPS navigation equipment. High-quality position data in two dimensions were available almost all of the time, even though the complete constellation of GPS satellites is not yet in orbit. An example comparison between a flight track based on GPS data and one based on Federal Aviation Administration (FAA) radar transponder locations is shown in Fig. 1. The GPS position is updated every second when three satellites are in view, while the FAA radar position is updated only every 6 to 12 seconds at best. The GPS position is accurate to within 30 m or s,o almost all of the time while radar position uncertainty increases with distance from the radar site. Fortunately, both

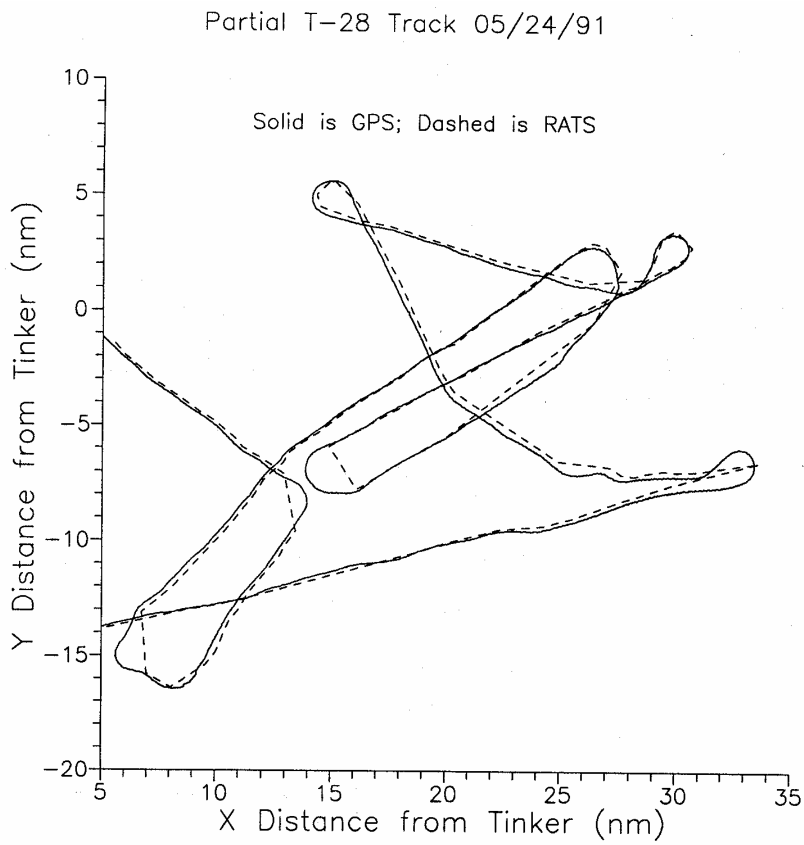

Fig. 1: Comparison of flight track for T-28 flight on 24 May 1991 based on (solid) GPS and (dashed) FAA surveillance radar. The interval between data points for the FAA radar track is 6 to 12 s, resulting in "cutting off" corners on some of the turns. The GPS position is updated each second.

1991 project areas were near FAA surveillance radar sites, allowing accurate positioning using both systems on most flights.

An added bonus from the frequent and accurate positions supplied by the GPS unit is a reliable ground speed calculation. This allows us to improve the accuracy of the vertical wind calculated using the method of Cooper as described in Kopp (1985). This method requires an estimate of the rate of change of kinetic energy of the aircraft. If this rate is estimated from changes in airspeed, a very noisy result is obtained which requires extensive smoothing and consequent loss of fine scale details. If the rate of change of kinetic energy is computed from accurate estimates of ground speed based on the GPS data, a much cleaner vertical wind profile is obtained, as shown in Fig. 2.

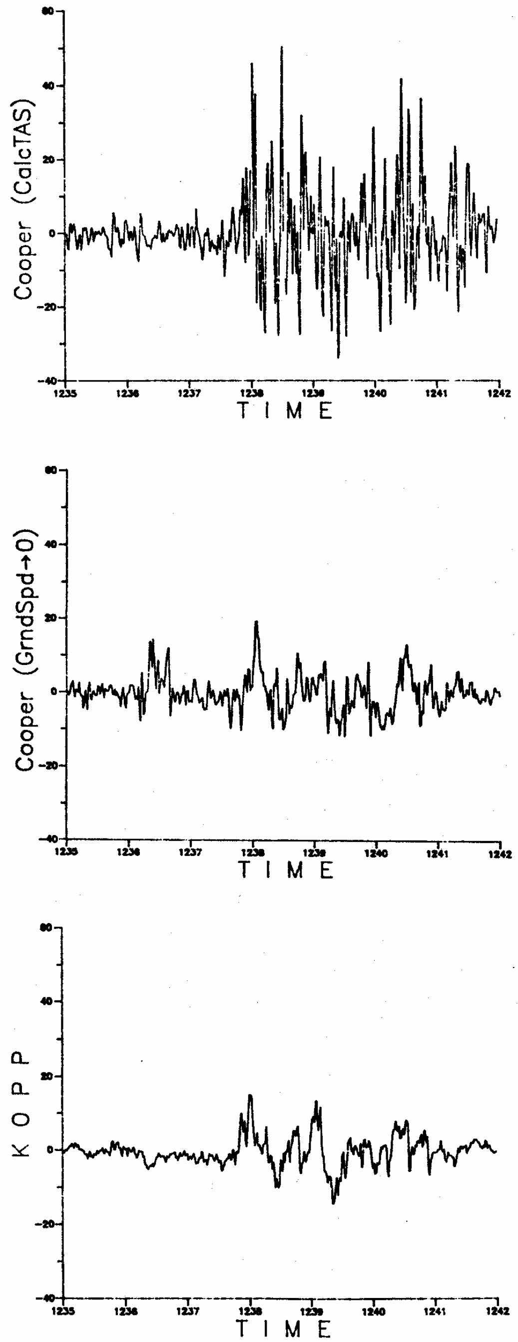

Fig. 2: Updraft record for a cloud penetration during COPS-91. Top panel uses old "Cooper method" of calculation involving rate of change of indicated airspeed. Middle panel shows the same calculation but using the rate of change of ground speed. Bottom panel shows calculation based on a different method that does not require an estimate of the rate of change of aircraft kinetic energy (Kopp 1985).

It was hoped initially that the GPS data would allow us to estimate horizontal winds with good accuracy. We have found that, while the GPS track is indeed accurate enough for establishment of the aircraft's ground velocity, the limited precision of our aircraft heading indicator and the absence of yaw-angle data are the limiting factors in the wind estimates. The heading indicator has a nominal accuracy of +/- 1 degree. We find that we cannot retrieve reliable horizontal winds when windspeeds are less than about 5 m/s.

While the GPS system was a star, somewhat more erratic performance was achieved by our newly installed and interfaced air-to-ground data telemetry system. When it was working, it provided invaluable real time information on the cloud environment and aircraft position to ground support people responsible for vectoring the aircraft to the most interesting targets. Unfortunately, the transmission range was significantly less in the field than we were able to achieve during pre-season test flights. A great deal of effort was expended trying to increase the range to better than 35 nautical miles in the field, while pre-season flights had indicated that our range could be greater than 100 miles. A post-summer overhaul at the factory showed that the aircraft unit receiver sensitivity was some 6 dB below the nominal specification; this problem is being corrected. On some flights, excellent data were received reliably in real time, giving us a taste of what to expect on every flight during our next project.

Another star of the season was a Particle Measuring Systems (PMS) OAP-2D-P probe loaned to us through the kind offices of Walter Strapp at AES Canada. Although both Aydin and Chandrasekar had requested that the T-28 fly a P-probe to obtain the precipitation-particle data they required, none is owned by our facility. In fact, because CaPE was such a major project, involving a major fraction of the domestic atmospheric research aircraft fleet, none was available within the US. The kind loan by AES of a reliable unit to the T-28 facility allowed us to obtain the data required to fulfill the multi-parameter radar missions specified in the requests.

A major but unavoidable disappointment was a small crack in one of our propeller blades, discovered midway through CaPE. That required our mechanic to return to Rapid City and drive a rented truck back to Melbourne with our spare propeller. This replacement task was accomplished in less than a week through yeoman effort from the facility mechanic. The stable funding provided by the current facility operation arrangement is responsible for our facility having had its own spare available. Prior to the initiation of the facility cooperative agreement in 1987, this type of situation would have shut us down for weeks due to lack of spares and would have ended our participation in a project like CaPE.

The dubious honor of being the biggest equipment headache of the season is shared by the reverse-flow temperature probe and the particle camera built by Ted Cannon (then at NCAR). Both instruments were initially carried by the T-28 during the National Hail Research Experiment in the mid 1970's. After years of reliable service, the reverse-flow electronics and/or sensor became extremely erratic during CaPE. The particle camera also did not survive well in the Florida climate, enduring almost daily trips to cool regions aloft, only to return to the sweltering surface where condensation of water coated most of its internal surfaces. Our facility engineer was out in the hangar during the wee cool hours near sunrise almost every morning nursing the aging circuitry and hardware in these two instruments.

The reverse-flow temperature data from COPS-91 are usable, but most of the data from CaPE are unreliable. Fortunately, our Rosemount aircraft temperature probe provides backup data for both projects. The Cannon camera was flown only in CaPE, and thanks to our engineer's efforts, valuable data was obtained on most flights. Because the thin-base film for which the camera was originally designed is no longer available, the film supply frequently did not last through the entire flight. It would be unwise to count on either of these instruments for reliable data in future projects unless they are extensively overhauled or refurbished.

Most of the remaining research and flight instrumentation functioned well through the long season. Two exceptions are the PMS FSSP cloud droplet probe and the aircraft VOR unit. The FSSP functioned well during COPS-91, but was frequently out of alignment during CaPE, rendering some of the CaPE FSSP data invalid. The VOR unit was unreliable throughout both projects despite repeated attempts to repair it or provide additional cooling air at its position on the instrument panel (the suspected cause of failure is a heating problem). The sucess of the GPS unit mitigates the need for the VOR data in reconstructing T-28 flight tracks for analysis purposes, so it now serves mainly as a real-time navigation aid. However, it needs to be replaced because it contains the ILS hardware; if it is not functioning properly, the aircraft cannot legally make an instrument landing requiring VOR or ILS approaches (something a storm-penetrating aircraft is called on to do with some regularity!). The alternative ADF is located to the rear of the pilot in the T-28, which makes its utilization marginal at best.

A highlight of the summer was performed by the hail catcher, carried under the right wing; with some help from the pilot, it successfully caught and preserved a centimeter-size hailstone during the COPS-91 flight on 5 June. This, in a small way, made up for the disappointment due to the malfunction of our normally reliable hail spectrometer on that day.

Of the three electric field mills purchased from New Mexico Institute of Mining and Technology (NMIMT) as part of the current agreement, two were mounted on the wing tips and performed well. The third was not mounted due to lack of time (it was not available for COPS-91 and arrived in Florida on the first day of CaPE), but was held in reserve as a spare. A couple of parts from it were actually used to help repair a mill of similar design on the NCAR King Air. (Two additional mills borrowed from NMIMT completed the set of four units for which the aircraft has been calibrated.) Plans are now being made to mount this third mill on one of the hail spectrometer pylons, to increase the full complement to five units.

Table 2 summarizes the various equipment actions during the year. Subsequent to the field season, effort has been devoted to the required aircraft inspections and to obtaining a functional long-blade propeller for re-installation on the aircraft. (The spare installed during CaPE is a short-blade version that leads to noticeable reduction in aircraft performance and endurance.) Two blades from the propeller with the crack are usable, and another spare blade is in for rework as the third one needed.

On the instrumentation side, attention has centered on solving the telemetry system and reverse-flow temperature (RFT) probe problems. Indications are that the former has been solved, but the RFT problem is still with us. The RFT sensing element needs replacement, and the entire unit should be refurbished. Further work has also been done on the imaging feature of the hail spectrometer, to make it compatible with the current onboard data acquisition system.

2.3 Software Developments

Our facility software engineer migrated all of the T-28 data processing software from the previous VAX system to MS-DOS personal computers. All data recorded on the Intel 80286-based data acquisition system can now be reduced, plotted, and analyzed in the field shortly after the aircraft returns from a research flight. This includes image data from PMS 2D probes, which can now be analyzed for particle types, concentrations, and size distributions on an inexpensive PC. The code is written in the "C" programming language and, with some modifi-cation to the screen display portions, should be suitable to be ported to UNIX-based workstations.

2.4 Data Exchanges and Information Requests

The facility staff responded to requests for data or information from the following during the year:

TABLE 2: Equipment Actions

16 February 1991 - 15 February 1992

- new laser for hail spectrometer
- refurbishment of Cannon camera film - drive
- Cannon camera frame counter interface to data system
- GPS interface to data system
- audio panel adjustments
- new inverter installed between COPS-91 & CaPE
- hydraulic pressure gauge for front cockpit
- VOR avionics and antenna work throughout both projects
- repair to #2 DME
- repair to hydraulic system during ferry home from CaPE
- repairs to long blade propeller following discovery of crack during CaPE
- repair to foil impactor drive motor and de-ice mechanism
- remove #3 radio and antenna
- new J-W head acquired
- new parachute
- fabricate alignment jig for FSSP

Rodger Brown, National Severe Storms Laboratory
Kathy Giori, SRI International
Gerd Hübler, NOAA Aeronomy Laboratory
Jerry Stegmaier, Aeromet, Inc.
Earle Williams, MIT

This is in addition to the data supplied to facility users or other participants in the COPS-91 and CaPE field projects. A photographer for National Geographic took copious in-flight photographs of the T-28 during the 4 August CaPE test flight; some may appear in a future issue of that magazine.

2.5 Travel by Facility Personnel

The facility manager attended meetings of the Observing Facilities Advisory Panel in Boulder, CO, on 17-18 April and 28-29 October 1991, as well as a meeting of the Facilities Allocation Council in Atlanta, GA, on 8 January 1992. He participated in a CaPE planning meeting in Boulder on 10-11 April 1991 and in the NCAR ATD Facility User's Conference on 15-16 April. The facility scientist and pilot were in Boulder, 6-7 March 1991, to participate in a CaPE aircraft operations planning meeting, while Dennis Musil (a consultant to the facility) participated in a COPS-91 planning meeting in Norman, OK, at the same time. The facility scientist traveled to Grand Forks, ND, 25-28 March 1991, to attend a planning session for a future North Dakota field project. He also presented a paper on 11 December at the AGU Fall Meeting in San Francisco, concerning some of the electric field measurements from CaPE. The facility manager attended part of the 4th International Conference on Aviation Weather Systems in Paris during the week of 24 June 1991.

The pilot took the aircraft to Bismarck, ND, on 6 May 1991, to have the audio panel repaired. The facility staff were in the field (or in transit) from 13 May - 13 June 1991 to support COPS-91, and from 5 July - 22 August 1991 to support CaPE. The facility manager made visits to both field projects. Following the field season, the pilot attended a very informative T-28 ground school on 26-30 October at Carlsbad, CA.

Two candidates for the T-28 postdoctoral scientist position visited the SDSM&T in November and early December 1991.

3. FUTURE PLANS

3.1 Research Projects to be Supported During the Next Year

A group of SDSM&T participants involved in a small field project called the "North Dakota Tracer Experiment" planned for the Bismarck, North Dakota, area has requested T-28 support for six weeks during the summer of 1992. The NSF ATM Facilities Allocation Council did not favor this request with support from the deployment pool. It also did not agree to provide requested deployment funds for an NCAR radar for this project. As of the date of this report, it appears that this project will be delayed until 1993 in hopes of securing better funding from its various supporting agencies. The only other field project that might involve the T-28, known at this time, is the RAPS-92 project, and discussions are in progress regarding that possibility. Heavy commitments of personnel, facilities, and funds to STORM-FEST and TOGA/COARE make it difficult to conduct other projects in this time frame.

3.2 Facility Development Activities

The instrumentation and hardware problems described above, and interest in improved measurements of various quantities, will keep facility staff busy through the period even if no field project develops. Areas targeted for special effort are:

Temperature measurement - refurbishment of the reverse flow probe hardware and electronics; replacement of the sensing diode with a platinum resistance element; investigation of a vortex housing on a third temperature probe.

Hail spectrometer - completion of imaging interface to data system.

Electric field measurement - acquisition of two additional field mills; mounting of 5th mill; monitoring discharge current from various points on the airframe during penetrations when the aircraft accumulates charges; development of sufficient knowledge to retrieve three-dimensional field vectors from four or five mills during storm penetrations.

Avionics - replace VOR and heading indicator with an integrated HSI.

3.3 Future Projects

The facility staff looks forward to the opportunity to participate in a 1993 NDTE and is hopeful that other rumored opportunities for mature storm studies in 1993 or later will materialize. These include potential projects related to STORM (summer 1994) and a possible atmospheric-electricity-oriented project in the Socorro, New Mexico, area.

4. PERSONNEL

It now appears that CaPE may be the last field project for Dan Custis, our current pilot. He plans to retire from flying the T-28 when he turns 60 this summer. He served as pilot during two long seasons, each involving almost back-to-back projects, in 1989 and 1991, as well as a short week-long test flight series in 1991. His skill in finding the most interesting parts of clouds to investigate, and at flying with sometimes marginal avionics, his aplomb when confronted with equipment (including engine) failures, and his interest in outfitting aircraft for thunderstorm research, will be sorely missed.

Ed Amiotte is currently training to take over duties as T-28 pilot when Dan steps down.

Dr. Richard Kelley has just joined the facility as a post-doctoral scientist. He will be pursuing his interests in atmospheric measurement problems while working to improve T-28 capabilities.

The facility concluded a consulting contract with J. J. "Dan" Jones of NMIMT this past fall for purposes of improving the retrieval of electric field information from the suite of field mills on the T-28. Dan's tragic death as a result of a traffic incident leaves us without valuable assistance in this area. We are currently discussing with his colleague Bill Winn ideas concerning future assistance in this area.

5. PUBLICATION ACTIVITY

Several publications involving work conducted under the T-28 facility cooperative agreement appeared during the year, and more are in progress. They are listed below, with indications of other sources of support where appropriate.

Published in Refereed Journals:

Huston, M. W., A. G. Detwiler, F. J. Kopp and J. L. Stith, 1991: Observations and model simulations of transport and precipitation development in a seeded cumulus congestus cloud. *J. Appl. Meteor.,* **30**, 1389-1406. (Jointly supported by the North Dakota Federal/State Cooperative Program.)

Musil, D. J., S. A. Christopher, R. A. Deola and P. L. Smith, 1991: Some interior observations of southeastern Montana hailstorms. *J. Appl. Meteor.,* **30**, 1596-1612. (Supported mainly by another NSF grant.)

Peterson, B. A., D. J. Musil and P. L. Smith, 1991: Computerized reduction of airborne foil impactor data. *J. Atmos. Oceanic Tech.,* **8**, 691-696. (Supported mainly by a NASA grant.)

Submitted to Refereed Journals:

Peterson, B. A., D. J. Musil and P. L. Smith, 1992: Some precipitation-particle observations from the interiors of COHMEX thunderstorms. [Submitted to *J. Appl. Meteor.*]

Detwiler, A. G., N. C. Knight and A. J. Heymsfield, 1992: Determination of error factors in measurements of snow particle masses. [Submitted to *J. Appl. Meteor.*]

Presented at Fall 1991 Meeting of American Geophysical Union

Giori, K. L., and A. G. Detwiler, 1991: Analysis of interactions among the T-28 aircraft, the atmospheric electric field, and cloud particles during cloud penetrations. [11 December 1991, San Francisco, CA]

Bulletins and other Items

Detwiler, Andrew G., 1991: Armored T-28 Research Aircraft Facility. April 1991. 20 pp.

Detwiler, A. G., and K. R. Hartman, 1991: IAS method for 2D data analysis on PCs. December 1991.

Detwiler, A. G., and P. Smith, 1991: Armored T-28 entering 24th year of storm research. [Submitted to NCAR *ATD Observer*.]

6. BUDGET INFORMATION

2nd Year Budget (Revised)

SUMMARY
PROPOSAL BUDGET

(SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING

ORGANIZATION IAS, SDSM&T					FOR NSF USE ONLY PROPOSAL NO.	DURATION (MONTHS) Proposed / Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR P. L. Smith					AWARD NO.	
A. SENIOR PERSONNEL: PI/PD. Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.6. show number in brackets)	NSF Funded Person-mos. CAL.	ACAD	SUMR	Funds Requested By Proposer	Funds Granted By NSF (If Different)	
[1]Facility Manager, P. L. Smith (.45 mo. cost-share)	1.55			$ 12,407	$	
[2]Facility Scientist, A. G. Detwiler (9 mo. cost-share)	0			0		
3.						
4.						
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)						
6. (2) TOTAL SENIOR PERSONNEL (1-5)	1.55			12,407		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (1) POST DOCTORAL ASSOCIATES	11.32			36,040		
2. (4) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	25.82			95,281		
3. ( ) GRADUATE STUDENTS						
4. ( ) UNDERGRADUATE STUDENTS						
5. (1) SECRETARIAL CLERICAL				3,430		
6. ( ) OTHER						
TOTAL SALARIES AND WAGES (A+B)				147,158		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				23,545		
TOTAL SALARAIES, WAGES AND FRINGE BENEFITS (A+B+C)				170,703		
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000:) 1. Horizontal Situation Indicator, $8,500 2. Electric Field Miles (2 @ $4,000 each), $8,000						
TOTAL PERMANENT EQUIPMENT				16,500		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				10,676		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER						
( ) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				7,496		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,242		
3. CONSULTANT SERVICES				0		
4. COMPUTER (ADPE) SERVICES				0		
5. SUBCONTRACTS				0		
6. OTHER				14,752		
TOTAL OTHER DIRECT COSTS				24,490		
H. TOTAL DIRECT COSTS (A THROUGH G)				222,369		
I. INDIRECT COSTS (SPECIFY RATE AND BASE) FY 1992: 42.5% of total salaries and wages ($7,762)						
TOTAL INDIRECT COSTS FY 1993: 43.5% of total salaries and wages ($56,069)				63,831		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				286,200		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)				38,800		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 247,400	$	

PI/PD TYPED NAME & SIGNATURE* P.I., P. L. Smith *Andrew Detwiler for*	DATE 02/14/1992	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE* T. G. Henderson *Sharon L Reid for:*	DATE 02/14/1992	Date Checked	Date of Rate Sheet	Initials-DGC

NSF Form 1030 (8/90) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

BUDGET EXPLANATION PAGE

Second Year: 15 May 1992-14 May 1993

	COLLEGE FY	EFFORT MONTHS	MONTHLY SALARY	REQUESTED FUNDS	COST SHARING MAN-MO	COST SHARING FUNDS
A. SENIOR PERSONNEL:						
1. Facility Manager						
P.L. Smith	1992	0.15	7,725	1,159	0.05	357
	1993	1.40	8,034	11,248	0.40	2,966
2. Facility Scientist						
A.G. Detwiler	1992	0.00	4,694	0	1.25	5,529
(State supported)	1993	0.00	4,882	0	7.75	35,649
Subtotal				$ 12,407		$ 44,501
B. OTHER PERSONNEL:						
2. Other Professionals						
a. Research Engineer						
G.N. Johnson	1992	0.75	5,094	3,821		
	1993	5.00	5,298	26,490		
b. Programmer						
K.R. Hartman	1992	0.75	3,025	2,269		
	1993	5.00	3,146	15,730		
c. Research Pilot						
	1992	0.40	5,120	2,048		
	1993	2.60	5,325	13,845		
d. Aircraft Mechanic						
J.E. Leigh	1992	1.50	2,578	3,867		
	1993	9.82	2,771	27,211		
e. Postdoctoral Scientist						
R.F. Kelley	1992	1.50	3,077	4,616		
	1993	9.82	3,200	31,424		
5. Secretarial	1992	0.30	1,612	484		
	1993	1.70	1,733	2,946		
Subtotal				$134,751		

*Salaries include a vacation accrual adjustment

BUDGET EXPLANATION PAGE

Second Year: 15 May 1992-14 May 1993
(continued)

	REQUESTED FUNDS	COST SHARING MAN-MO	COST SHARING FUNDS
TOTAL SALARIES AND WAGES:	$147,158		$ 44,501
C. FRINGE BENEFITS:			
1. Staff @ 16.0% of Salaries and Wages	$ 23,545		$ 7,120
TOTAL SALARIES, WAGES, AND FRINGE BENEFITS:	$170,703		$ 51,621
D. PERMANENT EQUIPMENT:			
1. Horizontal Situation Indicator	8,500		
2. Electric Field mills(2)	8,000		
Subtotal	$ 16,500		
E. TRAVEL:			
1. Domestic			
a. Travel to panel meetings, project planning meetings, and scientific conferences	8,206		
b. Local mileage for required travel between campus and airport(T-28 location)	2,470		
Subtotal	$ 10,676		
G. OTHER DIRECT COSTS:			
1. Materials and Supplies			
a. Miscellaneous small parts and repairs to support operation of T-28 and instrumentation system	4,200		
b. Fuel/oil for T-28 test flights(16 hrs @ $116/hr)	1,856		
c. Fuel oil for heating hanger(600 gal @ $1.40/gal)	840		
d. Miscellaneous supplies	600		
Subtotal	$ 7,496		

BUDGET EXPLANATION PAGE

Second Year: 15 May 1992-14 May 1993
(continued)

	REQUESTED FUNDS	COST SHARING MAN-MO	COST SHARING FUNDS
2. Publication costs			
a. Journal paper	1,533		
b. Conference paper	394		
a. Miscellaneous reproduction	315		
Subtotal	$ 2,242		
4. Computer (ADPE) Services			
a. Local PC's, etc provided	0		
5. Subcontract: none	0		
6. Others			
a. Rental of hangar/shop facility	5,103		
b. Utilities and trash	1,058		
c. Telephone service for hangar/shop,	504		
d. Liability coverage on T-28	2,100		
e. Annual subscriptions	908		
f. Maintenance and repair services that are beyond in-house capability	4,200		
g. Long distance telephone calls	600		
h. Miscellaneous services	279		
Subtotal	$ 14,752		
H. TOTAL DIRECT COSTS:	$222,369		$ 51,621
I. INDIRECT COSTS: On campus rate @ 42.5% of total salaries and wages, FY1992	7,762		2,502
43.5% for FY1993	56,069		16,798
Subtotal	$ 63,831		$ 19,300

BUDGET EXPLANATION PAGE

Second Year: 15 May 1992-14 May 1993
(continued)

	REQUESTED FUNDS	COST SHARING MAN-MO	COST SHARING FUNDS
J. TOTAL COSTS:	$286,200		$ 70,921
K. DEPLOYMENT RESIDUAL FUNDS	$ 20,400		
OTHER RESIDUAL FUNDS	$ 18,400		
L. AMOUNT OF THIS REQUEST	$247,400		

7. COST SHARING FUNDS

a) As of 31 December 1991, total cost-sharing by SDSM&T has been $40,240 ($25,668 in Salaries, $3,664 in Benefits, and $10,908 in Indirect Costs). We anticipate another $27,760 to be spent for the period 1 January - 15 May 1992 for a total estimated cost-sharing of approximately $68,000.

b) Anticipated cost-sharing expenditures in the next funding year will be $70,921 (see detailed budget).

8. ESTIMATE OF RESIDUAL FUNDS AS OF 15 MAY 1992

Estimated residual funds anticipated as of 15 May 1992 are as follows:

Base funds under facility agreement	$18,450
Operational (deployment) funds from COPS-91 and CaPE	$20,400
Total	$38,850

The residual in the first category results mostly from lower salary and associated benefit and indirect costs, due largely to the fact that the postdoctoral scientist joined the staff later than anticipated. The residual in the second category results from cost savings in a variety of areas during the 1991 deployments.

In conformance with a telephone conversation between P. L. Smith, T-28 Facility Manager, and C. A. Jacobs of NSF ATM CFS on 27 January 1992, the residual operational funds are indicated herein to be transferred to support the base facility operation during the second year of the agreement.

9. COST RECOVERY FUNDS

a) No cost recovery funds were collected during the current year. The T-28 participated in the COPS and CaPE projects and cost recovery funds were not generated on these projects as they were supported by the NSF ATM deployment pool.

b) For the coming year, we do not anticipate the generation of any cost-recovery funds at this time. Plans for the use of the T-28 facility are not finalized, but no users outside of projects likely to involve significant NSF support are as yet identified.

10. EQUIPMENT PURCHASED UNDER COOPERATIVE AGREEMENT

1.	3 - electric field mills for T-28 aircraft, received 7/91	$11,820.00
2.	Memory modules for data acquisition system received 7/91	$128.00
3.	2 - transceivers for PC's, ordered 1/92	$220.00

APPENDIX A

DEC 16 1991

PENNSTATE
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(814) 865-6337
Communications and Space Sciences Laboratory
The Pennsylvania State University
316 Electrical Engineering East
University Park, PA 16802-2707

December 12, 1991

Professor Paul L. Smith
Institute of Atmospheric Sciences
South Dakota School of Mines and Technology
501 E. St. Joseph Street
Rapid City, SD 57701-3995

Dear Professor Smith:

I'm sorry that my evaluation of your T-28 research aircraft facility was delayed this long. It has been a very busy period for me since the Oklahoma experiments ended in mid-June. Training new graduate students for research, doing the research, and teaching during the Fall semester was quite time consuming as you would undoubtedly understand.

I would like to start by stating that your T-28 research team headed by Andy Detwiler and Dennis Musil provided excellent support during the Oklahoma experiments from May 14 through June 12, 1991. I was impressed by their dedicated efforts in maintaining the aircraft and its instrumentation for rapid deployment and their ability in guiding it through storms. The telemetric transmission of real time data such as temperature, altitude, particle count on the 2D-P probe, etc., was very useful during the operations. Reports summarizing the data from the previous day's operations were valuable in assessing the needs for future operations. It was also very helpful to have access to the basic software for reading, browsing, and reducing the data. I understand that you are in the process of developing software for the statistical analysis of the 2D-P probe images. I fully support this effort since it would be a waste of resources if every user of such equipment had to develop similar codes. It would be very valuable if this code could distinguish the different shapes of hydrometeors (spherical, oblate, conical, irregular, etc.) as well as streaks of water that occasionally contaminate the data. This would then make it possible to obtain useful size and shape statistics of hydrometeors. Also, I recently read a paper from your group in JTECH describing an automated technique for reducing foil impactor data. I would suggest that this technique be made operational so that the analysis of foil impactor data becomes much less cumbersome than the presently used manual technique.

Let me give you an update on our activities regarding the data analysis from the Oklahoma experiments. As you may know, we had only six cases during which the T-28 and the CIMARRON radar simultaneously collected data. We have decided to initially focus on three of these: May 24, 30, and June 5. We will begin with June 5 which had hail reports on the ground. Unfortunately, the hail spectrometer on the T-28 had a problem that day, but the rest of the sensors were operational. We hope to use the foil impactor and the 2D-P images for this study. Once this case is completed, we will proceed with the events of May 24 and 30, both of which had small hail and graupel. We have already made some progress on the June 5 events by collecting ground reports of hail and viewing the radar data. Preliminary observations indicate good matching between the radar observations indicating hail and ground reports. Our next task is to correlate the T-28 data with the radar measurements. I will let you know of the results as soon as we complete our study.

Once again I'd like to thank you and your group for providing excellent support during the Oklahoma experiments. Best wishes.

Sincerely,

Kultegin Aydin

Kultegin Aydin
Associate Professor of Electrical Engineering

KA/lkk

cc: R. C. Taylor