Review and Evaluation of the  
South Dakota School of Mines and Technology Proposal  
For a Doctoral Program in  
Atmospheric and Environmental Studies  

By: John T. Snow  

Report prepared: 1 December 2004  

1. Background.  

In a 10 November 2004 letter from Dr. Paul Gough of the South Dakota Board of Regents (Attachment 1), I was charged with the following:  

a) Examine the proposal and supporting documents requesting the establishment of a new doctoral program in Atmospheric and Environmental Studies (AES) at the South Dakota School of Mines (SDSM&T);  

b) Interview faculty, staff, and administrators during a visit to SDSM&T;  

c) Evaluate facilities, equipment, and related services; and  

d) Prepare a written report addressing the questions related to the four topic areas given below.  

I was provided with copies of the proposal from SDSM&T together with other materials from both SDSM&T and the Regents. Dr. Gough arranged for me to visit SDSM&T on 21/22 November (Attachment 2 provides a copy of the agenda for my visit). This visit afforded me an opportunity to visit with administrators and faculty, and to see first hand the facilities on the campus of SDSM&T in Rapid City, South Dakota.  

2. General comments:  

The doctoral degree is inherently a research degree. Consequently, in evaluating the proposal for a new doctoral degree, it is essential to consider the nature of the research efforts in the institution and the quality and expertise of the faculty. Hence many of the points in my responses deal with the research efforts within which the proposed AES doctoral program would be embedded.  

The proposed program represents a continuation, in part, of a currently existing doctoral program, the Atmospheric, Environmental, and Water Resources (AEWR) program offered jointly with South Dakota State University (SDSU). The record of the AEWR program, as implemented by SDSM&T, is good, with a slow but steady production of PhD’s over the last
decade. The handling of the AEWR program by SDSM&T administration and faculty indicate a very high probability that the proposed AES doctoral program would be, as a minimum, equally successful.

It is important to note that the proposed AES program is more than a direct, one-to-one placement for the AEWR program. The proposed AES program does carry forward elements of the AEWR program but also proposes new research efforts unique to the SDSM&T – Black Hills context, emphasizing more strongly the meteorology-climatology-ecological/environmental aspects of the previous program. The proposed AES program de-emphasizes the Water Resources element of the AEWR program. As noted below, this causes some difficulties with the Civil Engineering connection.

While I have used the term “student” throughout, in reality doctoral students are junior professionals, typically in their mid-20s. Almost all will have completed 6 to 7 years of previous university study before embarking on doctoral work. They are far more independent and self-directed than undergraduates, and are generally well connected with peers at other institutions around the nation. One should think of such individuals more as aspiring colleague-collaborators with the faculty rather than “students” in the common usage of that word. Because of their larger experience base, good doctoral students tend to be more discriminating (and less tolerant) than undergraduates or even M.S. students in the way programs are operated.

Attracting high quality domestic doctoral students in the sciences and engineering disciplines is a challenge. There is great competition among leading research institutions for well-prepared domestic doctoral students because so many otherwise well qualified students elect to pursue careers in business, law, and medicine rather science or engineering. At present, the pool of foreign students is shrinking rapidly due to the challenges now faced by foreign students in obtaining visas to come to the U.S. for study. In the past, doctoral programs could rely on getting a good group of well-prepared foreign students each year, but for the foreseeable future such programs will need to compete effectively to attract a larger share of the available domestic students. A proactive faculty, a well-tailored web presence, and attractive hardcopy advertising and recruitment literature will be essential to obtaining the graduate students necessary for the proposed AES program to realize its full potential.

3. Responses to the four questions.

a. Program Curriculum:

1) Does the proposed curriculum meet or exceed current national standards and expectations for the discipline?

Yes. The proposal outlines a program of study that provides for a common core of required courses while remaining adaptable to each student’s research interests. The requirement that each student prepare a review literature relevant to his or her proposed research topic is a very positive feature of the program. An essential element of any doctoral program is for the student to become very knowledge about the literature in his or her area of interest. In many programs
this is handled implicitly; the fact that the propose program lays out explicit expectations in this regard is excellent.

2) *Will the proposed program provide students with sound preparation for their careers?*

Yes. The expectation for individuals holding the doctorate is that they will do original work in the area of their degree. The proposed program provides for a combination of course work, literature review, and research leading to a dissertation that should allow students to develop and then demonstrate their capacity for making original contributions. The faculty who will teach the proposed core courses and guide the student through the research component of the program have excellent reputations in their fields and a long history of working successfully with students at both the Masters and doctoral levels.

3) *What changes do you recommend?*

The proposed doctoral program is a good one, and I am confident it would produce well-prepared graduates if the situation at SDSM&T continued more or less as it is today. However, to become a nationally competitive program (which is what I heard both the institutional leaders and the faculty say they wanted to do), I strongly recommended that the faculty settle on a small number of research areas (say 3 or fewer) and focus\(^1\) their collective efforts on becoming the absolute best in the nation in those areas.

The description of the proposed doctoral program suggests a very broad program, one that will address topics ranging from climate change, to mesoscale modeling, to airborne instrumentation, to paleo-ecology. This may cause the program problems in attracting top quality students to SDSM&T. Students are attracted to a particular doctoral program for many reasons, but in the main they apply because of the reputation of the program in a specific, well defined area. There is also a question of resources. The resources -- people, space, and budget -- available to SDSM&T appear to be modest compared to major research universities such as the Univ. of Michigan or the Univ. of Texas – Austin, yet such institutions are the direct competition for students and research dollars. Consequently, institutions such as SDSM&T must focus their research programs on a few, very well defined areas to compete successfully and excel.

The program has several opportunities on the intermediate term to develop centers of excellence that would compete with the largest research universities in the nation:

- Several faculty I interviewed discussed the concept of a “Laboratory of the Black Hills”. This could be developed as very competitive proposal to the emerging National Ecological Observatory Program (NEON) at the National Science Foundation. The Black Hills region represents a unique area and would be a good location for a NEON Facility. Such an effort will require integration of the

\(^1\) “Focus” is a word that is often used in discussing programs such as the one proposed here. To clear, I am using the word “focus” to indicate that there should be a small but coherent set of interconnected research themes. This does not mean that all of the research done in the program would be in these few thematic areas. However, a retrospective view from 2015, say, of the theses and papers produced by the program should show that the majority fall into the theme areas.
meteorological, climatological, geological, and ecological expertise in the faculty. The faculty have the expertise and apparent interest to develop a NEON proposal and should be encouraged to do so.

- I was pleased to discover interest in wildfire research in the proposed AES program. Wildfire in all its forms is becoming a major natural hazard as our society spreads across the landscape. Up to the present, wildfire research has been limited to the National Center for Atmospheric Research and a few small government laboratories. With careful planning, I believe SDSM&T could develop a very interesting program in wildfire dynamics that would blend meteorology, ecologically, hydrology, and the social sciences. Research topics could range from evolution of the fuel load, to fire plume chemistry, to post-fire flooding and mudslides. Wildfire research represents an interdisciplinary area where SDSM&T could take the national lead. However, again careful planning will be required and funding sources identified.

- SDSM&T is well known for its decades of work with the armored T-28 aircraft, now retired. Its efforts to acquire an A-10 aircraft to continue its storm environment and storm penetration work are to be applauded. If this acquisition effort is successful, SDSM&T will have a unique facility with some base funding from the National Science Foundation. Again with careful planning, there are numerous opportunities for the AES program to lead the nation. I would encourage the faculty to consider taking advantage of the engineering expertise on the SDSM&T to develop local capacity to design and fabricate instrumentation for airborne research. Development of such local capability will not only enhance local research using the aircraft, but may also present opportunities for the development of spin-off companies.

Two final points on the above three opportunities: First, none are essential to the success of the proposed AES program. However, success with any one or any combination of the above three efforts would bring unique aspects to the program making it much easier to attract good students and research funding. Second, the above three efforts in many respects are complimentary and mutually synergistic. For example, technology could be developed to allow an A-10 platform to observe the details of the spread of a fire front in a wildfire.

b. Faculty:

1) Does the university have sufficient faculty with appropriate expertise to offer the program?

Yes. The current faculty are adequate in number, have a sufficient range of expertise, and are sufficiently established in their professional reputations to offer the proposed program, beginning today.

2) What professional development or additional expertise is needed to implement the program at a high level of quality?

SDSM&T and the State need to plan now for the possible rapid evolution of this doctoral program in the intermediate future. (Keep in mind that a doctoral program such as proposed
directly reflects the primary research thrusts of the institution.) As noted above, there are emerging opportunities for SDSM&T and the State to take national and international leadership roles in key areas such as wildfire dynamics, ecological studies, and airborne observations and measurements. However, this will happen only if the institution develops and implements a strategic plan for faculty replacement and new faculty hires (and the associated issues of start up, staff support, and space). The burden for developing such a plan falls on the institution since this is a multidisciplinary program. The institution should avoid the classic tendency for faculty to simply replace colleagues who have departed with individuals of similar skills. Rather, replacements and new hires should be made for the express purpose of strengthening specific research efforts.

At the time of this review, the faculty have underway various efforts which hold great promise (e.g., establishing a NEON site in the Black Hills, acquiring an A-10). How such efforts will play out over the next 12 to 18 months is not clear, but if only one of them comes to fruition, it will have a major impact on the kinds of research that will be done under this doctoral program. The institution should be doing some preliminary planning concerning the likely types of faculty and technical staff that will be needed over the next decade to maximize the impact of obtaining a NEON facility, acquiring an A-10, etc… (However, none of these efforts are essential to have an excellent AES program.)

**c. Facilities, Equipment, and Services:**

1) *Does the university have the facilities and equipment needed to offer an excellent program?*

The facilities available today should be characterized as marginally adequate. The spaces visited were clean and appeared well maintained. The equipment observed, including a very nice 3-D visualization facility and a chemical analysis laboratory, appeared to be in good to excellent condition. The GIS facility would be considered adequate, but given the centrality of GIS (or GIScience) to many of today’s science and engineering disciplines, it appeared that it could use some upgrading.

The most serious shortcoming in terms of facilities is the fact that the various elements – faculty offices, student spaces, laboratories and research spaces – are scattered around the campus. Particularly for a multidisciplinary program of the sort proposed, contiguous space to the maximum degree possible is highly desirable. Students from diverse professional backgrounds need to routinely interact to maximize the overall learning and research experience. While modern technology affords many ways of communicating and collaborating over short and long distances, the best science is still done sitting around a table with cups of coffee. Every effort should be made to house all the graduate students of this program together, ideally with as many of the research facilities as possible in the same location.

2) *Are support services (library, technology assistance) sufficient to support a high quality program?*

I did not have the opportunity to personally review the holdings of the SDSM&T libraries or to determine exactly what sort of on-line access to the literature is being provided to faculty, staff,
and students. However, during the interviews I received numerous comments that even though the institution is making investments in the library, access to materials remains marginal at best. This is worrisome since the proposed program will require students pursuing the AES degree to survey the modern and historical literature relevant to the selected research topic. While much can be done via interlibrary loan programs, learning to browse critically and effectively the vast (and rapidly growing) scientific literature is a skill that can not be developed except through real time access. Doctoral students in the proposed program will require access to all the publications of the major scientific societies in the relevant areas, such as the American Meteorological Society, the Ecological Society of America, and the American Geophysical Union, and should have access to the numerous commercial journals published by Elsevier and other large publishers. These last may be the high dollar items that are most difficult to obtain locally. Given the relatively modest number of students likely to be in this program, as a stopgap, it may be less expensive to establish a small fund to support student travel for a few weeks each year to a major research library such as the one at the National Center for Atmospheric Research.

3) **What additional investments, if any, do you recommend?**

If the SDSM&T is successful in its efforts to establish a program in wildfire dynamics, develop a NEON facility in the Black Hills, and/or to acquire an A-10 for development as a research aircraft, the institution needs to be prepared to make investments in terms of both human and fiscal resources. Of course, the long term payoff for projects of this scale can be quite handsome in terms of both prestige and research income, but there can be significant upfront costs that have to be covered to be competitive at this level. The SDSM&T administration needs to work very closely with the faculty on these and similar major efforts to ensure that if successful, the resources are in place to carry out the institutional commitments in a timely manner.

Investments need to continue to be made in the SDSM&T library. I suggest that the faculty of the proposed AES program establish a “library committee” that maintains a prioritized list of journals, on-line access, and other library materials (updated yearly) that are needed to support the proposed doctoral program. SDSM&T should commit doing what it can over time to provide as many of these materials as possible.

**d. Summary Recommendation:**

1) **What do you see as the strengths and weaknesses of the proposed program?**

I see few weaknesses and many strengths in the proposed AES program. The weaknesses deal with such relatively minor issues (minor at this stage anyway) as lack of contiguous space for the program, the weakening of the linkage to the water resources area, and the need to strengthen access to the scientific literature. The strengths of the proposed AES program lie with the faculty. The individual faculty members have national reputations (international in some cases) and appear to be a collegial group used to working collaboratively, to a large extent independently of traditional departmental boundaries.

My fear is that the State, the institution, and the faculty will set their goals for this program too low. There are some exciting possibilities with the proposed program, but the easy route is to
continue to do, more or less, that which has been reasonably successful under the AEWR program.

2) *What recommendations do have for the Board?*

I have the following recommendations for the Board of Regents:

Approve the program as proposed with the caveat that the SDSM&T administration work with the relevant faculty to bring more focus or coherency to the AES doctoral program; review at 18 months after approval.

Recognize that in absolute terms, this will be a relatively small program in terms of numbers of graduates (though potentially large in impact), so grant the waiver requested on the 7-10 rule for classes offered under this program which enroll only doctoral students.

I have the following recommendations for the SDSM&T administration:

Provide up to 8 or so months of support for graduate students each year, apportioned among the entering students to carry them from an August start date until grant support gets underway. In return of course, the supported students should serve as Teaching Assistants or in other appropriate capacities. The faculty have a serious challenge with providing students support at initial entry into the program. This arises from a mismatch between when students typically start (e.g., August) and when grant support may be come available (e.g., some months later). The administration can assist the faculty by taking more risk in making offers to potential doctoral students and provided some limited bridge funding for students, especially when a proposal has been accepted by not yet funded.

Ensure that the students currently enrolled in the AEWR program have an opportunity to complete their degrees under that program.

Ensure that the Masters program currently in place in Atmospheric Sciences remains strong, well populated, and retains a distinct identity. This MS program has produced many outstanding graduates that have gone on to highly productive careers. Starting the proposed AES doctoral program should be seen as an opportunity to for strengthening the Masters program by increasing the overall population of high quality students. Doctoral students can also be used as instructors to enhance the course offerings in the M.S. program. Avoid situations where many of the same courses are taken by both the M.S. and the doctoral students – this will weaken both programs.

Monitor the program to ensure that students receive adequate guidance and make good progress toward degree completion. In interdisciplinary programs of this type, most students will need careful guidance and advising to balance breadth with depth. It is also important that students move through the program in a timely manner. I suggest that one faculty member be identified formally as the program coordinator (or similar title) and
then be specifically charged with monitoring student progress. The coordinator should meet with every student and his/her advisor at least once per year to discuss progress toward the degree, and submit a summary report yearly to the SDSM&T administration. In addition, the coordinator should conduct an entry interview with every student admitted to the program (why did you select the SDSM&T?, what are your expectations?, etc…) and exit interviews with every graduate or student departing for other reasons (how did it go?, how can the program be improved?, etc…). The coordinator should also conduct a new student orientation program each year.

Explore with the faculty of Civil Engineering the development of stand-alone doctoral program in water resources. The water resources community (in large part, an engineering community focused on design and management questions) is quite different from the atmospheric and ecological science communities (which in the main are science communities focused on increasing our understanding). The atmospheric and ecological groups at SDSM&T appear to have grown and developed aspirations that are moving their research in directions away from a close alignment with “water resources”. Their new interests are aptly reflected in the name “Atmospheric and Environmental Studies” for the proposed degree program. While there will always be connections between the atmospheric and environmental sciences and the engineering community, these groups should not forced into a bad multidisciplinary marriage. It is important to many employers (and hence to students) that a doctoral program in the water resources field have a practical, design/management orientation and have the term “water” to appear in the degree title. With the loss of word “water” in the program title and the strengthened emphasis on the science components of the proposed AES program, there may be a transient fall off in doctorates granted due a decrease in the number of students in the water resources area who will go to more traditional engineering programs. I anticipate that from an institutional perspective, this loss may be offset overall by growth in new areas opened by the AES program. However, this will not help Civil Engineering per se. Given the productivity of water resource doctorates under the AEWR program, the SDSM&T administration and the Civil Engineering faculty should explore the possibility of establishing a stand-alone doctoral engineering program in water resources.

I have the following recommendations for the faculty who will participate in the AES program:

- Review and provide detailed guidelines for students concerning the route to and details of the qualifying examination. These guidelines should reflect the multiplicity of routes that students may take into the program: direct admission from the B.S (i.e., without first completing an M.S.); completion of an M.S. at SDSM&T in a relevant discipline; completion of an M.S. at another institution in a relevant discipline; etc… The goal should be that upon successful completion of the qualifying examination, all students are up to speed and are more or less equally prepared to move forward with their research programs, independent of their initial backgrounds.

- Collaborate on the development “knowledge expectations” for each of the core courses. Knowledge expectation documents state the general purpose of the course; the pre-requisites for the course; the goals of the course, including a brief discussion of how they
will be attained; and a listing of knowledge expectations or learning outcomes for the student. They are written at a higher, more general level than the course syllabus which contains the details of a particular offering of a course by a particular faculty member. Syllabi for the same course can vary with from semester to semester and between faculty members, but the knowledge expectations or outcomes remain the same. Since this is a multidisciplinary program with faculty from various departments, backgrounds, and interests, such documents can greatly assist in ensuring that all involved know in detail what others are teaching. Such documents can ensure that all necessary material is covered in ways that are mutually reinforcing while avoiding un-needed redundancy. Further, since all students in the proposed program must take the core courses and since the students likely have wide range of backgrounds, such documents help immensely in communicating to the student the learning outcomes expected from each course. I enclose two sample Knowledge Expectation documents in Attachment 3.

Move forward with the development of an NSF Integrated Graduate Research, Education, and Training (IGERT) proposal. This would be an outstanding way to initiate the program and call national attention to it. Be careful and deliberate in the preparation of the IGERT proposal. This is a highly competitive program where it often takes two or more submissions to win an award.

Consider adding a requirement that all doctoral students should be required to teach one regular class; provide a number of ways for students to fulfill such a requirement, including teaching a nearby institutions and in tribal colleges. Organizing and teaching a class is one of the best ways to learn material. Teaching a class also drives home the necessity of learning good presentation skills.

Consider adding to the core, perhaps in the sense of a capstone course, a course in entrepreneurship. If done properly, such a course will add breadth and an interesting dimension to the program, even for those students who plan to become academics.


I would like to thank Dr. Gough and my colleagues at SDSM&T for an enjoyable, informative visit.

John T. Snow  
Dean, College of Geosciences  
The University of Oklahoma

Attachments:
1) Letter, 10 November 2004, from Dr. Paul Gough, South Dakota Board of Regents  
2) Agenda for 21/22 November 2004 visit to SDSM&T  
3) Sample Knowledge Expectations documents