PROPOSAL FOR A MASTER OF SCIENCE

DEGREE PROGRAM

IN EXPLOSIVES ENGINEERING

(ExpEng)

Department of Mining and Nuclear Engineering

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Missouri University of Science and Technology

Rolla, Missouri 65409-0450

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May 2009
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Executive Summary – Master of Science in Explosives Engineering at Missouri S&T

1. EXECUTIVE SUMMARY

The proposed Master of Science degree in Explosives Engineering fulfills campus, state, federal and industry needs, as well as the wishes of prospective students. The proposed degree will attract new graduate students, as well as retain students who have completed BS degrees at Missouri S&T. The graduate program will help the campus attract and retain quality faculty with active research programs. With the retirement of Korea and Vietnam era technical experts in the defense base, there is a critical shortage of explosives engineers. In addition, there are over 5,000 engineers that will retire in the next decade from the mining industry (the major user of explosives), and the average age of technical personnel in explosives companies is over 50. The degree is designed to ensure that graduates will have the competencies employers are looking for, especially in their search for people with advanced skills who can move quickly into managerial positions. Academic institutions seek explosives engineers with MS degrees to teach in their undergraduate programs, and national labs also require explosives engineers to perform research and engineering vital for the nation’s security.

The degree is a logical outgrowth of Missouri S&T’s focus as a technological research university and recent expansion in explosives engineering, and is the logical step forward from the current undergraduate and graduate minors in explosives engineering\(^1\). The degree is unique to the state; the only other university to offer graduate classes in explosives engineering comparable to those at S&T is New Mexico Tech. The number of explosives-related courses that are currently offered has steadily increased to eight (24 credit hours). The addition of a second explosives faculty member in January 2008 allows further expansion and frequency of offerings, making an MS in Explosives Engineering sustainable. It is anticipated that graduates will have successful job placement comparable to related engineering fields.\(^2\)

This 30-hour program includes a thesis, explosives engineering core courses and electives, and a module of courses outside the department, if appropriate. Conservative projections show that the degree will produce revenue that will exceed expenditures after one year.

\(^1\) Between Fall 2005 (inception) and Spring 2009, 28 students graduated with undergraduate minors and 2 with graduate minors.

\(^2\) Supporting job placement statistics are given in Appendix A.
2. Form NP: NEW PROGRAM PROPOSAL FORM

Sponsoring Institution(s): University of Missouri

Program Title: Explosives Engineering

Degree/Certificate: Master of Science

Options:

CIP Classification: 14.2101

Implementation Date: January 2010

Cooperative Partners: N/A

Expected Date of First Graduation: May 2010

AUTHORIZED

Steve Graham

Senior Associate Vice President for Academic Affairs

Name/Title of Institutional Officer Signature Date

Steve Graham

Senior Associate Vice President for Academic Affairs 573-882-6396

Person to Contact for More Information Telephone Number
3. INTRODUCTION

Explosives engineering can be described as the application of explosives in scientific and engineering endeavors, and the science and technology of explosives, including their formulation, physics, effects and use. The United States is the largest consumer of explosives in the world, with US civilian sales estimated at 3.15 million metric tons in 2007.\(^3\) This is principally because the United States also has the largest mining industry in the world. 85.5% of explosives consumption is in the mining industry, with 66.3% of total consumption used in coal mining to remove rock from above coal seams, principally in the western United States (coal mined using explosives is responsible for over 30% of US electrical power generation). Of the remaining 14.5% of consumption, 11.6% is used in civil excavation for highway road cuts, tunnels, leveling ground for commercial structures, basements, trenches for utilities, etc. Non-mining and construction consumption accounts for the remaining 2.9%. The largest state consumer is Wyoming with 638,000 metric tons, followed closely by West Virginia at 489,000 metric tons and Kentucky with 368,000 metric tons. Missouri ranks as number 14 in the nation in explosives consumption at 50,500 metric tons. This is principally because of crushed stone production, where Missouri ranks number four in production in the nation at 81.3 million metric tons, and lead mining, where Missouri is the number one producer in the nation (over half of the vehicle batteries in the US come from Missouri lead).

The history of explosives at Missouri S&T goes back to its inception as the Missouri School of Mines (MSM). The use of explosives since the invention of dynamite by Alfred Nobel (of Nobel Prize fame) has been a fundamental cornerstone of the mining and civil excavation industries for the excavation of rock. Over the years, MSM/University of Missouri-Rolla/Missouri S&T has been one of the principal universities both in teaching explosives engineering and performing explosives research. Over the last decade it has emerged as the number one university for explosives engineering at the undergraduate level in the nation. This is based on the following facts:\(^4\) in 1997, it was the first to have an undergraduate explosives engineering emphasis, followed in 2005 by an explosives minor for both undergraduate and graduate degrees, and in 2007 by an explosives certificate. A master’s degree in explosives engineering is the natural progression. In addition, the university has provided the most PhD graduates in explosives engineering research that have gone onto university careers.

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\(^3\) Figures from USGS 2007 Minerals Yearbook - Explosives

\(^4\) Statistics are given in Appendix A.
The emphasis on explosives education has increased enrollment in the mining engineering program, resulting in more than a doubling of the department enrollment (from 77 in FS 2004 to a projected 190 in FS 2009)\textsuperscript{5}. The advertisement of the teaching of explosives classes has gained national attention, with TV coverage on The Learning Channel, the Discovery Channel, and the National Geographic Channel and even international coverage with the Canadian Discovery Channel, with programs aired throughout the world. More recently the summer explosives camp has gained national attention, published on the front page of the New York Times Science Times and in the International Herald Tribune, and airing on National Public Radio. This camp is for high school students, 16 years and older and the first camp student graduated with a mining engineering degree with an explosives engineering minor in May 2009 from the first pilot camp of three attendees in 2004. The camp has now grown to three camps of 20 students per year held in June and this is viewed as a major future source of students for the proposed program.

Since the fall of 2005 through the spring of 2009, a period of only four years, there have been 6 undergraduate explosives certificates and 2 graduate explosives certificates, 28 undergraduate minors and 2 graduate minors conferred. This represents an average of 8 minors or certificates conferred per year. In the fall of 2009, there were 26 students enrolled for minors in explosives engineering and seven students are ready to enroll for the master’s, degree, two of whom were undergraduate mining engineering majors at Missouri S&T.

This will be the first program in North America in Explosives Engineering, and because of this, there are no statistics on the employment of explosives engineers. However, out of the 30 explosives engineering minor and 8 certificate recipients to date, we have data (shown in Appendix A) tracking most of these graduates that verifies they were able to obtain good paying jobs (only 5 were non-mining students). The U.S. Department of Labor shows 5,333 explosives workers and 7,070 mining and geological engineers were employed in 2006, although these numbers appear to be conservative estimates.\textsuperscript{6} We also have letters supporting the need for an advanced degree in explosives engineering from industry, our alumni, industry

\textsuperscript{5} See mining engineering program enrollment statistics in Appendix A.

\textsuperscript{6} For example, the National Mining Association estimates that approximately 5,000 mining engineers will be retiring in the next decade and there are 3,000 U.S. International Society of Explosives Engineers (ISEE) members, which is not close to half of the explosives engineers (according to the Assistant to the ISEE Executive Director).
associations and prospective students wishing to obtain an explosives engineering degree (see Appendix G).

4. Overview of Market Analysis and Program Need

A market analysis revealed a strong need for, and interest in, the MS in explosives engineering program. Prospective employers are enthusiastic about the program and view it as a valuable opportunity to meet a critical need for experts capable of working with increasingly complex explosives technology and to replace an aging workforce. Current and prospective students have expressed a strong interest in explosives technology and the desire for a specialized degree in explosives engineering. In addition, letters of support from mining industry professional associations and alumni document the need for the program.

The demand for the degree is evident in the number of students choosing to obtain certificates and minors in explosives engineering. From the fall of 2005 through the spring of 2009, there have been 6 undergraduate certificates and 2 graduate certificates, 28 undergraduate minors and 2 graduate minors conferred in explosives engineering. In the fall of 2009, there were 26 students enrolled for minors in explosives engineering and seven students are ready to enroll for the master’s degree, two of whom were undergraduate mining engineering majors at Missouri S&T.

Market and enrollment analyses established the financial viability of the program, and indicate that the program will be viable with student enrollment numbers much less than those predicted by student surveys and employer demand for graduates. In a poll of 200 current undergraduate and graduate students, 31 responded positively regarding their intent to enroll in the program; an additional 11 graduating seniors have indicated they will enroll in the explosives engineering MS program. The three one-week explosives camps that fill each summer with high school students eager to learn more about explosives technology are a proven pipeline into Missouri S&T, with a significant percentage of these students planning to continue their studies in explosives.

In addition to the information solicited for the proposal, the need for graduates with expertise in explosives engineering has been expressed in mainstream media sources such as the New York Times, National Public Radio, the Learning Channel and the Discovery Channel. These discussions have focused on societal need and the aging workforce in this industrial sector, and acknowledge the resident expertise at Missouri S&T in this technical field.
Detailed market and need analyses are presented in subsequent sections of the proposal. A brief summary is provided here to highlight the thoroughness of the analysis and to demonstrate the broad support for the program among students, faculty, alumni and industry.

**Student Enrollment Projections (Section 5 – Form SE)**
A total of 81 students are predicted to enroll in the program within the first five years. These predictions are based on current enrollments in Missouri S&T certificate and minor programs in explosives. The proposed MS program will thus meet existing demand with current students. Five graduate students are prepared to immediately enroll in this program as soon as it becomes available.

**Program Characteristics and Performance Goals (Section 8 – Form PG)**
This section highlights the high demand for graduates with the MS in Explosives Engineering degree and the predicted placement rates.

**CBHE Clarifying Comments (Section 9 – Form CC)**
In subsection B, the strong current and prospective student interest is discussed as well as specific examples of the industry and societal need to increase the credentials of the explosives engineering workforce. In addition, this section discusses training and certification options in explosive engineering that will exist for enlisted soldiers at Fort Leonard Wood, as strong ties are already in place between the university and the army base.

**Criteria by the President (Section 10 – Form CP)**
Industrial market analysis data and survey results from current mining engineering students are summarized. Subsection B contains detailed information on the effective student recruitment programs already in place, such as the extremely popular summer explosives camps. Retention efforts to ensure the success of the program are also discussed.

**Employment, Graduation, and Enrollment Statistics (Appendix A)**
The employment history of Missouri S&T students who have graduated with expertise in explosives engineering demonstrates the demand for graduates in industry and the government sector. This section shows trend data for enrollment in the area of explosives and demonstrates that enrollment targets appear achievable.

**Recent Poll of Students (July 2009) (Appendix B)**
A poll of 200 current undergraduate and graduate students, described in this section, resulted in 31 students positively responded regarding their intent to enroll in the program with
an additional 11 graduating seniors indicating that they will enroll in the explosives engineering MS program.

**Letters of Support (Appendix G)**

To further illustrate the strong support for the program, quotes from industry associations, industries, and students are provided in the following section. The source of these quotes and additional support letters appear in Appendix G.

**Support from Mining and Explosives Associations**

- “The number of graduates of engineering schools with training in explosives cannot keep up with the demand in the mining industry, the leading employer of explosives engineers, and the current population of engineers in the field is aging toward retirement.” – The National Mining Association
- “The explosives industry has experienced rapid change in applied technology in recent years ... Well-trained explosives professionals that can effectively communicate with citizens and local officials have become an absolute necessity. ... I’m certain that the Missouri S&T graduates with advanced knowledge of explosives will be put to work as quickly as they become available.” – Steve Rudloff, Missouri Limestone Producers Association
- “We believe that an MS program in Explosives Engineering will help the industry meet its personnel needs.” – Lon Santis, Manager of Technical Services, Institute of Makers of Explosives
- “We have worked to encourage young people to enter our industry with an eye on the deficit of workers coming soon because of our aging workforce ... We have a problem in our industry... we ask you to continue that industry education support by approving the Master of Science degree in Explosives.” – Jeffrey L. Dean, Executive Director, the International Society of Explosives Engineers

**Support from Prospective Employers**

- “Using current market demand and projecting forward for 10 years, approximately twelve master level Explosives Engineers would be able to find employment with explosive manufacturers.” – Mitchell D. Lee, Vice President, Orica USA
- “In speaking with Dr. Paul Worsey recently, he had conveyed to me that the MS&T Mining Department is seeking to develop an accredited Masters Program in Explosives
Engineering. I feel this would be a very good step forward for the Explosives Industry, as well as for the University.” – Kurt B. Oakes, General Manager, Olson Explosives, Inc.

• “As an R&D company that deals primarily in the development, characterization, and safety testing of energetic materials, the lack of qualified personnel with explosives education and experience can be seen in all walks of industry ...” – Gary Eck, Vice President of Research and Laboratory Manager, UTEC Corporation.

• “There is a need for professionals with advanced education and training to develop and implement advancements in the development and usage of explosives materials.” – David Obergefell, Vice President, Manufacturing –International, US Gypsum Company

**Demand from Students**

• “MS&T is leading the nation in areas of industrial interest as well as reputation. Employers know that when an MS&T graduate is hired, that employee will be properly trained and experienced in all engineering aspects. The school now has a chance to optimize an economic situation by introducing a desired and well-implemented explosives engineering program.” – Buck Hawkins, Mining Engineering Undergraduate

• “I was struck by the enthusiasm of the faculty and the extent of the coursework relating to explosives and pyrotechnics, and after further research, found it to be the only school offering this kind of coursework ... I believe that the creation of an explosives engineering MS and my subsequent degree in it will open doors in industry and research that another degree would not ...” – Alexander Tyson, Missouri S&T Undergraduate

• “With the addition of the Masters of Explosives Engineering, I know that the school will have one more reason to advertise itself apart other institutions and draw additional students from more diverse areas of the U.S. and world ...” – Nathan Rouse, Missouri S&T Graduate student

**5. Form SE: STUDENT ENROLLMENT PROJECTIONS**

Table SE-1 contains the expected enrollment forecasts from year 1 (2009-10) to year 5 (2013-14) originally forecasted in fall 2008. These projections are based on our experience with the mining engineering ME program and on exploratory discussions with students currently enrolled and include projected students from external advertisement of the program once approved. To ensure financial viability we have still decided to use what we consider to be a
conservative estimate. The results of a more recent poll of students are appended in Appendix B. This poll indicates that our projections are overly conservative for years 1 and 2.
Table SE-1: Expected Enrollment Potential from Year 1 through Year 5 -Conservative Estimate

<table>
<thead>
<tr>
<th>Year (A/C)</th>
<th>1 (09-10)</th>
<th>2 (10-11)</th>
<th>3 (11-12)</th>
<th>4 (12-13)</th>
<th>5 (13-14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>5*</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Part-time</td>
<td>-</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>11</td>
<td>16</td>
<td>22</td>
<td>27</td>
</tr>
</tbody>
</table>

* We already have five students enrolled in graduate programs studying explosives engineering who are waiting to transfer to this program as soon as it becomes available. They are being housed currently in the mining MS program on a temporary basis with obtaining a mining MS with a minor in explosives engineering only as a fallback. Our only major enrollment concern is being swamped and we may have to be selective to restrict enrollment to a manageable level.

It has been suggested that mining MS enrollment will decrease as the explosives MS increases. However, this will not be the case, as department statistics show that, in the last 10 years, there have only been 10 MS in mining engineering degrees conferred (none within the last three years). The department’s statistics show that 40% of MS in mining engineering students go on to earn PhDs (four of the 17 PhDs awarded in the same period). Therefore, it is expected that a similar percentage of the MS in explosives engineering students will go on to do PhDs in mining engineering or other fields at S&T. MS programs are an important recruiting tool for PhD programs. Four of the 17 PhDs in mining engineering in the last 10 years had explosives-related dissertations and two of these were graduates who earned MS in mining engineering degrees. Of these four, three became assistant professors in US universities, teaching explosives classes and performing explosives-related research. The fourth went to a defense contractor and is overseeing explosives-related projects.

Table SE-2: Enrollment at end of Year 5 for the program to be financially and academically viable

<table>
<thead>
<tr>
<th>YEAR</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>FULL-TIME</td>
<td>8</td>
</tr>
<tr>
<td>PART-TIME</td>
<td>8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16</td>
</tr>
</tbody>
</table>

Under the budget estimations submitted to the S&T Budgetary Affairs Committee of the Faculty Senate, the program has net positive budget starting in year 1. This estimate is based on new students rather than students temporarily waiting in the mining MS program until
approval of the MS in explosives engineering. The projections (presented in detail in Appendix D) show positive net worth in years 1-5 with a cumulative of approximately $200,000 over that period. System has asked to rework these budgets to include the assignment of existing faculty to the explosives engineering program. It is anticipated that these paper costs will be balanced by the assignment of the additional faculty member’s costs to the mining engineering program for department activities such as undergraduate advising, service and teaching of non explosive MS students in explosives classes. Appendix C shows the break even projections.

6. **Form PS: PROGRAM STRUCTURE**

   A. **Total Credits Required for Graduation:** 30 hours

      The proposed MS degree in explosives engineering will meet or exceed requirements listed in the Missouri S&T Graduate Catalog. The program structure will vary according to the interests of candidates for the degree. All candidates will pursue a plan of study that emphasizes the preparation of a thesis in explosives engineering.

   B. **Residency Requirements:**

      Research work normally must be performed on the Missouri S&T campus. Exceptions may be made for persons working at government facilities, national labs, explosives industry private companies and private research facilities where comparable or superior facilities are available. In such cases, S&T will retain the academic supervision of this work.

   C. **General Education:** Not Applicable

   D. **Major Requirements:** Total Credit Hours = 30

      With guidance from their advisor and graduate committee, each candidate will complete a plan of study to satisfy the interests of the candidate and their advisor, plus requirements for the Master of Science degree, as described in the Missouri S&T Graduate Catalog:

      **Master’s Degree with Thesis** – minimum of 30 hours graduate credit; at least 6 hours to be 400-level courses; no more than 6 hours of 200-level courses; 6 hours minimum devoted to graduate research, ExpE 490; no more than 12 hours of research, special readings and seminar.
As part of this proposed MS degree program, candidates will complete four courses from a list of core courses. (The list of core courses will be reviewed and updated based on the availability of existing and new courses as they are developed.) If a student has already taken classes from this list as an undergraduate student (e.g., MinEng 307 which is a required mining class), other explosives engineering classes may be substituted.

The core classes are:

- (3) ExpEng/MinEng 307 Principles of Explosives Engineering
- (3) ExpEng/MinEng 350 Blasting Design and Technology
- (3) ExpEng 351 Demolition of Buildings and Structures
- (3) MinEng 383 Tunneling and Underground Construction Techniques
- (3) ExpEng 402 Environmental Controls for Blasting
- (3) ExpEng 406 Scientific Instrumentation for Explosives Testing and Blasting

In addition, candidates will select two or more courses from the core classes or the following elective Explosives Engineering courses\(^7\) (Exp Eng course descriptions are included in Appendix E with the proposed Graduate Catalog description):

- (3) ExpEng 309 Commercial Pyrotechnics Operations
- (3) ExpEng 313 Stage Pyrotechnics and Special Effects
- (3) ExpEng 305 Explosives Handling and Safety
- (0-3) ExpEng 491 Internship
- (3) ExpEng 401 Blast Mitigation
- (3) ExpEng/MinEng 407 Theory of High Explosives

Out-of-department courses may also be taken as elective courses according to a candidate’s special interests. Suggested out-of-department elective courses are listed below.

For those with an interest in rock blasting:

- (4) Geo 220 Structural Geology
- (3) Geo 301 Advanced Structural Geology (currently experimental)

\(^7\) Currently ExpEng designation does not exist and was formulated by the S&T registrar. It will be implemented when the MS is approved. The courses are currently designated with the same MinEng number. All of these courses are currently taught, with the exception of 491 Internship and 401 Blast Mitigation, which will be added.
(3) GeoEng 371 Rock Engineering

For those with an interest in demolition or blast protection:

(3) CvEng 217 Structural Analysis I
(3) CvEng 320 Structural Analysis II
(3) CvEng 223 Reinforced Concrete Design

For those with an interest in weapons systems design:

(3) McEng 336 Fracture Mechanics
(3) AeEng 251 Aerospace Structures I
(3) McEng 320 Advanced Mechanics of Materials

These classes are all currently listed in the S&T catalog. The list of elective courses will be reviewed and updated based on the availability of existing and new courses as they are developed. If a student has already taken classes from this list as an undergraduate student (e.g., MinEng 307 which is a required mining engineering class), other engineering classes may be substituted.

E. Free Electives

Twelve hours of core courses, six hours of program-specific courses and six hours of research are required, leaving 6 hours to be selected by candidates in consultation with their advisor from the other core courses, other explosives engineering elective courses or out-of-department courses. The 12 hours of core courses, 6 hours of program specific courses, 6 hours of research and 6 hours of elective courses add up to the 30 required hours.

F. Requirements for Thesis, Internship or Other Capstone Experiences:

All candidates will write and defend a thesis at the conclusion of their course work. An internship is recommended but not required. For those candidates without work experience in an explosives-related industry, an internship will be strongly encouraged.

G. Unique Features

The main unique feature of the explosives engineering master’s program is that it is the only program of its kind in the Americas. The most similar graduate program is a master’s in
engineering mechanics with a specialty in explosives engineering (12 hours of explosives-related coursework) at New Mexico Tech. Missouri S&T already exceeds New Mexico Tech’s offering with the S&T graduate minor (15 credit hours, details can be found in the S&T Graduate Catalog on line) in explosives engineering, available since 2005.

7. Form FP: FINANCIAL PROJECTIONS

Preamble

It is expected that the projected budget will be impacted by the current economic climate and we understand that we may not receive the level of funding we are requesting due to the uncertainty in state funding. For example, at present there is a partial hiring freeze and the potential for end-of-year withholding is very real. If the degree is approved and budget impacts mean that a new faculty member cannot be hired, we will have to delay the development of new courses and consider limiting enrollment until the necessary funding is available. However, we are already at a point where we could implement the MS in explosives engineering, as we have everything necessary to offer the degree, but with a slightly smaller course offering (in the last 12 months we have taught 9 different explosives classes totaling 27 credit hours excluding research). This is a realistic budget proposal based on normal operating conditions in 2008-09 dollars. Cost projections shown below and in Appendices C and D are based on the hiring of a tenure track faculty member. Based on program financials, economic conditions at the time and program success, a non-tenure track hire may be substituted for the tenure track hire.

Because of the demonstrated need (see Appendix G) the program is designed to be completed in one year with full-time students taking at least 12 hours a semester and 6 hours in the summer. This schedule would allow companies to send employees for one year and for them to complete their master’s degree. The budget is based on these assumptions and that out-of-state students will pay out-of-state tuition.
### FINANCIAL PROJECTIONS

<table>
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<th></th>
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<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
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</tr>
<tr>
<td><strong>A. One-time</strong></td>
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</tr>
<tr>
<td>New/renovated space</td>
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<td>$20,000</td>
<td>$20,000</td>
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<tr>
<td>Equipment</td>
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<tr>
<td>Library</td>
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<td>Consultants</td>
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<tr>
<td>Other</td>
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<td>$20,000</td>
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<td><strong>Total for One-time Expenditures</strong></td>
<td>$20,000</td>
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<td><strong>B. Recurring:</strong></td>
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<td>$23,387</td>
<td>$27,325</td>
<td>$84,433</td>
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<td>Equipment</td>
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<td>$27,000</td>
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<tr>
<td>Library</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Mining E&amp;E)</td>
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<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
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<td><strong>Total for Recurring Expenditures</strong></td>
<td>$46,837</td>
<td>$61,875</td>
<td>$123,675</td>
<td>$135,483</td>
<td>$147,191</td>
</tr>
<tr>
<td><strong>TOTAL (A + B)</strong></td>
<td>$46,837</td>
<td>$61,875</td>
<td>$123,675</td>
<td>$135,483</td>
<td>$147,191</td>
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<tr>
<td><strong>2. Revenues</strong></td>
<td></td>
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<tr>
<td>State Aid - CBHE</td>
<td>$55,201</td>
<td>$100,465</td>
<td>$146,743</td>
<td>$204,056</td>
<td>$265,209</td>
</tr>
<tr>
<td>State Aid - DESE</td>
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</tr>
<tr>
<td>Tuition/Fees</td>
<td>$55,201</td>
<td>$100,465</td>
<td>$146,743</td>
<td>$204,056</td>
<td>$265,209</td>
</tr>
<tr>
<td>Institutional/Resources</td>
<td></td>
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<tr>
<td><strong>TOTAL REVENUES</strong></td>
<td>$55,201</td>
<td>$100,465</td>
<td>$146,743</td>
<td>$204,056</td>
<td>$265,209</td>
</tr>
</tbody>
</table>

**A. Budget Justification**

A detailed budget spreadsheet is given in Appendix D, which includes a breakdown of the data for in-state and out-of-state students. Because of the high numbers of students
already taking some of the explosives engineering courses (e.g., MinEng 307, ExpE 309, MinEng 350) and the anticipated enrollment of additional MS students from this program, it is anticipated that one 1.0 FTE GTA position (broken down into 4 x 25% positions) will be required to assist faculty members with the explosives engineering course load from the beginning. Fifty percent of this position was assigned to the MS in explosives engineering budget, the other 50% would be applied to non-MS students (mining undergraduates and students in other departments) taking the same courses. (One FTE GTA position costs $33,300 for a 9-month appointment (2008-2009 rates)). From Year 2, $10,000 has been included for mining engineering program expenditures for support of the extra MS student numbers (for example, secretarial, printing, advertising, communications, supplies, etc.). Once student enrollment has increased to the level anticipated by the third year projections, the current two faculty members will be unable to cope with the course load and will need to be augmented. Lab courses are difficult to teach with more than 15 students per lab and we already teach three lab sections of MinEng 307 and are approaching the need for a second lab section of MinEng 350. At this point, it is anticipated that a third faculty member (either non-tenure track or tenure tack at the assistant or associate professor level) will be required at an estimated cost of $80,000 per year plus benefits (at current levels)\(^8\). A one-time expenditure of $60,000 split between Years 3, 4 and 5 is included for a start up package for this faculty member. The break down on FTE and allocation of effort is given in Appendix D.

Tuition and fees from the anticipated student enrollment should cover both recurring and one-time expenses. Tuition and fee income was calculated using the 2008-2009 rates for graduate students (including the engineering supplemental fee) on a conservative basis of full-time students taking 24 hours per year and part-time students taking 9 hours per year based on Dr. Worsey’s experience and expectations. These rates are $353.20 per hour for in-state students and $825.70 per hour for out-of-state students. It was estimated that one third of the full-time students will be out-of-state and all of the part-time students will be out-of-state. (Based on polling of current S&T students who are eager to enroll in the master’s, three of seven for the first year came to the university from out of state specifically to study explosives at the graduate level.) In the mining department, unlike other departments on campus, it is unusual for out-of-state tuition to be waived for MS students.

\(^8\) All financial information is based on 08-09 costs, as this was when the proposal was first submitted. All revenue and expenditures are based on figures for this year. For fees, only educational and engineering fees included.
One-Time Expenditures

The only one-time expenditures anticipated are $20,000 in Years 3, 4 and 5 for a start up package for a third faculty member in the explosives engineering area.

Recurring Expenditures

The recurring expenses for faculty and staff include salaries and benefits for a 50% FTE GTA in all five years, $10,000 for mining engineering program expenditures from Year 2 and for hiring a new faculty member from Year 3 dependent on new student enrollment. The costs for E & E and new faculty are to be dependent on the projected enrollment being achieved, such that the program is guaranteed to be of financial benefit to the university. No costs for explosive materials are included here since all explosives are donated from corporate partners, including Dyno Nobel and Orica. The Mining and Nuclear Engineering department has particularly strong industrial partnerships with firms both in and outside of the state of Missouri. There are also no costs included in the projections for library expenses, since required reference/resource materials are already available for the proposed program through the current minor and certificate options in explosives engineering.

B. Administrative Structure

The MS degree will be an integral part of the Department of Mining and Nuclear Engineering at Missouri S&T and the students will be counted as mining engineering program graduate students. The strengths of both mining and explosives engineering are augmented using this symbiotic relationship.
C. Facilities and Space Needs

Current facilities will accommodate the explosives engineering graduate students. These facilities include modern lecture facilities at McNutt Hall equipped with an instructor station (which includes a computer, VCR and a ceiling–mounted LCD projector) linked to the campus network through a high–speed data network, the Missouri S&T experimental mine and the energetic materials research facility.

- **Underground Mine Facility:** The Missouri S&T Experimental Mine is one of only a few such facilities available on a university campus for mining engineering education. The facility is used primarily by the students and faculty of Missouri S&T for instruction and research in mining and geological engineering practices. The Experimental Mine is located on Bridge School Road, just west of Rolla, 1-1/2 miles from the Missouri S&T Campus. It consists of two underground mines, two small quarries, explosives magazines, a classroom and office facility, a shop building, and a garage on a 19-acre site. The underground mine facility is already extensively used for explosives classes and research.

- **Surface Quarry Facility:** The Missouri S&T Experimental Mine also includes two small surface quarries used for teaching and research by mining engineering faculty and students. These quarries are already extensively used for explosives classes, research, demonstrations and of course explosives camp. The facility is also being used for the filming of “The Detonators” a Discovery channel series on explosive demolition that aired in the first half of 2009.

- **Energetic Materials Research Facility:** The Energetic Materials Research Facility (Explosives Research Lab) laboratory is housed in a converted former U.S. Bureau of Mines research foundry (Building 4) adjacent to the new entrance to the Missouri S&T campus. The laboratory contains two blasting chambers (rated for 1 kg and 4 kg of explosives, respectively), a shop, a computing workstation running Autodyne 3D© software (an industry standard for performing closely-coupled computational fluid dynamics/computational structural dynamics calculations), high-speed film (up to 1.25 M frames per second) and video cameras (up to 90k frames per second), gated ICCD camera (up to 55 nsec exposure), flash x-ray system, 16-channel digital data acquisition system, three high-energy pulser, two delay generators, two initiation systems for exploding bridgewire detonators, and explosive magazines. The laboratory is currently used for teaching MinEng 301, 350, 390, 406 and 490. The facility was recently
extended using funding from the Chancellor to house the new 11 ft diameter large scale blast chamber acquired from the Army Chemical Demilitarization Command in Tooele, Utah. This chamber is 84 tons and represents a major upgrade to the facility, raising the facility to the realm of world-class capabilities.

- **Facilities at Operating Mines and Quarries:** Field trips to operating mines have been used intensively to demonstrate real-world mining facilities, especially for rock blasting, the major use of explosives. In the past, many explosive research projects have involved industry participation for both funded faculty, undergraduate and graduate research. It is expected that these links will continue.

During the academic year 2007-2008, nine explosives engineering courses were taught at Missouri S&T (MinEng 307, MinEng 309, MinEng 313, MinEng 350, MinEng 351, MinEng 383, MinEng 402, MinEng 406, and MinEng 407) and the facilities can easily accommodate the extra courses anticipated for the MS program. MinEng 383 and MinEng 402 were taught distance only and MniEng 307 and MinEng 350 were taught distance concurrently with the on-campus classes. The mining engineering program has two tower DVD bulk copiers to facilitate the distribution of course DVDs for distance courses. The current facilities can accommodate the explosives engineering courses, the main need for the master’s program being extra personnel and graduate student assistance.

### 8. Form PG: PROGRAM CHARACTERISTICS AND PERFORMANCE GOALS

**A. Student Preparation:**

- Students will be required to meet the standard graduate school admission requirements for the Missouri University of Science and Technology.

**B. Faculty Characteristics:**

- *Any special requirements (degree status, training etc.) for assignment of teaching for this degree program?* This program will be supported with a combination of existing Missouri S&T regular faculty and adjunct industry instructors who bring specialized and practical experience to the courses they will teach. In the future, faculty from other academic institutions may teach additional courses. This would leverage what we have and allow us to provide more complete and varied course offerings. These academic faculty are expected to hold a PhD or its equivalent in their area of specialty.
Faculty involved in the program are based around existing faculty from the Department of Mining and Nuclear Engineering at Missouri S&T, instructors from industry currently employed on a flat rate to co-teach undergraduate mining department explosives classes and faculty from the Department of Civil Engineering at Missouri S&T and augmented as circumstances dictate by faculty from UMC, University of Kentucky and Texas Tech University. Preliminary exploratory communications have been made with the non-department faculty with agreement on principle but at this time it is not appropriate to go further until the MS is fully approved. These faculty are currently in reserve and will be called upon in the event of enrollment projections being exceeded and/or financial circumstances which delay the hiring of the third faculty member.

**Professor**

Paul Worsey, PhD, University of Newcastle upon Tyne (Missouri S&T)

Richard Bullock, D. Eng., Missouri School of Mines Emeritus (Missouri S&T)

Sam Kiger, PhD, University of Illinois at Urbana (University of Missouri Columbia)

Bruce Freeman, PhD, University of California Davis (Ktech, formerly at Texas A & M)

**Associate Professor**

Jason Baird, PhD, University of Missouri-Rolla (S&T) (Missouri S&T)

John Myers, PhD, Texas-Austin (Missouri S&T)

**Assistant Professor**

Braden Lusk, PhD, University of Missouri-Rolla (S&T) (University of Kentucky) 9

Brandon Weeks, PhD, University of Cambridge (Texas Tech) 9

**Adjunct Industry Instructors Currently Teaching Courses at Missouri S&T**

Greg Shapiro, BS, University of Missouri-Columbia Steel Blasting

Matt Suttcliffe Premier Pyrotechnics

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9 These have acknowledged interest in working with the program on an adjunct basis offering distance courses (from their current location), subject to S&T hiring policies & procedures.
Marty Gillette
Premier Pyrotechnics

We hope to broaden the scope of the program to involve professors from other disciplines on campus as the offering of courses expands. Some examples would be explosives chemistry, history of explosives, and shock wave physics in addition to cooperation with the civil engineering department on blast resistance.

- *Estimated percentage of credit hours that will be assigned to full-time faculty:* 80%

- *Expectations for professional activities, special student contact, teaching/learning innovation.* Faculty at Missouri S&T are expected to participate in teaching, research, service and outreach activities. Annual reviews, promotion and tenure, continuing membership on the graduate faculty and annual salary adjustments ensure the quality of faculty activities. The faculty of the explosives engineering program will be located in the Department of Mining and Nuclear Engineering. The name of the department will remain to reflect its undergraduate and highest degree (PhD) offerings. The tenure and promotion of the explosives engineering faculty will continue to reside for the foreseeable future with the mining engineering program.

C. Enrollment Projections:

- *Student FTE majoring in program by the end of five years:* 20 (Form SE)

- *Percent of full-time and part-time enrollment by the end of five years:* 45% full-time students; 55% part-time students (rounded based on projections). It is expected that part-time students will be in the minority in the first couple of years but because part-time students take longer to graduate, their numbers will eventually exceed those of full-time students. The part-time students will be working professionals.

D. Student and Program Outcomes

- *Number of graduates per annum at five years after implementation:* 15

  (10 full-time from year 4 (1+ years to graduate) and 5 part-time from year 2 (3+ years to graduate))

- *Special skills specific to the program:*

  Understanding and application of the functioning of explosives and initiation systems.
Understanding and application of explosion effects.

Understanding and application of safety as applied to explosives in field use, testing and demonstration environments.

Experience with the safe handling of energetic materials.

Understanding of the application of explosives for fragmenting rock and other materials.

Experimental design incorporating explosives.

Expertise in focused professional areas such as demolition, blast resistance, rock breakage or weapons systems design, loading and production.

Understanding of the challenges of using explosives and environmental impact.

Note: The graduate certificate has lower entrance requirements than a master’s due to it being a non-degree program.

- Proportion of students who will achieve licensing, certification, or registration: Graduates will become members of the International Society of Explosives Engineers and other professional organizations, as appropriate. At present there are no professional groups licensing graduates from explosives engineering programs. All licensing is at the state level, which comprises a) blaster’s licensing (which may be at multiple levels depending on the state), b) display fireworks operator licensing and c) pyrotechnician and special effects licensing. It is anticipated that the majority of graduates will obtain licensing in at least one of these areas.

- Performance on national and/or local assessments, e.g., percent of students scoring above the 50th percentile on normed tests: The only applicable tests are state explosives licensing tests. More than 80% of the students are expected to score above the 50th percentile on these tests. (Based on past performance of students. Source: Dr. Worsey, state certification program examiner 1990-2008.)

- Placement rates in related fields, in other fields, unemployed: There will continue to be growing opportunities for explosives engineers in the defense, mining and civil construction industries and in government institutions; therefore, we expect 100% of our graduates to be employed.
• **Transfer rates, continuous study:** The program will not only attract students with previous degrees from Missouri S&T but also attract students from other technological programs throughout the United States. We already have five full-time students signed up for a traditional master's, three of which obtained a bachelor’s at other institutions. These students are temporarily housed in the mining MS program. Our summer explosives camp has now been running since 2004 and indications show that many of the explosives campers who enroll at Missouri S&T for majors outside of mining also currently enroll in the explosives engineering minor. We anticipate that the majority of these students are potential candidates for the master’s degree in explosives engineering. Unfortunately the Safe Explosives Act of 2002 (implemented in January, 2003) prohibits the participation of foreign nationals (non-residents). The major exceptions to this are those currently employed by Missouri S&T and by obtaining relief from the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE), which can take as long as 18 months. It is therefore anticipated that this graduate program will be unusually high in U.S. nationals.

E. Accreditation

• There is no accreditation for graduate programs in explosives engineering. It is expected that the students will have BS degrees from programs already accredited in science, engineering or technology.

F. Alumni and Employer Survey:

• **Expected satisfaction rates for alumni including timing and method of surveys:** Missouri S&T will develop an assessment and evaluation plan for the curriculum in explosives engineering based on the ABET-accredited BS program in mining engineering. This will be developed after the MS is approved. We expect a 90% satisfaction rate of the alumni of the program. (Based on experience from our mining graduates.)

• **Expected satisfaction rates for employers including timing and method of surveys:** Graduates will be tracked and Missouri S&T will develop an assessment and evaluation plan for gathering information from the employers of the graduates after the program has graduated at least 5 persons. We expect 90% satisfaction from the employers. (Based on experience from mining engineering program surveys.)
9. Form CC: CBHE CLARIFYING COMMENTS

A. Alignment with Institution Mission

The Missouri S&T mission statement is:

“Missouri University of Science and Technology integrates education and research to create and convey knowledge to solve problems for our State and the technological world”.  

A master’s program with research thesis fits this mission. Specifically the explosives master's program emphasizes the integration of education and research by the graduate level education of students, their role in performing research for theses, and integration as a personnel resource for funded research after initial training. As the program advances, the number of faculty and graduate students will increase to complement the excellent facilities we have built and will significantly increase the level of scholarly activity. In addition, the uniqueness of the program allows the opportunity for meeting specific technological needs that the university does not currently address in any one program, as well as educating students and solving problems for the technological world in the areas of explosives, blasting, defense and homeland security.

The vision of the university is that Missouri University of Science and Technology will be recognized as one of the top five technological research universities in the nation. The tradition of this institution is based on mining (the Miners) and the first two programs on campus were mining and civil engineering, where 98% of civilian explosives are used. The expansion of the explosives engineering program, especially at the graduate level, will increase our visibility, which will afford increased research opportunities and lead to excellence. A healthy number of graduate students will allow us to expand our research load and the inclusion of graduate students in full-time employment in government institutions will afford new opportunities, including interdisciplinary collaboration. This program builds on the traditional history of the institution in an area with documented excellence. The suggested free electives will facilitate the opportunities for interdisciplinary collaboration.

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10 Mission Statement Approved January 2008 Board of Curators’ Meeting.

11 Tradition, Interdisciplinary Collaboration and Excellence are 3 of the 4 values included in the Missouri S&T mission statement.
The program also meets all four of the Strategic Objectives outlined in the FY 2008 – FY 2012 for the campus. These are:

1. **Enrich the Student Experience**

   The explosives engineering MS program covers both practical hands-on and theoretical aspects of explosives and their use, only available at S&T. The program not only provides a one of a kind degree but also a one of a kind experience.

   Explosives engineering interfaces with the entire student body at S&T. Explosives engineering students supervised by faculty, as one example, provide fireworks displays and special effects for events and celebrations on campus for the university, prospective students, student organizations and alumni. Such events have included night football games, athletic hall of fame inductions, opening week, Student Council block party, St. Pat’s, St. Pat’s coronation ceremony (indoors), the Indian Student Association Diwali celebration, homecoming and the list goes on. At present, the faculty and seniors (over 21) are stretched thin and cannot cover all requests. The increase in explosives graduate students will significantly increase the pool of license-eligible persons (due to age and maturity) and allow fuller support to the campus.

2. **Manage the Academic Portfolio and Increase Enrollment**

   The Master’s program fits this objective by increasing graduate enrollment. In addition, the existence of the degree will also help attract additional undergraduate students with an interest in explosives to the campus by cementing S&T as the premier institution in North American for explosives education and the publicity this will bring. It is a unique degree based on our history that represents a logical extension of our academic offerings.

3. **Expand and Elevate Research Performance and Reputation**

   This objective is met by the increase in explosives engineering faculty and graduate students, which will push us over the critical threshold and lead to a strong increase in academic scholarship. As an example, current explosives engineering students are encouraged to publish their research, etc. even at the undergraduate level. The strong increase in the number of graduate students and additional faculty will substantially increase the number of publications and research projects.
4. **Identify Opportunities and Secure Resources from External Constituencies**

The mining engineering program has over the years been very successful in securing resources from external constituencies, being one of the leaders on campus (considering its size) in scholarships, grants, endowments and donations. In particular, we have strong alumni and industry support. We will establish an industry development board to assess, provide direction and input for the program and to help obtain further resources. The creation of the explosives engineering MS will position the university to secure additional resources in the explosives area. As an example, the Orica (explosives) Partnership for Mining Education approached Dr. Worsey in July to see how they can increase their involvement. This is a direct result of our visibility in explosives education and the explosives MS will only help cement this relationship. Currently virtually all explosives, drilling equipment, magazines, training aids and equipment used in classes have been provided by industry with negligible cost to the mining engineering department.

B. **Student and Market Demand**

**Summary of Need for Program**

The Master of Science degree in Explosives Engineering will fulfill the following needs:

- Satisfy current and prospective student interest in a graduate program in explosives engineering.
- Strengthen Missouri S&T’s ability to recruit and retain graduate students with an interest in a technological field.
- Provide new opportunities for graduate research.
- Fulfill the market’s need for explosives engineers with a specialization in one or more areas of technology.
- Strengthen Missouri S&T’s ability to recruit and retain quality faculty in the explosives field and grow in this high profile subject area.
- Meet the needs of Department of Energy, Department of Homeland Security and Department Of Defense personnel, including those stationed at Fort Leonard Wood.
We currently have a Department of Energy (DOE) employee in our ME program who has requested the MS in Explosives Engineering program. He is doing research in explosive breaching for the protection of Department Of Energy assets. The Department Of Energy and Department Of Defense (DOD) research and development organizations want the highest qualified individuals and we have been told, for example by Picatiny Arsenal, that they would like to increase the credentials of their explosives engineering workforce. This led a few years back to a research contract for Dr. Baird to make a preliminary investigation for the set up of an energetic related PhD program. Unfortunately, the Iraq war preempted the funding for the performance of the project.

We have just received a $100,000 ALERT (Awareness and Localization of Explosives-related Threats) education initiative grant funded by the Department of Homeland Security, the abstract of which is included here:

“BROADER IMPACT: The educational component of the ALERT Program will advance frontiers and knowledge in the homeland security front. Homeland security is an essential component of measures for securing the Homeland against explosives-related threats. This program will educate the next generation of leaders, scientists, engineers and policy makers, from K-12 through undergraduate to graduate levels, in effectively combating the dangers and effects of explosives-related threats. This program brings together scientists and engineers from the partner universities to contribute to a collaborative education venture. This collaborative partnership will provide students different classroom experience, to encounter different experts, and to gain knowledge in different dimension of explosives-related threats. Overall, the education initiative is a vehicle, along with the research initiative, for achieving the broader vision of the Center of Excellence in Explosives-Related Threats envisioned by the Department of Homeland Security.”

This $100,000 grant indicates the importance of explosives engineering education. Missouri University of Science and Technology is part of a multi-university center for the ALERT program. S&T is recognized in this center primarily for its expertise in explosives education and its leadership in blast resistance research.

Mr. Steve Tupper, the S&T Fort Leonard Wood Liaison Officer has written the following comment concerning Fort Leonard Wood, the major army training base in Missouri and the home of the Army Engineer Center and Maneuver Support Center.

“Fort Leonard Wood is the training base for the Corps of Engineers whose missions include military demolitions. Each year 450 officers, all with fresh bachelor degrees from various ROTC programs and the Military Academy, are trained in basic explosives use, handling, safety, including hands-on application. Annually 25,000 newly enlisted soldiers are also trained on the same explosives basics, but since they have high-school degrees are not ready candidates for graduate studies. This training is done by a training cadre mix of officers and enlisted who are interested in more advanced explosive theory, practice and
design. This last group is currently inquiring with Missouri S&T for in-depth training and certification making them a market-sector for the explosives engineering master program."

Employment of Graduates

The major use of explosives is in the civilian sector, with over three megatons of explosives used in the United States each year (USGS Minerals Yearbook 2007). Of this, an estimated 85.5% is used in the mining industry (for extraction of metals, minerals, fuels and construction materials; for example Doe Run, the major mining company in Missouri, estimates that 10% of its current total mining costs come from drilling and blasting. An estimated 11.6% is used in the civil construction industry for road cuts, tunnels, structure basements and grading for large industrial, distribution and retail complexes. All other civilian uses of explosives combined account for 2.9%, including demolition, explosive welding, oil and gas exploration and production, etc. Another important segment is government, which includes the Department of Energy (DOE), the Department of Homeland Security (DHS), the Department of Defense (DOD) and the National Laboratories.

According to the New York Times\textsuperscript{12} and National Public Radio (NPR), the National Mining Association was quoted as saying, “The number of graduates of engineering schools with training in explosives cannot keep up with the demand in the mining industry, the leading employer of explosives engineers, and the current population of engineers in the field is aging toward retirement.” Five thousand mining engineers will be retiring in the next decade, and a substantial proportion of these are involved in the primary breakage of rock using blasting. In addition, the average age of technical personnel at Dyno (one of the country’s largest explosives manufacturers) is over 50. A similar situation exists in other explosives companies.\textsuperscript{13} With the Korean and Vietnam wars the defense industry was saturated with engineers, many of whom were in the same age group, the majority of which have now retired, leaving a substantial gap in expertise, especially in the area of explosives. The Department of Mining and Nuclear Engineering at Missouri S&T, having recognized national expertise in the areas of explosives education, training and research is becoming increasingly approached by defense contractors, including Westinghouse, Alliant Technologies, etc. and DOD installations (such as the U.S. Navy’s facility at China Lake, CA) and National Laboratories (such as the Idaho National Laboratory) for explosives engineers. Especially in the government sector advanced degrees

\textsuperscript{12} See Tuesday July 3, New York Times article in Appendix F.

\textsuperscript{13} Personal communications with explosives company representatives at all levels.
are encouraged and there is significant interest in an MS in explosives engineering to complement our graduate minor in explosives engineering.

There is also a need for existing graduate engineers in industry and government to further their education and obtain specialized training in explosives engineering; this degree will provide a means of fulfilling that need. Missouri S&T has an excellent opportunity to fill key industry positions and dominate the field of explosives engineering, and thus increase the university’s national standing in this area in industry and government. The Master of Science in Explosives Engineering is conceived as a specialist qualification for graduates holding accredited engineering, science and technology BS degrees, as is the practice in Europe and other parts of the world, paralleling the concept of an MBA.

The question has been asked “What does an MS provide that a certificate does not and how does this match need?” The answer is that an MS provides far more than a certificate, including appeal to potential students and sound academic credentials. From personal discussions, capable graduate students that are interested in explosives engineering want to take the MS rather than a certificate or minor. They recognize the increased value of a specialized advanced degree in the workplace in addition to its desirability.

**Societal Need**

The use of explosives is extremely important to our current standard of living. Without explosives, raw materials would be very expensive to extract from the ground. In fact, one of the most famous people in history, Alfred Nobel (of Nobel Prize fame) was the inventor of dynamite, the modern blasting cap and a whole host of other explosives and propellants. Explosives are not only used to break rock so that it can be removed and easily processed for the extraction of metals (from iron to platinum) and minerals (from road salt to borax) but also in the removal of overburden in surface coal mining. Surface coaling mining produces over 50% of the coal mined in the US, which in turn is responsible for the production of one third of our power generation. Explosives touch almost every aspect of our modern lives. There is an adage in mining that if it can’t be grown, it has to be mined. As far as explosives are concerned, if the rock is tough, then generally, explosives have to be used. The abundance of cheap raw materials and energy in modern civilization is attributed to high explosives and Alfred Nobel.

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14 A certificate is not tied to a degree like a minor and is principally designed for those persons who are not able to obtain a degree due to academic circumstances (inability to meet graduate school entrance requirements for an MS or PhD) or other considerations, such as career commitments, financial and family considerations, etc.
In civilian excavation and construction, explosives are extremely important for rock breakage. The majority of rock cannot be economically ripped using mechanical excavators, whilst explosives and blasting provide an economic solution, especially for the removal of large volumes of rock. Just in the state of Missouri, you only have to drive down the highways and marvel at some of the rock cuts, not only along I-44 and other highways, but also at the scale at which rock excavation has been undertaken in the Branson area, for example. Leveling and grading is extremely important for the construction of large industrial and retail facilities, not only for the efficient use of machinery but also for the Americans with Disabilities Act. An example of the importance of blasting is the Wal-Mart distribution center located in nearby St. James, one of the largest such facilities in the U.S. Although being sited on what appears to be a flat field it actually required over 50 thousand cubic yards of rock excavation by blasting so that the facility floor could be level.

An important item in maintaining the American way of life is the ability to defend the country, and explosives are an important part of this. We have placed a number of our graduates with qualifications in explosives engineering with governmental agencies and contractors in the defense industry, including China Lake and Applied Research Associates, Inc. Although the vast majority of these graduates have been BS mining majors, the mix of academic BS majors is changing and we anticipate because of this, placement in government agency positions to increase. There have been several recent inquires for graduates in the explosives area and requests for students with master’s in the explosives area. Offering a master’s in explosives engineering will allow valuable training for government and defense contractor personnel and provide a mechanism for personal advancement.

The terrorist attacks on September 11, 2001 brought home to American soil the threat of international terrorism. Before this terrorist act in the US, there had been numerous attacks on U.S. installations and personnel throughout the world using explosives. But now there is an increased need for research in combating explosive terrorism including blast resistance, detection and defeat mechanisms for terrorist explosive devices including improvised explosive devices (IEDs). A substantial amount of work has been started for the protection of critical infrastructure by the Idaho National Laboratory, including highly classified work. Several research contracts are in place at Missouri S&T to address portions of this need. Currently, there is a severe lack of personnel with adequate credentials and training in the field of explosives engineering to meet critical needs, as explained in the next section. Currently, the certificate only provides basic level training with 12 credit hours of study. Although the certificate provides a good foundation, it does not provide anywhere near a comprehensive
mastery of the subject. The master’s degree proposed provides in-depth training with a minimum of 24 credit hours of class work and six hours of research.

C. Efficient Use of Resources

Missouri S&T is particularly well suited and equipped to support a Master of Science degree program in explosives engineering to be offered by the Department of Mining and Nuclear Engineering. Key factors include the strength of the Department of Mining and Nuclear Engineering, the nature of Missouri S&T as a technological university and opportunities for research, internships, and co-ops.

Department of Mining and Nuclear Engineering

The department has several years of experience developing and teaching courses in explosives engineering as part of its minor in explosives engineering. It has capitalized on this long history of teaching and research in the explosives engineering field in recent years, increasing its course offerings and rebuilding its faculty in this area such that a sustainable master’s is now possible. Because Missouri S&T is a research university, the faculty have a strong tradition of research, teaching and service.

Missouri S&T as Missouri’s Technological University

Missouri S&T’s strong reputation as the state’s technological university and as one of the top providers of MS and PhD graduates in engineering and science in the country, along with its reputation and tradition in this field, make it the logical home for an explosives engineering program. In calendar year 2008, eight separate explosives engineering-related courses (totaling 24 credit hours) were taught (excluding 390 and 490 research courses and 300 and 400 special problems courses), thirteen $1,000 scholarships were given by the International Society of Explosives Engineers to Missouri S&T students and, with the assistance of the Chancellor, the full-time explosives faculty increased to two. In conjunction with industry instructors we have now reached a sustainable level where master’s students can obtain a degree in explosives engineering with a degree of flexibility of course selection within classes offered at Missouri S&T.

D. Benefits of Collaboration

The MS degree in explosives engineering does not involve collaboration with any external institution or organization, except for the collaboration of Profs. Lusk and Weeks at the University of Kentucky and Texas Tech University, respectively. However, the current Master’s
Degree rules allow for a maximum of nine hours of course work to be transferred from universities outside the University of Missouri, which allows for future cooperation with universities offering additional courses to those offered by Missouri S&T, which would be advantageous to a master’s candidate. There is the possibility of cooperation with the University of Missouri Columbia on a course or two on the blast resistance of structures and we will be looking at cooperation with other institutions (such as Texas Tech and the University of Kentucky) and former academics now in industry for courses in specialized explosives chemistry and other areas not covered within our course offerings.

The program we are proposing is unique. It is not duplicated on the campus, in the system, the state or anywhere in the Americas. It may also be unique in the world. The only other related degree that comes anywhere close at the moment is a Master of Science in Engineering Mechanics with Specialization in Explosives Engineering offered by New Mexico Tech. However, the requirements for this specialization are less than the requirements for the current graduate minor in explosives engineering at Missouri S&T and the specialization is more along the lines of the Missouri S&T undergraduate emphasis in explosives engineering. New Mexico Tech is not seen as a competitor. The degree is in engineering mechanics and the program is solely theoretically based, and the program restricts the handling of explosives to persons with military EOD certificates. At S&T, in comparison, hands-on practical explosives handling by on-site students is mandatory. Two examples of why New Mexico Tech is not a significant competitor are that one of their graduate students chose to send his son to our summer explosives camp over their version and two students who came to S&T in the summer of 2007 from NMT because they were not allowed to handle explosives at the NMT camp. In contrast, our students have handled explosives for at least 90 years, since the inception of the school experimental mine in 1918\textsuperscript{15}.

10. **Form CP: CRITERIA BY THE PRESIDENT**

1. **Implementation of the New Program**

Implementation of the MS will not negatively affect existing programs in the department of mining and nuclear engineering or other programs at the university. It is expected that implementation of the MS will increase graduate enrollment from the BS level of the mining department, as shown in Appendix B. Furthermore the MS will complement the

\textsuperscript{15} The first picture of a completed shaft and portal at the experimental mine that we have is dated 1920.
current MS and ME programs in mining engineering by enrolling additional graduate students who would otherwise go to industry. It is also anticipated that approximately 25% of these students will continue on to be new PhD admits in mining engineering or other departments on campus. This program is part of Objective 1.3 contained in the Mining Engineering Program Strategic Plan 2006-2010.

2. Market Analysis

According to the current industry job market evaluation there is a critical need for qualified graduates with advanced explosives training. Such evidence is based on industry and organizational support outlined in Appendix G, in which professionals are seeking highly trained graduates in explosives and explosives engineering to meet the growing vacancies due to retirement. As stated by Bruce Neil et al. of the Doe Run Company, “...the combined need for people with the best credentials, training, and experience in the form of advanced explosives engineering degrees would be at least 10 per year.”

According to a recent poll of approximately 200 S&T mining engineering students, nearly 20% expressed a definite interest in the MS in explosives engineering program. While this data is based on an internal study there is additional external interest with three outside students already enrolled waiting for the MS program to be approved. Due to snowballing interest it is now anticipated that enrollment in the MS may have to be limited soon after implementation. This interest is outlined in Appendix B and is based on practical experience with the explosives minor and ME in mining engineering. The department already has experienced substantial growth and been successful in the implementation of these programs. Both have shown exponential growth, as shown in Appendix A. The ME program started in 2001, the first graduate was in 2004 and there are now 13 graduates.

3. Business Plan

A. Financial Projection

The majority of resources to complete development and implementation of the MS program already exist at S&T. The mining department already offers nearly all of the needed courses and existing faculty members have the training, experience and skills required. Therefore, the initial implementation of the program will be at minimal cost (a GTA in year 1 plus E&E supplement from year 2). A break even analysis indicates that during the first two years of the program only three students (one from out of state and two in state) would need to be enrolled in order for the program to pay for itself. The only substantial increase in cost
would be the additional faculty member in year 3, for which 15 enrollees would be required in order to break even. Initial estimates for year 3 enrollment already exceed this requirement.\footnote{The original financial projections were given in 08/09 dollars because this was the financial year the proposal was initiated and Form FP was passed by the budgetary affairs subcommittee of the S&T Faculty Senate. They were based on out of pocket dollars. The new requirements are for the inclusion of the distribution between the mining engineering program and the new MS program, separately. Some time is included in the MS for faculty for the supervision of students but under the new scenario some GTA and new faculty costs will be for mining – the graduate student will be taking load off the explosives faculty in mining and the new faculty member will be expected to provide duties in mining non-specific to the MS.}

New Faculty

It is anticipated that a new faculty member at the non-tenure track, or at the assistant/associate tenure track level, will be needed to ease the burden on the existing faculty once the program has become established and as we ramp up. This faculty member will only be hired once the year 2 enrollment projections have been met and university resources may be committed.

Graduate Teaching Assistant

A GTA will be used to transfer load from department faculty already teaching explosives classes predominantly at the undergraduate level, allowing room for the extra graduate students and increased effort on graduate level classes by the faculty.

Expenses

The infrastructure is already in place for the mining engineering program to accommodate the increase in enrollment (including one GO administrative assistant and two soft money secretaries). $10,000 per year is budgeted to cover the secretarial, dissemination of materials and communications (traditional and new media) costs. The first year of E&E is for year 2 and is contingent on meeting the year’s enrollment goal, making it a performance incentive. Currently the total expected expenses for the first five years are $575,061.

Revenue

Tuition and fee revenue is projected at $771,674. The explosives engineering MS program will be financially self sustaining from the start and build up to a total of 27 students. With the current higher than originally estimated number of students interested in the program, limitations may have to be put in place. However this could have a positive effect on
revenue (for example if we meet year 3 projections in year 2) that will bring in additional revenue. The current projected revenue minus expenses brings the net worth of the MS program to $196,613, as shown in Appendix D.

**Budget Strategy**

We are currently in uncertain financial times but we are engineers acclimated to working with factors of safety on a routine basis and therefore are conservative by nature. Our budget strategy is simple and based on three tenants.

1. The program will be financially self sustaining.
2. It will make money for the university.
3. The projected expenses are strictly performance based – the hiring of the additional faculty member is contingent on our success in meeting enrollment goals.

Additional revenues are also likely through online course offerings, grants and contracts, but income from these sources has not been entered into the budget because they are not secured. Online courses are planned for development within the first five years. Additional financial support from grants and contracts is likely. Participating faculty members have successful research and/or service programs in the area of explosives. Any revenue generated from online courses, grants, or contracts will be re-invested in the explosives engineering program.

**B. Student Recruitment and Retention**

Target recruitment audiences for the explosives engineering MS will include current undergraduate students and professionals currently employed in industry, military and other government. The overarching recruitment goal is to obtain a highly qualified student body that is diverse across traditional/non-traditional student categories, discipline area, age, gender, and ethnicity. Students are often unaware of the explosives field and the opportunities afforded because of the industry’s past desire to maintain a low profile/transparency to the public (except for the explosives demolition industry). Recruitment methods will serve to educate the students about the field, but also challenge students to cross interdisciplinary fields and gain interdisciplinary exposure.
The demand for the program is expected to increase after the recruitment plan is implemented because student and industry awareness of the program will increase dramatically. Based on our experience in substantially increasing (more than doubling) enrollment in the mining engineering program, the recruitment plan will be comprehensive and use multiple proven methods to reach both traditional and non-traditional students. As it takes an average of four and a half years to obtain a BS in engineering, and with an anticipated start of 2010, some of the year 5 entrants are currently still in high school. We will continue to recruit students all the way from high school to BS graduates working in industry. The recruitment methods for high school, traditional undergraduate students and non-traditional industry graduates will include:

- Explosives camp (an extremely successful in-place program)
- Presentations/attendance at college fairs throughout Missouri
- Replies to e-mail correspondence (the majority of current enquiries are e-mail)
- Direct mail involving invitations and brochures of the program to other university departments and interested individuals
- Piggy back on mining ME program literature
- Degree-specific website that includes web-based services
- Paragraphs about and links to the explosives engineering program on collaborating academic units websites
- A continuation of broad based media exposure - newspapers, TV and new media
- Referrals from the International Society of Explosives Engineers
- Advertisements and written articles in industry-based journals for the recruitment of non-traditional students.

The additional costs of marketing this program are covered by personnel budgeting and in the $10,000 E&E. The funded $100,000 ALERT contract for DHS will provide base materials for this

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17 We have just received $30,000 from the ALET program funded by the Department of Homeland Security for the recruitment of potential junior college students for BS careers with job opportunities in DHS. The field of explosives is included in this plan.
program and significantly reduce the effort required for website generation. Extensive marketing may be reduced if we get overburden with applications.

The current system for recruiting for the mining BS, explosives minor and mining distance education will be utilized. The mining engineering program support staff will provide the pertinent informative literature on explosives engineering and the department at S&T. They will channel inquiries to the appropriate faculty member.

Student retention is already a priority in the department and each student is assigned an academic advisor who tracks their progress with considerable assistance from the support staff. The faculty advisors will guide students through course selection, monitor their progress towards completing graduation requirements, and provide information and advice on post-graduation employment. Students will also be advised and encouraged to utilize the many academic and career support services offered by both the department and Career Opportunities Center at S&T. The resources available at S&T and individual faculty member advising already attract and help to retain students.

C. Action Plan for Program Delivery

Nearly all of the courses required for the program are in place; we already offer nine classes in explosives engineering, which are enough classes to operate the program. In addition, the physical infrastructure is also in place. The explosives engineering MS program as outlined in the administrative structure on page 15 will be an integral part of the department of mining and nuclear engineering at S&T, and the students will be counted as mining engineering program graduate students. The explosive engineering MS will join the other four existing offerings in the graduate mining engineering program, PhD in mining engineering, MS in mining engineering, distance ME in mining engineering and graduate explosives engineering minor.

The existing reporting structure for explosives engineering will remain in place. Explosives Engineering is headed up by Dr. Paul Worsey, Professor of Mining Engineering and Director of Explosive Curricula who currently reports directly to the department chair, Dr. Frimpong. The program director’s home academic unit already provides support for the program infrastructure, such as budget management, human resource services for program staff and office space for the director, faculty, staff and graduate students. A development board will be created paralleling that of the mining department to provide industry and government input. The development board will also assist the explosives engineering program in obtaining industry support. The classes in the program are already taught by existing mining faculty (Drs. Worsey and Baird), Quenon Chair Professor Emeritus Dr. Bullock and with
assistance from adjunct instructors from industry. As the offering of courses increases we will draw additional faculty from other units on campus. Cooperation with faculty at other universities for specialized topics and additional adjunct instructors from industry is also a possibility.

D. Graduate Employment

Statistics on job placement for BS degreed individuals in mining engineering and graduates with a minor in explosives engineering in conjunction with letters of support from industry show that the graduates will be highly successful in securing employment. To facilitate successful employment matches with industry, government and the military, the program director and faculty will meet with employers on a regular basis. This will occur through a development board. Discussions will focus on the program meeting their current and future workforce needs. These meetings will ensure that the program offerings are updated on a regular basis and address their present needs. The development board will also help market the program and its graduates to current and potential employers. In addition to the department, S&T also has the Career Opportunities Center (COC) and students will be referred to their resources if and when needed. The COC not only interfaces with employers but provides career and interview counseling services to hone students’ interview skills and success in job application.

E. Evaluation

The effectiveness of the explosives engineering MS will be measured against several criteria. There will be three categories of evaluation – financial, graduation metrics and program effectiveness.

The financial evaluation of the program will be based on enrollment, number of classes completed and incurred costs. Enrollment statistics and costs versus targets will be assessed at the end of each year and the data used for program development purposes.

It is important that the program is financially sound and producing a sufficient number of master’s graduates. The annual number of graduates as a percentage of the matriculating students for each year will be tracked for both traditional students and non-traditional distance students. This is to make sure that the program is on track and retention targets are met. In addition, the placement rate of graduates will be tracked. It is expected that greater than 90% of graduates will find work within three months of graduation. This evaluation will begin as soon as we start to graduate students.
Program effectiveness will be measured using several criteria, including:

- Development board review of coursework and the overall program
- Alumni surveys used as a qualified measure of graduate satisfaction of the program, with strengths and weaknesses to be identified
- Employer surveys of satisfaction with graduates’ skills and abilities to work in explosives engineering and strengths and weaknesses of their knowledge base and skills

This evaluation of program effectiveness will be made at the end of each semester for the first and second years, annually for the next three years and biennially thereafter.

11. SECURITY CONSIDERATIONS

The importance of explosives education is vital to civilian industry, government and the defense industry, yet explosives knowledge, like that from the majority of other technical disciplines, can also be used against society. Since the terrorist attacks on September 11, 2001, U.S. academic institutions have come under increasing scrutiny. The Safe Explosives Act of 2003 expanded the number of categories of persons banned from possessing explosives to include non-U.S. residents, those with dishonorable discharges from the military and those who have renounced their citizenship. This list is in addition to felons, fugitives from justice and those who have been declared mentally defective. Not only is it illegal for these groups of people to have access to explosives but it is illegal for institutions to provide such persons with explosives without first obtaining a waiver from the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives.

The Safe Explosives Act requires background checks for users of explosives and so each prospective student will require a completed background check. Proof of an existing background check, such as holding a state blaster’s license or CDL with Hazmat endorsement, being a current member of law enforcement, military, appropriate government agency or national lab or holding a security clearance will be accepted. A prospective student without proof of an existing background check will have to pay for and undergo a highway patrol background check. The check needs to be completed before acceptance into the program.

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18 Both alumni and employer surveys are already used in the mining engineering program and will serve as a template.
Dr. Henry Wiebe, Dean of Extended Learning, strongly supports the teaching of explosives courses by distance to bona fide individuals and organizations, realizing that a degree of determination of the authenticity of these groups is necessary. Distance education is becoming increasingly important, especially to degreed professionals already entrenched in the work environment who are unable, because of work or family commitments and/or financial consequences, to pursue conventional higher education in specialist fields. He further supports the extension of the MS in explosives engineering to S&T’s distance education program. Note that in order to actually handle explosives a student would need to study on campus. In addition, distance students would be vetted so that not just anyone would be enrolled in the program; they would have to be admitted by the registrar first.

12. References


International Society of Explosives Engineers Personal Communication from the Assistant to the Executive Director, August 2009


Appendix A – Employment, Graduation and Enrollment Statistics for Explosives Engineering at S&T

The following data was compiled from listings given by the campus registrar and records kept by the mining engineering program. Unfortunately FERPA precludes the appending of the raw data as it includes student names.

Employment History

Of the 30 current graduates with explosives engineering minors, 24 were mining engineering BS, 3 aerospace engineering BS, one engineering management BS and 2 PhD in mining engineering. The employment statistics are listed in descending order, starting at 12:00 and progressing clockwise.

Of the four out-of-department students we have employment data for one, an aerospace engineering student who obtained employment with the US Government (Department of Defense) and his minor in explosives engineering was the key to him obtaining this job. The two PhDs are now teaching explosives at the University of Kentucky and New Mexico Tech. Of the 24 mining engineering BS graduates all 24 received job offers/employment, predominantly in the mining industry where the majority of explosives are used.
The mining engineering program keeps records of first jobs (or job offers) after graduation for its graduating students. A distribution of professions is given below.

The difference between the charts is attributed to changing job market (<5 years for the minor versus 10 years of numbers for the department) and a lower statistical population for the minors (30 versus 172). In addition, the number of explosives minors taking employment in coal is down because explosives are almost exclusively used in surface coal mining and very little is used in underground coal. On the other hand, the number of students entering the construction industry is dramatically higher because there is heavy explosives use in tunneling, road cuts and other major construction projects in rock.

**Emphases, Minors and Certificates**

Explosives Engineering first started at Missouri S&T in 1997 as an explosives engineering emphasis in the Mining Engineering BS program. The emphasis comprises 9 hours of explosives classes. As explosives courses were added, the popularity increased and a minor in explosives engineering (comprising 15 hours of explosives classes) was approved in 2005 and the first degree with a minor was given at the 2005 December graduation. At the same time a graduate minor was approved and subsequently undergraduate and graduate certificates were approved in explosives engineering (comprising 12 hours of explosives classes), principally for those who wanted to take additional explosives courses.
Since the inception of explosives engineering at S&T, a total of 67 emphases, minors and certificates have been awarded. The data by academic year is given in the table below and corresponding graph. This data illustrates the solid growth of explosives engineering at S&T since 2004 and shows the importance of the minor, as well as the potential for proposed MS degree.

Table 1. Explosives Qualifications Conferred per Academic Year since Inception in 1997.

<table>
<thead>
<tr>
<th>Ac. Year</th>
<th>97/8</th>
<th>98/9</th>
<th>99/0</th>
<th>00/1</th>
<th>01/2</th>
<th>02/3</th>
<th>03/4</th>
<th>04/5</th>
<th>05/6</th>
<th>06/7</th>
<th>07/8</th>
<th>08/9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>2</td>
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<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>29</td>
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<td>5</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>15</td>
<td>16</td>
<td>67</td>
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The cumulative awards are given in the table below and in the corresponding graph. It can be seen that the emphasis has a steady growth but the minor has a very rapid growth rate in comparison. Indications are that the undergraduate minor is a far more attractive option to undergraduates. In comparison, the graduate minor has not taken off, primarily because there

Table 2. Cumulative Explosives Qualifications Conferred 1991 to Date.

<table>
<thead>
<tr>
<th>Ac. Year</th>
<th>97/8</th>
<th>98/9</th>
<th>99/0</th>
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<th>01/2</th>
<th>02/3</th>
<th>03/4</th>
<th>04/5</th>
<th>05/6</th>
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<tr>
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<td>13</td>
<td>14</td>
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<td>Minor</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
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<td>0</td>
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<td>8</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>19</td>
<td>22</td>
<td>28</td>
<td>36</td>
<td>51</td>
<td>67</td>
</tr>
</tbody>
</table>

Cumulative Graduates
are few on-site MS and PhD students in the mining department. The majority of mining graduate students in the department are distance students and in the ME program\textsuperscript{19}. It is difficult to attract post-graduate students who want to pursue a course of study in explosives without having “explosives” in the degree title. In addition, many non-mining students are unwilling to spend time and money on preparatory classes in mining engineering to get a mining engineering rather than explosives engineering degree\textsuperscript{20}.

The breakdown on degree majors for the minors awarded to date is given below. As can be seen the majority of the majors were mining engineering. This is because of in-house advertisement with minimal out-of-house advertising taking place apart from word of mouth. In addition, the explosives engineering minor has only been in existence four years. The following current enrollment data provided by the registrar’s office shows a significant change in student profile.

\begin{tabular}{|l|c|}
\hline
Degree & Count \\
\hline
Mining Engineering & 26 \\
Aerospace Engineering & 3 \\
Engineering Management & 1 \\
\hline
Total & 30 \\
\hline
\end{tabular}

\begin{center}
\textbf{Distribution of majors for explosives minors awarded}
\end{center}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{distribution.png}
\end{figure}

\textsuperscript{19} The on-line ME program in mining is popular because there are only 12 mining engineering programs nationwide and the geographic location of the vast majority of mines and other job locations is incompatible with attending one of these universities on site. In addition, many employed engineers wish to increase their credentials in the field of mining and excavation without taking an absence from their well paying jobs, mainly due to financial commitments.

\textsuperscript{20} From personal observation and communication with graduate students and potential graduate students.
There are 26 students who are currently enrolled for the explosives engineering minor as of summer 2009\(^1\). The statistics on these students by department are provided below. These numbers are given to show the changing demographics of our students due to expanded interest outside the department as the word spreads about explosives at S&T even in the absence of formal advertising).

<table>
<thead>
<tr>
<th>Department</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Mining Engineering</td>
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</tr>
<tr>
<td>Civil Engineering</td>
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</tr>
<tr>
<td>Mechanical Engineering</td>
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<td>Architectural Engineering</td>
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<td>Chemical Engineering</td>
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<tr>
<td>Ceramic Engineering</td>
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</tr>
<tr>
<td>Chemistry</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>

\(^1\) Many students take the explosives classes but do not enroll for the minor until their senior year, some their last semester so this number represents a conservative estimation of graduates.
It is apparent from the statistics that our graduates with minors will be dramatically diversified across major disciplines.

**Mining Engineering Master of Engineering (ME)**

The ME program started in 2001-02, with the first student graduating in 2004. This student followed an accelerated program, taking multiple classes per semester. At one class per semester it is anticipated that a typical student will take 4-5 years to finish the 33-hour program. Subsequently, we are now starting to see the first students from the initial years graduating. The graduation rate is accelerating and 13 students have now graduated (only a half year’s numbers are available for 2009). We estimate to have in excess of 40 active online graduate students each semester.

![Cumulative Plot of Graduates from ME Program](image)

**Effect of MS in Explosives Engineering on Current Enrollment**

As discussed elsewhere in this document, there will be no effect on the mining engineering MS program. It is anticipated that a large number of the best students currently taking the minor will eventually hold off taking the classes at the undergraduate level and instead take them at the graduate level for the master’s. Although this will negatively impact the number of students earning a minor in explosives engineering, enrollment in the undergraduate minor is expected to continue to grow, but at a reduced rate. The MS will not
affect the number of undergraduates minoring in explosives engineering, but will increase graduate student enrollment. Undergraduate students who pursue the MS in explosives engineering will take 30 hours at the graduate level versus 12-15 hours for students pursuing the undergraduate minor.\textsuperscript{22} There will be no loss of revenue by the change of a few students from an undergraduate minor to the explosives engineering MS since they will take other mining technical electives at the undergraduate level. The change of workload produced by this will not be significant since it will only involve around 10-12 students enrolling in approximately 20 classes distributed across campus. It is anticipated that as the program grows, the majority of MS students will not be on appointment from General Operating fund money, although some will work on research grants.

**Mining Department Enrollment FS04 to FS08***

<table>
<thead>
<tr>
<th></th>
<th>UGRAD</th>
<th>GRAD</th>
<th>TOTAL</th>
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</tr>
<tr>
<td>FS05</td>
<td>109</td>
<td>29</td>
<td>138</td>
</tr>
<tr>
<td>FS06</td>
<td>126</td>
<td>32</td>
<td>158</td>
</tr>
<tr>
<td>FS07</td>
<td>160</td>
<td>83</td>
<td>243</td>
</tr>
<tr>
<td>FS08</td>
<td>140</td>
<td>94</td>
<td>234</td>
</tr>
<tr>
<td>FS09</td>
<td>190</td>
<td>100</td>
<td>290</td>
</tr>
</tbody>
</table>

* UB represents full-pay students through the Missouri S&T partnership with the University of Botswana.

\textsuperscript{22} Mining students already take one explosives class, mining 307, as a required class for the mining BS.
Appendix B- Recent Poll of Students (July 2009)

A poll of students enrolled in the S&T mining engineering program was made on the 28th of July 2009, six months after the submission of the original proposal. Of nearly 200 undergraduate and graduate students, 31 replied positively regarding their intent to enroll in the MS program. This poll also included students in other undergraduate programs on campus, which significantly adds to these numbers with an additional 9 students interested in the program. The 31 includes 6 graduate students that are currently enrolled in other existing master’s programs waiting to get into the MS in explosives engineering program. An additional 2 students who graduated in May 2009 with a BS in mining engineering have joined them since the original proposal was written and approved by the S&T Faculty Senate. An additional 11 graduating seniors have indicated that they will enroll in the MS explosives engineering program in the 2010-11 academic year. The table of new admits, not including those already admitted and waiting for the explosives MS approval is given below. (There was no discussion regarding funding of these students.) These data indicate that the student projections on which the budget is based were conservative. Year 1 is shown as 2009-10 to be consistent with the original submission.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Year</td>
<td>2009-10</td>
<td>2010-11</td>
<td>2011-12</td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>4</td>
<td>12</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Part-time</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>14</td>
<td>13</td>
<td>34</td>
</tr>
</tbody>
</table>

With the inclusion of those already enrolled in a master’s program and waiting for this program to be approved, these numbers alone by the end of year 2 nearly meet the original projection for year 3, and surpass that based on the number of full-time students enrolled. The students responding were principally juniors and seniors (reflected in years 1 and 2 above). These numbers exceed the original conservative projections. In the initial years it is expected that the program will be dominated by graduates from S&T; however, as others find out about the program by advertising and word of mouth, the S&T students will be augmented by an increasing number of graduates with degrees from other institutions. We believe this will be

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22 The undergraduate student body of the mining engineering program is a good source of prospective students with a high probability of both meeting entrance requirements and interest. We have not been involved in statistical questionnaire mailings as the cost involved would be prohibitive (thousands of dollars) unless funded. In addition, this would constitute external advertisement of a program that is not approved.
the case based on the growth and statistics of the explosives engineering minor where out-of-department enrollment is now the majority.

A composite of the majority of these students is shown in the photograph below. This slide was taken from a breakfast presentation to the Curators of the University of Missouri on the 3rd of April 2009 at the S&T campus. It is important that these students are not just statistics, rather real people with expectations.

Some of the 17 students

- Photographs of the students.

Other Students from Within the University

There are many other undergraduate students at Missouri S&T who are interested in explosives. For example in the explosives classes I am teaching this spring semester I have 12/51 outside of the mining engineering program, with 3 distance (MinEng 307, Principles of Explosives Engineering) and 8/20 outside of the mining engineering program (MinEng 351, Demolition). Many of these out of department students are currently signed up for the minor in explosives engineering. A lot of students specifically want to take explosives engineering but are not interested in a mining degree. We foresee a lot of these students taking a non mining
degree and then applying for the explosives master’s. For example, out of the mining department it takes 15 hours of extra classes to get the minor whereas the master’s is 30 hours, basically one extra semester and a summer plus research.

**Students from Outside the University.**

We have a significant number of inquiries every year about explosives engineering. Many of these are channeled through the International Society of Explosives Engineers to us. Most of these are from out of state. In the first six months of 2009 there were 30 inquiries about explosives engineering. Of these 7 were general in nature but the rest related specifically to academic programs and 5 were inquiries about the MS in explosives engineering. They ranged from an 11-year-old who has already decided he wants to be an explosives engineer to a government employee who subsequently enrolled in our graduate distance program.

**Minor in Explosives Engineering**

A total of 30 degrees have been awarded with explosives minors and 8 certificates have also been awarded from fall 2005 through spring 2009. A break down is given in the table below:

<table>
<thead>
<tr>
<th>Program Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate certificate</td>
<td>6</td>
</tr>
<tr>
<td>Graduate certificate</td>
<td>2</td>
</tr>
<tr>
<td>Undergraduate Minor</td>
<td>28</td>
</tr>
<tr>
<td>Graduate minor</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total (since 2005)</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>

25 undergraduate minors have been awarded in the first 3 years of the explosives program. This is a clear indication of the potential for success of the master’s program. It is envisaged (based on polling) that a high percentage of the students with grades sufficient for graduate school will forgo the minor in favor of the MS program.

**Explosives Camp – Recruitment and Marketing of Program**

Explosives camp was conceived in 2005 as a recruiting tool for attracting students into the mining department. The camp is filled on a competitive basis, with a high quality of successful applicants. It has been oversubscribed since the first full camp and currently three camps (20 students per camp) are being run consecutively (in both June 2008 and 2009). All subsidies to the camp have been eliminated this year and the camp is the highest cost camp on campus at $1,250, yet still it is over-subscribed.
The first of our explosives camp students (one of the first 3 in 2004) will graduate this May with an explosives engineering minor. It takes a minimum of 4 years to get a BS at S&T after high school and with the increase in size of explosives camp over recent years we are seeing a dramatic increase in our student body. For example in the mining freshman class, of those currently enrolled (Spring 2009) in Mine Safety (MinEng 151), we have 11 explosives camp students. There is probably the same number of freshmen in other departments across campus. Of the camp students that are enrolled at S&T, nine are currently enrolled for the explosives minor, six in the mining department and three in other majors.

Of last summer’s campers, every single camper put in an application to S&T. Of 62 campers, 38 were interested in Mining Engineering and the other 24 had varied interests in degree paths, in all areas such as Civil, Chemical, Nuclear and Computer Engineering. Obviously all of them will not enroll at S&T but we expect well over 1/3rd to enroll based on previous data. These students are prime candidates for the MS in explosives engineering and the number of them enrolled at S&T will climb over the next 5 years until a steady level is reached.

This is a clear indication of the interest in explosives education.

Final Note:

It is clear that today’s students are even more demanding in their expectations and desires. The majority of graduate students want a specific program and the majority of these persons will settle for nothing less. The master’s degree in explosives engineering, is bold, well-defined and definitely desirable. Because of this, it will be easy to market.

For example we could not fill 3 summer camps for mining engineering, even at $200 per camp. The explosives engineering degree is infinitely more desirable than a master’s in mining engineering with a graduate minor in explosives engineering or a graduate degree in something else, specializing in, or with an emphasis in, explosives engineering; especially to someone who wants to pursue higher education in explosives.
**Appendix C- Break Even Projection**

Income vs. new costs for explosives engineering MS program - break even minimum based on original budget in Appendix D.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>projected students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>full-time</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>break down out of state</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>in state</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>part-time</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

| Additional Expenses | | | | | |
|---------------------|---|---|---|---| |
| 1 GTA | $16,500 | $16,650 | $16,650 | $16,650 | $16,650 |
| Faculty | $23,387 | $27,325 | $75,325 | $84,433 | $93,541 |
| Fringe | $6,800 | $7,900 | $21,700 | $24,400 | $27,000 |
| Start up package | | $20,000 | $20,000 | $20,000 | |
| E&E | | $10,000 | $10,000 | $10,000 | $10,000 |

| | | | | | |
|---------------------|---|---|---|---| |
| Tuition full-time | $30,195 | $31,099 | $75,447 | $78,079 | $86,734 |
| Income part-time | $14,863 | $30,614 | $71,296 | $73,791 | $84,861 |

| | | | | | |
|---------------------|---|---|---|---| |
| Total income | $45,058 | $61,713 | $146,743 | $151,870 | $171,595 |
| Total expenses | $46,837 | $61,875 | $143,675 | $155,483 | $167,191 |

| | | | | | |
|---------------------|---|---|---|---| |
| Net worth to university | -$1,779 | -$162 | $3,068 | -$3,613 | $4,404 |
| **Cumulative worth** | **-$1,779** | **-$1,941** | **$1,127** | **-$2,486** | **$1,918** |

Notes: Same as Appendix D

The break even scenario is given above. The spreadsheet is the same as in Appendix D with numbers of enrollment adjusted to give a near break even for each of the 5 years and a positive net worth over the 5 year period. Full-time students include in-state and out-of-state (all at 24 hours/year). Part-time students are only out-of-state (all at 9 hours per year).

The necessary enrollment per year is:
As can be seen, the break even for the first two years is only 3 full-time and 2 part-time students, which covers the cost of the 0.5 GTA, faculty salaries and related expenses. The 3\textsuperscript{rd} year break even is 8 full-time and 9 part-time students, and increases to 9 full-time students and 9 part-time students for year 5. This increased enrollment requirement is due to the addition of a faculty member in year 3.

All years are close to break even and for these enrollment projections, the program is revenue neutral for the first five years. As shown in appendix D, with actual enrollment projections, the program is revenue generating. The authorization for the extra position should be based on meeting projected goals. For instance, if it takes an extra year to meet goals then the position can be delayed a year.

If the resources allocated to the program by the S&T campus are trimmed due to fiscal constraints the break even numbers on enrollment will be reduced even further.

\textbf{Risk Assessment}

The known students that wish to participate in the master’s of explosives engineering program far exceed the minimum requirements for break even in the first 2 years. Therefore there is no risk in the first 2 years.

The addition of the faculty position should be dependent on the success of the program. Therefore, there is minimal risk over the short term (first 5 years). With the addition of the faculty position, further courses can be added, especially focusing on courses that can be taught both locally and by distance, which will bring in extra part-time students including those interested in post graduate explosives certificates.

Overall the risk to the university is very minimal whereas the potential for success is great. (Costs for the break even projection are explained in Appendix D.)
## Appendix D – Net Worth of Program

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Break down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-state</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>In-state</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Part-time</td>
<td>0</td>
<td>5</td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

### Additional Expenses

<table>
<thead>
<tr>
<th>Faculty</th>
<th>1 GTA</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worsey</td>
<td>$16,650</td>
<td>$16,650</td>
<td>$16,650</td>
<td>$16,650</td>
<td>$16,650</td>
<td>$16,650</td>
</tr>
<tr>
<td>Baird</td>
<td>$15,512</td>
<td>$15,512</td>
<td>$15,512</td>
<td>$20,683</td>
<td>$25,853</td>
<td>$25,853</td>
</tr>
<tr>
<td>New</td>
<td>$7,875</td>
<td>$11,813</td>
<td>$11,813</td>
<td>$15,750</td>
<td>$19,688</td>
<td>$19,688</td>
</tr>
<tr>
<td>Fringe</td>
<td>$48,000</td>
<td>$48,000</td>
<td>$48,000</td>
<td>$48,000</td>
<td>$48,000</td>
<td>$48,000</td>
</tr>
<tr>
<td>Start up</td>
<td>$6,800</td>
<td>$7,900</td>
<td>$21,700</td>
<td>$24,400</td>
<td>$27,000</td>
<td>$27,000</td>
</tr>
<tr>
<td>E&amp;E</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

### Annual Expenses

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries</td>
<td>$103,413/AY</td>
<td>$78,751/AY</td>
<td>$80,000/AY</td>
<td>$103,413/AY</td>
<td>$78,751/AY</td>
</tr>
</tbody>
</table>

For tuition income, it is assumed that in-state students will receive a waiver for course hours 7 through 9. This is a conservative estimate since not all in-state students will receive a stipend. For out-of-state students, it is assumed that all students (full-time or part-time) will be “full pay” students. These students will be supported privately or through their employer.
The percentages shown in the FTE allocation table above represent effort to be made directly in the explosives engineering program. The balance of effort will be in the mining department. Specifically 50% of the 100% FTE GTA will be used to reduce the burden on Dr. Worsey and Dr. Baird teaching students from existing programs. The additional time for Dr. Worsey will comprise 5% for the administration of this small program plus a ramp up from 10 to 20% for the advising of students as the program grows. Dr. Baird is initially started at 10% for advising and then will ramp up as the program increases. In the third year the new faculty member is put in place and once acclimated will take over a major role in advising to 25%. This will also cover the development of a new course every other year. The new faculty member is shown as 60% effort in the program because the tenure-track position will have responsibilities for obtaining tenure outside of the master’s program. This will include service to the department and the field and scholarly activities such as research and publication. The addition of a new faculty member will allow an increase in course offerings and a substantial part of their time will be for the development of new courses. Under the column for each year the number of projected students for that year is listed as on campus, part-time and total. The current adjunct instructors are already paid at a flat rate from very successful undergraduate courses. The additional adjunct faculty are not currently budgeted as they will primarily be use for overflow above projections and as a back-up in case the third full-time explosives faculty position cannot be funded.
Appendix E - Graduate Catalog Description

Explosives Engineering
Master of Science

The Explosives Engineering program offers an MS degree for students with bachelor’s degrees in engineering, science or technology. Due to the age profile of the explosives industry and attrition of personnel, as well as the rapid change in technology within this field, there is an immediate and growing need for highly trained explosives professionals in both the civilian explosive, mining and civil excavating fields and government and the defense industry. Employers are looking for engineers and scientists with sophisticated skills in the integration of explosives technology into complex systems in a wide range of applications. Employers are also seeking MS graduates because they can move quickly into managerial positions.

Faculty involved in a variety of explosives-related research programs teach and direct the program in conjunction with instruction by industry specialists in a wide range of applications. Students will have opportunities to assist these faculty, both in research and teaching, as well as working alongside faculty and graduate students in other engineering and science fields such as Civil, Architectural, Mechanical, Chemical, Aerospace, Electrical, Geological and Materials Engineering and Geology, Geophysics, Chemistry and Physics. The explosives engineering faculty and students will be active in the leading professional societies such as the International Society for Explosives Engineers.

The program requires a minimum of 30 hours of graduate credit and includes a thesis. A core of four courses is required of all students, and a module of allied courses in departments outside of explosives engineering is encouraged. A security background check is required.

Degree Requirements

MS with Thesis: The MS degree with thesis requires the completion of 24 hours of graduate course work and six hours of research (ExpE 490), and the successful completion and defense of a research thesis. Four of the following core courses are required of all MS students in Explosives Engineering:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExpEng 307</td>
<td>Principles of Explosives Engineering</td>
</tr>
<tr>
<td>MinEng 307</td>
<td></td>
</tr>
<tr>
<td>ExpEng 350</td>
<td>Blasting Design and Technology</td>
</tr>
<tr>
<td>MinEng 350</td>
<td></td>
</tr>
<tr>
<td>ExpEng 351</td>
<td>Demolition of Buildings and Structures</td>
</tr>
</tbody>
</table>

24 Based on past experience with explosives-related contracts and other research.

25 These courses are currently offered in Mining Engineering
Students select 12 hours of ExpE and other appropriate elective courses. MS in Explosives Engineering candidates are advised to group out-of-department courses into a module that fits their special interest.

**Faculty**

Faculty involved in the program include existing faculty from the Department of Mining and Nuclear Engineering at Missouri S&T and instructors from industry, augmented by faculty from the Department of Civil Engineering at Missouri S&T and faculty from the University of Missouri--Columbia, University of Kentucky and Texas Tech University.

**Professor**

Paul Worsey, PhD, University of Newcastle upon Tyne (Missouri S&T)  
Richard Bullock, D. Eng., Missouri School of Mines Emeritus (Missouri S&T)  
Sam Kiger, PhD, University of Illinois at Urbana (University of Missouri Columbia)  
Bruce Freeman, PhD, University of California Davis (Ktech, formerly at Texas A & M)  

**Associate Professor**

Jason Baird, PhD, University of Missouri Rolla (S&T) (Missouri S&T)  
John Myers, PhD, Texas-Austin (Missouri S&T)  

**Assistant Professor**

Braden Lusk, PhD, University of Missouri-Rolla (S&T) (University of Kentucky)  
Brandon Weeks, PhD, University of Cambridge (Texas Tech)  

**Adjunct Industry Instructors Currently Teaching Courses at Missouri S&T**

Greg Shapiro, BS, University of Missouri Columbia  
Matt Sutcliffe and Marty Gillette  
Steel Blasting  
Premier Pyrotechnics  

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26 These have acknowledged interest in working with the program on an adjunct basis offering distance courses (from their current location), subject to S&T hiring policies & procedures.
We hope to broaden the scope of the program to involve professors from other disciplines on campus, such as Civil and Architectural Engineering (for example, blast resistance design), Chemistry (examples: explosive formulation, chemistry of high explosives), Chemical Engineering (examples: treatment of explosive process streams, explosion evaluation) and History (example: history of explosives) as the offering of courses expands. We have already made exploratory contacts.

**Catalog Description of Proposed Explosives Engineering Courses**

The majority of the following courses are currently listed under Mining Engineering with the MinEng prefix. The purely explosives classes will be moved to an ExpEng prefix. However, those classes that are directly mining-related will be co-listed.

**ExpEng 301** (3)  Special Topics  
This course is designed to give the department an opportunity to test a new course.

**ExpEng 305** (3)  Explosives Handling and Safety (originally MinEng 305)  
Basic handling and safety for explosives, explosive devices and ordnance related to laboratory handling, testing, manufacturing and storage, for both civil and defense applications.

**ExpEng 307/MinEng 307** (3)  Principles of Explosives Engineering  
Theory and application of explosives in the mining industry; explosives initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations. Prerequisites: GeEng 50; accompanied or preceded by either CvEng 215 or Geo 220 or Geo 125.

**ExpEng 309** (3)  Commercial Pyrotechnics Operations (originally MinEng 309)  
Provide participants with basic pyrotechnic operator certification (with passing of the PGI test) and advanced lead pyrotechnic operator training. Class work will be complemented by practical training in laboratory sessions, culminating in a full pyrotechnic show, from start to finish. Prerequisites: Chem 1, US Citizen or permanent resident (to fulfill the requirements of the SAFE EXPLOSIVES ACT 2002), resident enrollment at Missouri S&T (i.e., not distance or internet).

**ExpEng 313** (3)  Stage Pyrotechnics and Special Effects (originally MinEng 301)  
Use of energetic materials in close proximity to audiences. Provide participants with training preparing for Missouri Pyrotechnics Display Operators License. Covers close proximity, indoor and outdoor pyrotechnics and special effects. Working with stage crews and talent, safety and permitting.
ExpEng 350/MinEng 350 (3) Blasting Design and Technology
Advanced theory and application of explosives in excavation; detailed underground blast design; specialized blasting including blast casting, construction and pre-splitting. Introduction to blasting research. Examination of field applications. Prerequisite: ExpE 307/MiEng 307. Student must be at least 21 years of age.

ExpEng 351 (3) Demolition of Buildings and Structures (originally MinEng 351)
Provide participants with basics and solid grounding in the equipment, techniques and processes required for the demolition and remediation of mine plant and processing equipment sites and non-mining structures such as buildings, factories, bridges etc. Prerequisites: IDE 50 or 140, and IDE 110 or MiEng 232, plus US citizen or permanent resident. *Requirement due to the Safe Explosives Act 2002.

ExpEng 400 (variable) Special Problems
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ExpEng 401 (3) Special Topics
This course is designed to give the department an opportunity to test a new course.

ExpEng 402 (3) Environmental Controls for Blasting (originally MinEng 402)
Advance blast mechanics; overbreak control including comprehensive coverage of perimeter and smoothwall specialist blasting techniques and geotechnical factors affecting blast vibration, including limits, analysis, monitoring and control; air blast control including limits, monitoring and atmospheric and topographic effects. Prerequisite: ExpEng 307 or MinEng 307.

ExpEng 406 (3) Scientific Instrumentation for Explosives Testing and Blasting (orig. MinEng 406)
Application of scientific principles, equipment description and operation for instrumentation of explosive events including blasting. Topics: Blast chamber design, set up, high-speed photography, motion detection and measurement, explosives sensitivity testing, explosives properties testing, vibration measurement and analysis, destruction and demil.

ExpEng 407/MinEng 407 (3) Theory of High explosives
Study of the application of chemical thermodynamics and the hydrodynamic theory to determine properties of high explosives; application of detonation theory to steady-state detonations in real explosives; application of the above to the blasting action of explosives. Prerequisite: ExpEng 307 or MiEng 307.
ExpEng 490 (3) Research
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

ExpEng 491 (0-6) Internship
Internship will involve students applying critical thinking skills and discipline specific knowledge in an explosives-related work setting based on a project designed by the advisor and employee. Activities will vary depending on the student’s background and the setting.
Appendix F – New York Times (Science Times) Article
July 3, 2007
Appendix G – Letters of Support

We have categorized our letters of support into four categories:
1. Industry associations,
2. Companies,
3. Alumni,
4. Student requests,
and given a sample of State, national and international support for the first three categories.

The proposed Masters program is of importance to 4 different constituents and each has different perspective and needs. These range from the vision of industry associations, the workforce demands and projections of industry, the importance some of our alumni in the industry see for the program, their aspirations for their alma mater and their pride in its place beside industry and its academic standing, to the aspiration, needs and wants of the students excited about the opportunities that this new program provides for both their education and potential employment.

Industry Associations

To start, the industry associations include the Missouri Limestone Producers Association, the Institute of Makers of Explosives and the International Society of Explosives Engineers. The Missouri Limestone Producers Association is the state crushed stone association which provides huge quantities of materials essential for infrastructure in Missouri and elsewhere. Crushed stone is the largest component of concrete, asphalt, and road base and would not be possible without blasting. The Institute of Makers of Explosives represents the US explosives manufacturers, and we are the largest producer and consumer of explosives in the world. The international society of explosives engineers represents the broad explosives and blasting industry and is primarily made up of people who use explosives but also represents explosives and blasting companies and support such as vibration monitoring, drilling, consultants, academia etc.
September 2, 2009

Dr. Samuel Frimpong
Department Chair of Mining and Nuclear Engineering
Missouri University of Science and Technology
226 McNett Hall
Rolla, MO 65409

Dear Dr. Frimpong:

I am encouraged to learn that Missouri S&T may offer a Masters Degree in Explosives Engineering. Graduates with this educational background will fulfill a critical need in the mining and construction industries.

The Missouri Limestone Producers Association represents a high percentage of our state's crushed stone production. We traditionally rank in the top ten among all states in crushed stone production. Much of this production is in the form of construction aggregate, which is used, among other things, as the primary constituent of concrete and asphalt. In Missouri, about 85 percent of construction aggregate is in the form of crushed limestone. It is used on virtually every infrastructure, commercial and residential construction project. About one-half of crushed stone production is used on publically-funded projects such as highways, bridges, water/sewer systems, airports, etc. It’s also important to note that Missouri is a leading producer of cement and lime, which uses limestone as a basic ingredient. Blasting is the primary, and the only practical, means of breaking rock so that it can be processed. Without explosives the cost of crushed stone would be substantially higher.

 Crushed stone is produced in all but two states. The ten leading states in production are Pennsylvania, Texas, Florida, Missouri, Illinois, Ohio, Georgia, Virginia, Kentucky and North Carolina. These states account for a high percentage of total U.S. production, and represent potential career locations for Missouri S&T graduates with an advanced education in Explosives Engineering. Construction firms that operate in these and other states dealing with the vast quantities of rock excavation that occur every day also need access to personnel with expertise in explosives.

The explosives industry has experienced rapid changes in applied technology in recent years. Highly precise and accurate electronic blast initiation systems is but one example. This and other advances allow efficient, cost-effective rock breakage while creating minimal secondary effects such as noise and ground vibration. Control of noise and ground vibration is becoming increasingly important as commercial and residential development continue to expand closer to long-established mining operations. Well-trained explosives professionals that can communicate effectively with citizens and local officials have become an absolute necessity.
As our nation’s infrastructure, commercial and residential construction continues to expand in response to our growing population, we have an inherent need for additional personnel with a high degree of explosives training. Accelerating this demand is the ongoing high retirement rate of professionals in the mining and construction industries. Much of the acquired intellectual asset that these retirees represent will leave a serious productivity void that must be replenished with college graduates. This “knowledge gap” is also occurring in the field of explosives as a corollary to this trend in the mining and construction industries.

I’m certain that the Missouri S&T graduates with advanced knowledge of explosives will be put to work as quickly as they become available!

Sincerely,

Steve Rudloff
Executive Manager

/sr
Dr. Samuel Frimpong  
Quenon Chair in Mining and Department Chairman Department of Mining and Nuclear Engineering  
226 McNutt Hall  
Missouri University of Science and Technology  
Rolla, MO 65409  

Dear Dr. Frimpong:  

I am writing you to express support for a Masters of Science program in Explosives Engineering.  

The IME is the safety and security institute of the commercial explosives industry. Our mission is to promote safety, security and the protection of employees, users, the public and the environment; and to encourage the adoption of uniform rules and regulations in the manufacture, transportation, storage, handling, use and disposal of explosive materials used in blasting and other essential operations. The IME represents U.S. manufacturers of commercial explosives and other companies that distribute explosives or provide related services. IME’s member companies produce over 98 percent of the commercial explosives consumed annually in the United States. The United States consumes approximately 7 billion pounds of commercial explosives annually with 85 percent of that used in mining.  

Many explosives industry professionals have years of experience and are nearing retirement. We expect a substantial demand for engineers with advanced training in the use and theory of explosives in the future. Several factors lead to this expectation including an aging workforce, growth in explosives-related industries, the increased technical nature of explosives work and significant regulatory challenges. These trends will require competent and versatile personnel who possess the expertise to address such challenges.  

IME strongly supports higher education in the explosives field. We believe that an MS program in Explosives Engineering will help the industry meet its personnel needs. We wish your department success in approval and implementation of your proposed MS program and hope that we may soon add it to the list of higher education opportunities on the training page of our website.¹  

Sincerely,  

Lon Santis,  
Manager of Technical Services, Institute of Makers of Explosives  

---  
August 31, 2009

Dr. Samuel Frimpong  
Department Chair  
Mining and Nuclear Engineering  
226 McNutt Hall  
Missouri S&T  
Rolla, MO 65409

Dear Dr. Frimpong:

The International Society of Explosives Engineers is a nonprofit association formed in 1974 by a group of dedicated individuals in the blasting industry who recognized the need for an organization that would promote the science and art of explosives engineering and the safe and secure use of commercial explosives.

The founding members of ISEE established broad goals related to education for individuals who work in the explosives industry. For thirty-five years our members through our volunteer Board of Directors, Committees, Chapters, and through general member support have been dedicated to producing education forums, technical literature, training programs, research, forums for regulatory information and education, the promotion of education for those who use commercial explosives primarily in mining, quarrying, construction, and the general public. Many of our education activities have also been supported by and funded through the Society of Explosives Engineers Education Foundation.

The Society’s members number about 4,700 worldwide with the majority of members in the United States. As a professional association we are well aware of the statistics that related to the human resources in this industry. As a result, we have worked to encourage young people to enter our industry with an eye on the deficit of workers coming soon because of our aging work force. We know that the impact on the explosive industry will be felt in every quarter including field workers, researchers, government regulators, manufacturers and college professors. We know that most of the explosives produced are used in the mining industry and that the mining industry does not happen without the use of explosives. We see no other technology on the horizon that is going to replace the use of explosives in mining. We have a problem in our industry.

The International Society of Explosives Engineers is working on that problem. We are supporting and developing materials for education programs for field worker training. We are now at work developing the 18th Edition of the ISEE Blasters’ Handbook which is a core reference for training and retraining cited by many states that require licensing for blasters. The Handbook is a reference book owned by most individuals in our industry. The Handbook development work is happening because of a dedicated group of industry subject matter specialists who care enough about education to put thousands of volunteer hours into this project and along with other education efforts.

ISEE is in support of two technical college programs for blasters one at Fleming College in Canada as well as the blasting technology program in development at Bridgemont Community Technical College, West Virginia. In addition, we continue to provide scholarships for university students in four-year engineering programs, graduate programs, and doctorate programs. These scholarships are granted by twenty-two endowed funds through the SEE Education Foundation.
Our scholarship funds have been developed as memorials to individuals who have served our industry, by our ISEE chapters and by annual contributions made by our members. This is an industry that has a stake in an educated work force. We know that your university has been doing its part and we are confident with the dwindling human resources available to the mining industry in particular, that a unique Masters program in explosives is the next important step in higher education.

Missouri University of Science and Technology has had ISEE and our SEE Education Foundation support for many years. Many of your alumnae are members and supporters of this organization. Robert Ropier and Richard Ash distinguished members have long association with Missouri S & T, both served on our Board of Directors. Since 1995 the SEE Education Foundation has provided over fifty scholarships to students at Missouri S & T and one of our most active student chapters is on your campus.

Missouri S & T graduates are on our committees and overall the graduates have served the industry and ISEE well. We are, as an international Society, aware that our graduates have an international impact as we have current members who have attended the program at Rolla and have returned to their home countries with that education to pass it on or have stayed in the United States to work at other universities.

We are aware that the university has worked with dedication to continue developing a program that serves the explosives industry. We help support that effort and we ask you to continue that industry education support by approving the Master of Science degree in Explosives.

Thank you for this opportunity to extend our support and express our concern for the continued development of critical education for this important industry.

Sincerely,

[Signature]

Jeffrey L. Dean, IOM CAE, Executive Director and General Counsel
Companies

Letters of support from several companies are included including the leading world manufacturer of explosives, Orica, explosive distributors (Oslon Explosives), explosives testing (Utech), the number one manufacturer of bulk explosives delivery systems in the US (Tread), and the principal users of explosives (over 85%) which are mining corporations (US Gypsum, Martin Marietta, Vulcan and Doe Run). USG is the largest manufacturer of sheet rock in the US, which is comprised of mined gypsum rock. Martin Marietta and Vulcan are two of the top 5 aggregates producers in the nation to whom explosives are essential in the primary breakage of rock and Doe Run is the largest mining corporation actively mining in Missouri and the largest consumer of explosives in the state. This sample of companies spans a broad range of explosives and their use.
September 15, 2009

Attn: Dr. Samuel Frimpong  
Department Chair of Mining and Nuclear Engineering

Subject: Support for Masters in explosives engineering at Missouri S&T

Orica is focused on providing technologically innovative products and services to our customers. The explosives industry values innovation and is continually searching new ways to bring the value of innovation to the mining industry. Our innovation is driven by understanding, anticipating and responding to the needs of industry users.

We believe that new talent will need to be infused into the explosives industry to support continued growth. The demographics of our workforce is skewed toward many years of experience. I project that in the next decade Orica as well as other explosive manufacturers will find gaps in their organizations. In an attempt to begin to fill these gaps, Orica has recently created a program called, "Orica Partnership for Mining Education." The goals of this program are threefold: introduce Orica product and services to mining students, provide real life experience and education to students, and attract talent into our organization. We believe that the explosives industry will benefit from the development of a Master in Explosive Engineering program at Missouri S&T.

Using current market demand and projecting forward for ten years, approximately twelve master level Explosive Engineers would be able to find employment with explosive manufacturers. This number continues to grow as the explosives industry becomes more regulated, mining methods continue to evolve, and demand for sustainability increases.

Orica strongly supports the introduction of the program at Missouri S&T. Please keep me informed on the progress of this program's advancement.

Sincerely,

Mitchell D. Lee  
Vice President Orica USA
Date: 18 August, 2009

Dr. Samuel Frimpong  
Department Chair Mining and Nuclear Engineering  
226 McNutt Hall  
Missouri University of Science and Technology  
Rolla, MO 654091

RE: MS Explosives Engineering

Dr. Frimpong:

In speaking with Dr. Paul Worsey recently, he had conveyed to me that the MS&T Mining Department is seeking to develop an accredited Masters Program in Explosives Engineering. I feel this would be a very good step forward for the Explosives Industry, as well as for the University. The levels of technology we work with in the explosives field are advancing steadily, and the need for highly educated professionals has escalated accordingly. Overall the mining/explosives industry is an aging workforce, from the blaster’s in the field, to the manufacturer’s representatives and field technical personnel. In many cases, organizations (both explosives and mining) are hiring individuals without the appropriate background or education, due to low numbers of qualified professionals. Blasting and Explosives Engineering will always be a “marriage” of science and art form, however with the available levels of technology rising, and regulatory influences tightening, these technological improvements enable the blaster/explosives engineer an improved means in which to achieve the desired results, without further imposition to the surrounding communities or environment. But in order to do so the blaster/explosives engineer needs to be able to utilize these advanced technologies in their favor. That’s where the graduate level program in Explosives Engineering comes into play; developing industry professionals who can spread the word, and train other explosive professionals, in order to give them the ability to apply these advancements in a safe and productive manner.

Thank You, for allowing me to voice my support of such a program. If you have any questions, please feel free to give me a shout, or e-mail.

Take Care, Be Safe!

Kurt B. Oakes  
General Manager  
Olson Explosives, Inc.
August 14, 2009

Dr. Samuel Frimpong
Department Chair of Mining and Nuclear Engineering
Missouri University of Science and Technology
Rolla, MO

The explosives industry has been losing qualified, trained professionals at a rate far exceeding those receiving a proper education in the field. Add to this the fact that a large number of those entering the field today are over the age of forty, and that many currently in the explosives industry will be eligible for retirement in the next ten years, it is easy to see that the future of the explosives industry could be in desperation. In a recent article in *The Journal of Explosives Engineering*, a retiring and well respected 50-year explosives chemist, Milos Bila, states, “...the shortage of educated and experienced explosives chemists and engineers is very real everywhere.” (*July/August 2009*).

UTEC currently operates an energetic materials testing facility in Southeastern Kansas, and has in the past worked with the University of Missouri, Rolla, on several explosives testing projects. UTEC’s laboratory has been in operation for more than 50 years, and it staff of chemists, physicists and testing technicians have well over 100 years of combined experience in the field of energetic materials research and testing. I would like to note that one of our experienced project chemists is an UMR graduate (major in chemistry and minor in mining engineering). As an R&D company that deals primarily in the development, characterization and safety testing of energetic materials, the lack of qualified personnel with explosives education and experience can be seen in all walks of the industry, including development, testing and process control. It should also be noted that there has been talk recently in Europe of a lack of explosives education programs and the need to develop a system. Currently, there are no advanced explosives education programs in place in the USA. Other than a few limited blasting programs scattered around the country, explosives education is exclusively from on-the-job training.

There are many facets of explosives applications, all with differing needs: military explosives and propellants, automotive safety devices, rifle and pistol ammunition, display pyrotechnics, metal-cladding, and others, not to mention the extensive commercial explosives used in the mining industry, which consumes more than 3 million metric tons of explosive per year. It would be reasonable to expect the explosives industry to have availability to hire a dozen or so educated persons each year, with several more being sought by the government in the military and government agencies.

It is my belief that an advanced explosives education program would be extremely beneficial to the explosives industry and to the country as a whole, placing trained, experienced persons into increasingly vacated positions in the research, development and processing of energetic materials.

Sincerely,

Gary Eck
Vice President of Research and Laboratory Manager,
UTEC Corporation
August 26, 2009

Dr. Samuel Frimpong  
Department Chair of Mining and Nuclear Engineering

Dear Dr. Frimpong,

My name is Richard Thomas Watts, President of Tread Corporation. I am responsible for all facets of the operation, including the manufacture, sales, service and marketing of the product offering. Tread Corporation located in Roanoke, Virginia, USA has been in business since 1957. Tread is the leading designer and manufacturer in the world of explosives storage and handling equipment, with sales to all major explosives companies in the U.S.A. and forty foreign countries. I have served as President of the ISEE, Board Member of ISEE, Chair IME Transportation and Distribution Committee, and Governor of IME.

Tread Corporation

Company Profile

- Tread Corporation has been in business since 1957.
- Sales are $28 - $30 million/year.
- Tread produces anywhere from 100 to 150 trucks a year, plus manufacturing plants for explosives, storage containers, railcar unloading systems, and packaging machines.
- We employ 150 people at our facility in Roanoke. This number also includes our field service technicians.
- We have a 65% share of the U.S. market and are the largest supplier of bulk explosives storage and handling equipment in the world.
- Currently, Tread exports equipment to 40 countries worldwide.
- Tread has sales to all major international explosives companies operating in the countries below
  - Western Hemisphere: Canada, Mexico, Chile, Peru, Argentina, Venezuela, Colombia, Guyana
  - Europe: United Kingdom, Spain, Norway, Belgium, Portugal, Turkey
  - Africa: Tunisia, Ghana, South Africa
- The total number of units Tread has sold is 2,000
- Certified by the American Society of Mechanical Engineers as a code shop for the building of pressure vessels

Bulk Handling Equipment and Explosives Storage Magazines
The part of my job that I enjoy the most is traveling around the world and doing my best to help people solve problems. This lets me see operations of all types and the challenges are always different. These challenges come in many forms: regulations, rock formations, weather, terrain and availability to transport raw materials. These are common challenges that are universal around the world. As different as they may appear on the surface, there is always a common bond between these apparent obstacles. The common bond is always people.

This industry has as many good people as many industries and more than most. People truly make the difference. Each time a situation changes there is always an opportunity and the positive, progressive person sees this. The less fortunate see changes only as obstacles. Change is sometimes hard to visualize as an opportunity. I once read a quotation, "Obstacles are what you see when you take your eyes off of the target".

I have said before that we are a misunderstood industry in an uncertain time. These changes and uncertain times produce opportunities. We are going to be facing more competition for imports and export regardless of the country where we live. It is going to be our industry's biggest challenge in the future to find, attract, and keep the best people we can. This is the very essence of our future.

I have just finished reading the book, written by Jack Welch the past CEO of General Electric, Jack, straight from the gut. General Electric has been a model company for all of us to aspire to. In the last twenty years, General Electric has changed the way they do virtually everything and has now globalized to the point of 40% of their business being outside the United States. The theme of the entire book is consistent throughout. Find, keep, and reward the best people you can. If you have not read this book, I highly recommend it.

Jack Welch cites example after example of taking a mature industry and breathing new life into it and producing outstanding results. In a mature industry, we have all asked ourselves many times what can we do to make things better. Breathing new life into a company through the addition of new hires that do not have the bias and prejudices of us old guys can be great. We have hired young people in every facet of our business and their views are very refreshing in regards to many problems we have fought for years.

Within our industry, we are well aware of the importance of new graduates possessing the right credentials with Masters Degrees in Explosives Engineering to till the inevitable vacancies as our predecessors near retirement. These young people with advanced training in explosives engineering are our industry's future.

Best regards.

Tom Watts
President
August 11, 2009

Dr. Samuel Frimpong  
Department Chair of Mining and Nuclear Engineering  
288 McNutt Hall, 1870 Miner Circle  
Missouri University of Science and Technology  
Rolla, MO 65409

RE: Proposed Master's Degree in Explosives Engineering

Dear Dr. Frimpong;

The use of explosives in the fields of mining, construction, and demolition has long been as much art as a scientific discipline. Drilling and blasting practices are often the result of trial and error and/or recommendations made by explosives vendors. The statement “This is way that we have always done it” is often heard at mining sites, many times without rationale as to why the practices are done this way.

Undergraduate curricula in mining engineering generally contain requirements for coursework in drilling and blasting practices, fundamentals of design, as well as in the proper and safe handling of explosives. These courses provide the basic knowledge and skills for an entry level mining engineer to apply in their first job.

There is a need for professionals with advanced education and training to develop and implement advancements in the development and usage of explosives materials. In addition to the development and usage of explosives in mining and construction, there is a "darker" side of the world of explosives. The Safe Explosives Act was promulgated in response to the attacks of September 11, 2001. The Department of Homeland Security's Science and Technology Directorate Explosives Division researches the concepts, science, technologies and systems that increase protection of people and infrastructure from explosives.

As the mining workforce matures and retires, the need for trained personnel will increase to staunch the "brain drain" of experience in explosives techniques. The consumption of explosives components is a costly part of the mining process. Improved fragmentation of rock by the use of advanced explosive materials, programmable delays for more precise sequencing, etc. will result in lowering mining costs, decreased explosives consumption, and other benefits such as noise abatement. These advancements will also improve practices of specialized blasting, often done in urban areas for the installation of utilities.

Sincerely,

David Obergefell  
VP Manufacturing - International  
USG Corporation
Dr. Samuel Frimpong  
Department Chair of Mining and Nuclear Engineering  

Dr. Frimpong:  

I have been informed that your Department is considering an MS in Explosives Engineering.  
The need for experienced, qualified, people in the explosives industry has been a subject that has concerned me for a long time as an individual who has been in the explosives and mining industry very close to 40 years. I was lucky enough to have joined the industry when the manufacturers took the responsibility for the internal training to ready an individual to enter the explosives field. I spent time in quality control, manufacturing, technical support, and sales of explosives and explosives related products, basically within a mentor program that always allowed someone to go to if you had a problem. During these several years while still early in my career, I was involved in the manufacture of nitric acid, anhydrous ammonia, prills, water gels, dynamite, emulsions and detonators. Now, in trying to analyze a problem, one can adequately talk about pH of liquor, detonator base charge, wire extrusion, etc, etc.  
With the consolidation of the industry and with several, if not all, of the companies that created the explosives industry in the United States leaving the industry, that training, background and experience is quickly being lost, and not being replaced. An advanced degree that could take the basis of a Bachelor’s degree and provide another level of background and experience is certainly needed in our industry and I believe would be supported by students understanding the need for additional depth when moving into such a critical industry.  
With the relatively new introduction of electronic detonators, we continue to move into fields that heretofore have not been thought of, or previously not possible to quantify, with the introduction of signature hole modeling, electronic or digital mine planning, potential elimination of the 8 ms rule, structural monitoring with displacement sensors, etc. The list will grow, as will the need for individuals to develop and interpret the data, and it will be sorely needed in not only our industry, but also within many of our regulatory agencies that govern our industry.  
Good luck in your endeavor.  

Regards,  

Dean A. Wiegand  
Martin Marietta Materials  
Manager- Explosives Engineering
Dr. Samuel Frimpong                                                                   August 10, 2009
Department Chair
Mining and Nuclear Engineering
Missouri University of Science and Technology
226 McNutt Hall
Rolla, MO 65409-0450

Subject: Explosives Industry Demand for Employee's with a M.S. in Explosives Engineering.

Dear Dr. Frimpong,

In the coming decade there will be a significant demand for people with advanced qualifications within the explosives industry. This is significant since there will be a requirement to replace many retiring individuals within the industry. Therefore, the industry will require a highly trained workforce to assist in replacing the knowledge and experience that will be lost. Further, the demand for individuals with an MS in Explosives Engineering will continue to rise due to the advances in explosives product technology that will require a technically versed workforce.

My work experience within the explosives industry has been vast. I have worked for the largest manufacture of commercial explosives in the world and now the largest producer of aggregate material in the United States. The safe storage, transportation, and use of explosives products have become a critical operating parameter of manufactures and end users. A highly qualified educated workforce will be instrumental to ensure the success of the explosives industry as well as our domestic infrastructure.

Lastly, please do not hesitate to contact me should you require discussing this matter. I can be reached at 708-595-3875.

Best regards,

Frank V. Camodeca
Regional Drill & Blast Manger
Midwest Division
Vulcan Construction Materials, LP
5500 Joliet Road
McCook, IL. 60525
August 11, 2009

Dr. Samuel Frimpong  
Department Chair of Mining and Nuclear Engineering  
226 McNutt Hall  
Rolla, MO 65409

Dear Dr. Frimpong:

This letter should serve to inform you that The Doe Run Company is in support of advanced training for explosives engineers at the university level. Our industry (mining) is heavily dependent on our ability to break rock efficiently and effectively. Approximately 10% of our current total mining costs come from drilling and blasting, and it is critical we keep this portion of our cost structure to a minimum. Advanced knowledge in explosives engineering from future engineers will be critical in helping our Company remain competitive in a global commodity market.

In the past few years, our industry has gone through some changes with personnel. The demand is higher than it has ever been for mining engineers which means we can benefit by a broader skill set from both our current and future engineers. Engineers that we hire must have more advanced knowledge and skills than ever when they leave the university to keep us competitive. We also encourage our current employees to pursue their education at an advanced level and explosives engineering is a perfect fit.

Between the mining industry, explosives companies, contract drilling and blasting companies, we are sure that the combined need for people with the best credentials, training, and experience in the form of advanced explosives engineering degrees would be at least 10 per year.

We hope that this letter helps provide some insight into our current industry situation from our perspective. Should you have detailed questions, please contact Greg Sutton at (573) 689-4513.

Sincerely,

Bruce Neil  
CEO

Jerry Pyatt  
COO & VP of NA Operations

Bob Roscoe  
General Manager  
SEMO Operations

Greg Sutton  
General Mine Manager  
SEMO Operations
Alumni

We perceive alumni support of importance. Our Alumni represent our past and heritage and are part of our departments’ extended family. Our Alumni are very strong supporters of the department and the university providing substantial physical support, input and guidance.
SUPPORTING LETTER

Attn. Dr. Samuel Frimpong
Department Chair of Mining and Nuclear Engineering

I highly recommend Dr. Paul N. Worsey as a candidate for a curators teaching professor fellowship in the proposed Masters in Explosives Engineering at Missouri S&T.

Paul was fundamental for my own progress as a mining engineer and person. Exactly 11 years ago I was starting my doctorate at UFRGS, Federal University of Rio Grande do Sul (Brazil) and was trying to develop a new ANFO mixture for mining companies. The general idea was to mix ammonium nitrate and wasted mineral oil, however I had several problems in my research. That time I was impressed with Paul’s papers related to ANSOy, ammonium nitrate and soy oil, what was similar to my own research. Nobody in Brazil could help me that time, so I sent a couple of letters to Paul, asking him to work for him and start a sabbatical in Rolla. He was completely open, and helps me a lot during 1999 and after when I moved to Rolla. Some years later I finished my doctorate and my thesis had a great acceptance in the local industry, helping major mining companies in Brazil reduce its blasting costs and also with better environmental results. That work would be impossible without Paul’s help and all his support and patient. After that we start a prosperous relationship. I was contracted by a Brazilian explosives manufactory (Pilar Quimica do Brasil) to help improve the use of ANFO and emulsion (training people, solving technical problems in the field and also doing research. I invited Paul to teach short courses all over the country for blasters, miners, mining companies, blasting industries and universities. Paul is now a kind of reference in Brazilian blasting community. Recently I found my own company (Nitro Representação Comercial) in Brazil. We are a consulting firm mainly based on explosives performance and blasting vibration. Paul is always working for us and helping, as our recent audit for VALE south mines in Minas Gerais, Brazil. He got a great reputation in Brazil in the local blasting companies (Britanite and Dinacon) the government (CREA), mining associations (ANEPAC) and also the universities. UFRGS invited him in 2006 for sabbaticals what had excellent results. He
had several kids really impressed with the classes’ quality and all they really learned. After him, I got a position at the same university and now I’m teaching "DESMONTE DE ROCHAS COM EXPLOSIVOS" following most of his classes.

I think a MS in explosives engineering would be an excellent choice for anyone interested in improve himself as a human being and a blaster engineer. I’m convinced that Paul Worsey is someone unique, he got a solid reputation, a lot of visibility in the media (Paul’s shows at Discovery channel in Brazil are famous), and most important he is an excellent teacher and researcher. A little “exotic” sometimes, but interestingly this helps people learn, nobody forgets a class with someone with such “charisma”. Paul has an excellent communication skill; he is focused and reliable. In my opinion, a Masters in Explosives Engineer at MST would be a great asset for your University and has my highest recommendation. If you have any further questions with regard to Paul’s background or qualifications, please do not hesitate to contact me.

Sincerely,

Enrique Munaretti
July 27, 2009

University of Missouri

Dear Sir or Madam::

I am writing in support of the suggested expansion of the proposed Masters degree program of Mining Engineering Dept. of MST that will encompass explosives engineering.

I'm an alumnus of University of Missouri-Rolla with over 40 years in the mining industry. In my roles in operations, applied R&D, commercial (mining) finance, and communications (editor-in-chief of the then-premier international mining trade publication, Engineering & Mining Journal) I’ve had a unique opportunity to see the broad needs of the industry from both headquarters and mine levels.

Consequently I’ve seen the ever-increasing needs for:

1. Professionals with competence in ever increasingly technologically complex roles;

2. Trained replacements for an industry that, for many years—due to a poor economy for commodities—did effectively skipped the hiring (and training of) a generation. Indeed, advanced-degree holders in explosives engineering have been a rare breed in my experience; and

3. Expertise to deal with increasingly demanding requirements to minimize environmental impacts of blasting operations that are often dealing with encroaching urban development.

Furthermore, the Rolla faculty is uniquely situated with credibility in all the major sectors of mining, i.e. metal/non-metal, coal, and aggregates. Therefore its graduates have entrée to almost any mining company in the United States, if not the world.

Sincerely,

Richard W. Phelps
Principal
September 23, 2009
Dr. Paul Worsey
1870 Miner Circle
Rolla, MO 65401

Dr. Worsey:

I am very happy to hear that the Missouri University of Science and Technology are pursuing a program to provide MS degrees in the area of Explosives Engineering. As a graduate from the Mining Engineering program there, I can attest to the quality of explosive education that is provided. There is a serious need to train the next generation of Explosives Engineers. The need is broad based and includes the mining industry as well as the defense industry in the form of explosion effects experts and weapons designers. The laboratory settings and capabilities available at MS&T are perfectly suitable for meeting this national need.

With the training I received while attending the University of Missouri-Rolla, I have been capable of very quickly establishing a robust research program in the area of Explosives Engineering at the University of Kentucky. I have already attracted over $3 million in research funding through federal agencies such as DHS, DOD, and OSM due to my unique expertise in explosives. This is a direct result of the quality training and education I received from the Mining Engineering department at MS&T. There is no shortage of interest in people who are trained in the use and effects of explosives. It is indeed a niche field; however, there are a precious few locations to receive formal training. Furthermore, MS&T is known for preparing engineers with hands on experience that allows for immediate performance when entering the job market.

I do not view the program as any competition for the Mining Engineering department there. Rather, I see this program as an opportunity to recruit top notch graduate students from across the nation due to its unique format. There is currently no curriculum that is purely based on explosives, blasting, and blast effects. I am certain that this unique program would be capable of sustaining a high level of research funding and producing highly recruited graduates.

I cannot stress enough how excited I am to learn that an Explosives Engineering program is a possibility. I would be happy to discuss my support for this program with anyone who may be interested. If there is anything I can do to further support this important endeavor, please feel free to contact me at 859-257-1105

Sincerely,

Braden Lusk, Assistant Professor
University of Kentucky Mining Engineering Department
Student Requests

Last but definitely not least are student requests. The letters of support/request from students are a sample of those who want to enroll in the program and support the viability of the program as far as enrollment, their perspective of our standing in the field and their dedication to obtaining significant academic credentials in this field. Their letters contain information which confirms many of the statements we have made in the proposal. These students are very focused on meeting their goals and are here for explosives. It is hoped that their letters crown this package of support and impress the reader.
Sir/Madam:

After spending better than 3-years on a communications degree, it finally dawned on me that obtaining a career working with explosives was what I truly desired. Armed only with a military background and not knowing where to turn, I called the International Society of Explosives Engineers (ISEE) and was directed to attend MS&T, then UMR. I was told that if I wanted to study explosives Dr. Paul Worsey was the person I needed to see. At the time, explosives engineering was still an emphasis, however, there were very few institutions that could accommodate my goal. I finished my degree, moved to Rolla and, as a non-traditional student, enrolled in a second bachelor’s.

It didn’t take long to realize I made a good decision and was completely impressed with the facilities and curriculum at MS&T. Since I’ve been here, explosives engineering has become a minor, and the student base involved with explosives research has multiplied. Seizing the opportunity to recruit and retain young, intelligent students, the department added to the curriculum and faculty. These measures have proven invaluable to the explosives work conducted by the students.

The university is now confronted with the opportunity to once again set the standard in explosives research. Not only will the implementation of an MS in explosives engineering retain students, but it will also draw additional graduates to MS&T seeking a degree that can only be earned here in Rolla. In fact, I have witnessed first hand the impact the discussion is having on current students. Those seeking additional higher learning are now inspired to improve grade point averages and apply for research opportunities. I can attest to the fact that an MS in explosives engineering will be the only factor to keep me in Rolla after completing my BS.

MS&T is leading the nation in areas of industrial interest as well as reputation. Employers know that when an MS&T graduate is hired, that employee will be properly trained and experienced in all engineering aspects. The school now has a chance to optimize an economic situation by introducing a desired and well-implemented explosives engineering program. I hope the administration will give the proposal its proper consideration and understand how industry, the school and students will benefit greatly from Dr. Worsey’s and the department’s efforts to take explosives research to a new level.

Respectfully,

Buck Hawkins
MS&T Undergraduate
Mining Engineering
To Whom It May Concern,

My name is Alexander Tyson and I am a Missouri S & T student seeking to obtain my M.S. in explosive engineering in May of 2010. My journey to this university began 4 years ago as an undergraduate chemistry student at the University of California at Berkeley looking for graduate school opportunities that lined up well with my interests in pyrotechnics and explosives. After coming across an NPR news feed article about the explosives camp offered to high school students here, I wrote a quick email to the professor who sponsored it, and heard back from Dr. Worsey that very same day. I was struck by the enthusiasm of the faculty and the extent of the coursework relating to explosives and pyrotechnics, and after further research, found it to be the only school offering this kind of coursework. I found out, however, that there was not yet a M.S. program in place, so I decided to delay applying.

After nearly 3 years of teaching and developing curriculum as a science teacher post-graduation, it finally looked as if the M.S. in explosive engineering would come to fruition, so I uprooted and left all that I knew behind to move to Missouri. It turned out that the creation of the M.S. would not be so simple though, so I enrolled in Mining Engineering M.S. with the expectation that soon I would officially become a candidate for the degree I had been working toward. In speaking with directors of research at national labs in both California and New Mexico, there is strong interest in researchers with formal training and experience in explosives and a chemistry background like mine, and having an advanced degree in explosive engineering specifically rather than mining will give me the legitimacy and credentials to continue research post-graduation.

My experience thus far at Missouri S&T has been a very positive one, and I’ve been able to talk about my coursework and this university to friends, family, and colleagues around the country that would not otherwise know about the opportunities available here. I believe that the creation of an explosive engineering M.S. and my subsequent degree in it will open doors in industry and research that another degree would not, and that this new M.S. most accurately reflects my course of study now and in the future here at Missouri S&T.

Sincerely,

Alexander Tyson
To Whom It May Concern:

I am a new Graduate student enrolled in the Mining Engineering Department at Missouri S&T. I have been interested in explosives throughout my time as an undergraduate student in the same department. As such, my goal as a Graduate student is to obtain the Masters in Explosives Engineering.

I have spent two summers working in the petroleum industry conducting explosives research, and also work in the explosives research program while at school. I have completed half of the classes I require for the M.S. in Explosives Engineering and possibly the entirety of my research, and I am mainly waiting on the approval process of the degree to graduate.

I am not completing a M.S. of Mining Engineering as I want to be more diverse with my studies. The Masters of Explosives Engineering allows me to do this without straying too far from my B.S. studies.

I joined the Mining Engineering department mainly due to the promise of the experience I would gain in mining and especially hands on explosives learning. I don't know if I would have known about these opportunities if I hadn't asked the department professors. With the addition of the Masters of Explosives Engineering, I know that the school will have one more reason to advertise itself apart other institutions and draw additional students from more diverse areas of the U.S. and the world because it will be the only school to offer such a degree.

Sincerely,

[Signature]

Nathan Rouse

Missouri S&T
My name is Salvador Aguirre, I just enrolled as a grad student to the online ME in Mining Engineering. I'm a mining engineer with a bachelor's degree from Universidad de Sonora in Mexico, when I was in college I attended MTU for about three semesters as an exchange student. Right after graduation I was hired by Orica Explosives (now Orica Mining Services) I worked for them for 5 years in Mexico, 4 as blasting supervisor and one as Site manager. In 2008 I was offered the Drilling and Blasting Engineer position at the Phoenix mine of Newmont Mining Corporation. I have been working for Newmont for over a year now. Ever since I graduated I've always wanted to pursue a master’s degree, but it's until today that I have the opportunity to do it online. As my background has always been Blasting. I tried to find a masters degree focused 100% in blasting but so far the closest I found was getting my masters through the Blasting engineering certificate at MST. I wish you had a Masters in Blasting, so I could take more drilling, blasting and explosives related courses. I'm hoping very soon something becomes available at MST. A master's in Blasting would be a really helpful tool for professionals like me that work in the drilling and blasting side of mining. A masters in Blasting not only would benefit the student, it would also be of greatest value to the mining industry, in my case Newmont Mining Corporation, It would help me to get the necessary tools to improve fragmentation, have better understanding of the explosives properties, reduce vibration, reduce ore dilution, better blast design, better explosive selection…. Etc…. and all this translates into money saving……

I'm really excited to be part of the program and I'm looking forward to help it grow.

Sincerely

Strip mining prevents forest fires!

Salvador F. Aguirre
Drilling and Blasting Engineer
Newmont Mining Corporation
Phoenix Mine
Battle Mountain, NV 89820-1657
Phone: (775)635-4922
salvador.aguirre@newmont.com

visit us online at www.newmont.com
Maggie Hettinger
910 East 9th St.
Rolla, MO 65401
July 31, 2009

To Whom It May Concern:

I am currently an undergraduate in Mining Engineering with a minor in Explosives Engineering. I entered the Mining Engineering Department at Missouri S&T because of my interest in Explosives Engineering. If the minor in Explosives Engineering had not been available, when I began my undergraduate education, I would never have entered the department.

I would very much like to be able to continue my education by obtaining the MS in Explosives Engineering. If the MS in Explosives Engineering was not an option, I would not pursue the MS in Mining Engineering as an alternative. Thank you.

Sincerely,

Maggie Hettinger
August 14, 2009

Christopher Searing
1702 N. Cedar St.
Rolla, MO 65401

To whom it may concern,

I am writing to you regarding the proposed Masters of Explosives Engineering program for the Missouri University of Science and Technology. I am currently a senior in Mining Engineering at Missouri S&T, and would like to continue my education under the proposed program at the conclusion of this academic year. I believe it is of great interest to the state and university to establish this Masters program.

The prospect of working with explosives is what initially drew me to the Mining Engineering department. The mining industry is the top consumer of commercial explosives, yet for the amount utilized annually, research in this field is low. Creating the Explosives Masters would establish Missouri S&T as the first university with a dedicated explosives research program. We are already well known throughout the industry for our in-depth undergraduate focus on explosives, along with our extensive lab-based courses on the subject. It would be a difficult task to find better faculty and staff than those at Missouri S&T, and I feel they have much to offer in this field. A Masters program of this sort would also bring new graduate students to the university. Five years ago, Dr. Worsey created a summer Explosives Camp for high school juniors and seniors, thanks to which a noticeable increase in enrollment to the university and mining department can already be seen. An Explosives Masters would continue to build upon this reputation, and continue to maintain Missouri S&T as a premier research institute and one of the leading universities with regards to the mining industry and related fields.

As I am on the verge of completing my undergraduate degree, I am faced with the decision of whether or not to enroll in a graduate program. If a graduate program in explosives is not available, it is unlikely I will pursue a graduate degree and will instead begin my career in the industry. I also find the possibility of returning to graduate school later in life unlikely. While there may be a graduate degree that will roughly allow me to study this particular field at another university, I will not be able to find a dedicated research-based explosives program and certainly not one with a faculty and staff of the same caliber as Missouri S&T. I strongly urge you to not pass on this great opportunity and to allow for the establishment of the Masters of Explosives Engineering degree.

Sincerely,

Christopher Searing
Missouri University of Science & Technology
Department of Mining Engineering

Dear Reader,

I was always fascinated with explosives, but until recently, I was not aware of the extensive engineering that lay behind blasting. Explosions are very impressive, loud, and seem to be a great deal of fun, especially in the movies. I attended Explosives Camp at MST [when it was called UMR] in the summer of 2005. Here I was exposed to the principles and the technical details behind blasting. I realized that blasting was not a haphazard act of laying some explosives here and there and setting them off. It required careful planning and calculating. I was awed and impressed. From then on I was certain what I wanted to do for the rest of my life. I was completely and forever hooked on explosives engineering.

I specifically enrolled in MST [formerly UMR] because there was an explosives engineering program. I understood that it was not possible to major in this topic, but it was possible to enroll in explosives courses and gain some practical experience. I decided to major in mining engineering as a second choice. Mining makes extensive use of explosives and this would be close to what I really wanted. This is not to imply that mining engineering is in any way unsatisfactory. I have greatly enjoyed the mining engineering program and I intend to graduate with a major in mining engineering.

I, now, plan to enroll in the program leading to a Masters Degree at MST. Currently, the only suitable choice is mining engineering. While this is satisfactory, it is not my first choice. I would prefer to obtain a Masters Degree in explosives engineering. If offered, I would leave the mining engineering program for an explosives engineering program.

Thus, I would strongly support [and personally appreciate] the creation of a Masters program in explosives engineering.

Sincerely,

Adam Doerfler