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ANNUAL PROGRESS REPORT ON T-28 AIRCRAFT FACILITY COOPERATIVE AGREEMENT (ATM-8620145)

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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-8620145 between the National Science Foundation (NSF) and the South Dakota School of Mines and Technology (SDSM&T). The agreement provides for 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 1989-15 February 1990. During this period flight support was provided to two field projects: the Precipitation Augmentation for Crops Experiment conducted by the Illinois State Water Survey (May 1989) and the North Dakota Thunderstorm Project conducted by a federation of investigators (June-July 1989). A set of four borrowed electric field mills was installed and operated on the aircraft during both field projects. Facility upgrade activities included the installation of the new on-board data acquisition system and the procurement of components that can serve as a ground-station computer system for data reduction in the field. Acquisition of a new air-to-ground telemetry system to facilitate real-time data examination in the field is in progress.

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1. INTRODUCTION

This annual progress report on T-28 research aircraft facility activities under Cooperative Agreement No. ATM-8620145 covers the period 16 February 1989-15 February 1990. During this third year of the agreement, the T-28 spent nine weeks in the field supporting two different research projects, making 1989 the busiest T-28 research season since the CCOPE project in 1981. Ten research flights were performed, as well as eight additional instrumentation test flights. The T-28 is typically employed mainly for penetrations of relatively large and potentially hail-bearing convective clouds. It was also employed for some transport and diffusion studies and cloud seeding observations in smaller clouds and storms during the two 1989 projects.

The benefits of the extensive facility refurbishments and upgrades accomplished in the previous years included improved on-station time, improved data acquisition, and excellent mission readiness. Only one potential research opportunity was missed as a result of equipment problems, that one being due to failure of the data acquisition computer during its first attempted takeoff in 100°F ambient conditions. (This problem was subsequently solved.) The facility staff is proud of its record in performing state-of-the-art meteorological data acquisition in hostile mature storm environments using a 40-year-old platform; the facility support from the National Science Foundation is largely responsible for making such success possible.

2. PROGRESS DURING THE YEAR

2.1 Field Project Support

The T-28 facility supported two field research projects in 1989. The first was the Precipitation Augmentation for Crops Experiment (PACE) based in Champaign, Illinois. This project was directed by the Illinois State Water Survey with primary financial support coming through NOAA under the Federal/State Cooperative Program in Atmospheric Modification Research. The aircraft participated in the first three weeks of PACE field operations during May. Its mission was to follow the development of precipitation in large convective storms, and to monitor changes in cloud microphysical properties following treatment with glaciogenic agents. Other major facilities deployed for PACE were a heavily-instrumented Beech Baron used for cloud seeding and microphysical/dynamic measurements in-cloud, the CHILL multiparameter meteorological research radar, and a CLASS sounding unit.

During its three-week stay (9-31 May), the T-28 performed three instrumentation and procedural test missions and three research missions. One research mission included penetrations of a severe hail-bearing thunderstorm, another involved six penetrations following the development and decay of a weakly-electrified storm, and the third included detailed microphysical studies of a moderate-sized cumulus cloud following seeding. Data quality was good for all three flights. An abstract concerning observations from the hailstorm penetrations has been submitted for presentation at the October 1990 16th Conference on Severe Local Storms. Preliminary inspection of the data suggests that a coalescence-freezing mechanism was involved in the hail development. Further analysis of all three cases will be pursued by both Water Survey and School of Mines personnel as the level of support for analysis effort permits.

The second field project supported by the T-28 was the North Dakota Thunderstorm Project (NDTP) based in Bismarck, North Dakota from 12 June through 22 July. This project was organized and conducted by a federation of investigators from universities, private companies, the National Center for Atmospheric Research, and various state and federal agencies. Primary funding for the project came from the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), again under the Federal/State Cooperative Program. Table 1 lists the facilities deployed for the NDTP.

The T-28 carried out seven research flights and three additional equipment test flights, almost always in coordination with one or more of the three project radars and one or more of the five other project aircraft. The basic T-28 role during the North Dakota project was to coordinate with other aircraft and the ground facilities in studies of

TABLE 1

Facilities Deployed During the North Dakota Thunderstorm Project

Radars:	CP-3
	CP-4
	NOAA-C
	FAA Air Route Surveillance Radar (flight tracks)
Soundings:	Bismarck NWS
	Two CLASS units
	Acoustic
Aircraft:	UND Citation
	WMI Duke
	SDSM&T T-28
	UW King Air
	NOAA WP-3D
	NCAR Sabreliner
Photography:	GOES Satellite
	Center
	Elgin
	Goodrich
	Bismarck WSR-74C Video
Other:	Hail sensors
	Lightning Detection Network
	Cloud models
	PAM stations (2)

the microphysical, dynamical, and electrical characteristics of mid to large size convective clouds. A high priority was assigned to coordinated multiple-aircraft studies involving use of sulfur hexafluoride tracer gas to investigate transport, dispersion, entrainment, and ice nuclei activation processes in the clouds.

The North Dakota climate delivered a mixed bag of convective activity. Many of the larger thunderstorms occurred well outside the area of prime dual-Doppler radar coverage, or came through too late in the evening for safe aircraft operations. Many of the afternoon convective storms were poorly organized with short-lived convective elements that were not amenable to coordinated multiple-aircraft studies. Nevertheless, several coordinated studies involving the T-28 were carried out (none, unfortunately, with successful multiple-aircraft tracer detections); the T-28 also made two solo flights through the central portions of large convective complexes. In addition, the T-28 coordinated with the UND Citation for one study of the dispersion of sulfur hexafluoride released from the ground.

The NDTP operations directors typically launched the T-28 only when large potentially hail-bearing clouds were within range of the project radars. As 1989 was typical of a drought year in which the frequency of large storms is reduced, this type of situation was not common. The T-28 therefore accumulated fewer flight hours than had been anticipated. Of course, it also penetrated some of the heaviest precipitation of all project aircraft. Especially interesting data were obtained during the storm penetrations on 27 June and 6, 10, and 17 July. The electrification data from the 7 July flight were also of great interest.

The T-28 again performed SF_6 tracer measurements for its second season of support for North Dakota Federal/State program field research operations. The SF_6 analyzer equipment operated flawlessly up to altitudes near 19,000 ft, mainly due to careful attention from North American Weather Consultants workers. As it turned out, most of the clouds encountered in the transport and dispersion studies in which the T-28 was involved were relatively disorganized. Consequently, little coherent transport was observed.

The aircraft was also outfitted with a precipitation particle catcher built by Walter Grotewold and Nancy Knight at NCAR. Attempts were again made to capture hail particles in-flight for further analysis on the ground, but none were caught. Attempts to "seed" suspected hail embryo formation regions in feeder clouds with fluorescent particles and trace the development of hail by later capturing hailstones containing these particles in the air or on the ground were also not successful. The opportunities to attempt this experiment were limited by a lack of suitable storms in the project area.

Electric field measurements were performed in both projects using a suite of four rotating-vane mills borrowed from the New Mexico Institute of Mining and Technology and from the National Center for

Atmospheric Research (NCAR). Intriguing correlations between in-cloud electric fields and precipitation development were noted in both Illinois and North Dakota. The mill measurements allow a qualitative estimate of fields in the clouds, but further calibrations must be performed to make more precise quantitative estimates.

A presentation made at the Fall 1989 American Geophysical Union meeting concerned correlations between microphysical and electrical characteristics of a portion of a squall line penetrated on 17 July, during the NDTP. T-28 electric field data obtained during a formation flight involving the P-3 and T-28 have been supplied to John Hallett at the Desert Research Institute. He is using the field measurements, which include a response to the charge on the P-3, to study the P-3's self-charging behavior.

Table 2 gives a summary of T-28 flight activity for the field season.

2.2 Equipment and Aircraft Maintenance

A summary of equipment and maintenance activity during the year is given in Tables 3 through 6. The "QEC kit" (Table 3) was acquired through a trade with the University of Washington, made possible with funding provided by the SDSM&T Foundation. The QEC kit turned out not to contain a carburetor that could be used as a spare. Therefore a carburetor already on hand was sent in for overhaul and certification as an airworthy spare unit. The data system components acquired are spare-part units identical to those in the on-board data acquisition system, but they also can be configured as a ground-station computer. This can serve as both a stand-alone system for data reduction in the field and a source of spare parts in case of any failure in the on-board data system.

During the PACE work, the T-28 had to be flown to Bloomington, Illinois, for repair of faulty ATC transponder and VOR units (Table 4). The aircraft stood out overnight in very heavy rain (2.5 in +) and we suspect that contributed to the eventual cylinder and valve problems encountered on the ferry flights back to Rapid City. Subsequent replacement of the cylinder and magneto seems to have corrected the problem. During a hiatus in the NDTP weather, the T-28 was flown to Minneapolis for repair of a leaking seal in the propeller hub. The in-flight failures of the generator and #2 cylinder exhaust valve were the most serious equipment failures during the year. The other repair items are typical of the repairs needed to keep the facility serviceable.

The SF_6 analyzer (Table 5) had been reworked by North American Weather Consultants to provide satisfactory operation up to altitudes of about 19,000 ft. The chance to work with the improved SF_6 analyzer and the set of four field mills again helped improve our ability to derive useful measurements from these "non-standard" (for the T-28, anyway) instruments.

TABLE 2

T-28 Flights May - September 1989

DATE	FLT #	FLT TIME (hr)	INFORMATION
5-03-89	491	1.2	Spearfish: Static, Transponder Ck
5-03-89	492	1.2	Pilot Fam to Rapid City
5-05-89	493	1.0	Inst Test
5-08-89	494	0.5	Trip Abort - Comm Problem
5-08-89	495	2.5	Fuel Stop - Des Moines
5-08-89	496	1.5	Land Champaign, IL, for Project
5-10-89	497	1.4	Champaign - Lcl Inst Test
5-12-89	498	1.3	Champaign - Lcl Inst Test
5-17-89	499	1.9	Champaign - Lcl Inst Test
5-18-89	500	0.7	Champaign-Bloomington, Transponder and VOR Repair
5-20-89	501	0.7	Bloomington-Champaign
5-24-89	502	2.2	CMI - Research
5-25-89	503	1.0	CMI - Research
5-30-89	504	2.5	CMI - Research
5-31-89	505	1.5	Ln Kirksville, MO, w/smoke in cockpit (gen. siezed)
6-01-89	506	1.1	Ln Clarinda, IA, w/engine problems
6-03-89	507	1.6	Ln MHE - Fuel stop
6-03-89	508	1.6	Ln RAP
6-09-89	509	1.8	Lcl Test
6-11-89	510	1.2	Ln Bismarck for Project
6-16-89	511	2.0	Lcl Test
6-17-89	512	1.4	Lcl Test
6-19-89	513	1.9	To MSP - Prop Repair
6-21-89	514	2.3	Return to Bismarck
6-23-89	515	2.6	Research
6-27-89	516	2.6	Research
7-06-89	517	3.0	Research
7-07-89	518	2.6	Research
7-10-89	519	1.8	Research
7-14-89	520	2.4	Research and Inst. Test
7-17-89	521	2.0	Research
7-22-89	522	2.0	Ferry Bismarck to Rapid
9-21-89	523	0.6	Field mill Test
Total Flight Hours:		55.6	

TABLE 3

Equipment Acquisitions

1) Quick engine change (QEC) kit -- including exhaust system components and a generator.

2) Spare data acquisition boards and cassette drive (configured as a ground station computer for quick-look data reduction).

3) Cockpit video data display.

TABLE 4

Repairs and Replacements

1) ATC transponder (repaired).

2) VOR (repaired).

3) Heading indicator (repaired).

4) Generator (replaced due to bearing failure).

5) #2 cylinder (replaced cylinder assembly and piston following exhaust valve failure).

6) 2D-C probe tip heater (replaced).

7) 2D-C controller card (swapped in a spare; repaired the original).

8) Propeller spider shaft outerseal (replaced).

9) DME (repaired).

10) Attitude indicator (repaired).

11) ATC marker beacon receiver (repaired).

12) J-W cloud water sensor head (repaired).

13) Inverter for aircraft instrumentation (replaced).

14) Spare carburetor (overhaul).

TABLE 5

New Instrumentation Installed

1) Cockpit video data display (permanent).

2) High voltage power supply (permanent -- for testing field mill response).

3) Four electric field mills (temporary).

4) SF_6 analyzer (temporary).

5) Hail catcher (temporary).

The entire complement of pressure instrumentation was recalibrated at NCAR, as were the reverse-flow temperature sensor and the FSSP cloud droplet probe (Table 6). Intercomparisons between the T-28 and other project aircraft, as well as special test-flight maneuvers, made it possible to refine a number of the data reduction routines. These included static temperature recovery from the reverse-flow temperature probe, the rate-of-climb computation based on the Ball variometer, the vertical wind computation, and the estimates of ambient electric field.

TABLE 6

Instrumentation Calibrations in the Lab

1) FSSP.

2) Reverse-flow temperature sensing element.

3) Ball static pressure transducer.

4) Giannini static pressure transducer.

5) Rosemount static and differential pressure transducers (two each).

A test "weeping wing" section for possible use in aircraft anti-icing was flight tested during the NDTP for survivability during storm penetrations. No problems were encountered, but as no large hail was encountered the tests were incomplete.

The performance of the new on-board data acquisition system was generally excellent. It provides 16-bit resolution in the conversion of the analog data channels (versus 12 bits in the system it replaced). The in-flight rebooting capability worked consistently, although it tended to write over previously-recorded data; this software defect has been corrected. A solution to the high-temperature problem noted in Sec. 1 has also been implemented. The cartridge tape, as expected, proved adequate to record all the data from a flight without running out of tape.

The performance capability of the aircraft as a facility was substantially improved by the various refurbishments and upgrades which have been carried out during the course of this cooperative agreement. The aircraft endurance was increased to 3.0 hours (as verified by Flight No. 517, logged on 6 July 1989). The current estimate of the scientific payload capacity is 500 lb (227 kg), which includes the "normal" scientific instrumentation system on the aircraft. When that full system is installed, the remaining capacity for additional user-furnished equipment is about 150 lb (68 kg). The entire rear cockpit of the aircraft is now free to accommodate the user-furnished equipment. We also have about 560 W of 28-volt DC power or 700 VA at 115 V/400 Hz available for user instrumentation.

One final note is that the facility loaned its Pertec 9-track tape drive and controller to the Illinois State Water Survey for use in reducing their voluminous data records from the PACE program this year.

2.3 Software Developments

The data acquisition software in the new on-board system is coded in C language. The ground-station hardware is essentially identical to the on-board system, so for compatibility considerations and other reasons, the data reduction software was coded in C as well. Software for quick-look 2-D particle image display was also completed. The software required to digitize and analyze data from the T-28 foil impactor was adapted to current campus computer equipment. (Most of the foil analysis is performed on satellite image processing equipment made available by Professors Ronald Welch and Sailes Sengupta.)

Some 2D image analysis software was supplied to the Illinois State Water Survey along with the aircraft data from the PACE flights.

2.4 Instrumentation Developments

Estimation of particle masses from the PMS-probe 2D images is a continuing problem. The facility scientist (A. G. Detwiler) has worked with N. C. Knight and A. J. Heymsfield of the National Center

for Atmospheric Research on this problem. They coordinated 2D images from a probe in the laboratory with ice particles collected on slides to relate the masses to image characteristics. This work will be reported at the July 1990 Cloud Physics Conference.

Dr. Detwiler also worked with Vernon Plank at the Air Force Geophysics Laboratory and Hillyer Norment (a private consultant) on further studies of Plank's "M-meter" concept for measuring condensate mass concentrations from aircraft. The instrument concept needs further study, but a proposal to NSF for such study, headed by Norment, was declined.

Evidence suggesting possible wetting of the reverse-flow temperature sensor under conditions of heavy icing has been encountered. Study of this problem is under way by D. J. Musil.

2.5 Data Exchanges

During the past year, T-28 data were sent to various scientists besides the direct facility users involved in the projects supported (cf. Sec. 2.1). These included:

David Kingsmill, UCLA (COHMEX data)

Steven Goodman, NASA Marshall SFC (COHMEX data)

John Hallett, Desert Research Institute (NDTP data)

Albert Bruetsch, McClellan AFB (hail data)

Neal Barr, Mike Patnoe, Bill Tank, Boeing Co.
(precipitation mass concentrations)

In addition, we supplied information about T-28 operations to the Alaska Department of Natural Resources (who have begun to operate several T-28's in fire-fighting activities).

2.6 Travel by Facility Personnel

The facility manager (P. L. Smith) attended the Facility Advisory Panel meetings in Boulder on 16-18 April and 23-24 October. He made a presentation on the T-28 at the 3rd Interagency Airborne Geoscience Workshop in La Jolla, California (21-24 February), and attended the 5th IAMAP Scientific Assembly in Reading, United Kingdom, and an associated meeting of the International Commission on Cloud Physics. The facility sent representatives to a PACE planning meeting (Champaign, Illinois, 8-9 March) and an NDTP analysis planning meeting (Boulder, 2-3 November).

The pilot visited McClellan Air Force Base in Sacramento, California, on 26 September to discuss the available Air Force information on T-28 structural integrity and modifications. He obtained several documents related to structural integrity of the aircraft and inspections needed to insure continued safe operation.

He learned that responsibility for the T-28 systems has been transferred to Kelly Air Force Base in San Antonio, and that some parts should still be available in the Air Force supply system. He also discussed structural implications of any modifications to increase the T-28 aircraft fuel capacity, and the possibility of obtaining assistance with the transportation of the aircraft to Australia (cf. Sec. 2.7). No help could be provided with the latter, but this project has not materialized anyway.

2.7 Promotional Activities

Facility descriptions and request procedures were furnished to a group planning a pilot project in Oklahoma for the summer of 1990. The research involved comparison of aircraft observations with multi-parameter radar and electrification data. A request for flight support was submitted and evaluated at the October Facility Advisory Panel meetings. However, no research proposal was ever submitted for the project.

Information about T-28 facility capabilities was furnished to planners of a cloud physics/atmospheric electricity study being conducted in the vicinity of Darwin, Australia, in early 1990. Inquiries were made through NSF and U.S. and Australian Navy channels about possible "lift-of-opportunity" transport for the aircraft. However, no formal request for aircraft support of the project materialized.

Information was also furnished to planners of 1991 projects in Florida (CAPE) and Oklahoma (COPS). Discussions were held with Dr. Bluestein of the University of Oklahoma about plans for a study of "low-precipitation" supercell storms. Information was also sent to prospective users of the facility at Flight Technology, Inc. (Pomona, CA) and the Air Force Geophysics Laboratory (Bedford, MA).

The facility scientist made more than a dozen presentations during the year to elementary and high school students concerning T-28 activities.

3. FUTURE PLANS

3.1 Research Projects to be Supported

As the Oklahoma 1990 project mentioned in Sec. 2.7 failed to materialize, there are no approved allocations of T-28 flight support for the summer of 1990. In the absence of participation in a major field project, the facility staff plans to carry out a small test flight program to:

1) Investigate problems with temperature probe wetting;

2) Test the new air-to-ground telemetry system; and

3) Further refine reduction procedures for the field mill data.

To accomplish the last item, the facility plans to request support from the nascent NSF field deployment fund pool to carry out intercomparison work with either Tzvi Gal-Chen and Dave Rust in Oklahoma or Bill Winn and Charles Moore in New Mexico. Final arrangements will be made when these potential collaborators have more definite word on their funding and availability of personnel. If this possibility does not materialize, an alternative would be to work in the Boulder/Fort Collins/Greeley area, where the NCAR/NOAA sailplane will be carrying out electrical measurement tests and where support from the CHILL radar might be available.

3.2 Future Projects

No other definite requests for T-28 flight support are pending at this time. However, fairly definite plans are being laid for two different convective-storm field programs in 1991. These are the COPS program in Oklahoma and the CAPE program in central Florida. T-28 participation would benefit both programs and has been discussed with potential participants. If both programs are funded at reasonable levels, 1991 could be another busy year for the T-28 facility.

The future planning for other projects which might need T-28 flight support is less clear at this time. The North Dakota component of the Federal/State Cooperative Program currently expects to return to the field in 1992, and the T-28 has been involved in the two most recent North Dakota field projects (1987 and 1989). Another possibility is a program of physical, chemical, and electrical studies of convective storms in the Socorro, New Mexico, area. The facility staff will continue to support the planning for these and other possible future projects in appropriate ways.

3.3 Facility Development Activities

With the completion of the new T-28 facility data acquisition and reduction system this year, the most pressing scientific need is for a permanent electric field mill installation on the aircraft. This would require supplemental funding, but continues to be a high priority need for such future projects as CAPE or COPS. The addition of a PMS 2D-P probe to the instrumentation complement would also enhance the capability of the facility to support many projects.

From an operational standpoint, the most pressing need is to improve the aircraft navigational capability. This will require a Horizonal Situation Indicator to replace the present 40-year-old equipment, which has become unreliable and difficult to repair. The HSI would provide heading data along with VOR and glide slope displays in a single unit. The HSI unit can then be coupled to an RNAV system to improve our ability to go directly to selected way points. This would permit better coordination of T-28 flights with other project aircraft. The fall 1987 facility review panel viewed the addition of this capability favorably.

We therefore propose to commit the remaining facility use charge funds ($12,515) from the PACE project to the upgrade of the T-28 navigational capability. Our cost estimates suggest that it should also be possible to replace our homemade and increasingly troublesome audio panel with a new unit that has proper isolation between channels, within the limits of the use charge funds available.

Other work to maintain the aircraft, the associated instrumentation, and the data system will continue as required.

4. KEY PERSONNEL

Norm Vine, the T-28 pilot since 1981, was unable to get his FAA medical certification renewed in time for the summer 1989 field season. A nationwide search was conducted for a temporary replacement pilot; more than 80 applications were received. Four candidates were interviewed; on balance, Dan Custis of Spearfish, South Dakota, was selected as the most suitable candidate for this position. The facility was very fortunate to obtain the services of Mr. Custis, on relatively short notice, for essentially full-time service as T-28 pilot during the two field programs. He adapted to the regimen of penetrating storms in a rugged aircraft with great enthusiasm and success.

The advertisements of this opening attracted attention from several useful contacts concerning currently available sources of spare parts, maintenance facilities qualified to work on the T-28, and additional documentation on the T-28.

Delays in getting Mr. Custis rated on our T-28 insurance policies contributed to some delays in the initial test flights this spring. This problem, coupled with input from a State insurance management office, led to a decision to incorporate the T-28 in a group-type liability policy for State aircraft, as of 15 May. This also resulted in a reduction of over $1,000 in the annual premium for this insurance.

Mr. Custis has, for the present, taken over the off-season duties previously performed by Norm Vine. Mr. Vine is currently residing in Montana while pursuing the resolution of the FAA medical certification questions. If all works out well, the facility will have access to the services of two qualified and experienced pilots for future projects.

There were no other changes in facility personnel.

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

Blackmore, W. H. III, D. J. Musil, P. L. Smith and A. Waldvogel, 1989: Spatial and temporal variations of the interior characteristics of Swiss thunderstorms. Atmos. Res., 23, 135-161. (Supported mainly by another NSF grant)

Detwiler, A. G., 1988: Comment on "Homogeneous nucleation rate for highly supercooled cirrus cloud droplets." J. Atmos. Sci., 46, 2344-2345.

Musil, D. J., and P. L. Smith, 1989: Interior characteristics at mid-levels of thunderstorms in the southeastern United States. Atmos. Res., 24, 149-167. (Supported mainly by a NASA grant)

Musil, D. J., and P. L. Smith, 1989: Hail growth processes in an Alberta hailstorm. J. Wea. Modif., 21, 65-72.

Smith, P. L., and A. Waldvogel, 1989: On determinations of maximum hailstone sizes from hailpad observations. J. Appl. Meteor., 28, 71-76.

In Press

Stith, J. L., A. G. Detwiler, R. F. Reinking and P. L. Smith, 1989: Investigating transport, mixing and the formation of ice in cumuli with gaseous tracer techniques. Atmos. Res. [In press] (Jointly supported by the North Dakota Federal/State Cooperative Program)

Detwiler, A. G., and V. Ramaswamy, 1989: Radiative heating profiles in simple cirrus cloud systems. J. Atmos. Sci. [In press]

Submitted for Publication

Peterson, B. A., D. J. Musil and P. L. Smith, 1990: Computerized reduction of airborne foil impactor data from COHMEX thunderstorms. [Submitted to J. Atmos. Oceanic Tech.] (Supported mainly by a NASA grant)

M.S. Theses

Christopher, S. A., 1989: T-28 hail observations and radar characteristics of Montana thunderstorms. M.S. Thesis, Department of Meteorology, S.D. School of Mines and Technology, Rapid City, SD. 99 pp. (Supported by another NSF grant)

Huston, M. W., 1989: One- and two-dimensional model results compared with observations from a North Dakota cloud. M.S. Thesis, Department of Meteorology, S.D. School of Mines and Technology, Rapid City, SD. 90 pp. (Supported by the North Dakota Federal/State Cooperative Program)

Reports and Bulletins

Musil, D. J., A. G. Detwiler and P. L. Smith, 1989: T-28 participation in the 1989 Precipitation Augmentation for Crops Experiment in Illinois. Report SDSMT/IAS/R-90-08, Institute of Atmospheric Sciences, S.D. School of Mines and Technology, Rapid City, SD. 39 pp. (Jointly supported by the Illinois Federal/State Cooperative Program)

Hartman, K. R., and A. G. Detwiler, 1989: Further explanation of the IAS versions of TOUCH2D and ANALYZE 2D. Bulletin 89-2, Institute of Atmospheric Sciences, S.D. School of Mines and Technology, Rapid City, SD. 26 pp.

Conference Presentations

Bringi, V. N., S. Sur, D. J. Musil, P. L. Smith and R. Rasmussen, 1989: Microphysical evolution of convective clouds inferred from multiparameter radar measurements and aircraft penetrations. Preprints 24th Conf. Radar Meteor., Tallahassee, FL, Amer. Meteor. Soc., 13-17. (Jointly supported by a NASA grant)

Detwiler, A. G., and J. H. Helsdon, Jr., 1989: Electrical characteristics of a squall line from the North Dakota Thunderstorm Project. Fall American Geophysical Union meeting, San Francisco, CA, Dec 1989.

Some T-28 data were also used in a paper by Moore and Ray at the 24th Conference on Radar Meteorology (Moore, P. D., and P. S. Ray, 1989: Doppler radar observations of the evolution of a small convective storm during COHMEX. Preprints 24th Conf. Radar Meteor., Tallahassee, FL., Amer. Meteor. Soc., 54-57).

6. BUDGET INFORMATION

6.1 General

This is a request for fourth year funding under a four-year cooperative agreement. This fourth year total cost is $208,525, less the $12,525 user fee (cost recovery) funds for year three, less $12,500 anticipated residual funds, making the request to NSF for new monies equal to $183,500.

6.2 Salaries and Benefits

Salary rates are those set by the Regents of Education of the State of South Dakota for college FY1990 and inflated by 10% for FY1991 for professional staff and 5% for secretarial support. (Actual approved FY1991 rates will be charged the sponsor.)

Institute personnel earn vacation at the rate of 10 hours per month if they have 15 years or less of service, and an average of 13.33 hours per month if their period of service exceeds 15 years. This vacation is handled in the budget by including the appropriate accrual adjustment in the salary rate. This procedure is utilized for all sponsored Institute projects to insure that each one pays only its pro rata share of the vacation authorized.

Fringe benefits for the purpose of estimating costs are calculated as 16.0% of the total salaries and wages.

6.3 Permanent Equipment

Three equipment items are being requested in this fourth year of the agreement at a total estimated cost of $12,525. The items include a) a Horizontal Situation Indicator ($7,750); b) an RNAV unit ($3,500); and c) an Audio Panel ($1,275).

6.4 Indirect Costs

The latest indirect cost rate approved by the cognizant government audit agency of the South Dakota School of Mines and Technology is 42.5% of salaries and wages, exclusive of overtime. All salaries and wages in this renewal qualify for the on-campus rate.

The cognizant government audit agency for this institution is:

Director, Division of Cost Allocation
Regional Administrative Support Center
Department of Health and Human Services
Room 1185, Federal Office Building
1961 Stout Street
Denver, CO 80294

6.5 Cost Sharing

This budget will not be charged for the effort expended by the T-28 scientist, Dr. A. G. Detwiler. The State of South Dakota has appropriated some funds to support this position as cost-sharing. Dr. Detwiler will be cost shared at 10 months of effort and Dr. Smith at 0.4 months for this fourth year funding; thus, the cost sharing total including benefits and overhead is $72,837.

FOURTH YEAR

(Revised)

SEE INSTRUCTIONS ON REVERSE BEFORE COMPLETING)

SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION: Institute of Atmospheric Sciences
South Dakota School of Mines and Technology

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Paul L. Smith

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. P.I.: P. L. Smith	1.4			$ 10,551	$
2. Scientist: A. G. Detwiler				-0-	
3.					
4.					
5. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
6. (2) TOTAL SENIOR PERSONNEL (1-5)	1.4			10,551	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) (4)	25.82			90,218	
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL-CLERICAL				3,473	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				104,242	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				16,679	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 120,921	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000.)					
KCS55A Horizontal Situation Indicator $7,750 RNAV612 RNAV Unit $3,500 KMA24H Audio Panel $1,275					
TOTAL PERMANENT EQUIPMENT				12,525	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,081	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				7,350	
2. PUBLICATION COSTS/PAGE CHARGES				2,130	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				600	
5. SUBCONTRACTS					
6. OTHER				14,615	
TOTAL OTHER DIRECT COSTS				24,695	
H. TOTAL DIRECT COSTS (A THROUGH G)				164,222	
I. INDIRECT COSTS (SPECIFY) On-Campus Rate At 42.5% Of Total Salaries and Wages					
TOTAL INDIRECT COSTS				44,303	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 208,525	
K. RESIDUAL FUNDS $12,500 & Cost Recovery Funds $12,525				25,025	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 183,500	$

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY
Paul L. Smith Paul L. Smith	3/1/90	INDIRECT COST RATE VERIFICATION
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date of Rate Sheet / Initials - DGC / Program
Timothy G. Henderson Sharon L Reid for	3/1/90	

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*SIGNATURES REQUIRED ONLY FOR REVISED

BUDGET EXPLANATION PAGE

Fourth Year: 15 May 1990-14 May 1991

	COLLEGE FY	EFFORT MAN-MO	MONTHLY SALARY	REQUESTED FUNDS	MAN-MO	COST SHARING FUNDS
A. SENIOR PERSONNEL:						
1. Principal Investigator						
P. L. Smith	1990	0.20	$6,942	1,388	0.00	-0-
	1991	1.20	$7,636	9,163	0.40	2,820
2. Research Scientist						
A.G. Detwiler	1990	0.00	$4,218	-0-	1.50	5,963
	1991	0.00	$4,640	-0-	8.50	37,171
Subtotal				$ 10,551		$ 45,954
B. OTHER PERSONNEL:						
1. Other Professionals						
a. Research Engineer						
G. N. Johnson	1990	0.75	$4,578	3,434		
	1991	5.00	$5,036	25,180		
b. Programmer						
K. R. Hartman	1990	0.75	$2,719	2,039		
	1991	5.00	$2,991	14,955		
c. Research Pilot						
D. P. Custis	1990	0.40	$4,600	1,840		
	1991	2.60	$5,060	13,156		
d. Aircraft Mechanic						
J. E. Leigh	1990	1.50	$2,407	3,611		
	1991	9.82	$2,648	26,003		
2. Secretarial	1990	0.30	$1,666	500		
	1991	1.70	$1,749	2,973		
Subtotal				$ 93,691		
TOTAL SALARIES AND WAGES:				$ 104,242		$ 45,954
C. FRINGE BENEFITS:						
1. Staff @ 16.0% Of Salaries And Wages				$ 16,679		$ 7,353
TOTAL SALARIES, WAGES, AND BENEFITS:				$ 120,921		$ 53,307

*Salaries include a vacation accrual ajustment

BUDGET EXPLANATION PAGE

Fourth Year: 15 May 1990-14 May 1991
(continued)

	REQUESTED FUNDS	COST SHARING FUNDS
D. PERMANENT EQUIPMENT:		
1. KCS55A Horizontal Situation Indicator	7,750	
2. RNAV612 RNAV Unit	3,500	
3. KMA24H Audio Panel	1,275	
Subtotal	$ 12,525	
E. TRAVEL:		
1. Domestic		
a. Travel to project planning meetings and scientific conferences	3,925	
b. Local mileage for required travel between campus and airport (T-28 location)	2,156	
Subtotal	$ 6,081	
G. OTHER DIRECT COSTS:		
1. Materials And Supplies		
a. Miscellaneous small parts and repairs to support operation of T-28 and instrumentation system	3,000	
b. Fuel/oil for T-28 test flights, (20 hrs @ $130/hr)	2,600	
c. Fuel oil for heating hanger, (600 gal @ $1.25/gal)	750	
d. Miscellaneous supplies, tools, etc.	1,000	
Subtotal	$ 7,350	
2. Publication Costs		
a. Paper for scientific conference	300	
b. Journal paper (12 pgs @ $110) + ($150 for reprints)	1,470	
a. Miscellaneous reproduction	360	
Subtotal	$ 2,130	
4. Computer (ADPE) Services		
a. Cyber, (2 hrs @ $300/hr)	600	
Subtotal	$ 600	

BUDGET EXPLANATION PAGE

Fourth Year: 15 May 1990-14 May 1991
(continued)

	REQUESTED FUNDS	COST SHARING FUNDS
G. OTHER DIRECT COSTS: (continued)		
6. Others		
a. Rental of hangar/shop facility, (12 mo @ $400/mo)	4,800	
b. Utilities, hanger, ($62/mo)	744	
c. Telephone service for hangar/shop, (12 mo @ $48/mo)	576	
d. Trash service, (12 mo @ $24/mo)	288	
e. Liability coverage on T-28 and accident insurance for pilot	3,500	
f. Annual subscription to federal airworthiness directives, aviation parts	658	
f. Maintenance and repair services that are beyond in-house capability	3,000	
g. Long distance telephone calls, ($40/mo)	480	
h. Miscellaneous services	569	
Subtotal	$ 14,615	
J. TOTAL DIRECT COSTS:	$ 164,222	$ 53,307
K. INDIRECT COSTS: On Campus Rate @ 42.5% Of Total Salaries And Wages	$ 44,303	$ 19,530
L. TOTAL COSTS:	**$ 208,525**	**$ 72,837**

7. CURRENT AND PENDING SUPPORT

7.1 Principal Investigator, Paul L. Smith

A. Current Support:

1) Supporting Agency: North Dakota Atmospheric Resource Board
Project Title: To provide Personnel and Services for Acquisition and Analysis of Data for the North Dakota Thunderstorm Project
Award: $102,800
Period of Award: 1 May 1989-31 Mar 1991
Commitment: 2.4 months/year
Location: Rapid City, SD

2) Supporting Agency: National Aeronautics and Space Administration
Project Title: Microphysical and Electrical Structure of Small Convective Systems in the Southeastern Part of the United States
Award: $169,791
Period of Award: 20 May 1987-19 May 1990
Commitment: 1.2 months/year
Location: Rapid City, SD

3) Supporting Agency: National Science Foundation
Project Title: Armored T-28 Aircraft Facility for Research Requiring Storm Penetrations
Award: $190,000
Period of Award: 15 May 1989-14 May 1990
Commitment: 1.8 months
Location: Rapid City, SD

4) Supporting Agency: National Science Foundation
Project Title: Aircraft and Radar Investigations of Hailstorm Processes as Part of the North Dakota Thunderstorm Project
Award: $270,034
Period of Award: 15 Feb 1989-14 Feb 1991
Commitment: 2.4 months/year
Location: Rapid City, SD

B. Pending Support:

1) Supporting Agency: North Dakota Atmospheric Resource Board
Project Title: Analysis of Data for the North Dakota Thunderstorm Project
Amount Requested: $178,480
Period of Request: 1 Apr 1990-31 Mar 1991
Commitment: 1.95 months
Location: Rapid City, SD

B. Pending Support: (Paul L. Smith, continued)

2) Supporting Agency: National Aeronautics and Space Administration
Project Title: Continued Investigation of Satellite Area-Time-Integral Techniques for Rainfall Estimation
Amount Requested: $55,000
Period of Request: 1 May 1990-30 Apr 1991
Commitment: 0.6 month/year
Location: Rapid City, SD

3) Supporting Agency: National Science Foundation
Project Title: Armored T-28 Aircraft Facility for Research Requiring Storm Penetrations
Amount Requested: $183,500
Period of Request: 15 May 1990-14 May 1991
Commitment: 1.8 months/year
Location: Rapid City, SD

4) Supporting Agency: Harza Engineering
Project Title: Support of Flood Forecasting/Telemetry Projects in Pakistan
Amount Requested: $43,040
Period of Request: 1 May 1990-30 Apr 1991
Commitment: 3.0 months/year
Location: Rapid City, SD and Pakistan