Final Panel Report on Montana Tech's Contribution to the Proposed PhD Program in Material Science at Montana Tech, University of Montana and Montana State University

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Date submitted: March 9, 2012

Introduction:

The panel was invited to visit Montana Tech on February 9th and 10th, 2012, in order to review the faculty, facilities and students as they relate to a proposed PhD program in Materials Science. We were given the following charge from Chancellor Donald M. Blackketter:

"Montana Tech asks the four person review panel to provide the campus with open and candid input on our Material Science PhD proposal, our faculty, facilities, students, and any other areas that the committee deems appropriate. We would ask that the review panel provide us with identified strengths in each of the aforementioned areas as well as any areas in which we need to focus our efforts to make the joint PhD a quality program."

We were also asked to be prepared to provide feedback and answers to questions such as the following:

- Is there a need for a Montana-based PhD program in Materials Science?
- What are the national needs for material science in the context of the proposed program?
- What are the strengths and weaknesses of the proposed program?
- What collaborative opportunities exist with other institutions and PhD programs: regionally, nationally, globally?
- What funding opportunities exist regionally, nationally, globally?
- Are the courses currently offered by Montana Tech adequate? Should courses be developed or improved to cover specific areas?
- Are the Montana Tech facilities (classrooms, labs, equipment, etc.) adequate?
- Are faculty qualified and their number adequate? Can they be competitive?
- What are areas in which we may need to focus our resources?

Findings:

- **Is there a need for a Montana-based PhD program in Materials Science?**

The external review team concluded that there is a strong need for a PhD in Materials Science in Montana based on several factors:

1. Through discussions with most of the Montana Tech metallurgy and materials faculty and several individuals representing the University of Montana and Montana State University, the review team observed an expressed need and desire for such a program at each of the three universities. It is critical that a majority of the relevant faculty at all three institutions be committed to the joint PhD. The team was able to determine that all faculty at Montana Tech were committed to the program. Reasons for support of the program varied, but it was clear that Montana Tech is already a strong research university, as of course are the other two institutions, and that the lack of a PhD program is holding back the involved departments and students. It is noted that a number of students have in effect already earned a PhD in Materials Science through a joint Individual Interdisciplinary Program (IIP) between Montana Tech and the University of Montana, demonstrating a need for the program as well as an ability to collaborate between these two institutions. It is also clear that many students have left the Montana higher education system to pursue Materials Science related degrees at institutions in other states due to the lack of such a degree in Montana. The review team had the opportunity to interview one student in the IIP program who expressed strong opinions that he wanted a PhD in Materials Science rather than the Interdisciplinary PhD. His views were apparently shared by other students in the past who left Montana to pursue degrees elsewhere.

2. Through discussions with seven representatives of six Montana companies, the team learned of the strong support of industry for the program. These companies were Resodyn, REC Silicon, GE SeaCast, Montana Process Engineers, MSE-TA, and UTRS. Several of these companies are already collaborating with the Universities on materials science projects. All expressed very strong interest in a PhD program. All were interested in recruiting students and in collaborations, and indicated a sincere interest in providing support to the program. The review team was impressed by this very strong support from local industry.

3. The proposed joint PhD in Materials Science is quite unique in several respects. First, the capabilities of Montana Tech in the areas of primary minerals and materials beneficiation, extraction and refining technologies are no longer common at U.S. Universities. Consequently Montana Tech is well poised to address many emerging issues associated with critical materials and energy production in the U.S. See for example:

http://energy.gov/articles/department-energy-releases-its-2011-critical-materials-strategy

The University of Montana brings both strong Physics and Chemistry programs and research capabilities that are strongly synergistic with Montana Tech's research and education emphases. Montana State University has strong programs in Chemistry, Physics, and Mechanical Engineering; a particularly successful research program is in the area of bio-interfaces and biomimetic materials, which is also strongly synergistic with both the University of Montana and Montana Tech programs. Combined, the three Universities would provide a unique and very strong foundation for a Materials Science PhD program positioned to address many materials related issues associated with critical materials, energy materials, biomaterials, and advanced materials for extreme environments.

In summary, the team concluded that there is a clear need for a PhD program in Materials Science in the state of Montana based on the national need, the need of both faculty and students, and the strong local and regional needs of industry for such a program.

- **What are the national needs for material science in the context of the proposed program?**

There is clearly a strong national need for PhDs in Materials Science fields. At the most recent Deans' Council meeting in Washington D.C. (week of 2/6/2012) Energy Secretary Chu encouraged university deans to concentrate on research and education that will bolster a renaissance in manufacturing. He cited "huge opportunities in power electronics" as well as high-strength steels, and predicted "a golden age in materials and materials manufacturing." John Holdren, Assistant to the President for Science and Technology, issued a report in June 2011 which announced the "Materials Genome Initiative for Global Competitiveness." This initiative was adopted by a number of federal funding agencies in 2011 including NSF, DOE, DOD, and NIST. These agencies are now directing funds to further strengthen research in materials science and engineering with emphasis on renewing the U.S. strength in materials manufacturing. A link to this report is provided below.

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDwQFjAB&url=http%3A%2F%2Fwww.whitehouse.gov%2Fsites%2Fdefault%2Ffiles%2Fmicrosites%2Fostp%2Fmaterials_genome_initiative-final.pdf&ei=Nok2T73xIo7XiAL2y5GnCg&usg=AFQjCNEtejxPGT65mGDq0IZwABtdvPUlzQ

The national need for materials scientists was also addressed well in the Universities' proposal to the Montana Board of Regents, which cited U.S. Bureau of Labor Statistics Occupational Outlook data for growth in this area, and the need for individuals with advanced degrees, particularly PhDs.

- **What are the strengths and weaknesses of the proposed program?**

The strengths of the proposed program include a well-established and well recognized metallurgical and materials engineering department at Montana Tech, an existing collaboration between Montana Tech and the University of Montana in chemistry and an opportunity to work with Montana State University in several important materials science and engineering areas (i.e. biomaterials, chemical engineering, mechanical engineering, etc.). Each of the three universities can provide part of an excellent platform for the development of this program. The combination of strengths can lead to an excellent Material Science PhD program. Specifically, Montana Tech's strength lies in the faculty, students and facilities in Metallurgical and Materials Engineering. The mature nature of this program, its track record in funded research, its excellent industry and alumni base, and its international recognition, will provide credibility to the new program.

The weaknesses are largely related to the development of the resources needed to grow this program and to assure the quality of the program. The ability to hire new faculty that can serve both the undergraduate programs, develop fundable research proposals and carry out supervision of PhD level work is very important. The ability to have graduate teaching assistants available is also very important, as is the ability to support technicians for maintaining and repairing laboratory equipment. A final weakness is a lack of clarity in the plan to administer and direct this program as a statewide collaborative effort.

- **What collaborative opportunities exist with other institutions and PhD programs: regionally, nationally, globally?**

The potential exists for the Material Science PhD program to develop collaborations with other universities, national laboratories and research institutions through various mechanisms. Having a PhD degree program will open doors that are not currently available to Montana Tech. Montana Tech and Montana State both have research facilities that are not widely available elsewhere in the U.S., making them valuable partners in collaborative programs. Numerous collaboration opportunities arise through solicitations from the U.S. Department of Energy, Department of Defense, and the National Science Foundation (NSF). Notable global opportunities include the Materials World Network (MWN) initiative periodically sponsored by NSF.

http://www.nsf.gov/pubs/2004/nsf04599/nsf04599.htm

What funding opportunities exist regionally, nationally, globally?

The primary funding opportunities are those that exist are on the national level. Two such opportunities are from the U.S. Department of Education and NSF. The Department of Education program that supports students in graduate programs is called the Graduate Assistance in Areas of National Need (GAANN).

http://www2.ed.gov/programs/gaann/index.html

The proposed Materials Science appears at first glance to be a program that would be considered for GAANN support. Another national program to consider for support of PhD students (domestic) is the NSF Integrative Graduate Education and Research Traineeship program (IGERT).

http://www.igert.org

The multi-disciplinary, multi-institutional Materials Science PhD program appears to be well suited for support by the IGERT program. Private foundations too should be considered for funding of the program, e.g., the Gates Foundation and their Innovation and Technology program for secondary education.

http://www.gatesfoundation.org/postsecondaryeducation/Pages/innovation-and-technology.aspx

Another potential NSF program that should be targeted for Mat Sci program development is the Research Infrastructure Improvement (RII) program.

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503429

The RII program cycle is five years and holds the potential for $20M in funding. Consequently, the RII cycle might be such that the PhD program creation might occur in advance of the next RII cycle.

Internal sources of funding within the Montana system must also be explored. Funding may exist through redirecting existing GRA/GTA lines from supporting programs like Metallurgical Engineering, Chemistry and General Engineering or through sunsetting programs that no longer meet the long term vision of the university. One option that should be explored is alternate year teaching of many of the junior and senior level courses (e.g. EMAT 401, EMAT 460) to essentially reduce faculty teaching loads by 50%. Such curricular revisions undoubtedly would require great thought and consideration of course prerequisites.

- **Are the courses currently offered by Montana Tech adequate? Should courses be developed or improved to cover specific areas?**

The available MT Tech courses are primarily at the upper undergraduate/M.S. student level. The courses should be critically evaluated to elevate and create new courses specific to the proposed PhD level. Of course, creation of new PhD courses must occur while simultaneously reducing the teaching loads of the faculty from the current 3-4 courses per semester. Such an effort can only occur by some combination of the following: 1) adding new faculty lines 2) streamlining the undergraduate curriculum to make it more efficient and 3) using distance education to share PhD-level courses.

During the site visit the team did not visit the distance education classrooms. If a state-of-the art distance classroom does not exist on all three campuses this infrastructure should be put in place to support the proposed program. For example, use of the Access Grid has been demonstrated in a number of locations to provide quality distance education graduate courses. System constraints in terms of cross listing of courses, minimum number of students registered to allow teaching of courses should be addressed by each campus to facilitate distance course sharing. There should be a reward system put in place to encourage development of distance courses (perhaps a one course reduction the first time a distance course is taught). Comparison of the list of program–related courses offered by UM, MT Tech, and MSU shows several courses that seem to be redundant. This offers the opportunity for intercampus rationalization.

The three campuses should consider developing core courses specific to the new program, perhaps one core course per campus initially. The MSU course on Kinetics and Dynamics (CHMY 559) is an example of this type of course; the MT Tech course on Characterization and Analysis (EMAT 471) is another. Faculty who develop these courses, along with the faculty guiding graduate students in the Mat Sci PhD program, should meet face-to-face at least once every six months to build the necessary personal relationships necessary for a successful multi-institutional program. Similarly, a program director (head) needs to be identified that has overall authority over the program. This position could rotate between campus to reflect the statewide nature of the program.

- **Are the Montana Tech facilities (classrooms, laboratories, equipment, etc.) adequate?**

The evaluation team did not see any classrooms, most importantly the distance education classrooms. See the previous comments concerning the need for state-of-the art distance education classrooms to deliver cross listed PhD level courses.

The evaluation team was impressed by the research infrastructure (space, equipment) available. Put succinctly, the MT Tech research facilities are “PhD program ready.” The need for technician support bears repeating.

A plan should be put in place to share major equipment holdings between the three campuses. For example, MT Tech would benefit by a cyber-enabled TEM at one of its partner campuses. This should be a primary task, along with course coordination, of the Statewide Director.

- **Are faculty qualified and their number adequate? Can they be competitive?**

Only the Montana Tech faculty was interviewed, so this only relates to Tech. The faculty in Metallurgical and Materials Engineering, the technical staff of CAMP, and the faculty in Chemistry and in Geosciences all are committed to developing this program. The faculty is qualified to supervise PhD level work and have been doing so through the IIP program. They

have a track record of externally funded research over many years. There is no question that they can do what is needed to develop a credible PhD program. Although they will start the program with no new faculty, the proposal calls for additional faculty at each school that will be funded through the growth of the program and the indirect costs that will be generated.

The panel feels very confident that, given the required resources, the faculty at Montana Tech can be competitive.

- **What are areas in which we may need to focus our resources?**

Resources for the PhD in Materials Science

Combined, the three universities have very good resources for executing a PhD in Materials Science including facilities and human capital. Unfortunately, the team was only able to visit one of the three institutions, Montana Tech. But through discussions with faculty and surveys of each websites, the team was able to gain a relatively comprehensive understanding of each University's resources. The following are comments and recommendations of the review team concerning resources:

1. Individually, it would appear to be quite challenging for any one of the three Montana universities to develop a PhD program without significant additional resources. Collaboratively, the three universities have an opportunity to develop a unique, highly competitive PhD program, with minimal need for new resources.

2. The proposed PhD could be leveraged strongly by institutional support at Montana Tech and the University of Montana through the Individual Interdisciplinary PhD program.

3. The proposal has identified six University of Montana faculty (Chemistry and Physics), 13 Montana Tech faculty (Metallurgy & Materials Engineering, General Engineering, Chemistry, and Biological Sciences), and 18 Montana State University faculty (Chemistry, Physics, Mechanical & Industrial Engineering, and Chemical & Biological Engineering) that could potentially contribute to the program. Thus, the total number of faculty that would contribute to the program is approximately 37. This level of faculty capital is more than adequate to support a PhD program in Materials Science, given that they have sufficient time to dedicate to the program.

4. While neither the proposal nor discussions with the faculty, administration, or industrial representatives provided the review team with any specific numbers, it was clear that there is strong community support for the proposed PhD in Materials Science. If created, the team felt assured that significant industrial support for the program would be inevitable.

5. The review team found the quality and quantity of materials research at Montana Tech, in particular, quite remarkable given the lack of a formal Materials Science PhD. The

existence of a PhD program in Montana will enable the universities to compete for competitive grants and raise the quality of research at all three universities in the materials field. Consequently, the team believes that the PhD will lead to an increase in extramural support at the three universities.

6. The review team feels that it is important for faculty involved in the program to have reduced course loads in order to assure a high quality PhD program. This should be done without negatively influencing the undergraduate programs. Mechanisms for reducing teaching loads include using adjuncts, adding new faculty or lecturers, finding course efficiencies through distance education between the three institutions, and reducing the number of required credits for both undergraduate and graduate degrees, which are currently high. New funding may be required to add new faculty or distance education resources, while no funding is needed to reduce credits and identify redundancy or synergies in course offerings among the three institutions.

7. The review team recommends that the Montana Universities strengthen their proposal by including projected budgets and/or specific recommendations for achieving teaching efficiencies among the departments. This requires establishing a detailed curriculum for the PhD program including a multi-year course plan and assessment of faculty teaching loads. While the faculty have indicated no new resources are required to initiate the program, the reviewers feel that the program will suffer in the long run. The enthusiasm and motivation of the faculty certainly gave the review team confidence that the PhD will be successfully implemented; institutional support of this research-intensive degree is needed to assure longevity. While state support appears to be unlikely, the universities and industrial partners should identify mechanisms for financial support.

Final Comments:

1. Montana Tech is already supporting a PhD degree program as has been demonstrated through the utilization of the IIP program with the University of Montana. This can be expanded through this new program to include a more discipline specific degree.

2. It is the panels believe that the current resources and capabilities are sufficient to start the program and that it will grow.

3. The panel believes that it is in the best interest of the students and faculty from Montana Tech that the PhD students enrolled in this program should receive their degrees from Montana Tech.

4. The (materials science) relationships between MSU and faculty at Montana Tech and UM are clearly not strong. This could have significant political ramifications if the structure of the degree is not formalized sooner rather than later.

5. The Montana Tech department has had some reliance on government appropriations. With the elimination of much of this funding nationally, the proposed PhD program could suffer somewhat. They will need to increase the percentage of funds coming from competitive grants and/or industrial partners.

6. Ways to reward or incentivize collaborations between universities need to be developed.

7. There is a need for a Statewide Director/Coordinator that could be rotated between campuses, but has a clear expectation to make the program successful.