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ANNUAL PROGRESS REPORT ON ARMORED T-28 AIRCRAFT FACILITY COOPERATIVE AGREEMENT (ATM-9618569)

By: Paul L. Smith and Andrew G. Detwiler

Prepared for:

Division of Atmospheric Sciences
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

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

TABLE OF CONTENTS

ABSTRACT

This is the annual progress report required under the terms of Cooperative Agreement No. ATM-9618569 between the National Science Foundation (NSF) and the South Dakota School of Mines and Technology (SDSMT). The agreement provides base support for the operation of the SDSMT armored T-28 meteorological research aircraft as a national facility for investigations into cloud, thunderstorm, and hailstorm processes. Field deployments as allocated by the NSF Facilities Advisory Council to support research projects are funded through other sources, including the NSF Lower Atmospheric Observing Facilities Deployment Pool. This report covers the period 16 December 1998 through 15 December 1999. During this period, the T-28 supported the Turbulence Characterization and Detection project, a collaborative effort to determine the ability of aircraft weather radar systems to provide useful indications of turbulence hazards in and around convective storms. Work also began on a project to identify the capabilities (and limitations) of the T-28 to provide measurements of trace gases in the atmosphere. Facility staff organized a community workshop to discuss the present capabilities and experience, as well as future needs, for storm-penetrating research aircraft. In addition, research results from prior projects supported by the T-28 were described in research papers in refereed journals and presented at national conferences. A High Volume Precipitation Spectrometer with a particle charge sensing capability was ordered for the aircraft. Additional work in the areas of instrumentation refurbishments and upgrades, aircraft system improvements, and data analysis and interpretation was carried out.

1. INTRODUCTION

This annual progress report on T-28 research aircraft facility activities under Cooperative Agreement No. ATM-9618569 covers the period 16 December 1998 through 15 December 1999. The T-28 research project support activity during this period included the Turbulence Characterization and Detection project conducted in Colorado in June, as part of the National Aviation Weather Program. The T-28 provided *in situ* observations of turbulence and other characteristics of regions in and near convective storms that had been identified by weather radar systems on two other project aircraft as presenting potential flight hazards. Work also began on a "Trace Gas Test" to establish the ability to obtain measurements of atmospheric trace gases uncontaminated by T-28 engine exhaust products. The principal upgrade to the facility capabilities was the delivery of a High Volume Precipitation Spectrometer (HVPS). A particle-charge-sensing feature is being added to this instrument as this reporting period ends.

Subsequent sections present further details of these and related activities, along with plans for future facility activities.

2. PROGRESS DURING THE PERIOD

2.1 Project Support

Support was provided to two research projects during the year. An out-of-cycle request for support of a third project (SEET) was declined per recommendation of the NSF Observing Facilities Advisory Panel and Facilities Advisory Council, primarily because of lack of deployment funds.

2.1.1 Turbulence Characterization and Detection

The purpose of the Turbulence Characterization and Detection (TCAD) project was to gain a better understanding of the air motion characteristics associated with convective activity and to determine how turbulence associated with such activity can be more reliably detected by airborne Doppler weather radar. The facilities deployed for the project included two instrumented research aircraft in addition to the T-28, two fixed S-band research Doppler weather radars (one of which also had dual-polarization capabilities), and a mobile meteorological sounding facility. Support for this program was provided by the National Aeronautics and Space Administration as part of the National Aviation Weather Program, and by Allied-Signal/Honeywell and Rockwell-Collins, two airborne weather radar manufacturers who were part of the study.

A Convair 580, operated by AlliedSignal/Honeywell, and a Rockwell Sabreliner, operated by Rockwell-Collins, each carried research airborne Doppler weather radars as well as instrumentation for measuring the aircraft response to turbulence. The armored T-28 carried a complement of meteorological, aircraft motion, and microphysical instruments, and a suite of six electric field meters. The Pawnee and CSU-CHILL radars, operated by the Colorado

State University, were used as a dual-Doppler weather radar network providing storm surveillance for guiding operations and for post-analysis of storm characteristics. The Research Applications Program (RAP) of the National Center for Atmospheric Research (NCAR) carried out atmospheric soundings on demand to monitor the thermodynamic characteristics and wind profile in the storm environment, and provided forecasting and real-time radar interpretation for operations.

Operations were directed from the CHILL radar site northeast of Greeley, Colorado. Aircraft were based at Ft. Collins-Loveland Regional Airport (FNL), in Loveland, Colorado, about 50 km due west of the CHILL radar site. The mobile sounding unit was deployed from the Foothills Laboratory of NCAR, on the northeast side of Boulder, Colorado.

When suitable convective activity developed, the aircraft were launched from FNL. They usually rendezvoused near the VORTAC (aircraft navigation beacon) near Gill, Colorado, a few kilometers northeast of the CHILL site. Under direction of an aircraft coordinator stationed in the CHILL operations trailer, the aircraft fell into a three-in-trail formation and proceeded to penetrate convective storm regions in this formation. The T-28 took the lead, with the others in trail, one about 8 km and the other about 15 km behind the T-28. The weather radars on the two trailing aircraft scanned the T-28 environment as it penetrated the storms. When appropriate, indications from those radars were used to help direct the T-28 into regions of most interest. The trailing aircraft followed the T-28 through if conditions were not too severe, or diverted around the severe regions and reformed with the T-28 on the other side of the storm. Three to five coordinated runs were performed on most days. A typical T-28 flight level was FL 200 (20,000 ft or 6.1 km MSL) with the trailing aircraft 1000 ft (300 m) above and below the T-28. In some cases, the Sabreliner operated independently of the other two aircraft in order to sample higher-altitude regions (up to FL 330) of storms while the Convair and T-28 sampled conditions near FL 200. This project also provided the first opportunity for extensive flight testing of the new 6-field meter configuration for measuring ambient electric fields from the T-28.

The first day of flight operations was Wednesday, 2 June, and the final day was Friday, 25 June. Operations were conducted 7 days a week, whenever suitable weather was present. It was a very active weather pattern, with convective weather suitable for flight operations in the project area on 15 days during this period. Table 1 gives a summary of the T-28 flights. The AlliedSignal organizers of the project provided a very favorable evaluation of the T-28 support to the project (Appendix A). A draft summary report of the T-28 participation in the project has been posted for review by project participant, and the final version will be available early in 2000.

Table 1. T-28 Flights Conducted During TCAD						
Date (1999)	*T-28 Flt. No.*	*Project Flt. No.*	*No. Hours*	*Type Mission*	*Origin*	*Pilot*
05-24	722		1.6	Test Flight	RAP	CS
06-01	723		1.8	Ferry RAP-FNL	RAP	TR
06-02	724	1	1.8	Wx Research	FNL	TR
06-05	725	3	1.9	Wx Research	FNL	TR
06-09	726	4	2.0	Wx Research	FNL	CS
06-10	727	5	1.2	Wx Research	FNL	CS
06-11	728	6	1.8	Wx Research	FNL	CS
06-11	729	7	2.1	Wx Research	FNL	CS
06-12	730	8	1.8	Wx Research	FNL	CS
06-14	731	10	2.1	Wx Research	FNL	TR
06-17	732	11	2.0	Wx Research	FNL	TR
06-18	733	13	1.9	Wx Research	FNL	TR
06-19	734	14	2.1	Wx Research	FNL	TR
06-20	735	16	2.0	Wx Research	FNL	TR
06-21	736	18	1.8	Wx Research	FNL	CS
06-22	737	20	2.0	Wx Research	FNL	CS
06-25	738		1.4	Ferry FNL-RAP	FNL	CS
			31.3 hours			
17 Total Flights 14 Total Weather Research Flights						

2.1.2 Trace Gas Test

Work was initiated on a small local test program to ascertain the potential for measuring atmospheric trace gases with the T-28 system without unacceptable contamination from engine exhaust products. Plans are to test (1) the sampling mast that was mounted atop the canopy in past projects where the T-28 carried a SF_6 analyzer for in-cloud tracer experiments and (2) inlets located in a wing pylon or at the wingtips. An NO_x analyzer and a CN counter

will be used to test for the presence of exhaust products. Two students in a Mechanical Engineering design course have undertaken the design of pylon and wingtip inlets and sampling lines as a course project.

2.2 Instrumentation and Data System Developments

The instrumentation refurbishments and upgrades planned under the cooperative agreement (Table 2) are nearing completion. An HVPS has been delivered for the T-28 and is currently being fitted with a particle charge sensor (a new capability not included in the original planning). The augmentation of the electric-field-mill system for the T-28 has been completed and comprehensive calibration procedures worked out. In addition, a three-axis (unstabilized) accelerometer was acquired and installed to provide additional aircraft response data in support of the turbulence project discussed in Sec. 2.1.1. The video camera, damaged by hail and water during the turbulence project, was replaced and a sturdier window assembly is being fabricated. Two Mechanical Engineering students (different from the two working on the trace gas sampling problem) are working on an improved anti-icing scheme for the window. We discovered, and are correcting, what may have been a long-standing error in the plumbing to the instrumentation variometer (rate-of-climb indicator) used for back-up calculations of vertical winds .

Table 2
T-28 Instrumentation Refurbishments and Upgrades 1997-1999

Item	Status
Cloud liquid water probe	New probe acquired and installed
FSSP cloud droplet probe	Refurbished and reinstalled
2D-C imaging probe	Refurbished and reinstalled
HVPS imaging probe	Unit for T-28 being fitted with charge sensor
Field mill system	Augmented
Video camera & recorder	Acquired and installed

2.3 Aircraft and Avionics Developments

Routine inspections were completed as scheduled, and the aircraft continues to be maintained under FAR Part 91 with an Airworthiness Certificate. Over the course of the year, the artificial horizon, generator, starter and vacuum pump were replaced as required with rebuilt units. The installation of an improved oil separator for the vacuum pump is awaiting FAA approval. The hydraulic pressure gage was replaced. We reconfigured the antenna array on the belly of the aircraft to reduce problems with RF interference affecting some of the data channels. The antiquated heading indicator on the aircraft failed, and a modern Horizontal Situation Indicator is being ordered to replace its functions.

2.4 Software Development

The facility software engineer developed a package to process image data from the HVPS probe. Particle image classification, artifact rejection, and calculations of concentration and size distribution statistics are supported. This software has been shared with two NCAR scientists who are working with HVPS data. In addition, he has completed an archiving project including all T-28 data acquired since 1987, and most data from 1981 onward.

2.5 Administrative and Scientific Meetings

The T-28 facility was represented at the April and October 1999 meetings of the NSF Observing Facilities Advisory Panel by the Facility Manager. He also served during this period as the University Facility representative on the NSF LAOF Facilities Advisory Council. The Facility Manager visited the NSF in February to discuss facility management and funding matters, and the NSF LAOF Program Officer paid a site visit to the T-28 facility in August.

The Facility Scientist participated in planning meetings for STEPS (formerly CESAR; see Sec. 3.1) in April, June, and November. He visited the University of Wyoming in April to present a seminar and discuss research topics, then participated (along with the T-28 Chief Pilot) in a planning meeting for the turbulence project (see Sec. 2.1.1) at Ft. Collins, CO. The Facility Scientist then attended the 29th International Conference on Radar Meteorology in Montreal in July, as co-author of a paper based on observations from the June 1998 T-28 deployment to Colorado.

The Facility Postdoctoral Scientist took part in the HIAPER planning meeting in Boulder in May and the 11th International Conference on Atmospheric Electricity in Huntsville, AL in June. The full facility staff participated in the Storm Penetrating Aircraft Workshop in Boulder in October; in addition, travel support was provided to seven Workshop participants from other institutions. Both the Facility Scientist and Facility Postdoctoral Scientist are participating in the Fall Meeting of the American Geophysical Union as of the date of this report.

2.6 Educational and Informational Activities

2.6.1 Storm Penetrating Aircraft Workshop

A workshop to explore future scientific needs for a capability to obtain measurements from the interiors of mature convective storms, and potential ways to meet those needs, was held in Boulder, CO, on 21-22 October. The T-28 facility staff took primary responsibility for organizing the workshop, with important logistics assistance from the NCAR Atmospheric Technology Division, and for compiling the results into a workshop report. About 35 people participated in the workshop, which discussed the scientific requirements for such observations, capabilities required of the observing system, and potential platforms that might serve as a basis for a future storm-penetration facility. The T-28 was flown to Jeffco airport for static display to interested workshop participants. A detailed draft report of the workshop has been completed and is being reviewed by participants prior to issuance of the final version.

2.6.2 Other Activities

Television news and educational video production organizations showed much interest in the T-28 facility activities this year, partly as a consequence of facility involvement in the turbulence project (Sec. 2.1.1). Three video production groups visited the T-28 facility, one in Rapid City and two during the Colorado deployment discussed in Sec. 2.1.1. A program segment prepared by one of the latter, Talking Turkey Productions, appeared on The Learning Channel's "Understanding Weather" program on 14 November. News segments including the T-28 appeared on ABC network news in June and on a local Rapid City newscast in November. A photograph of the T-28, taken during the TEXARC deployment in 1995, appeared (without acknowledgment of NSF or SDSM&T involvement) in a 24 July *Science News* article on weather modification.

Information was provided to the Western Kansas Weather Modification Project about past North Dakota SF_6 tracer experiments in which the T-28 was involved. In March, the facility staff hosted an afternoon visit by Gene Remmer from the Office of Naval Research and explained the capabilities of the armored aircraft facility for airborne research. Facility staff discussed turbulence research with Karl Posey, a writer for *Aviation Week*, and with Roger Bloom, a pilot and writer for the magazine of the Aircraft Owners and Pilots Association. The Chief Pilot addressed a regional meeting of the 99s (national organization for women aviators) in August regarding storm characteristics as perceived from the cockpit of the T-28. In the fall, facility staff presented a seminar to the SDSM&T community on their participation in the June convective turbulence project.

The Postdoctoral Scientist participated in a state-conducted leadership training course in November. Two undergraduate students are participating in the Trace Gas Test project (Sec. 2.1.2), and two others are working on the video camera system (Sec. 2.2).

A master's degree candidate at the University of Oklahoma, Matt Loney, completed a study of multiparameter radar detection of hail which involved analysis of T-28 observations in a VORTEX-95 storm under radar surveillance. Mr. Loney presented his results at the 29th International Conference on Radar Meteorology, and is preparing a paper for submission to a journal.

The T-28 facility staff provided an additional report in October to contribute to the NSF response to the requirements of the Government Performance and Results Act.

3. PLANS FOR NEXT FUNDING YEAR

3.1 Projects to be Supported

Work on the Trace Gas Test project will continue into the next funding year, with completion targeted for the spring of 2000.

A request for T-28 flight support of the STEPS project in May-July 2000 was reviewed by the NSF Observing Facilities Advisory Panel and Facilities Advisory Council at meetings in October. After the initial requested length of the project was reduced and some budgetary considerations were worked out, allocation of the T-28 (along with other facilities) to support STEPS was recommended. Current plans are to base the T-28 at Goodland, KS for the period 22 May - 14 July 2000.

The MIT Lincoln Laboratory has made inquiries about possible T-28 support of two projects. One would involve measurement of electric fields in wintertime storms in the Pacific Northwest, to support investigation of lightning hazards to aircraft on approach or departure paths at airports in the region. The other would involve studies of the response of an airborne weather radar system (to be carried on the T-28) to severe storms that contain hail. Both of these projects involve difficult feasibility questions, and exploration of the possibility of providing support is under way. An inquiry was received about possible T-28 support of research connected with on-going hail suppression activities in Argentina. Formidable funding and logistics obstacles make further pursuit of this possibility unlikely.

3.2 Facility Refurbishments and Upgrades

As noted in Sec. 2.2, the refurbishments and upgrades initially planned under this Cooperative Agreement will be completed with the final installation of the HVPS with a charge-sensing attachment next spring. Using cost-recovery funds generated by the turbulence project (Sec. 2.1.1), a new Horizontal Situation Indicator will be procured to replace the antiquated, and malfunctioning, heading indicator on the T-28. This will improve flight safety under IFR conditions and also permit removal of two 30-lb (14 kg) rotary inverters that will no longer be needed. Some upgrading of facility test instrumentation and ground data processing equipment is also being contemplated.

3.3 Data Analysis Efforts

The T-28 facility staff will continue with data analysis and publication work as time and resources permit. Initial emphasis will be placed on data from the 1999 Turbulence Characterization and Detection project. A major rework of the indicated-airspeed signal processing algorithm (Sand *et al.* 1976) is being contemplated to provide improved estimates of the turbulence spectrum and eddy dissipation rate. Ongoing analysis will be completed of a unique set of electric field observations in the stratiform region of an MCS in Oklahoma in 1991 involving the T-28, a NOAA P-3, and several instrumented balloons. Following completion of the STEPS deployment, the reduction and analysis of the data from that project is expected to be a major activity for facility staff.

4. PERSONNEL

The key personnel indicated in Section I.10 of the Agreement as amended remain committed to the project at the levels indicated.

5. PUBLICATION ACTIVITY

Journal Papers

Detwiler, A.G. and H. Norment, 1999: The M-Meter: A simple airborne hydrometeor measurement instrument. *Journal of Atmospheric and Oceanic Technology*, **16**, 960-969. (Reports instrument development work carried out by the T-28 Facility Scientist and colleagues. This light-weight low-power instrument can be used on a wider range of platforms than current instrumentation and will help improve understanding of precipitation processes in clouds.)

R.E. Feind, A.G. Detwiler, and P.L. Smith, 2000: Cloud liquid water measurements on the armored T-28: Intercomparison between Johnson-Williams cloud water meter and CSIRO (King) liquid water probe. Revised version submitted to *J. Atmos. Ocean. Tech*., Dec. 1999. (Reviews the history of cloud liquid water concentration measurements by the T-28 and provides new information concerning the interpretation of these measurements in the context of important physical processes in thunderstorms, such as hail growth and electrification.)

Mo, Q, R.E. Feind, F.J. Kopp, and A.G. Detwiler, 1999: Improved electric field measurements with the T-28 armored research airplane. *J. Geophys. Res.,* **104,** 24,485-24,497. (Describes procedures developed for calibrating the electric field mill system on the T-28, and dealing with charge buildup on the aircraft as well as corona emissions.)

Smith, P.L., D.J. Musil, A.G. Detwiler, and R. Ramachandran, 1999: Observations of mixed-phase precipitation within a CaPE Thunderstorm. *J. Appl. Meteor.,* **38**(2), 145-155. (Shows the importance of cloud physics considerations in inferring hydrometeor characteristics from polarimetric radar observations.)

Conference Papers

Kennedy, P.C., A.G. Detwiler, and P.L. Smith, 1999: Radar and aircraft observations of microphysical evolution in updraft regions of a High Plains multicellular thunderstorm. *Preprints, 29th Int'l. Conf. Radar Meteorology,* Montreal, Amer. Meteor. Soc., 355-357. (Presents an overview of coordinated observations by the T-28 and a polarimetric radar from a Colorado storm studied during an instrument-test project in 1998. Evidence is uncovered for multiple precipitation recirculation paths important in hail growth.)

Papers by Other Authors Using T-28 Data

Liu, H. and V. Chandrasekar, 1999: Classification of hydrometeor type based on multiparameter radar measurements: Development of neuro-fuzzy system and in-situ verification. Preprints, *29th Int'l. Conf. Radar Meteorology,* Montreal, Amer. Meteor. Soc., 172-175. (Uses T-28 observations of precipitation particles to aid in validating a radar algorithm for particle characterization.)

Lemon, L.R., 1999: Operational uses of velocity spectrum width data. Preprints, *29th Int'l. Conf. Radar Meteorology,* Montreal, Amer. Meteor. Soc., 776-779. (Uses T-28 observations of updraft and turbulence characteristics of a storm in Montana as an aid in the analysis.)

Loney, M.L., 1999: In-situ and multiparameter radar observations of an isolated Oklahoma supercell at far range. M.S. thesis, University of Oklahoma, Norman, OK. 152 pp.

Loney, M.L., D.S. Zrnić, A.V. Ryzhkov and J.M. Straka, 1999: In-situ and multiparameter radar observations of an isolated Oklahoma supercell at far range. Preprints, *29th Int'l. Conf. Radar Meteorology,* Montreal, Amer. Meteor. Soc., 188-191. (Uses T-28 and radar data to study shedding of raindrops from hailstones in a thunderstorm.)

Zrnić, D.S. and A.V. Ryzhkov, 1999: Polarimetry for weather surveillance radars. *Bull. Amer. Meteor. Soc.,* **80**, 389-406. (Uses T-28 measurements to help validate an algorithm for polarimetric weather radars.)

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Paul L. Smith

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Armored T-28 Aircraft Facility for Research Requiring Thunderstorm Penetrations

Source of Support: NSF

Total Award Amount: $1,030,970 Total Award Period Covered: 15 March 1997-29 February 2000

Location of Project: Rapid City, SD

Person-Months Per Year Committed to the Project. Cal: 1.5 mo Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Upper Missouri River Basin Hydrology Project

Source of Support: NASA

Total Award Amount: $800,000 Total Award Period Covered: 1 February 1998-30 September 2000

Location of Project: Rapid City, SD

Person-Months Per Year Committed to the Project. Cal: 1.8 mo Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Continuation of Kwajalein Radar Evaluation and Calibration Work

Source of Support: Aeromet Inc. (U.S. Army)

Total Award Amount: $26,500 Total Award Period Covered: 1 March 1999-31 December 1999

Location of Project: Rapid City, SD

Person-Months Per Year Committed to the Project. Cal: 1.25 mo Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Further Calibration Work on the Kwaj-Pol Radar

Source of Support: Aeromet Inc. (U.S. Army)

Total Award Amount: $26,850 Total Award Period Covered: 1 January 2000-31 December 2000

Location of Project: Rapid City, SD

Person-Months Per Year Committed to the Project. Cal: 1.3 mo Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

In-Situ Verification of Hydrometeor Algorithms for Polarimetric Radar

Source of Support: National Science Foundation

Total Award Amount: $395,000 Total Award Period Covered: 15 December 1999-30 November 2002

Location of Project: Rapid City, SD

Person-Months Per Year Committed to the Project. Cal: 3.6 mo Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

NSF Form 1239 (10/99) USE ADDITIONAL SHEETS AS NECESSARY

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Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Paul L. Smith

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
T-28 Deployment for the Severe Thunderstorm Electrification and Precipitation Study (STEPS)

Source of Support: NSF
Total Award Amount: $129,000 Total Award Period Covered: 1 June 2000-31 May 2001
Location of Project: Rapid City, SD
Person-Months Per Year Committed to the Project. Cal: .40 mo Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Atmospheric Water Fluxes and Budgets in Complex Terrain

Source of Support: NOAAGCIP
Total Award Amount: $510,000 Total Award Period Covered: 1 May 2000-30 April 2003
Location of Project: Rapid City, SD
Person-Months Per Year Committed to the Project. Cal: 1.2 mo Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Armored T-28 Aircraft Facility for Research Requiring Storm Penetration

Source of Support: NSF
Total Award Amount: $160,700 Total Award Period Covered: 1 March 2000-28 February 2001
Location of Project: Rapid City, SD
Person-Months Per Year Committed to the Project. Cal: 1.5 mo Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

NSF Form 1239 (10/99) USE ADDITIONAL SHEETS AS NECESSARY

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7. COST SHARING FUNDS

As of 1 December 1999, SDSM&T has provided $185,955 in cost-sharing expenditures in support of this Cooperative Agreement. This exceeds the amount called for under the provisions of Paragraph I.B.4 of the Agreement.

8. RESIDUAL FUNDS

We anticipate a residual balance at 29 February 2000 of about $63,300. This is almost entirely in the Salaries and Benefits category, with associated Indirect Costs. The unexpended funds in these categories resulted primarily from the relatively slow pace of T-28 deployment in the initial stages of this Agreement. A request for a one-year extension of this Agreement, submitted by letter dated 27 October, included a budget that reflected this carryover estimate.

There is also a current residual balance of about $8,000 in the account for the Trace Gas Test deployment.

9. COST RECOVERY FUNDS

Cost recovery funds in the amount of $22,876 were generated during the period covered by this report, from the Turbulence Characterization and Detection project (Sec. 2.1.1). At this time no cost-recovery deployment activity has been allocated or requested for the next funding year; it is possible that a request will develop from the MIT Lincoln Laboratory inquiries (Sec. 3.1).

10. REFERENCES

Sand, W.R., J.L. Halvorson and T.G. Kyle, 1976: Turbulence measurements inside thunderstorms used to determine diffusion characteristics for cloud. *Proc. 2nd World Meteorological Organization Conference on Weather Modification,* Boulder, CO, 539-545.