

Form NP

NEW PROGRAM PROPOSAL FORM

Sponsoring Institution(s): Missouri University of Science and Technology

Program Title: Explosives Engineering

Degree/Certificate: Ph.D.

Options: _____

CIP Classification: 14.2101

Implementation Date: January, 2014

Cooperative Partners: _____

Expected Date of First Graduation: August, 2014

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Executive Summary

The proposed Ph.D. 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 M.S. 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 Ph.D. degrees to teach in their undergraduate programs and national labs also require Ph.D. 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 success of the M.S. in explosives engineering. The degree is unique to the nation, if not the world. The number of explosives-related courses that are currently offered by the department of Mining and Nuclear Engineering at Missouri S&T has steadily increased to fourteen (42 credit hours) with a further course in development. The addition of a second explosives faculty member in January 2008 and the use of adjunct instructors have allowed further expansion and frequency of offerings, making a Ph.D. in Explosives Engineering sustainable. It is anticipated that graduates will have successful job placement comparable to related engineering fields.

This 72-hour program includes a dissertation, 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

¹ Supporting job placement statistics are given in Appendix A.

1. 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 2.68 million metric tons in 2010.² This is principally because the United States also has the largest mining industry in the world.

The major use of explosives is in the civilian sector. Of this, an estimated 88% is used in the mining industry (for extraction of metals, minerals, fuels and construction materials). 71% of total explosives consumption is 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). 8% is used in metal mining. Missouri is the number one producer of lead in the nation (over half of the vehicle batteries in the US use lead from Missouri) and Doe Run, the major mining company in Missouri, estimates that 10% of its current total mining costs come from drilling and blasting. An estimated 9% is used in the civil construction industry for road cuts, tunnels, trenches for utilities, structure basements and grading for large industrial, distribution and retail complexes. 9% is also used for quarrying crushed stone. Missouri ranks as number 12 in the nation in explosives consumption at 62,700 metric tons. This is principally because of crushed stone production, where Missouri ranks number three in production in the nation, and lead mining (Missouri has five of the nine lead mines in the nation). All other civilian uses of explosives combined account for 3%, including forestry, oil and gas exploration and production, explosive welding, demolition, etc. Another important segment of explosives use is government, which includes the Department of Energy (DOE), the Department of Homeland Security (DHS), the Department of Defense (DOD) and the National Laboratories.

This will be the first Ph.D. program in North America in explosives engineering, and because of this, there are no statistics on the employment of graduates. All of the graduates from the explosives engineering MS program apart from the two that went on to full-time Ph.D. study have immediately obtained jobs on graduation. In some cases companies were prepared to wait a year after the job offer and in others the students started work and switched to part-time study to finish their MS. Table 1 shows where the MS graduates found employment. At least one of the students who will graduate this semester already has a job and others have been approached by explosives industry representatives. It is anticipated that the Ph.D. graduates will follow a similar employment pattern, in addition to teaching.

² Figures from USGS 2010 Minerals Yearbook – Explosives, Lead and Crushed Stone

Table 1: Employment of Graduates

Year (A/C)	1 (10-11)	2 (11-12)
Consulting Company	1	
Explosives Company	1	
Homeland Security	1	
Mining Industry		2
Defense Industry		1
Government Lab.		1
Ph.D.	1	1

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:³ 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 engineering certificate. A master's degree in explosives engineering, which was approved in 2010, was the natural progression and the phenomenal success of the M.S. program and the demand of its graduates for a Ph.D. in explosives engineering has led to the request of the chairman of the Department of Mining and Nuclear Engineering at Missouri S&T to implement this proposal.

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 182 in FS 2012)⁴. 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. The first camp student (from the first camp in 2004) graduated with a mining engineering degree with an explosives engineering minor in May 2009, and additional camp alumni are currently enrolled for an M.S. in explosives engineering. The first camp student to graduate with an M.S. in explosives engineering graduated this fall semester 2012. The camp, held every June, has grown to three camps of 20 students each. The summer explosives camp is viewed as a major future source of students for the proposed program.

³ Statistics are given in Appendix A.

⁴ See mining program enrollment statistics in Appendix A.

Since the fall of 2005, when the minor in explosives engineering was implemented, through the summer of 2012 – a period of only seven years – there have been 13 undergraduate explosives certificates, 13 graduate explosives certificates, 71 undergraduate minors and 2 graduate minors conferred. The students who go on to pursue a graduate degree have usually come from these students. Historically 75% of graduate certificate graduates go on to the master's degree, and in the 2012-2013 academic year, there are 27 students in the master's degree program. In its first year, 4 students graduated with the M. S. and five students in each of its second and third years, and this number is projected to steadily rise. It is these graduates of the M.S. program that have been asking for the Ph.D. program and it is from these students that the majority of Ph.D. candidates are expected to come.

Dr. Paul N. Worsey, the current Director of Explosives Engineering in the Department of Mining and Nuclear Engineering at Missouri S&T will be responsible for Ph. D. Explosives Engineering program along with the M.S. in Explosives Engineering, Undergraduate and Graduate Minors in Explosives Engineering, Undergraduate and Graduate Certificates in Explosives Engineering and the Graduate Certificate in Explosives Technology. No additional administrative position costs are anticipated.

The current strength within the program is the explosives background linked to mining and defense from Dr. Worsey and the defense, mechanical, explosives power generation and blast protection background of Dr. Baird. A request to fill the 3rd permanent explosives position budgeted in year three of the masters of science in explosives engineering proposal will be granted in 2015 as we have exceeded our targets for enrollment and graduation. We will emphasize a non-mining background for this position to both enhance and expand our core research areas. At the present time we are discussing the hiring of a junior faculty in explosive chemistry and synthesis or someone with perhaps a civil or aerospace degree to complement and help us expand in the area of homeland defense.

Our current core research areas are rock fragmentation, blast resistance for civil structures, explosive driven pulsed power and new uses of explosive devices. Some target areas for introduction definitely include explosives chemistry and a broader suite of homeland defense and other defensive/protection applications, plus advances in the commercial application of explosives.

The entrance requirements for a Ph.D. in mining engineering require a substantial amount of prerequisite courses. The required background coursework in conjunction with the degree title makes it unpalatable for many potential students from other disciplines. The Ph.D. in Mining Engineering is therefore almost exclusively stacked with mining students. In stark contrast the Ph.D. in Explosives Engineering opens up opportunities for long-term graduate students with majors other than mining in other engineering and physical science disciplines. This new program offers a high amount of diversification compared to our present situation. The introduction of civil, mechanical, chemical, materials, electrical, etc., students within the program will bring in out-of-department committee members (see Appendix E) from the respective disciplines from across campus, the university system and nation. The degree program will go a long way to further

interdisciplinary research across the major engineering and science disciplines linked by explosives engineering and explosives-related homeland defense and other defense needs. We have worked across disciplines in the field of explosives research for some time, but because of the high workload of S&T faculty, have found it difficult to pry loose faculty time. We foresee that having a nucleus of Ph.D. students from varied disciplines will allow us to springboard forward to new opportunities in conjunction with faculty from other departments both intra and inter campus, and universities, both in the state of Missouri and nationwide.

2. Fit With University Mission and Other Academic Programs

2.A. Alignment with Mission and Goals

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”.*⁵

A Ph.D. program in explosives engineering fits this mission. Specifically the Ph.D. program involves the integration of education and research at an advanced level, the performance of research to solve problems for a dissertation, and as a personnel resource for funded research and instruction. As the program advances, the number of Ph.D.-level 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 in the Strategic Plan for FY2012-FY2016 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**⁶ of this institution is based on mining (the Miners) and the first two programs on campus were mining and civil engineering where 97% of civilian explosives are used. The expansion of the explosives engineering program to the Ph.D. level will increase our visibility, which will afford increased research opportunities and lead to **excellence**. A healthy number of Ph.D. students will allow us to expand our research load and the inclusion of our graduated Ph.D. 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.

⁵ Mission Statement Approved January 2008 Board of Curators' Meeting.

⁶ Tradition, Interdisciplinary Collaboration and Excellence are 3 of the 4 values included in the Missouri S&T mission statement

The program also meets all five of the Strategic Objectives outlined in the FY 2012 – FY 2016 Strategic Plan for the campus. These are:

1. *Enrich the Student Experience*

The explosives engineering Ph.D. 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 etc. At present, the firework displays are under the direction of two M.S. students, both of whom are graduating this year and want to stay on to do a Ph.D. in explosives engineering. 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 Enrollment and the Academic Portfolio*

The Ph.D. 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 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, even at the undergraduate level. The strong increase in the number of graduate students will substantially increase the number of publications and research projects.

4. *Develop External Resources and Partnerships*

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 and provide direction and input for the program, and to

help obtain further resources. The creation of the explosives engineering Ph.D. will position the university to secure additional resources in the explosives area. 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. Two \$50,000 gifts (totaling \$100,000) from alumnus, Stephen Lang of Centerra Gold, for the explosives labs is an example.

5. Develop & Retain Human Capital, Physical Facilities and Cyber- infrastructure

The Ph.D. in explosives engineering will attract the best students to ensure adequate quantity and quality of graduate teaching and research assistants as well as ensure that our excellent facilities are used to their full potential.

The expansion of the explosives engineering program is part of the strategic objectives of the mining engineering program at Missouri S&T. Action 1.2.4 of strategic goal 1.2, "Create and Maintain a Well-Diversified Mining Engineering Program at Missouri S&T," is "Expand the masters in Explosives Engineering to incorporate a teaching faculty and the doctoral program." Action 1.5.2 of strategic goal 1.5, "Expand Explosives Engineering Program" is "Program Expansion: Develop the PhD Program in Explosives Engineering.

Because there is no explosives engineering B.S., the Ph.D., like the M.S. will be a subarea of the mining program. Mining is not a glamorous subject area, although it is vitally important to our nation's economy and standard of living. Therefore it is difficult to attract U.S. graduate students, whereas there are plenty of foreign students. In contrast, explosives is a much more desirable subject area and much easier to sell. In addition, explosives engineering not only encompasses mining but also a broader field of application such as civil construction, demolition, military, defense, homeland security, thereby attracting people from more varied backgrounds. Traditionally the department has attracted a lot of foreign students as Ph.Ds. but with explosives, Federal regulations and their current enforcement narrow the field of applicants to U.S. citizens, which means the explosive engineering Ph.D. is more likely to fill the needs of Missouri and its citizens. As a combined result, the explosives Ph.D. is going to help build our Ph.D. program within the department to a healthy mix and level.

2.B. Duplication and Collaboration Within Campus and Across System

No duplication exists at the UM System, state or national level. As far as we know there is no other Ph.D. in Explosives Engineering in the world. The Mechanical Engineering Department at New Mexico Institute of Technology, which has an MS in Mechanical Engineering with Specialization in Explosives Engineering does not offer a Ph.D. It is possible to do Ph.D. studies in explosives in other mining engineering departments and at the Cranfield Institute of Technology in the UK but the degree would not be in Explosives Engineering.

The Ph.D. degree in Explosives Engineering does not involve collaboration with any external institution or organization, except for the transfer of course work from universities outside the University of Missouri. There is the possibility of cooperation with the Civil Engineering

Departments at S&T and the University of Missouri – Columbia on a course or two on the blast resistance of structures and again we will be looking at cooperation with other institutions and former academics now in industry for further courses in specialized explosives chemistry and other areas not currently covered.

3. Business-Related Criteria and Justification

3.A. Market Analysis

3.A.1 Need for Program

According to the New York Times⁷ 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. According to Dave Kanagy, the executive director of the Society for Mining, Metallurgy & Exploration, as many as 78,000 additional U.S. workers will be needed by 2019 to replace retirees, and there were only 178 mining engineering graduates in 2011⁸ (27 were from Missouri S&T). 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.⁹ 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 those engineers have now retired, leaving a substantial gap in expertise, especially in the area of explosives. According to Kevin Loughrey, the chairman and chief executive officer of Thompson Creek Metals Co., “There are shortages everywhere in mining, so it’s an employee’s market right now.”¹⁰

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 are encouraged, and there is significant interest in a Ph.D. in explosives engineering to complement our M.S. in explosives engineering.

⁷ See Tuesday July 3, New York Times article in Appendix F

⁸ www.bloomberg.com/news/2012-09-17/harvard-losing-out-to-south-dakota-in-graduate-pay-commodities.html

⁹ Personal communications with explosives company representatives at all levels.

¹⁰ www.bloomberg.com/news/2012-09-17/harvard-losing-out-to-south-dakota-in-graduate-pay-commodities.html

This will be the first Ph.D. program in North America in explosives engineering, so there are no statistics on the employment of explosives engineers. The U.S. Department of Labor shows 6,800 explosives workers and 6,400 mining and geological engineers were employed in 2010, although these numbers appear to be conservative estimates.¹¹ The Bureau of Labor Statistics estimates that a 10% increase in the number of mining and geological engineers will be required by 2020. This increase is broken down into a 4% increase in state government workers, a 58% increase in management, scientific and technical consulting services, a 3% increase in company management and a 20% increase in testing laboratory workers. Graduates with a Ph.D. in explosives engineering would fit into any of these areas.

In addition to the demand shown for our MS graduates, there is also a demand for Ph.D. graduates, as there is a substantial gap in expertise in the area of explosives with the approaching retirement of many research engineers. A fourfold gain in metal commodities in the past decade reflects both surging demand and the industry's failure to keep up. "While new mineral deposits are getting harder to find, companies also are struggling to add enough skilled workers," according to a recent Bloomberg.com/news article.¹⁰ "That's partly a legacy of U.S. colleges cutting back on mining programs." There is also the need for existing graduate engineers in industry and government to further their education and obtain specialized training in explosives engineering, and this degree will provide a means of fulfilling that need. Missouri S&T has another opportunity to fill key industry positions and dominate the field of explosives engineering and thus increase the university's national standing in this area.

We were approached by Picatinny Arsenal for the development of a Ph.D. program in explosives engineering prior to our submission of the Master's program, and nearly received a grant for a feasibility study. However, the funds available were eaten up by the need for armament for the first gulf war and although the need remained, the funding vanished. Since this time we have continued to slowly build the explosives program one course at a time until we were ready and self-sufficient by ourselves.

The Ph.D. degree in Explosives Engineering will fulfill the following needs:

- Satisfy current and prospective student interest in a Ph.D. 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 and strengthen Missouri S&T's ability to obtain research grants.
 - Fulfill the market's need for explosives engineers with a specialization in one or more areas of technology.
 - Meet the needs of Department of Energy, Department of Homeland Security and Department of Defense personnel, including those stationed at Fort Leonard Wood.

¹¹ 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).

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 do not have college degrees, they 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. We haven’t yet implemented the master program in explosives engineering and it is already a success in that the Army are asking me to hurry taking the wraps of this and make it more accessible. It now appears appropriate to suggest that you could make the pathway deeper – up to the Ph.D. or Doctor of Engineering levels – while I work on opening it up wider for better access, less restrictions and available to a wider military-related student pool.”

Our proposed Ph.D. program has strong support from a wide spectrum of our field, including professional associations, civilian and government employers, academics and students. The support from our constituents illustrates the need for qualified professionals within the various applications of explosives engineering, the uniqueness of our proposed program, the endorsement of our ability to successfully implement the program, the quality of education that we currently provide, and the keen interest in our program by prospective candidates. Multiple letters of support from each of our constituencies are provided in Appendix B.

3.A.2 Student Demand for Program

The MS in Explosives Engineering Degree, which was approved in 2010, has been extremely successful. The first year of the program was actually 2010-2011 rather than the originally projected 2009-2010 but as can be seen from Tables 3.A.2.1 and 2, student numbers have far exceeded the projected numbers.

Table 3.A.2.1: Expected Enrollment Potential from Year 1 through Year 5 - from MS Proposal

Year (A/C)	1 (09-10)	2 (10-11)	3 (11-12)	4 (12-13)	5 (13-14)
Full Time	5	6	8	10	12
Part Time	-	5	8	12	15
Total	5	11	16	22	27

Table 3.A.2.2: Actual MS Enrollment from Year 1 through Year 3

Year (A/C)	1 (10-11)	2 (11-12)	3 (12-13) anticipated maximum
Full Time	14	13	15
Part Time	8	14	12
Total	22	27	27

The projected student numbers for year four of the program were actually reached in the first year and the projected numbers for year five were reached in year two and sustained in year three. In addition the expected rate of graduation of five students per year was reached in the second year of the program, as can be seen from Table 3.A.2.3. The full- and part-time division we have found to vary. We have students lured to top paying industry jobs who have switched to part time and part-time students who have switched to full time.

Table 3.A.2.3: Actual & Expected MS Graduates from Year 1 to Year 3

Year (A/C)	1 (10-11)	2 (11-12)	3 (12-13)
Full Time	4	4	10
Part Time	-	1	5
Total	4	5	15

Based on the success of the MS program and the student demand we have been asked to implement a Ph.D. in Explosives Engineering by Dr. Samuel Frimpong, the chairman of the Mining and Nuclear Engineering Department at S&T. Of the nine current graduates of the program, six have gone on to pursue Ph.D. studies, two full-time and four part-time whilst working for the mining, consulting and research companies that snapped them up as soon as they graduated. A seventh intends to pursue a Ph.D. after a couple of years of industry experience.

At least one student will not continue unless the Ph.D. in Explosives Engineering is implemented. The proposed Ph.D. will attract new graduates and students who are similarly not interested in obtaining a Ph.D. in mining engineering. We are currently working with the US Army

Captains Career Course at Fort Leonard Wood to put in place a military demolition course taught jointly by staff at Fort Wood and S&T faculty, and have several military personnel enrolled in the MS program who have expressed an interest in returning for a Ph.D. in Explosives Engineering. The program would attract such students who are extremely bright and very motivated and are just the sort of student that S&T wants to attract. We recently had a Department of Energy (DOE) employee graduate from our M.S. program who has requested the Ph.D. 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 such as Ph.D. graduates.

Table 3.A.2.4. Student Enrollment Projections (anticipated total number of students enrolled in program during the fall semester of given year).

Year	1	2	3	4	5
Full-Time	4	5	6	6	6
Part-Time	4	5	6	6	6
Total	8	10	12	12	12

If the program was available today we would have 6 students. All of these are *polled* existing graduate students, some of which are currently enrolled in the Ph.D. program in Mining Engineering hoping for the Explosives Ph.D. program to become a reality before they graduate (see Appendix C).

The *projected* intake is from outside of the polled group. It represents persons outside of the polled group and includes current undergraduates and prospective graduate students from industry, the military and government. We have projected a modest growth of these numbers. These are what we can probably handle once we have a third explosives faculty member and we may have to limit the number of Ph.D. students, but to a number that guarantees us meeting program review quotas.

**Form SE
STUDENT ENROLLMENT PROJECTIONS**

Table 3.A.2.5. Student Enrollment Projections (anticipated number of students enrolled during the fall semester of given year who were new to campus).

Year	1	2	3	4	5
Full-Time	2	4	6	6	6
Part-Time	1	3	6	6	6
Total	3	7	12	12	12

We anticipate that the overwhelming majority of Ph.D. students will first complete the explosives engineering M.S. and as such the majority of incoming students will be at the master's rather than the Ph.D. level.

Table 3.A.2.6. Projected Number of Degrees Awarded

Year	1	2	3	4	5	6	7	8	9	10
# of Degrees Awarded	2	2	3	3	4	4	4	4	4	4

3.B Financial Projections

3.B.1. Additional Resources Needed (Expenses)

- A continuation of broad-based media exposure - newspapers, TV and new media
- Referrals from the International Society of Explosives Engineers

The new military demolition course being developed in conjunction with Fort Leonard Wood will add significant (military) value to their existing course and provide an attractive enticement for engineering officers to come in to the M.S. in Explosives Engineering Program. These officers represent a significant pool for quality graduate students for the university in the form of distance classes as well as on site classes. It is the intention in the long run to recruit M.S. students from the lieutenant class and for them to take a large proportion of their classes distance before returning for the captain's career course, and then to recruit them into the Ph.D. program through distance classes as well as on-site classes after retirement from the military.

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 recruiting students for the M.S. program, the recruitment plan will be comprehensive and use multiple proven methods to reach both traditional and non-traditional students. We will continue to recruit students all the way from B.S. graduates to M.S. graduates working in industry.

Marketing costs will be shared with the costs of marketing the M.S. in explosives engineering for which we have had no marketing costs to date as everything has been by word of mouth. We are anticipating that at some point we will have to limit the number of Ph.D. students to a number that the faculty can handle.

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, mentor them through their research, 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 and Employee Relations at S&T. The resources available at S&T and individual faculty member advising already attracts and retains students.

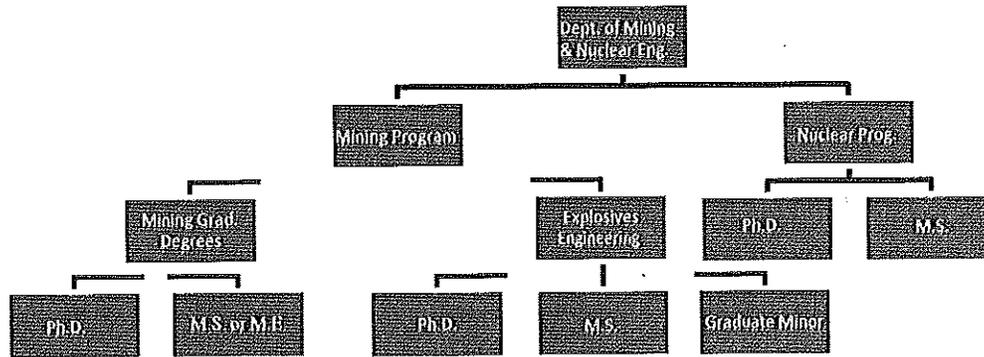
We are going to apply what we are already doing in the master's program and use the master's as the main recruiting toll for the Ph.D. following on from the M.S.

4. Institutional Capacity

Missouri S&T is particularly well suited and equipped to support a Ph.D. 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 research university and opportunities for research, internships, and co-ops.

Department of Mining and Nuclear Engineering

The Ph.D. 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 program graduate students. The strengths of both mining and explosives engineering are augmented using this symbiotic relationship.



The department has several years of experience developing and teaching courses in explosives engineering as part of its minor, certificate and MS 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 Ph.D. 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 research university and as one of the top providers of M.S. and Ph.D. graduates in engineering and science in the country, and its reputation and tradition in this field make it the logical home for an explosives engineering Ph.D. program. In calendar year 2012, fourteen separate explosives engineering related courses totaling 42 credit hours were taught (excluding 390 and 490 research courses and 300 and 400 special problems courses): Exp Eng 301 (two separate new classes), Exp Eng 307, Exp Eng 309, Exp Eng 313, Exp Eng 350, Exp Eng 351, Min Eng 383, Exp Eng 401, Eng 402, Exp Eng 406, Exp Eng 407, Exp Eng 497, Exp Eng 498. The facilities can easily accommodate the extra courses anticipated for the Ph.D. program. Min Eng 383 and Min Eng 401 were taught distance only, and Exp Eng 307, Exp Eng 350, Exp Eng 351, Exp Eng 402 and Exp Eng 407 were taught distance concurrently with the on-campus classes. The mining 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 Ph.D. program being extra personnel in the form of adjunct instructors and graduate student assistants. Since the implementation of the MS in Explosives Engineering a couple of courses have been taught by GTAs under faculty supervision to lighten the load on current faculty and the availability of Ph.D. students should allow this to increase. In conjunction with industry instructors we have now reached a sustainable level where Ph.D. students can obtain a degree in

explosives engineering with a degree of flexibility of course selection within classes offered at Missouri S&T.

Facilities and Space Needs

Current facilities will accommodate the explosives engineering Ph.D. 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. A new classroom building is currently in the process of being built with offices for faculty and graduate students. 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 as well as explosives camp in the summer.

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 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 pulsers, two delay generators, two initiation systems for exploding bridgewire detonators, and explosive magazines. The laboratory is currently used for teaching Exp Eng 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.

Form PG

Program Characteristics and Performance Goals

5. Program Characteristics

5.A Program Outcomes

Learning outcomes for the program include the following specific skills: 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.

Special skills of graduates specific to the program include:

- Demonstrated research skills and the ability to spearhead research in the explosives, propellants and or pyrotechnics arenas.

5.B. Structure

The Ph.D. degree requires a minimum of 3 years of full-time study beyond the bachelor's degree, including research work for the dissertation. Minimum requirements for Ph.D. candidates include completing 72 credit hours of graduate credit with at least 24 credit hours of dissertation research (Exp Eng 490) and a minimum of 24 credit hours of coursework, with at least 15 credit hours of course work completed at Missouri S&T. Students are encouraged to enroll in at least 15 credit hours of 400-level lecture courses and are required to pass the qualifying, comprehensive and final oral examinations for the Ph.D. research.

5.C. Program Design and Content

The Ph.D. in explosives engineering has been design to build on the existing M.S. program to meet the program outcomes with the addition of more courses and research for a dissertation.

The sequence of explosive courses is shown below and in Appendix D. Appendix D contains the Graduate Catalog Description of the explosives engineering program at Missouri S&T, including course syllabi descriptions.

Major requirements

Total credits specific to degree: 48 hours

Courses (specific course or distribution area and credit hours):

Course	Hrs
400 level courses	15
Other courses	9
490 (Research)	24

Course	Hrs

Course	Hrs

4. Free elective credits

Total free elective credits: Research (490) and/or coursework 24 hrs

The sum of hours required for general education, major requirements and free electives should equal the total credits required for graduation.

5. Requirement for thesis, internship or other capstone experience:

A dissertation, embodying the results of an original investigation, must be written upon a subject approved by the student's major advisor.

7. Any unique features such as interdepartmental cooperation: Doctoral research will normally be conducted on the Missouri S&T campus. In special cases, all or part of the research may be conducted elsewhere in cooperation with an off-campus entity such as an employer, but must be supervised by a member of the Missouri S&T faculty. Students who conduct off-campus research must have prior written approval of their advisor, the department chair, and the Vice Provost for Graduate Studies.

At least half of the credit hours must be taken at Missouri S&T but the other half may be taken in cooperation with other institutions.

5.D. Program Goals and Assessment

The process for assessing learning outcomes for a Ph.D., where the major portion of the work is dissertation research, is the final assessment by the student's committee and approval/disapproval of the Ph.D. dissertation.

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.)

The goal for retention and graduation rates is that 80% of the students graduate.

Number of graduates per annum at three years after implementation:	3
Number of graduates per annum at five years after implementation:	4

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.

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.

5.E. Student Preparation

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

U.S. law requires citizenship or permanent residence and in addition has several prohibited categories for explosives handling (see section 6). The students are expected to be engineering and physical science graduates, the majority of which will have an M.S. in explosives engineering.

5.F. Faculty and Administration

Dr. Paul N. Worsey, Director of Explosives Engineering in the Department of Mining and Nuclear Engineering at Missouri S&T will be responsible for this program along with the M.S. in Explosives Engineering, Undergraduate and Graduate Minors in Explosives Engineering, Undergraduate and Graduate Certificates in Explosives Engineering and Graduate Certificate in Explosives Technology. It is anticipated that 20% of his time will be dedicated to the Ph.D. degree.

Faculty involved in the program are based around existing faculty from the Department of Mining and Nuclear Engineering at Missouri S&T and instructors from industry currently employed on a

flat rate to co-teach explosives classes. It is hoped that faculty from the Department of Civil Engineering at Missouri S&T, augmented as circumstances dictate by faculty from UMC, New Mexico Institute of Technology, University of Kentucky and Texas Tech University will also develop additional courses. Preliminary exploratory communications have been made with the non-department faculty with agreement on principle but at this time only the New Mexico Institute of Technology agreement is in place. Additional faculty are currently in reserve and in negotiation because MS enrollment projections are being exceeded and financial circumstances have delayed the hiring of the third faculty member projected in the MS proposal, but once he or she comes onboard in 2015, 30% of their time will be dedicated to the Ph.D. degree.

Faculty Currently Teaching Courses

Professor

Paul Worsey, Ph.D., University of Newcastle upon Tyne (Missouri S&T) (20%)

Richard Bullock, D. Eng., Missouri School of Mines Emeritus (Missouri S&T) (5%)

Associate Professor

Jason Baird, Ph.D., University of Missouri Rolla (S&T) (Missouri S&T) (20%)

Assistant Professor

Gillian Worsey, Ph.D., University of Missouri-Rolla Adjunct (Missouri S&T) (20%)

Soekbin Lim, Ph.D., University of Missouri-Rolla (New Mexico Institute of Technology) (5%)

Adjunct Industry Instructors Currently Teaching Courses at Missouri S&T

Greg Shapiro, B.S., University of Missouri Columbia Steel Blasting (5%)

Matt Suttcliffe Premier Pyrotechnics (5%)

Stephen Hall, B.S., University of Missouri-Rolla Hercules (Retired) (5%)

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.

Faculty Who May Teach Additional Courses in the Future

Professor

Sam Kiger, Ph.D., University of Illinois at Urbana (University of Missouri Columbia)

Bruce Freeman, Ph.D., University of California Davis (Ktech, formerly at Texas A & M)¹²

Associate Professor

John Myers, Ph.D., Texas-Austin (Missouri S&T)

Braden Lusk, Ph.D., University of Missouri-Rolla (University of Kentucky)¹²

Brandon Weeks, Ph.D., University of Cambridge (Texas Tech)¹²

This program will be supported with a combination of existing Missouri S&T regular faculty and adjunct industry instructors who will have a background and experience in explosives relevant to the subject matter being taught and bring specialized and practical experience to the courses they will teach. CVs of adjunct professor currently teaching classes and Missouri S&T faculty willing to be co-advisors for explosives engineering Ph.D. students can be found in Appendix E. Faculty from other academic institutions may also teach additional courses. This would leverage what we have and allow us to provide more complete and varied course offerings. The academic faculty are expected to hold a Ph.D. or its equivalent in their area of specialty.

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

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 offerings. The tenure and promotion of the explosives engineering faculty will continue to reside for the foreseeable future with the mining engineering program.

A two-page CV for each Missouri S&T faculty member can be found in Appendix E.

5.G. Alumni and Employer Survey

Missouri S&T will develop an assessment and evaluation plan for the curriculum in explosives engineering based on the ABET-accredited B.S. program in mining engineering. This will be developed after the Ph.D. is approved. We expect a 90% satisfaction rate of the alumni of the program. (Based on experience from our mining graduates.)

Graduates will be tracked and Missouri S&T will develop an assessment and evaluation plan for

¹²These 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.

gathering information by surveying 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 program surveys.)

5.H. Program Accreditation

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

6. 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 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. Otherwise a prospective student will have to pay for and undergo a highway patrol background check. This needs to be done before acceptance into the program as an entrance requirement.

Dr. Henry Wiebe, Vice Provost for Global 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 Ph.D. in explosives engineering to S&T's distance education program. Note: 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.

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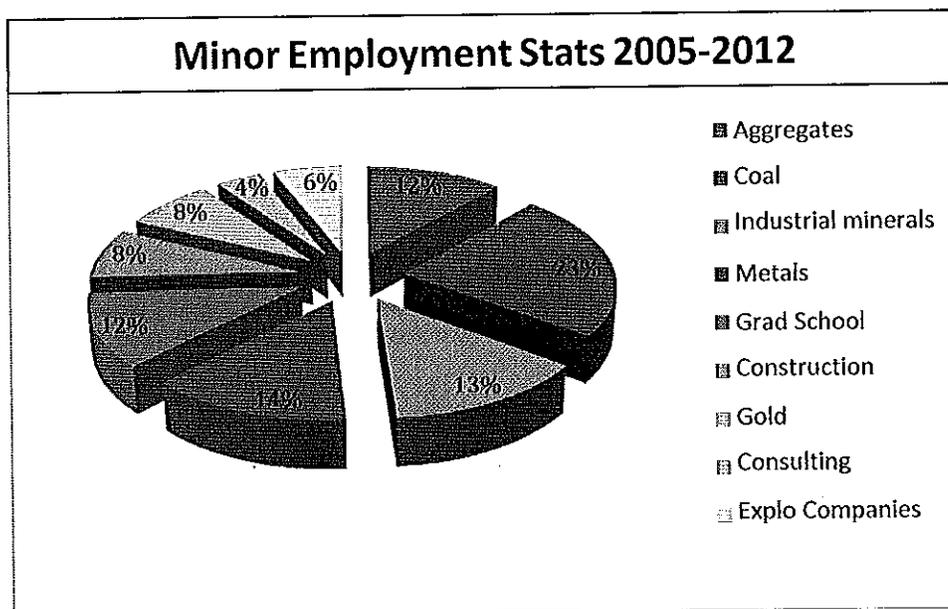
8. Appendices Appendix A

Employment, Graduation & 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

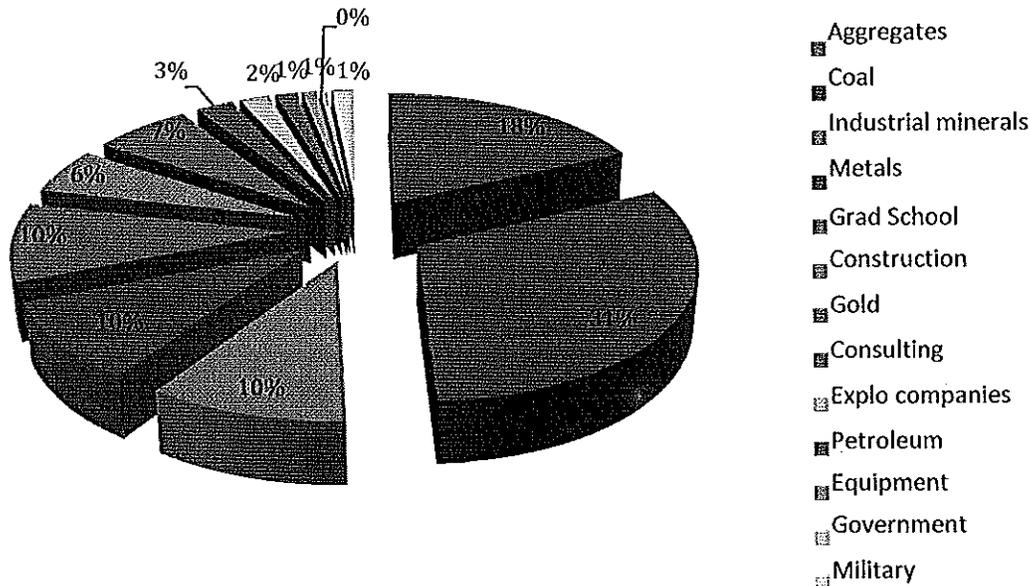
Of the 73 current graduates with explosives engineering minors 55 were mining engineering BS, 4 aerospace BS, 3 civil BS, 3 nuclear BS, 2 mechanical BS, one engineering management BS, one electrical BS, one architectural BS, one chemistry BS and 2 PhD in mining engineering. Because there have only been nine M.S. graduates so far, the employment statistics for these students from the mining department (not including other majors) are listed in descending order, starting at 12:00 and progressing clockwise.



Of the 16 out of department students we have employment data for one, an aerospace 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 Institute of Technology. Of the 55 mining BS's all 55 received job offers/employment, predominantly in the mining industry, where the majority of explosives are used.

The Mining program keeps records of first jobs (or job offers) after graduation for its graduating students and a distribution of professions is given below.

Where Our Mining Graduates Were Employed – Last 10 Years



The difference between the charts is attributed to changing job market (7 years for the minor versus 10 years of numbers for the department) and a lower statistical population for the minors (55 versus 172). In addition, the number of explosives minors taking employment in coal is less because explosives are almost exclusively used in surface coal mining and very little is used in underground coal (which has picked up more recent graduates) whereas construction employment is higher because there is heavy explosives use in tunneling, road cuts and other major construction projects in rock.

Emphases, Minors, Certificates and Master's

In the following section, the statistics on the current explosives program, for the emphasis through master's, are provided with discussion. The purpose is to document and show the trends that are sequentially occurring from undergraduate through master's from which we have used the basis for our predictions for the PhD program.

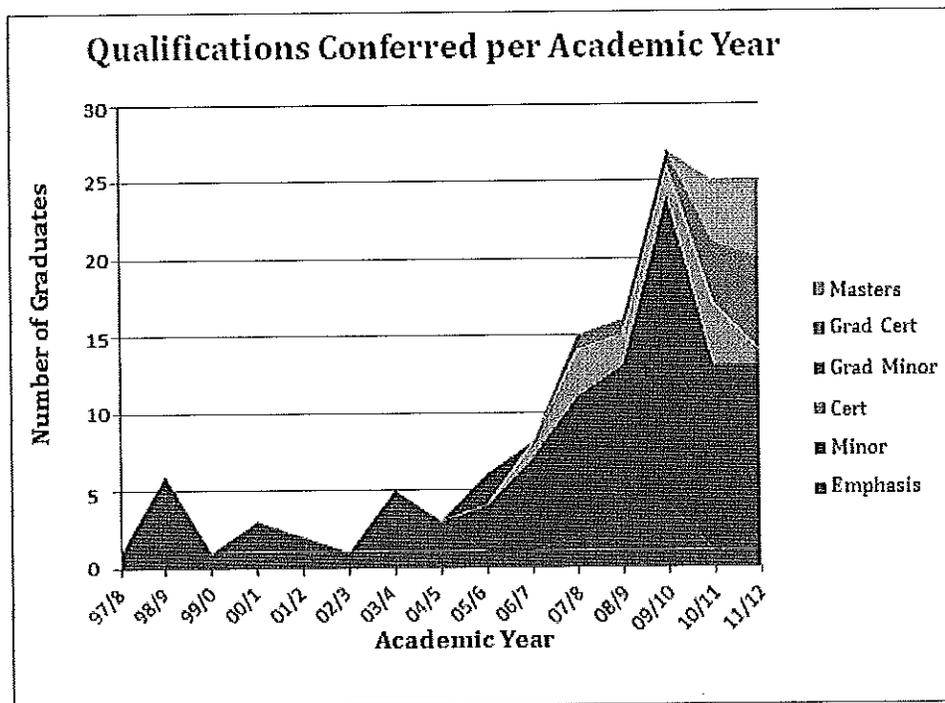
Explosives Engineering first started at Missouri S&T in 1997 as an explosives engineering emphasis in the Mining Engineering BS program. The emphasis comprises 9hrs of explosives classes. As explosives courses were added, the popularity increased and a minor in explosives engineering (comprising 15hrs of explosives classes) was approved in 2005 and the first degree with a minor was awarded at the 2005 December graduation. At the same time a graduate minor was approved and subsequently, in 2006, undergraduate and graduate certificates were approved in explosives engineering (comprising 12hrs of explosives classes), principally for those who just wanted to take additional explosives courses. The M.S. degree was added in the

summer of 2010 and a non-thesis option (to cater better for distance students) in the fall of 2011. In its first year four students graduated with a Master's degree (principally those who had started earlier and were waiting for the approval of the M.S.), five in the second year and between 6 and 10 are projected to complete in academic year 2012-2013.

Since the inception of explosives engineering at S&T a total of 135 emphases, minors and certificates have been awarded in addition to the 9 M.S. degrees. The data by academic year is given in the table below and corresponding graph.

Table 1. Explosives Qualifications Conferred per Academic Year Since 1997

Ac. Yr.	97-05	05/6	06/7	07/8	08/9	09/10	10/11	11/12	Total
Emphasis	22	1	1	2	3	4	1	2	36
Minor		3	6	9	10	20	12	11	71
Cert			1	3	2	2	4	1	13
Grad Min		2							2
Grad Cert				1	1	1	4	6	13
M.S.							4	5	9
Sum	22	6	8	15	16	27	25	25	144

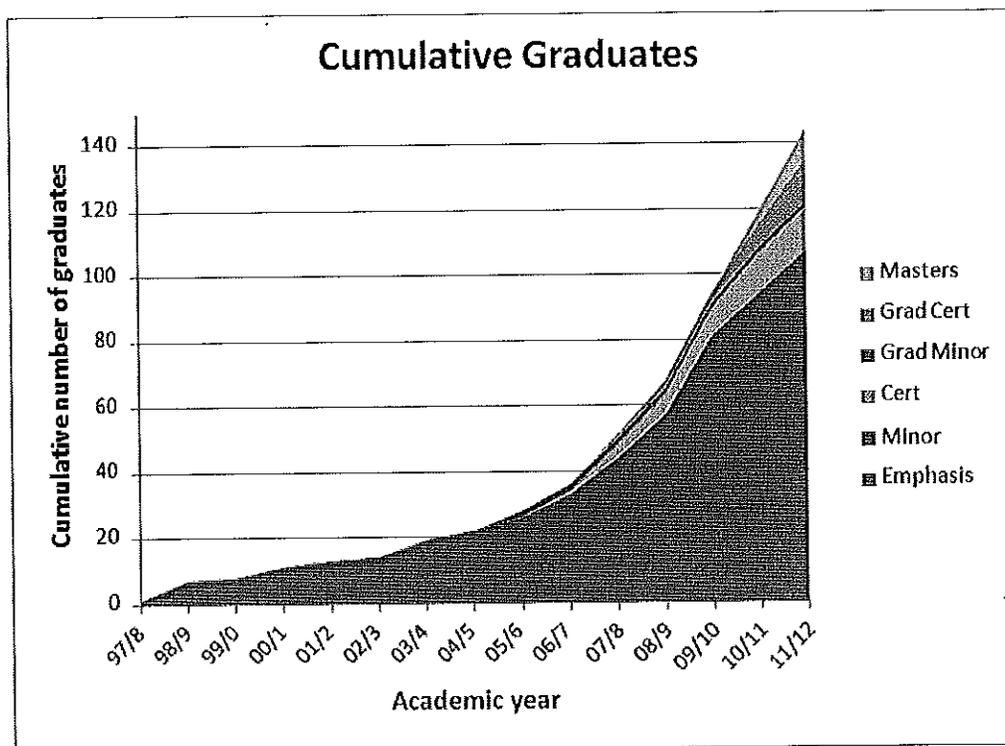


This data illustrates the solid growth of explosives engineering at S&T since 2004 and shows the importance of the minor. Note that there is a move from undergraduate to graduate as the master's came on line and also a dramatic increase in the graduate certificate, which provides a stepping stone to the master's. We expect this trend to continue and to increase with the addition of the Ph.D.

The cumulative awards are given in the table below and 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 are few on-site masters and PhD students in the mining department. The majority of mining graduate students in the department are distance students and in the Masters of Engineering program¹³.

Table 2. Cumulative Explosives Qualifications Conferred 1997 to Date

Ac. Yr.	97-05	05/6	06/7	07/8	08/9	09/10	10/11	11/12
Emphasis	22	23	24	26	29	33	34	36
Minor		3	9	18	28	48	60	71
Cert			1	4	6	8	12	13
Grad Min		2	2	2	2	2	2	2
Grad Cert				1	2	3	7	13
M.S.							4	9
Sum	22	28	36	51	67	94	121	144



It was difficult to attract post graduate students that want to pursue a course of study in explosives

¹³ The Masters of Engineering program in mining is popular because there are only 12 mining 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.

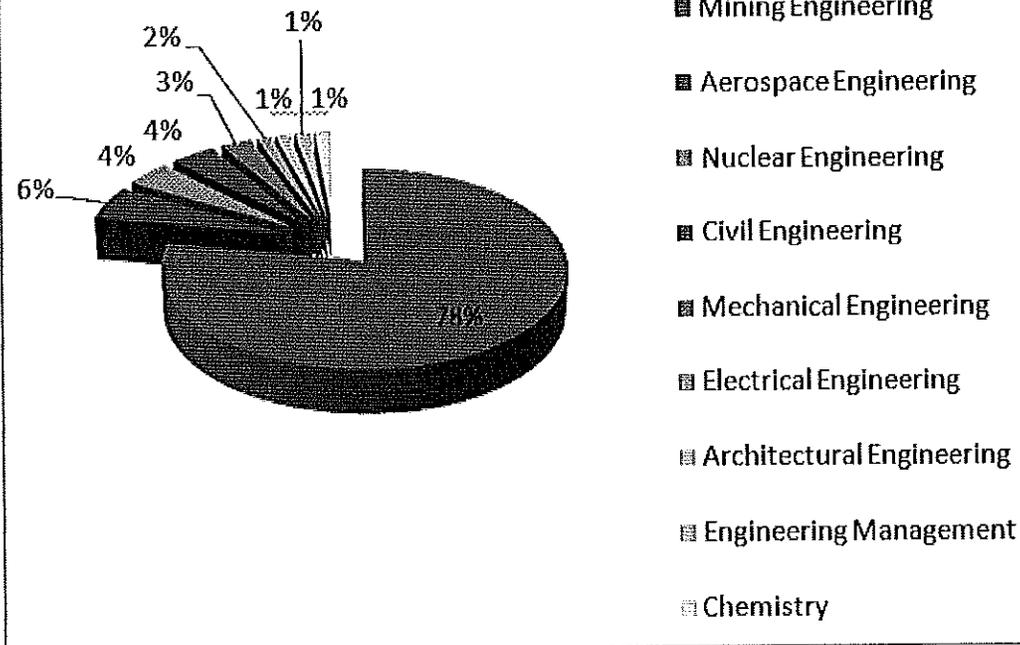
but not having the title explosives in their degree. In addition many non-mining students are unwilling to take and spend money and time on makeup classes in mining engineering to get a mining rather than explosives degree¹⁴. The M.S. in explosives engineering fixed this at the master's level and it is expected that the same will happen with the Ph.D. in explosives engineering.

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 little out of house apart from word of mouth. The following current enrollment data provided by the registrar's office shows a significant change in student profile.

Mining Engineering	57
Aerospace Eng.	4
Civil Engineering	3
Nuclear Eng.	3
Mechanical Eng.	2
Electrical Eng.	1
Architectural Eng.	1
Chemistry	1
Eng. Management	1
<hr/>	
Total	73

¹⁴ From personal observation and communication with graduate students and potential graduate students.

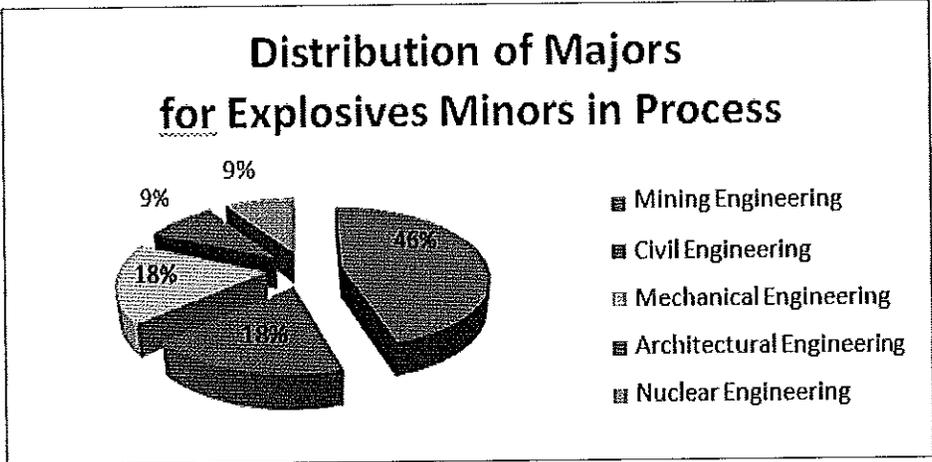
Distribution of Majors for Explosives Minors Awarded



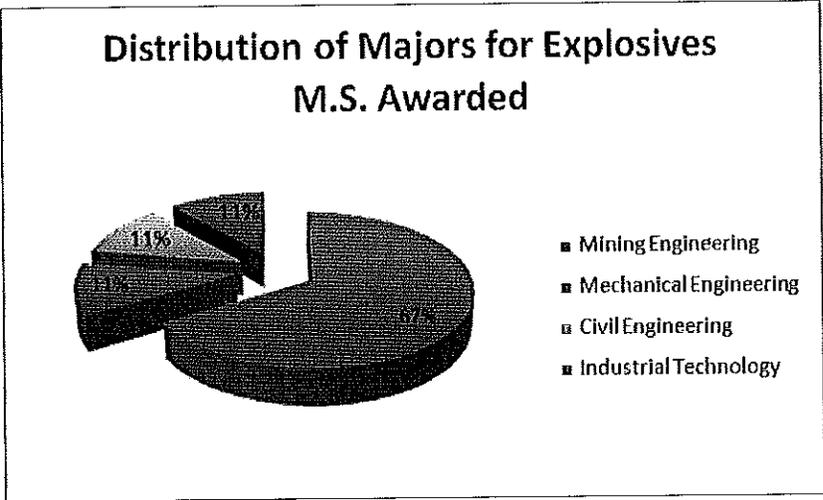
There are 11 students who are currently enrolled for the minor as of fall 2012¹⁵. The statistics on these by department are provided below. These numbers are given to show the changing demographics of our students due to expanded interest outside the department as the word spreads about explosives at S&T (even without any advertising).

Mining Engineering	5
Civil Engineering	2
Mechanical Eng.	2
Architectural Eng.	1
Nuclear Engineering	1
<u>Total</u>	<u>11</u>

¹⁵ 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. The recent drop in minors reflects students staying on to do the master's of explosives engineering now we have it in place.

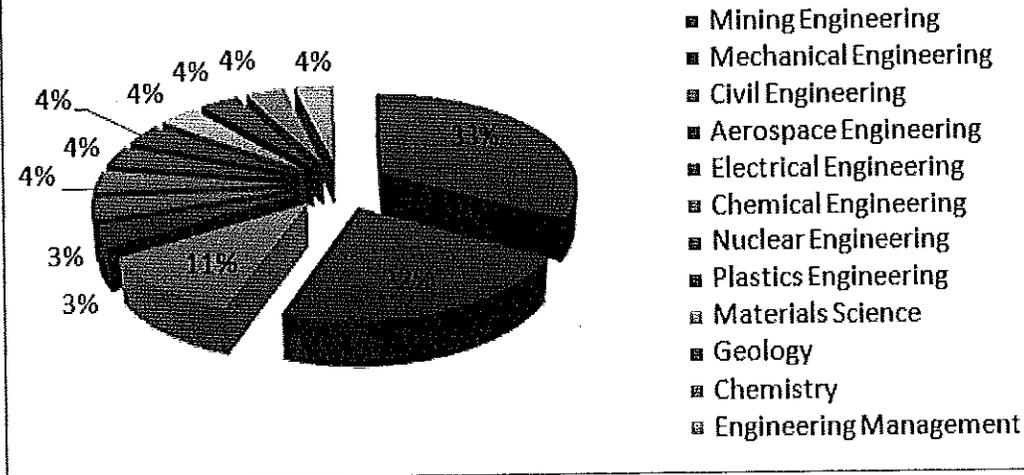


It is apparent from the statistics that our graduates with minors will be dramatically more diversified, however it is anticipated that the mining share is underreported as the mining students have been traditionally the most likely to only sign up at the last moment/when necessity dictates as they have priority access to department classes.



The distribution of majors for the M.S. in explosives engineering shows very similar trends. Of the 9 students that have graduated, 6 had a mining engineering B.S. degree and the other three each had a degree in a different major. However the distribution of majors for students currently enrolled for the M.S. in explosives engineering shows that the fraction of students with mining engineering degrees has shrunk from two thirds to one third, with mechanical and civil engineering majors making up another third and another 9 disciplines being also represented.

Distribution of Majors for Explosives M.S. in Process



Effect of Ph.D. in Explosives Engineering on Current Enrollment

There will be no effect on the mining Ph.D. program, as already discussed in the main document. 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 and Ph.D. Although this will negatively impact the current minor program it is expected to continue to grow, but at a reduced rate. We are seriously considering capping it. The MS will not affect the number of undergraduates, but is significantly increasing graduate student enrollment. The change for these students will be 12-15¹⁶ additional undergraduate hours for 30 graduate hours. There has been no loss of revenue by the change of a few students from an undergraduate minor to the explosives master's 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 around 20 classes spread around campus. As the program continues to grow, the majority of master's students are not on appointment from general operating fund money, although some work on research contracts. Those on general operating fund money are GTAs and assisting in the teaching of explosives and mining classes, principally to undergraduates, allowing the faculty to teach more explosives classes aimed at graduate students, with our current primary push for graduate distance students.

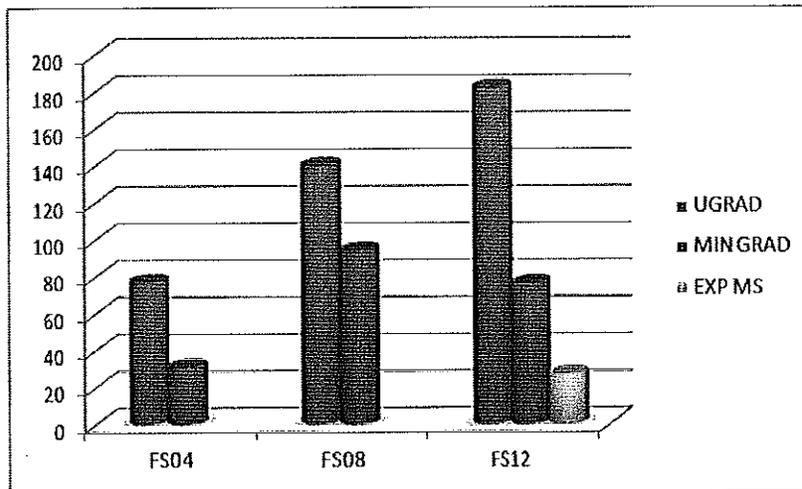
The main recruitment for the explosives engineering Ph.D. will be from the already established and successful M.S. program. Having explosives Ph.D. students will increase the length of stay of explosives-trained graduate students on campus, providing an improved pool of graduate

¹⁶ Mining students already take one explosives class, mining 307, as a required class for the mining BS.

students available for assisting in the teaching of explosives classes and will provide better continuity. The offering of the Ph.D. in explosives engineering is also anticipated to attract new people to the program that are primarily interested in obtaining a Ph.D., which will in turn enhance the M.S. enrollment numbers. Enrollment figures for both undergraduate and graduate students in the mining department are given below.

Mining Department Enrollment FS04 to FS08

	UGRAD	MIN GRAD	EXP MS	TOTAL
FS04	77	31	-	108
FS08	140	94	-	234
FS12	182	76	27	285



Appendix B – Letters of Support

We have categorized our letters of support into four categories:

1. Industry associations
2. Companies and Government
3. Academic
4. Student requests

The proposed Ph.D. program is of importance to four different constituents and each has different perspective and needs. These range from the vision of industry associations, the workforce demands and projections of industry to the aspiration, needs and wants of students excited about the opportunities that this new program provides for both their education and potential employment/advancement.

The letters placed in these categories in many instances transcend the category boundaries, for example one company president was a university department chair and the executive director of a professional industry association in the span of his career. We believe that the letters of support give a good perspective and verify the applicability, need, our ability to provide the program, its high potential for success and the gainful employment of its future graduates.

Industry Associations

The industry associations that specialize in and primarily cover the use of explosives are the Institute of Manufacturers of Explosives (IME) and the International Society of Explosives Engineers (ISEE). The IME represents the manufacturers of commercial explosives, and other companies that distribute explosives or provide related services. IME's member companies produce over 98% of the commercial explosives used in the US. ISEE represents the industry as a whole, provides member services related to explosives and puts on the most attended annual conference on explosives each year.

In addition a support letter is included from the ISEE education foundation, which promotes explosives education and provides scholarships to students studying in areas related to the use of commercial explosives. The foundation has supported numerous undergraduate and several of our graduate students since its inception in 1996. The foundation is a separate legal entity from the ISEE. A substantial amount of money has already been accrued by the foundation.



institute of makers of explosives

The safety and security institute of the commercial explosives industry since 1913

October 30, 2012

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 PhD in Explosives Engineering at the Missouri University of Science and Technology.

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 were encouraged with your start of a MS program in Explosives Engineering. We are enthused with the quality of students produced by the explosives program, as evidenced by their fine work with us on the SciPan5 test last summer. The thought that students such as Matt Ortel may carry on his education with a PhD is most encouraging. We wish your department success in approval and implementation of your proposed PhD 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

¹ http://www.ime.org/dynamic.php?page_id=6



**International Society of
Explosives Engineers**

December 14, 2012

Dr. Paul N. Worsley, PhD
Professor
Missouri University of Science & Technology
Department of Mining Engineering
226 McNutt Hall
Rolla, MO 65409

Dear Dr. Worsley:

I am writing this letter of support in regards to the Doctorate of Explosives Engineering program. We at International Society of Explosives Engineers (ISEE) are extremely excited that you are moving forward with this program and firmly believe that it will get as much attention as the Masters program received.

The goals of the Doctorate of Explosives Engineering program provides for a systemic approach to raising academic achievement of students at the Missouri University of Science & Technology. The University's history demonstrates the commitment of Missouri S & T to developing high quality programs based on educational research and providing the support necessary to successfully implement these programs. The result has been communicated through the continuous improvement in the academic achievement of students.

As the Executive Director of the ISEE, I highly support the Doctorate of Explosives Engineering program and believe the implementation of this program will provide data that can be used for increasing academic achievement in universities throughout the country.

Sincerely,

J. Winston Forde
Executive Director
www.isee.org



December 12, 2012

Dr. Paul N Worsay
Missouri S&T
Department of Mining Eng
226 McNeil Hall
Rolla, MO 65409 USA

Dear Dr. Worsay,

It is with great pleasure that the Society of Explosives Engineers Education Foundation supports the development of a Doctorate Program in Explosives Engineering by Missouri University of Science and Technology.

As a part of its organizational mission the SEE Education Foundation supports education programs and awards scholarships to qualified students who are pursuing technical undergraduate, graduate or doctorate degrees in the fields related to the use of commercial explosives in mining and other industry fields. The SEE and our foundation have been staunch supporters of the Masters Program in Explosives Engineering at Missouri S&T and will continue the efforts with the development of a Doctorate Program in Explosives Engineering.

We, as an international professional association, have seen the continued involvement of the Missouri S&T Explosives program graduates in our industry. In this last year a Missouri graduate has helped to develop an ISSE student chapter in Peru. Two Missouri graduates are faculty liaisons for ISSE student chapters in the United States. The International Society of Explosives Engineers has just hired a graduate of the Masters Program in Explosives Engineering to take over the Director of Education roles for both the ISSE and the SEE Education Foundation as the current director retires. These are just a small sample of leadership roles taken on by the program's graduates in the industry.

The SEE Education Foundation Scholarship Program came into being because there is an education need with the exodus of professionals in the industry as retirements are taking place. The Missouri Explosives Program is unique and has been a trend setter in education for our industry. The Missouri program has integrated explosive curriculum not only for students in mining but in other facilities. The development of the Explosives Camp is a feeder for the university as it introduces possibilities to potential students and the Doctorate in Explosives Engineering will offer a complete education program. These developments show a planned vision for the university's programs and a place for our referrals.

The SEE Education Foundation has been an ongoing supporter of the Missouri program as evidenced by the numbers of scholarships that have been awarded to Missouri graduates since our program began in 1996. Since that time almost twenty percent of our scholarships have gone to Missouri S&T students. The university has turned out a good product. As the university works on developing further education resources for the industry the ISSE, its foundation, and our industry members will be supporters of the university's ongoing development for industry related programs.

Sincerely,

Ariene Chase,
Program Director, SEE Education Foundation

Society of Explosives Engineers Education Foundation - 30325 Balubridge Road - Cleveland - Ohio
44139-2295 • Tel: 440-349-4400 • Fax: 440-349-3788

Companies and Government

This grouping of support letters affirms the need for individuals with credentials at the Ph.D. level focused on explosives. They comprise two defense contractors heavily involved in research, two consultants, one of which is also an explosives manufacturer, an explosives R&D and testing company, an explosives manufacturer, a government agency and finally a letter of support from the recently retired chief scientist at DTRA. Background information on the persons and companies for each letter are given as follows:

Dr. Bill Brown is of Applied Research Associates. This company is a leading technical defense contractor focusing in military research with extensive research work in the explosives and effects arena and currently employs two of our explosives graduates, one with a Ph.D. in Mining Engineering (2006) and one with an M.S. in explosives engineering (2011).

Dr. Millard Rose is the Vice President for Research of Radiance Technologies of Huntsville, Alabama. This company provides support to the DoD, armed services, intelligence agencies and other government agencies.

Claude Cunningham, consultant, is a former employee for AEL (South Africa) who spearheaded the Icon electronic detonator system. He was a key player on the editorial board of the FragBlast Journal and symposium chairman for the 6th International Symposium on Rock Fragmentation by Blasting.

Dr. Calvin Konya of Precision Blasting Services is president of an international explosives manufacturer for the mining industry. He is also past department chairman of the department of Mining Engineering at Ohio State and past executive director of the International Society of Explosives Engineers (ISEE).

Gary Eck is Vice President of Research and Laboratory Manager at UTEC Corporation. This is the principle third party development and testing entity for explosives manufacturing companies in the U.S.

Richard Goodridge is the general manager for research at Orica which is the world's largest provider of commercial explosives. Orica is one of the top two explosives companies in the United States and we have recently placed 4 of our explosives/mining engineers including one master's graduate with them. They are starting to heavily recruit from our department.

Kevin McNeil is the Chief of the Research and Development Division of the National Center for Explosives Training and Research of the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF). Kevin is currently working on his Masters in Explosives Engineering and has been instrumental in setting up an MOU for the distance education of ATF agents for the new Graduate Certificate in Explosives Technology. We currently have 14 ATF agents in this program with recent confirmation of 24 additional students for this academic year and a further 24 in process for the 2012/14 academic year (depending on agency funding).

Finally Dr. Eric Rinehart recently retired as the Chief Scientist of the Test Division of the Defense Threat Reduction Agency (DTRA). He comments on the current difficulties in identifying young people that are well qualified in the explosives field.



Missouri State Coordinating Board for Higher Education

Dear Madam/Sir:

I write this letter in support of the proposed new PhD program in Explosives Engineering at the Missouri University of Science and Technology (Missouri S&T).

For more than 20 years with Applied Research Associates (ARA) I have performed defense-funded research involving various aspects of explosive science and engineering. Throughout these research efforts, I have found that the level of knowledge of explosive materials required for project success is often commensurate with the depth of study that one encounters in a PhD program. For almost 10 years, I have worked closely with a PhD graduate, and more recently with an MS graduate, of the Mining Engineering program at Missouri S&T. For the last 3 years, ARA has teamed with Missouri S&T to execute an innovative explosives-related research program for the Office of Naval Research. Because of these experiences, I believe that a PhD program in Explosives Engineering will provide an excellent complement to the outstanding PhD program in Mining Engineering.

I strongly endorse the establishment of a PhD program in Explosives Engineering at Missouri S&T.

Respectfully yours,

William Brown

William Brown, PhD
ARA Associate
ARA Fellow
Distinguished Member of the Technical Staff
Applied Research Associates, Inc.
Defense Sciences Group
801 North Quincy St.
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801 NORTH QUINCY STREET, SUITE 600, ARLINGTON, VA 22203
(703) 816-8886 • FAX (703) 816-8861

RADIANCE TECHNOLOGIES

9 November 2012

Dr. Samuel Frimpong
Mining and Nuclear Engineering
Missouri University of Science and
Technology
226 McNutt Hall
Rolla, MO
65409-0450

Dear Professor Frimpong,

I write this letter in support of the petition to establish a PhD degree in Explosives Engineering at the Missouri University of Science and Technology. I am personally aware of the capability of the University in advanced explosives technology through collaborative interactions with Dr. Jason Baird and his staff in the field of explosive energy conversion. In my experience, it is highly unusual for a University to have the capability that Missouri University of Science and Technology possesses in the area of advanced explosives technology. The rapid growth in your recently established MS program provides ample evidence of the interest in the student community and I am sure that, due to the uniqueness of the program and your one-of-a-kind capability, there will be continued growth in the numbers of students enrolled in the program.

The basic knowledge that underpins any technology comes from the R&D community resident in the University and in selected industrial and government laboratories. In all of the technologies that I have sufficient knowledge to judge, most of that base comes from the PhD level scientists and their students/post-docs and staff. The knowledge so generated forms the basis for understanding explosive energetics, safety, any environmental concerns, and the basis for certification and training of engineers and technicians that use explosives in such diverse ways as spacecraft, airbags, heavy construction, and weapons (both lethal and non-lethal). There are pressing needs within the military and homeland security for means to detect and nullify explosive devices such as Improvised Explosive Devices, IED, that take a deadly toll on both soldiers and innocent bystanders on a continual basis. The key to nullifying these insidious devices may reside in the basic science of explosives and yet to be discovered. The proposed PhD program would certainly provide talent that can address issues such as detection and nullification of IED devices.

At Radiance, I have certified explosives operators that operate a field facility engaged in explosives energy conversion and IED detection. We also have several employees in Iraq and Afghanistan who are constantly exposed to the IED threat. The question is constantly asked "how can we detect and neutralize IED's." The solutions to critical problems such as this are dependent on fundamental knowledge of explosive processes

that can only be gathered by a cadre of highly trained researchers -a need that will continue for the foreseeable future. I am certain that the scientists and engineers that would participate in such a PhD program would be highly relevant to future advances in explosives technology at all levels.

Radiance Technologies enthusiastically support the proposed program and will certainly look at scientists and engineers trained in this program for our workforce.

I will be happy to provide further information if requested.

Sincerely yours,

Millard F. Rose, PhD,
Vice President for Research and Chief Technical Officer
Radiance Technologies, Inc.
froser@radiancetech.com

CVB Cunningham Pr Eng
Mining and Explosives Engineer

4 Naboom Rd
RANDPARK RIDGE X3
2104 South Africa

PO Box 2478
NORTHCLIFF
2115 South Africa

***Blasting Investigations and
Consultancy***

To:

Dr P N Worsey
Professor Mining Engineering and Director of Explosives Education
Department of Mining & Nuclear Engineering
University of Missouri-Rolla

RE: PhD Explosives Engineering

Dear Dr Worsey

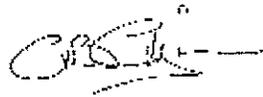
Following your enquiry into support for the proposed higher degree in Explosives Engineering, this is to express my strong support for the move.

Currently there are all too few institutions, in any country, providing specifically blasting, as opposed to explosives education. As a result, there is a dearth of well-informed expertise around the application of explosives to rock blasting, and research tends to be either heavily biased toward detonation modelling (which is science-, rather than engineering-based), or else tends to be repetitively focussed on already well-covered and essentially superficial issues. The latter results from the lack of sufficiently experienced and qualified authorities to provide guidance and evaluation of the work.

In my estimation, the breadth of disciplines required for good judgment and the depth of the topics involved calls for full support for learning and research beyond the Masters level, particularly if this is focussed on the control of blasting effects rather than the isolated components of blasting dealt with by detonation science.

The benefit of the support will be much improved understanding of the nature of blasting and subsequent ability to undertake projects with less likelihood of adverse impact on civil structures, the environment and population, while ensuring more productive and therefore more rapid completion of difficult projects.

Sincerely



C V B Cunningham Pr Eng, MSc (RAND) BSc (ARSM)
Blasting Specialist

☎ 027 11 792 8936

☎ 027 82 556 1134



PRECISION BLASTING SERVICES

A DIVISION OF THE INTERCONTINENTAL DEVELOPMENT CORPORATION

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E-MAIL: info@idc-pbs.com • www.idc-pbs.com

November 1, 2012

University of Missouri Board of Curators
316 University Hall
Columbia, MO 65211

Dear Board Members,

My name is Calvin J. Konya. I graduated with my BS, MS and Ph.D. degrees in Mining Engineering with my thesis and dissertation in the area of explosives and blasting. I graduated in 1972 from UMR and have worked in explosives and blasting for the last 40 years.

The background I received at MSM/UMR helped me excel as a professor and research director at West Virginia University and Ohio State University, founder of the International Society of Explosives Engineers, my consulting company, Precision Blasting Services, the Academy of Explosives and Blasting Technology and an emulsion explosives manufacturing company, called Energia KFT, founded in Hungary in 1990. I formulated all of our explosives with the help of courses I took at UMR. I received an Honorary Doctorate from the Mining University in Hungary and was honored by becoming a member of the National Academy of Sciences in Hungary. I have worked worldwide on all continents with the help of what I have learned at UMR.

I believe that my background qualifies me to discuss the need for a Ph.D. degree in Explosives Engineering at The Missouri University of Science and Technology. There is no university in the USA that offers degrees in Explosives Engineering other than Missouri S&T. It is a natural progression that this university with all its facilities and skilled, experienced professors offer the Ph.D. degree in Explosives Engineering.

There are many jobs available for a Ph.D. in Explosives Engineering. Since there is no such degree available today these jobs are filled by poorly trained Civil Engineers, Mining Engineers, and other professionals.

The following are some of the companies and Government agencies that would hire a Ph.D. in Explosives Engineering.

- Metal Mining Companies
- Surface Coal Mining Companies
- Quarry Companies
- Explosives Manufacturers

- Civil Engineering Consulting Companies
- Mining Engineering Consulting Companies
- Explosive and Blasting Consulting Companies
- US Army Corp of Engineers
- Dept. of Homeland Security
- NIOSH
- US Army
- US Air Force
- US Navy

The list above is just a few places that could employ a Ph.D. in Explosives Engineering. There are also international employment opportunities for graduates with this degree. There are few universities in the United States that have staff capable of teaching an introductory course in Explosives Engineering. Universities offering degrees in Civil and Mining Engineering would also be sources of employment for Explosives Engineers with a Ph.D. degree.

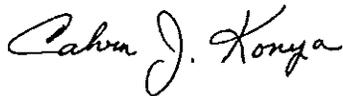
Missouri S&T has the reputation for excellence in mining and explosives technology and research. This reputation was built over a period of more than 100 years. The next logical step in this progression is a Ph.D. in Explosives Engineering.

The University already has an excellent reputation in the explosives field. The University already has the world class professors in this field who are recognized worldwide for their accomplishments. The existing explosives and blasting equipment and facilities are the best in the USA and unmatched by any University program or department. It would take little effort and expense to make Missouri S&T the university that offers the best explosives and blasting education as well as a MS and Ph.D. Degree in Explosives Engineering in the world.

This Ph.D. degree program will promote the additional high quality, high profile, research that will bring grants and funded research to the University and in turn grow the university, produce funds to purchase additional equipment and fund additional staff in explosive engineering.

I am well pleased with what I learned with a Masters Degree and Ph.D. Degree in Mining Engineering with an emphasis on explosives and Blasting at UMR. It has served me well in my career. A Ph.D. degree in Explosives Engineering would have given me additional knowledge and enhanced my acceptance and recognition in the industry. I strongly encourage the Board of Curators to initiate this new degree program.

Sincerely,



Calvin J. Konya Ph.D.



UTEC CORPORATION / R&D LABORATORY

8500 SE JAYHAWK DR, RIVERTON, KANSAS 66770 · (620) 783-1361 · FAX (620) 783-1360
EMAIL: gary@utec-corp.com

Dr. Paul Worsley
Professor Mining Engineering and Director of Explosives Education
Department of Mining & Nuclear Engineering
Missouri University of Science and Technology
Rolla, MO

October 12, 2012

The explosives industry has been losing qualified, trained professionals at a rate far exceeding those receiving a proper education in the field of energetic materials. Add to this the fact that a large number of those in this field today are over the age of forty, and that many currently in the explosives industry will be eligible for retirement in the next five years, it is easy to see that the future of the explosives industry could be in desperation. In a past 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 a privately owned 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 its 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 senior 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/performance 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.

The institution of the Masters of Explosives Engineering program at Missouri S&T has been a major step in solving some of the lack of qualified personnel problems felt by the explosive industry. And, it can only follow, that the institution of a PhD in Explosive Engineering program will help to better serve this same goal.

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. As a commercial explosives company logo wisely states, "*If you cannot Grow it, then you have to Mine it*". It would be reasonable to expect the vast number of explosives related commercial and government industries to have the availability to hire increasing numbers of higher educated persons each year.

It is my belief that a continued expansion of Missouri S&T's 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



November 13, 2012

Samuel Frimpong
Professor and Chair
Department of Mining and Nuclear Engineering
Missouri University of Science and Technology

Subject : Support for PhD in Explosives at Missouri S&T

Orica is committed to developing tomorrow's technologies and solving today's challenges for our customers. Founded in 1874, we have built a proud tradition of leadership, innovation, quality and safety. Today, Orica is a truly global company with a diverse workforce of over 15,000 people. We have operations in more than 50 countries with customers in more than 100. Orica is the largest provider of commercial explosives and blasting systems to the mining and infrastructure markets, the global leader in the provision of ground support in mining and tunnelling, and the leading supplier of sodium cyanide for gold extraction.

Orica invests significantly in research and development and is the largest investor in our industry. Orica is interested in technologies that can improve process safety, environmental performance, process efficiency, blasting and mining.

Missouri S&T have a great reputation in the mining community and is in the top 5 for mining education in the USA. The master in explosives course has expanded the depth and breadth of the academic offering from the University and one that makes it more attractive to Orica.

I am excited to hear that Missouri S&T are considering the addition of a PhD program to their curriculum. The Global R&D group for Orica regularly recruits PhDs of many disciplines and it is rare to find people who have specifically done research related to explosives. This will be a great advantage to Orica in the future and I can see many employment opportunities for PhD graduates in the R&D group both in the USA and internationally.

I am happy to provide my support to Professor Frimpong, his team and the proposed PhD program.

Yours sincerely,

Richard Goodridge
General Manager -- Research & External Networks
Orica Ltd.



U.S. Department of Justice

Bureau of Alcohol, Tobacco,
Firearms and Explosives
Huntsville, AL 35898

www.afj.gov

750000: SKM
1210

Dr. Paul W. Worsey
Director of Explosives Engineering Education
Department of Mining & Nuclear Engineering
Missouri University of Science and Technology
226 McNutt Hall
1400 N. Bishop
Rolla, MO 65409-0450

Dear Dr. Worsey:

It is a pleasure to write in support of your proposed Ph.D. in Explosive Engineering under the Mining and Nuclear Engineering Department of Missouri University of Science and Technology (MST). The Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) shares your dedication to providing highly trained explosive experts who enhance our understanding of the function and effects of explosives.

As the Bureau within the U.S. Government tasked with regulating the explosives industry and investigating the criminal misuse of explosives, we strive to ensure the safety and security of the public. In our efforts to achieve these goals, we have recognized a void in the formal education system that addresses our need for engineers and analysts with a solid foundation in the physical processes and underlying theory of shockwaves, detonation, and initiation. We feel strongly that your proposed program aligns with our efforts.

We look forward to our continued relationship in the education of our Special Agents in your Graduate Certificate in Explosive Engineering program and fully endorse your Ph.D. proposal.

Sincerely yours,

SKM

S. Kevin McNeill
Chief, Research and Development Division
National Center for Explosives Training and Research

Dr. Eric J. Rinehart
140 Chula Vista, N.E.
Albuquerque, New Mex 87106
(505) 255-5847

Dr. Gillian Worscy
Mining Engineering
University of Missouri, Rolla
Rolla, Missouri

I recently retired as the Chief Scientist, Test Division, Defense Threat Reduction Agency with the Department of Defense. The Test Division is involved with testing and understanding most aspects of high explosives and military weapon effects that use high explosives. We have a rigorous testing program that deals with large (up to 200T) explosives to small scale (10g) testing. We are key, either with government personnel or with the aid of our contractors, in experiment design, pretest predictions using analytical fast running tools or state-of-the-art computer simulations, test measurements and data recording, and test analysis.

We continue to have difficulty in identifying new, young persons that are well qualified in the high explosive testing areas and were pleased that ARA was able to hire such a person recently graduated with an MS in Explosive Engineering. I have always seen a need for persons perhaps qualified at a higher level, or able to have demonstrated keen interest in the research area of explosive, what we called Test Scientists. At this time we find it necessary to hire and train in-house such expertise. Of course this is time consuming, resource limited and often discouraging as a person finds this kind of work does not suit their long term goals. It is also many times hit and miss as specific testing needs arise. It would be highly beneficial to have opportunities to hire personnel at the PhD level—ones who really are excited with this kind of work, and are willing to work with our military in support of the Nation. I would like to encourage you and your department to support the Explosive Engineering at the PhD level. Perhaps in the future, these types of students could be part of DTRA's student/intern programs. I have reviewed your MS level studies, and have talked with Laurin Bookout regarding the courses and research that she is intending to take at Missouri. A program such as this would, indeed, be beneficial.



Eric Rinehart, PhD
Geophysicist

Academic

We have selected three academic letters of support, those from Drs. Sam Kiger, Braden Lusk and John Wilson. These have excellent knowledge of current explosives programs and directly know both our past and current successes and ability to provide a quality Ph.D. program.

Dr. Sam Kiger is the Director for Expulsion Resistant Design at Mizzou (UMC) and Associate Dean of Engineering. Sam has spent many years in explosion resistant design, including work for the U.S. Department of Defense and NATO.

Dr. Braden Lusk received his Ph.D. from MS&T in 2006 in mining engineering, specializing in blasting. He was recently promoted to Associate Professor of Mining Engineering at the University of Kentucky where he teaches blasting and explosive courses and researches ground vibrations from blasting and blast resistance. Braden is a rising star at UK and is very well versed in our teaching and research capabilities.

Dr. John Wilson is a past department chair of mining engineering at UMR during the initial rise of the explosives engineering program. He knows our capabilities and the requirements of and opportunities in the mining industry and government agencies involving explosives engineering.

UNIVERSITY *of* MISSOURI

COLLEGE OF ENGINEERING
OFFICE OF THE DEAN
October 3, 2012

Missouri Department of Higher Education
Missouri State Coordinating Board for Higher
Education 205 Jefferson Street
P.O. Box 1469 Jefferson City, MO 65102-1469

Re: Letter of support for a proposed new PhD degree program in Explosives Engineering at the Missouri University of Science and Technology (MS&T).

To: Missouri State Coordinating Board Members:

I am pleased to write in support of this new PhD program. To my knowledge this PhD degree in Explosives Engineering would be the first of its kind in the nation. My own research often deals with explosion effects and explosion resistant design, and over the past 15 years I have frequently worked with the MS&T Mining and Nuclear Engineering faculty. Based on my personal experience, I believe they are very capable of developing and teaching a high quality, widely accepted PhD degree program in Explosives Engineering. I also frequently teach training courses for practicing engineers in the area of explosion effects and blast resistant design, so I am aware that there is a lot of interest in explosives engineering from the mining industry; from within the engineering community at large; from the federal sector, especially from the Department of Defense; from research institutes; and from the national labs. I believe graduates of this PhD program in Explosives Engineering would be in high demand.

In summary, I strongly support approval of this new PhD degree in Explosives Engineering at MS&T. I believe the faculty of the Mining and Nuclear Engineering Department at MS&T are most capable of developing and teaching this new degree program, and I believe that graduates of this program will be in high demand from numerous industries and research facilities. I also expect there will be a lot of international interest in this new degree program.

Please contact me if there are any questions about this letter of support.

Dr. Sam A Kiger, PE,
Fellow of the American Society of Civil Engineers Engineering Research
Associate Dean
Director, Center for Explosion Resistant Design
Editor-in-Chief, Journal of Critical Technologies in Shock and Vibration
Office 573-882-3285
Mobile; 573-999-7742
Email; KigerS@Missouri.edu
<http://engineering.missouri.edu/tag/sam-kiger/>

W1025 Thomas and. ell Lafferre Hall Columbia, MO 65211 Phone: 573-882-4375 Fax: 573-882 -2490 Web:
<http://engineering.missouri.edu> - *Missouri's Flagship University*

Dr. Braden Lusk

*234-D Mining and Mineral
Resources Building
Lexington KY 40506-0107
Fax: (859) 323-1962
lusk@enr.uky.edu*

October 3, 2012
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 PhD 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 \$5 million in research funding through federal agencies such as DHS, DOD, and OSM due to my unique expertise in explosives. I was able to achieve tenure at UK and have been very successful here. This is a direct result of the quality training and education I received from the Mining Engineering department at MS&T. When I chose to study mining engineering for my PhD, I would definitely have chosen Explosives Engineering had that been an option. 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.

The success of the MS program is evidence that success with a PhD program is likely. Many of the same students working in the MS program will likely continue on to a PhD. 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 a PhD 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, Associate Professor
University of Kentucky Mining Engineering Department

John W. Wilson PhD
10 Glensiding Pond Place
The Woodlands
Texas 77382

281 419 5507
jwilson@mst.edu

Dr. Samuel Frimpong
Chairman and Professor,
Department of Mining and Nuclear Engineering
Missouri University of Science and Technology,
226 McNutt Hall,
Rolla,
Missouri 65409-0450

October 4, 2012

Letter of Recommendation for PhD program in Explosives Engineering

Dear Dr. Frimpong,

It has been brought to my attention that the Department of Mining and Nuclear Engineering is seeking to introduce a new PhD program in Explosives Engineering. In this regard I would like to offer my support for this initiative and recommend that you and your colleagues seek the appropriate approval from the Missouri State Coordinating Board for Higher Education.

Preamble

As a former Chair and Professor of Mining Engineering at UMR (1990-2000) I recall the increase in interest in explosives engineering as the Department's enrollment increased each year in order to meet the requirements of the companies operating in the mining and minerals industries. This strong demand for explosive expertise encouraged the Department to introduce an "Explosives Emphasis" to the BS Mining Engineering degree and students interested in this qualification were required to select and take explosives courses offered as technical elective courses in the Mining Engineering curriculum. Although I was no longer at UMR/MST at the time, further advancement occurred in explosives education and qualifications in the mining degree program and this included a "minor in explosives" added to the undergraduate and graduate degrees.

With the growth in the global mining industry in the late 1990s, companies continued to seek entry-level mining graduates with explosives knowledge, and simultaneously, there was a growing interest in explosives research by government agencies and the military. As a result of these requirements and the benefits to the Department and UMR, an MS program in Explosives Engineering was developed in 2008 and approved and implemented in 2010.

During the last 10 years or so there has been further growth in domestic and international mining operations as well as an increase in the need for explosives expertise by government

agencies including the military and homeland defense. These opportunities, and the current increase in enrollment levels in the Department and MS Explosives programs, along with the high demand for graduate and post graduate students, clearly shows that the current MS program is very successful. The logical next step to advancing explosives technology, expertise and research further is to establish a PhD program in this specialty area of Explosives Engineering.

Needs for a PhD program in Explosives Engineering

In many ways the growth and development being experienced in Explosives Engineering appears to be following that of other specialty areas such of Mine Ventilation and Rock Mechanics. Since the development of PhD programs in these two disciplines there have been great strides made in research and practical applications in the mining and civil professions, and it is clear that a PhD Explosives Engineering degree has the same potential.

In addition to the growing needs for qualified explosives engineers with higher degrees by the mining, civil and various government agencies, a PhD degree in this field will also help meet the needs of academia as university engineering departments search for qualified new young faculty. There is also a need for such PhD graduates in the US National Laboratories where they typically seek PhD level graduates for staffing their various research projects needs.

Since the retirement of the Korean and Vietnam wars eras, there has been a universal lack of research in explosives and explosion effects and this void provides an opportunity for MST via a new PhD Explosives Engineering program.

The Department of Mining and Nuclear Engineering already has a student chapter of the International Society for Explosives Engineers and access to the publication of their scientific journals. With the long history of explosives education and research at Rolla, it would be appropriate to provide students studying explosives to earn a PhD qualification and make contributions to this professional organization.

The long history of explosives research at MST together with the establishment of a PhD program in Explosives in the Department of Mining and Nuclear Engineering will ensure that MST will be the leading university in the country in this area of expertise.

Enrollment and Placement of PhD graduates in Explosives Engineering

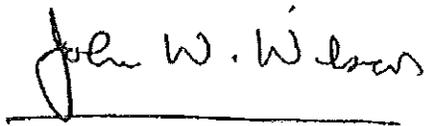
It is understood that there has been a continued rapid growth in the MS Explosives program in recent years--far in excess of the levels originally planned. The composition of students enrolled in this program (27 MS and 8 post graduate certificate students) is made up of on-campus students and distance learning students and many of the distance learning students are professionals employed in the mining and construction industries, consulting companies, government agencies and the military, It is clear from this strong interest in explosives and the teaching/research expertise in place at MST, there is sufficient demand and expertise available for the introduction of a PhD program in Explosives Engineering and these factors should make the program an immediate success.

With the demand for explosives expertise at the higher degree level, the placement of graduates from the PhD program should not be a concern as many of the potential students are already in industry and working for consultant firms, mining companies and government agencies. A PhD degree earned by such candidates will provide promotional opportunities for these individuals and bring additional expertise/knowledge to their companies/organizations.

Concluding Remarks

With the facts presented to me of the desire to establish a new PhD program in Explosives Engineering by the Department of Mining and Nuclear Engineering and my personal experience and knowledge of explosives teaching and research at MST, together with the growth and technical improvements continually being a goal of the mining, civil and government agencies, I strongly recommend that the PhD program in Explosives Engineering be approved and implemented as soon as practicable.

In addition to providing a valuable service to the private and public sectors and enabling interested students to obtain a PhD in Explosives Engineering, MST and its Mining and Nuclear Engineering Department will gain further domestic and international recognition because of the initiative shown to be the first university to develop and offer a PhD in Explosives Engineering. This move could also play a significant role in increasing access to government and possibly industrial research funding programs.



A handwritten signature in cursive script that reads "John W. Wilson". The signature is written in dark ink and is positioned above a solid horizontal line that serves as a separator between the signature and the typed name below.

John W. Wilson
Emeritus Professor in Mining Engineering
Mining Consultant

cc Dr. K. Wray

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 it is hope that their letters crown this package of support and impress the reader.

The letters are not only from current onsite M.S. students but also those gainfully employed by the full spectrum of industry and government. In addition we have letters from M.S. explosives graduates who are being temporarily housed in the mining engineering Ph.D. program.

Laurin Bookout
255 S. Pickett St.#301
Alexandria, VA 22304

29 October 2012

Dr. Paul Worsey 226 McNutt Hall Missouri S&T Rolla, MO 65409

Dr. Worsey,

My enrollment in, and subsequent graduation from the M.S. in Explosives Engineering offered by Missouri S&T has given me many professional opportunities. While working as a graduate research assistant, I was able to secure an internship with the Naval Surface Warfare center in Florida solely due to the unique nature of my education. Over the course of the internship I met many individuals with experience in various areas of explosives research that were quite enthusiastic about the prospect of new graduates trained in theory and safe handling, use, and theory of explosives.

During my job search just prior to graduation, I was able to secure multiple written offers which is becoming rare even for engineering students. After accepting an offer I received several phone calls from individuals who I had met or knew of me through a mutual contact inquiring if I was still available to accept a position. The high level of interest shown in me during that time leads me to believe that there are many opportunities for new graduates who are competent, motivated to learn, and are confident in their abilities.

I am currently taking courses as a distance student with the intention of enrolling in the PhD for Explosives Engineering as soon as it is approved. Several of my professional mentors and colleagues have encouraged me to pursue a PhD since it will be very beneficial to my professional success and advancement.

Missouri S&T has a great opportunity to provide graduates with explosives expertise who will learn from and later move into the roles of today's experts who are nearing retirement.

This is why I support the movement to add a PhD in Explosives Engineering at Missouri S&T.

Sincerely, Laurin Bookout Staff Engineer
Applied Research Associates

Jacob Miller
411 Oak Tree Drive
Oliver Springs, TN 37840
October 25, 2012

Dr. Paul Worsey
Director of Explosives Engineering Education
& Professor of Mining Engineering
Missouri University of Science & Technology
226 McNutt Hall
1400 N. Bishop
Rolla, MO 65409-0450

Dear Dr. Paul Worsey:

As per your request, I am writing to express interest in earning a PhD in Explosives Engineering at the Missouri University of Science & Technology.

Recently, I received a Masters in Explosives Engineering as well as a Masters in Mining Engineering at MS&T. To further my education and pursue professional goals, I enrolled in the Mining Engineering PhD program, also at MS&T. A PhD in Explosives Engineering would be a more desirable pursuit for me, based on those goals.

While working toward my graduate degrees, I have been employed full time with B&W Y-12 as a Sr. Technical Engineer. B&W is the contractor that operates Y-12, which is one of the four facilities that manufacture nuclear weapons components for the United States Federal Government. There are, as you may assume, unique requirements related to the production, storage, and security of these components. My employer believes that having a highly trained expert in the field of Explosives Engineering would be beneficial to the site.

Developing my skills and broadening my knowledge in the field of Explosives Engineering through the pursuit of a PhD have become quite important. Were a PhD program in Explosives Engineering to become available at MS&T, it would be quite valuable to me.

Please use this letter as you see fit Dr. Worsey.

Sincerely,



Jacob Miller

B.S. Mechanical Engineering '03	UMR
M.E. Manufacturing Engineering '05	UMR
Masters Certificate, Explosives Engineering '08	MS&T
M.E. Mining Engineering '12	MS&T
M.S. Explosives Engineering '12	MS&T

Jaime Xavier Hinojosa
16274 Heartland Lane
Saint Robert, MO 65584
October 30, 2012

Missouri University of Science and Technology
1870 Miner Circle
Rolla, MO 65409

To Whom It May Concern:

I am writing this letter to explain my intentions to apply for admission in the Explosives Engineering Doctoral Program. Let me begin by explaining my background education and experience. I am a Combat Engineer Officer in the United States Marine Corps stationed at Fort Leonard Wood, Missouri and hold the rank of Captain. As an undergraduate student I attended New Mexico State University in Las Cruces, New Mexico where I graduated in December 2005 with a Bachelor of Science in Mechanical Engineering. In January 2006, I was commissioned a Second Lieutenant in the United States Marine Corps and attended The Basic School in Quantico, Virginia and the Combat Engineer Officers Course in Camp Lejeune, North Carolina. The Basic School trains and educates newly commissioned officers in the high standards of professional knowledge, esprit-de-corps, and leadership required to prepare them for duty as company grade officers in the operating forces, with particular emphasis on the duties, responsibilities and war-fighting skills required of a rifle platoon commander. The Combat Engineer Officers Course teaches Second Lieutenants to be proficient in military construction management, demolitions, and the skills necessary to be a military engineer platoon commander and staff officer.

Upon graduation of my entry level military schools, I reported to Marine Wing Support Squadron 374 where I served as a Platoon Leader and the Engineer Company Commander in 29 Palms, California and two deployments to Iraq. My unit was responsible for providing aviation ground support for the Marine Air Wing. Our missions mainly included the construction of helicopter landing zones, expeditionary roads and airfields, and force protection measures.

Currently, I hold the rank of Captain and am an instructor at the United States Army Engineer School for the Engineer Captains Career Course(ECCC). At the ECCC, I am a Cell leader and am responsible for the operations and instruction of 2 twenty-one week courses a year. As the cell leader I supervise 7 small group instructors and 112 students during the period of instruction. Our course includes the subject areas of general engineering, military tactics, combat engineer officer planning, and leadership.

I have been very fortunate to be stationed at Fort Leonard Wood as a Marine Officer as our graduate education opportunities are very limited while we are on active duty. Since moving to the area in 2010 I have attended Missouri University of Science and Technology. I plan to graduate with a Master of Science in Engineering Management and a Master of Science in Explosives Engineering during the spring 2013 semester. My graduate education in engineering management and explosives engineering will help me further develop the tools and techniques we use in military engineering. In the future I would like to enhance the skills of combat engineers in military demolitions by reviewing the courses we teach at our schools and propose an advanced military demolitions class. There are many modern techniques that I learned during my time at MS&T that can be incorporated into military demolitions to make combat engineers more effective as they operate throughout the world. Very few, if any engineer officers have had the opportunity to obtain graduate level education in engineering management and explosives engineering. I would like to take my graduate education and make our Marines and Soldiers better as combat engineers and leaders.

Sincerely,

Jaime X. Hinojosa
Captain, USMC



DEPARTMENT OF THE ARMY
4TH ARMORED BRIGADE COMBAT TEAM, 1ST ARMORED DIVISION
FOB LIGHTNING, AFGHANISTAN
APO AE 09364

04 October 2012

TO WHOM IT MAY CONCERN

Dear Sir or Madam:

My name is Steve Williams and I am writing to you today to express my interest and support for the proposed PhD program in Explosives Engineering at the Missouri University of Science and Technology. I am a Captain in the United States Army Engineer Regiment, currently deployed to Forward Operating Base Lightning, Afghanistan. Before my deployment, I attended graduate school at Missouri S&T where I completed a Master of Science degree in Civil Engineering, and later enrolled in the Explosives Engineering Master's program through the Missouri S&T Distance and Continuing Education Center. My studies are currently on hold until I return from this deployment.

As an Army Engineer, I have been studying or working around explosives for most of my career. I am a graduate of the Engineer Basic Officer Leader Course, where we learn the proper handling and application of explosives, and the Engineer Captains Career Course, where the planning and implementation of explosive obstacles is a central topic. The Army has also certified me as an Explosive Ordnance Clearance Agent, which qualifies me to identify and detonate unexploded ordnance and certain types of improvised explosive devices. In my current assignment, I serve as the advisor to the Engineer for the Afghan National Army's 203rd Corps. One of my duties is validating the quality of the counter explosive-hazard training the Soldiers of the 203rd Corps currently receive. Following my deployment, I plan to seek an instructor position at the US Military Academy at West Point or a fellowship with the Defense Threat Reduction Agency.

For me, the Master's program in Explosives Engineering offered by Missouri S&T was the next logical step in my professional education, and I believe a PhD will be of great interest and relevance to the United States Army. I see it as a great opportunity not only to continue my education, but also to contribute to the academic and professional community through research. I strongly urge you to approve the proposal for a PhD program in Explosives Engineering at Missouri S&T. Please feel free to contact me at stephen.e.williams@afghan.swa.army.mil or at my student e-mail, sewhg6@mail.mst.edu.

Sincerely,

STEPHEN E. WILLIAMS
CPT, EN, USA
Brigade Engineer / Corps Engineer Advisor

To Whom it May Concern:

I am writing this letter in support of the Ph.D. program in Explosives Engineering. Personally, I was honored to have the chance to complete my studies in the recently approved M.S. program in Explosives Engineering. Earning the M.S. in Explosives Engineering has allowed me to broaden my focus from my bachelor's degree and stay involved in the blasting industry. Without the M.S., I would not have the same opportunities to direct my career focus to the study of explosives, the broader depth of knowledge and thirst for knowledge that I gained in school, or the same ability to stay involved in the professional society for explosives engineers, the International Society of Explosives Engineers. The approval of the M.S. program in Explosives Engineering was a life altering event for me. I am currently employed in the mining and blasting industry as well as working toward my Ph.D. in mining engineering. However, I am studying blasting and would be interested in changing my major should the Ph.D. program be approved.

I support the approval of the Ph.D. program in Explosives Engineering for my own benefit and the benefit of other students interested in this specialized field. The opportunity to study this subject is one that very few students have or will probably ever have. No other university offers the same quality of education, the same level of expertise and experience, or the same concern for students that the Mining and Explosives Engineering Department offers at Rolla. This program would be one more step in making that department the best in the world and the most desirable program to enroll in in the world.

Without a doubt, the students, Mining and Explosives Department, and University of Missouri System would considerably benefit from the approval of the program for the Ph.D. in Explosives Engineering.

Sincerely,
Nathan Rouse
B.S. Mining Engineering, '09
M.S. Explosives Engineering, '10

To Whom It May Concern,

My name is Matthew Coy. I am interested in pursuing a Ph.D. in Explosives Engineering. I first became interested in explosives during an MST-hosted summer camp I attended during high school. Since then I have pursued an education centered around explosives. After receiving my B.S. in Mining Engineering in December 2010, I began my pursuit of a Masters Degree in Explosives Engineering. Through these degree programs I became qualified and am currently a holder of a Missouri Blaster's License as well as Missouri Pyrotechnic Operator Licenses for both NFPA 1123 and 1126 pyrotechnic displays. Pursuing a Ph.D. in explosives would help me further this education, expanding both my knowledge and abilities. It would better enable me to produce works that both are scholarly and contribute to the advancement of the explosives industry. Aside from that, I also would expect to obtain a sense of self-accomplishment as well as increase my research discipline. I believe that such a program has the potential to produce very valuable assets to the research community.

Warmest regards,
Matthew Coy

To Whom It May Concern,

I would like to offer my support for a Ph.D. Program in Explosives Engineering at the Missouri University of Science and Technology. I am an Alumn of the University who has worked over 5 years in the Gold Mining Industry. I am currently taking advantage of the Master's Certificate program in Explosives Engineering offered at MS&T. I have been using this Master's Certificate program to test the water's and see how value adding the course work is for a professional in the Mining Industry. I have come to the conclusion that the Explosives Engineering program as a whole is a value adding program for both academics and industry professionals. I feel a Ph.D. program in Explosives Engineering not only holds a lot of potential for research and growth in our knowledge of Explosive Engineering, but it would also be a beneficial program for many Industry Professionals. This includes myself, and is something I am interested in adding to my future plans if it becomes available.

Thank you,
Tyler Acorn

October 03, 2012

Mr. Worsey,

I am writing to express my interest in pursuing a Ph.D. in Blasting Engineering from Missouri University of Science and Technology. Currently, I am in my last class for the Blasting Certificate and I am also working towards my Masters in Mining Engineering. After this current class I will have 6 credits left to finish the Masters program, so I would be available to start taking Ph.D. classes possibly as early as the Fall of 2013 or the Spring of 2014. Thus, I am very interested in knowing more about the program and when it is available. So, please consider me as a prospective student in the Ph.D. in Blasting Program, and if you have any questions for me or information on the progress of this program, please let me know. Thank you.

Sincerely,

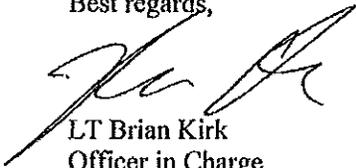
Mike Castner

10 October 2012

To Whom It May Concern,

I'm writing to express my interest in a future PhD program in Explosives Engineering at Missouri University of Science and Technology. I've previously expressed my interest to Judy Russell when a call for interest was sent out. I'm currently working on the Graduate Certificate with the plan to matriculate into the MS Explosives Engineering Program after finishing the certificate.

Best regards,

A handwritten signature in black ink, appearing to read 'Brian Kirk', written over a horizontal line.

LT Brian Kirk
Officer in Charge
Explosive Ordnance Disposal Mobile Unit Two Detachment Crane
300 HWY 361 Bldg 2721
Crane, IN 47522



MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Formerly University of Missouri-Rolla

October 5, 2012

Chairman Department of Mining and Nuclear Engineering

Dear Dr. Frimpong:

As you know 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. We haven't yet implemented the master program in explosives engineering and it is already a success in that the Army are asking me to hurry taking the wraps off this and make it more accessible. It now appears appropriate to suggest that you could make the pathway deeper – up to the PhD or Doctor of Engineering levels – while I work on opening it up wider for better access, less restrictions and available to a wider military-related student pool.

Sincerely,

A handwritten signature in cursive script that reads "S. H. Tupper".

S. H. Tupper
Liaison to Fort Leonard Wood

Liaison Office • 197 Replacement Avenue • Fort Leonard Wood, MO 85473
Phone: 673-320-8515 • Fax: 673-320-8509 • Email: tuppers@mst.edu

An equal opportunity institution

Appendix C- Recent Poll of Students

A poll of students enrolled in the S&T explosives M.S. program was made in September 2012. Of these students, 10 replied positively regarding their interest in the Ph.D. program. There was no discussion regarding funding of these students. It is believed that although some students will be on GTA or GRA appointment, the majority will be company or self funded. Six students are already enrolled in the mining Ph.D. program with the hope that the Ph.D. in explosives engineering becomes a reality.

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 the case based on the growth and statistics of the explosives engineering M.S.

A composite of the majority of these students is shown in the photograph below. It is important that these students are not just statistics but rather real people with expectations.



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, then applying for the explosives master's and then applying for the Ph.D. degree.

Students from Outside the University

We have a significant number of enquiries every year about explosives engineering. Many of these are channeled through the International Society of Explosives Engineers to us. Most of these are out of state and it is hoped that we can attract new students to the university through the Ph.D. in explosives engineering degree.

Explosives Camp

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 (since 2008). All subsidies to the camp have now been eliminated 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) graduated in May 2009 with an explosives engineering minor and the first student to enroll for the M.S. in explosives engineering graduated in May 2010 and is scheduled to graduate with his M.S. in December 2012. We currently have two other explosives camp students enrolled in the M.S. program. These students are prime candidates for the Ph.D. in explosives engineering and this is a clear indication of the interest in explosives education. Explosives camp will be a key recruitment tool for the Ph.D. in the future.

Final Note

It is clear that today's students are even more demanding in their expectations and desires. The majority of graduate students want something specific and the majority of these persons will settle for nothing less. A program that is watered down without focused substance is bound to fail. The Ph.D. degree in explosives engineering, is bold, well defined and definitely desirable. Because of this, it will be easy to market.

Appendix D - Graduate Catalog Description

Explosives Engineering

The Explosives Engineering program in the department of Mining and Nuclear Engineering offers the Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in Explosives Engineering 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 M.S. and Ph.D. 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 the 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.)¹⁷ The explosives engineering faculty and students will be active in the leading professional societies such as the International Society for Explosives Engineers and those in a wide range of associated areas. A security background check is required for all students in the program.

M.S. Degree Requirements

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

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

Exp Eng 307/Min Eng 307	Principles of Explosives Engineering
Exp Eng 350/Min Eng 350	Blasting Design and Technology
Exp Eng 351 ²⁵	Demolition of Buildings and Structures
Min Eng 383	Tunneling and Underground Construction Techniques
Exp Eng 402 ²⁵	Environmental Controls for Blasting
Exp Eng 406 ²⁵	Scientific Instrumentation for Explosives and Blasting

¹⁷ Based on past experience with explosives related contracts and other research.

Students select 12 hours of Exp Eng and other appropriate elective courses. M.S. in Explosives Engineering candidates are advised to group out-of-department courses into a module that fits their special interest.

M.S. without Thesis (by coursework): The M.S. degree without thesis requires the completion of 30 hours of graduate coursework with the same stipulations as above. The six hours of research is replaced by an explosives related cooperative work experience (Exp Eng 497) or industry project (Exp Eng 498) with an established company or government agency commonly using explosives and an additional explosives course. In addition the candidate is required to present a formal presentation (oral or poster) with abstract to an established scientific or industry society and present a formal oral and/or electronically recorded presentation with abstract to the Mining/Nuclear/Explosives engineering seminar.

Ph.D. Degree Requirements

The Ph.D. degree requires a minimum of 3 years of full-time study beyond the bachelor's degree, including research work for the dissertation. Minimum requirements for Ph.D. candidates include completing 72 credit hours of graduate credit with at least 24 credit hours of dissertation research (Exp Eng 490) and a minimum of 24 credit hours of coursework, with at least 15 credit hours of course work completed at Missouri S&T. Students are encouraged to enroll in at least 15 credit hours of 400-level lecture courses and are required to pass the qualifying, comprehensive and final oral examinations for the Ph.D. research.

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 UMC, New Mexico Institute of Technology and Penn State.

Professor

Paul Worsey, Ph.D., University of Newcastle upon Tyne (Missouri S&T)
Richard Bullock, D. Eng., Missouri School of Mines Emeritus (Missouri S&T)
Sam Kiger, Ph.D., University of Illinois at Urbana (University of Missouri Columbia)
Bruce Freeman, Ph.D., University of California Davis (Ktech, formerly at Texas A & M)¹⁸

Associate Professor

Jason Baird, Ph.D., University of Missouri Rolla (Missouri S&T)
Braden Lusk, Ph.D., University of Missouri-Rolla (University of Kentucky)¹⁸

John Myers, Ph.D., Texas-Austin (Missouri S&T)

¹⁸These 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.

Brandon Weeks, Ph.D., University of Cambridge

(Texas Tech)³

Assistant Professor

Soekbin Lim, Ph.D., University of Missouri-Rolla (New Mexico Institute of Technology)

Gillian Worsey, Ph.D., University of Missouri Adjunct (Missouri S&T)

Adjunct Industry Instructors Currently Teaching Courses at Missouri S&T

Greg Shapiro, B.S., University of Missouri Columbia Steel Blasting

Matt Suttcliffe Premier Pyrotechnics

Stephen Hall, B.S., University of Missouri-Rolla Hercules (Retired)

Catalog Description of Explosives Engineering Courses Exp Eng 301

(3) Special Topics

This course is designed to give the department an opportunity to test a new course.

Exp Eng 305 (3) Explosives Handling and Safety

Basic handling and safety for explosives, explosive devices and ordnance related to laboratory handling, testing, manufacturing and storage, for both civil and defense applications.

Exp Eng 307/Min Eng 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: Min Eng 151; accompanied or preceded by Civ Eng 215 or Geology 220 or Geology 125; Successful background check.

Exp Eng 309 (3) Commercial Pyrotechnics Operations

Provide participants with training preparing for Missouri Licensed Display Operator (Outdoor) License 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: Both Chem 1 & Chem 2 or their equivalent, US Citizen or permanent resident, Successful background check, resident enrollment at Missouri S&T.

Exp Eng 313 (3) Stage Pyrotechnics and Special Effects

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. Prerequisites: Both Chem 1 and Chem 2 or their equivalent; US Citizen or permanent resident, successful background check, resident enrollment at Missouri S&T.

Exp Eng 350/Min Eng 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: Exp Eng 307/Min Eng 307. Student must be at least 21 years of age. Successful background check.

Exp Eng 351 (3)**Demolition of Buildings and Structures**

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. Field trip required. Prerequisites: Proceeded or accompanied by IDE 50 or IDE 140; US citizen or permanent resident; successful background check.

Min Eng 383 (3)**Tunneling & Underground Construction Techniques**

Cover both mechanical excavation and conventional excavation techniques for underground tunneling and construction. The emphasis will be on equipment selection and prediction of performance expected of the equipment. Ground control systems will be covered as technology emerges. Excavation methods and support of large caverns, often found in civil structures, will also be discussed. A limited focus will be on underground construction specifications and underground advance rate and cost estimation techniques.

Prerequisites: Min Eng 331, Min Eng 324 or Civ Eng 215, Civ Eng 216 or Geo Eng 371.

Exp Eng 400 (variable)**Special Problems**

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

Exp Eng 401 (3)**Special Topics**

This course is designed to give the department an opportunity to test a new course.

Exp Eng 402/Min Eng 402 (3) Environmental Controls for Blasting

Advance blast mechanics; overbreak control including comprehensive coverage of perimeter and smooth-wall 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. Prerequisites: Exp Eng 307/Min Eng 307, successful background check.

Exp Eng 406 (3) Scientific Instrumentation for Explosives Testing and Blasting

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 demilitarization. Prerequisite: Exp Eng/Min Eng 307 and successful background check.

Exp Eng 407/Min Eng 407 (3) Theory of High explosives

Study of the application of chemical thermodynamics and the hydrodynamic theory to determine the 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: Successful background check and graduate standing.

Exp Eng 408 (3) Regulatory Issues in the Explosives Industry
Comprehensive coverage of the federal regulations governing the explosives industry, including those governing storage of explosives (ATF), transportation of explosives (DOT and TSA), the environment (EPA) and use of explosives (OSM, MSHA & OSHA). Prerequisite: Graduate standing.

Exp Eng 490 (1-6) Research
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

Exp Eng 497 (3) Graduate Cooperative Experience
Students on an approved internship will complete a project designed by the advisor and employer. The project selected must require that the student apply critical thinking skills and discipline specific knowledge in the work setting. A major report and a formal presentation are required. Prerequisite: 12 hours Exp Eng coursework.

Exp Eng 498 (3) Industry Project
Students who are currently employed may complete a project in their work setting designed by the advisor and employer. The project selected must require that the student apply critical thinking skills and discipline specific knowledge. A major report and a formal presentation are required. Prerequisite: 12 hours Exp Eng coursework.

Appendix E – Curriculum Vitae of Missouri S&T Faculty

PAUL N. WORSEY, PH.D., M.SC., B.SC. (HONS), C.ENG., PROFESSOR

Dr. Paul Worsey was born in Lichfield, Staffordshire, UK and attended King Edward VI Grammar School in Lichfield from 1967 to 1974. He then attended the University of Bristol, UK, graduating with a Class III B.Sc. (Honours) in Applied Geology in 1977, followed by the University of Newcastle upon Tyne, UK, graduating with an M.Sc. in Rock Mechanics and Excavation Engineering in 1978 and a Ph.D. in Mining Engineering specializing in Explosives Engineering in 1981. His thesis title was “Geotechnical Factors Affecting the Application of Pre-Split Blasting to Rock Slopes.”

Since then Dr. Worsey has been working full time in explosives related research, teaching and consulting. He has twenty eight years of service at Missouri University of Science and Technology (MST), first as an Assistant Professor (1981-1991), then as Associate Professor (1991-2001) and currently as Professor of Mining Engineering. He has been responsible for multi-million dollars of research contracts at MST, a major research thrust in the past twenty years being the demilitarization of explosive ordnance. His research interests also include blast disturbance/damage, perimeter blasting, explosives safety, electronic initiating systems and fuse technology, explosive properties, fragmentation and the manufacture of new explosives. Current interests include blasting perception and blast resistance. In addition to his expertise in explosives he has a broad background in Mining and Geotechnical Engineering with emphasis in Rock Mechanics Excavation and Slope Engineering. He has over 280 publications and has received numerous awards.

Dr. Worsey is the Director of the Explosives Engineering Education at MST and leads the Explosives Engineering M.S., minor, emphasis area and certification programs in the Mining Engineering Department at MST. He has also been the director or principal instructor of over 50 explosives and blasting related short courses and seminars both nationally and internationally and been guest lecturer on countless others. He is responsible for many innovative courses, including firsts in the nation in commercial and stage pyrotechnics and choreography and demolition. He practices what he preaches and holds Missouri State Blaster License number 2 and Missouri State Pyrotechnician License number 20. He is a Chartered Engineer on the Engineering Council Register in the United Kingdom (11/1990 – date), a FENI registered Group I European Engineer (10/1991 – date) is an MSHA safety instructor for both surface and underground mines (11/10 – date) and holds an MSHA Underground Metal and Non-Metal Safety Training Certificate (05/1982 – date). He is a member of the International Society of Explosives Engineers, a Fellow of the Institute of Explosives Engineers (UK), a Fellow of the North of England Mining Institute (UK) and a Member of the Institute of Materials, Minerals and Mining (UK).

Dr. Worsey’s many awards and honors include: Missouri Limestone Producers Association Honorary Member Award for Outstanding Service to the Crushed Stone Industry (2010/12); Missouri University of Science and Technology Faculty Service Award (2010/02); Global

Learning, Missouri University of Science and Technology Outstanding Teaching Commendation Award, School of Extended Learning, University of Missouri –Rolla Outstanding Teaching Award of Excellence (2006/05); MST-MSM- UMR Alumni Association Outstanding Advisor Award (2005/10); School of Extended Learning, University of Missouri – Rolla Outstanding Teaching Commendation Award (2005/04); School of Materials, Energy and Earth Resources, University of Missouri – Rolla Sustained Excellence in Laboratory Instruction and in Teaching, (2003-2005); International Society of Explosives Engineers President’s Award (2002/02); American Defense Preparedness Association Best Paper Award, International Symposium on Energetic Materials Technology (1994/03).

Education:

Ph.D. in Engineering, Mining (Explosives) Engineering major, University of Newcastle upon Tyne, (1981); M.Sc. in Rock Mechanics and Excavation Engineering, University of Newcastle upon Tyne, (1978); B.Sc. (Honours) in Applied Geology, University of Bristol, (1977).

Years of Service:

Thirty one years on the Missouri S&T faculty; **Original appointment date:** August 15, 1981 as assistant professor, associate professor August 15, 1991, professor August 15, 2001.

Employment History:

Worsey and Associates Incorporated, Rolla MO: President (09/00 – Date); Explosives Engineering Education, MS&T, Rolla, MO: Director (05/06 – Date); Rock Mechanics and Explosives Research Center, UMR, Rolla MO: Senior Research Investigator (08/81 – 05/07); Loki Incorporated, Rolla MO: Vice President (08/00 – 12/05); Department of Mining Engineering, University of Newcastle upon Tyne, Newcastle upon Tyne England: Laboratory Analyst (10/79 – 08/81); Transport and Road Research Laboratory (Scottish Branch), Livingstone Scotland: CASE Industrial Award Recipient Asst. Scientific Officer grade (10/78 – 08/81).

Consulting:

Principal Consultant: Affholder, St. Louis, Missouri (10/12 – date); Magruder Limestone, Troy, Missouri (09/12 – date); Geoengineering, Springfield, Missouri (01/12 - 13/12); JCI Industries, Jefferson City, Missouri (05/11 - 09/11); Doe Run Mining Company, Viburnum, Missouri (04/10 – date); Upper Big Branch Mine, Montcoal, West Virginia (04/10 – 10/11); Humatec, Overland Park, KS, (05/10 – 04/11); Dyno Nobel, Union, Missouri (05/10); Oklahoma Aggregates Association (02/09); Rainbow Fireworks, Ozark, Missouri (04/09); Ed Rau Drilling and Blasting Company, Washington, Missouri (09/09 – 04/10); White River Valley Electric Coop., Branson, Missouri J. H. Berra Construction Company Inc., St. Louis, Missouri (1/09 – 05/10); Affholder, St. Louis, Missouri (01/09 – 04/12); Fred Weber Inc., St. Charles, Missouri (12/08 - 05/10); Binns and Stevens, Oskaloosa, Iowa (12/08-03/10); Simpson Materials, Valley Park, Missouri (10/08 - 01/09); Companhia Vale do Rio Dolce, Minas Gerais, Brazil (09/08); Magruder Limestone, Troy, Missouri (11/07 – 06/09); Association of Missouri Electric Coops, Jefferson City, Missouri (05/04-Date); Lafarge North America, Herndon, Virginia (08/04-07/07); Bear Fork Resources, Robinson Creek, Kentucky (05/07 – Date); Missouri Department of Transportation, Jefferson City, Missouri (01/07 – 08/07); River Products Company, Iowa

City, Iowa (02/07); Companhia Vale do Rio Doce, Itabira, Brazil (07/07); Fred Weber Inc., St. Louis, Missouri (10/05 – 09/06); Sago Mine, Tallmansville, West Virginia (07/06 – 11/11); Kolb Grading, St. Charles, Missouri (05/06); Sterling Excavation, Jefferson City, MO (04/06); Sunset Fireworks, Bonita Springs, Florida (05/06 – Date); Transystems, Kansas City, Missouri (09/06 – 02/07); American Coal Company, Galatia, Illinois (03/05 – 04/05); United States Army, Fort Leonard Wood, Missouri (02/05); City of Little Rock, Little Rock, Arkansas (05/05); Pacific Underground, Pacific, Missouri (08/05); Strata Services, St. Charles, Missouri (07/05), Edward Rau Drilling and Blasting Company, Washington, MO (02/04 – 03/04); Willard Blasting Committee, Willard, Missouri (06/04).

Professional Registration: Chartered Engineer on Engineering Council Register in United Kingdom (11/90-Date); FENI registered Group 1 European Engineer (No. 10254-Gg, 10/91-Date); MSHA Safety Instructor Surface & Underground (11/10 – date); MSHA Underground Metal & Non-Metal Safety Training Certificate (05/81-Date); MLPA Certified Blaster (12/97-06/08), MO Licensed Pyrotechnic Display Operator (08/04-Date); MO Licensed Pyrotechnic Special Effects Operator (08/04-Date), State of MO Licensed Blaster (06/08-date).

DR. JASON BAIRD, LT. COL. USAF, RETIRED

Associate Professor, Department of Mining and Nuclear Engineering Deputy Director, Rock Mechanics and Explosives Research Center

Missouri University of Science and Technology

226 McNutt Hall, 1870 Miner Circle, Rolla, MO 65409-0660

Phone: (573) 341-6648; Fax: (573) 341-4368; E-mail: jbaird@mst.edu

Education:

Ph. D., Mining Engineering, Univ. of Missouri – Rolla (UMR), 2001. M.S., Aeronautical Engineering, Air Force Institute of Technology (AFIT), 1982.

B.S., Engineering Sciences, Honor Graduate, United States Air Force Academy (USAFA), 1978.

Years of Service:

Associate Professor, Department of Mining and Nuclear Engineering, Missouri S&T (2008 – Present). Research Associate Professor, Explosives Laboratory, Rock Mechanics and Explosives Research Center, University of Missouri-Rolla (UMR) (2006 – 2008). Research Assistant Professor, Explosives Laboratory, Rock Mechanics and Explosives Research Center, UMR (2003 – 2006).

Employment History:

Associate Professor, Department of Mining and Nuclear Engineering, Missouri S&T, 2008 – Present; Deputy Director, Rock Mechanics and Explosives Research Center, Missouri S&T, 2010 – Present; President, Loki Incorporated (small business engaged in energetic materials research, with contracts in blast mitigation, structure protection against small arms, and compact explosive-driven pulsed power devices), 1999 – Present. GAANN Graduate Fellow in Mining Engineering/Explosives at UMR, 1997 – 2001. Science Teacher, Rolla Public Schools, Rolla, MO, 1995 -1997. Deputy Director, Missile Propulsion Division, Propulsion Directorate, Phillips Laboratory, United States Air Force, Edwards AFB, CA, 1994 – 1995. Department Head and Lecturer in International and Strategic Studies, Defense Studies Department, Royal Air Force College Cranwell, Cranwell, UK, 1991 – 1994. Officer Commanding, RAF Cranwell Service Arms Shooting Team, Department of Physical Training Instruction, RAF Cranwell, Cranwell, UK, 1991 – 1994. Deputy Director, Applications Engineering Division, Propulsion Directorate, Phillips Laboratory, United States Air Force, Edwards AFB, CA., 1991. Chief, Aerospace Launched Missile Branch, Astronautics Laboratory, United States Air Force, Edwards AFB, CA., 1989 – 1991. Associate Professor of Aerospace Studies, Detachment 880, Air Force Reserve Officer Training Corps, Virginia Military Institute, Lexington, VA., 1986 – 1989. Chief, Air Vehicle Branch; Warhead Engineer; Propulsion Engineer – AMRAAM Joint Systems Program Office, United States Air Force, Eglin AFB, FL., 1983- 1986.

Consulting:

Expert witness in legal cases regarding explosives and pyrotechnics, consulting engineer for blast mitigation and security.

Professional Registration:

Holder of U.S. BATFE Explosives License, Missouri Certified Blaster Certificate (now License) (since 1998), Certified Miner in Surface, Underground, Shaft & Slope Mines for Coal, Metal, and Nonmetals. Certified at Level III in Systems Planning, Research, Development, and Engineering for the Department of Defense (1995)

Publications (a brief list; complete list available upon request):

- Worsey, P.N., J. Baird, and M. Schmidt. "Maximizing Resolution of the High-Speed Photography of Explosive-Driven Power Generator (EDPG) Armatures in Operation," IEEE Transactions on Plasma Science, Special Issue: Pulsed Power Science and Technology. Winter 1999.
- Baird, J., M. Schmidt, and P.N. Worsey. "Effects of Defects on Armatures Within Helical Flux-Compression Generators," Proceedings of the PPPS-2001 Joint Conference of the IEEE Pulsed Power and Plasma Sciences Societies, 17 – 22 June 2001.
- Baird, J. and P.N. Worsey. "The Causes of Armature Surface Fracturing Within Helical Flux-Compression Generators," IEEE Transactions on Plasma Science Special Issue on Pulsed-Power Science and Technology, October 2002, Vol 30 No 5, ISSN 0093-3813, IEEE Nuclear and Plasma Sciences Society.
- Baird, J. "Sappington Bridge: An Opportunity for Strengthening Research and Demolition Training," Proceedings of the 29th Annual Conference on Explosives & Blasting Technique, 2-5 February 2003.
- Gertsch, L., J. Baird, and P. Worsey, "Blast designs for NEO destruction and deflection," paper and poster presentation at the 2007 Planetary Defense Conference, Washington DC, 5-8 March 2007.
- Shkuratov, S., E. Talantsev, J. Baird, and L. Altgilbers, "Dominant Role of the Explosively Expanding Armature on the Initiation of Electric Discharge in Magnetic Flux Compression Generators," Proceedings of the 2009 IEEE International Pulsed Power Conference, 28 Jun - 2 Jul 2009.
- Shkuratov, S., J. Baird, E. Talantsev, and L. Altgilbers, "Operation of Longitudinal Shock Wave Ferroelectric Generators in the Resistance Mode," Proceedings of the 2009 IEEE International Pulsed Power Conference, 28 Jun - 2 Jul 2009.
- Shkuratov, S., E. Talantsev, J. Baird, L. Altgilbers, and A. Stults, "Energy Transfer from shock wave Ferromagnetic Prime Power Sources to Magnetic Flux Compression Generators," Proceedings of the 13th International Conference on Megagauss Magnetic Field Generation and Related Topics, 6 – 10 July 2010.
- Explosive Pulsed Power, L.L. Altgilbers, J. Baird, B.L. Freeman, C.S. Lynch, and S.I. Shkuratov, World Scientific Publishing Company, ISBN 978-1-84816-322-5 and 1-84816-322-3, Dec 2010.
- "Application of piezoelectric ceramics in pulsed power technology and engineering," Chapter 14 in Piezoelectric Ceramics, ISBN: 978-953-307-122-0, Sciyo, October 2010.
- Explosive Pulsed Power, L.L. Altgilbers, J. Baird, B.L. Freeman, C.S. Lynch, and S.I. Shkuratov, World Scientific Publishing Company, ISBN 978-1-84816-322-5 and 1-84816-322-3,

Dec 2010.

Mulligan, P., J. Baird, J. Hoffman, "The Effects of the Flyer Plate's Radius of Curvature on the Performance of an Explosively Formed Projectile," Proceedings of the 17th APS Topical Conference on Shock Compression of Condensed Matter, June 26 – July 1, 2011.

Bookout, L., J. Baird, "Impact Effects of Explosively Formed Projectiles on Normal Strength Concrete," Proceedings of the 17th APS Topical Conference on Shock Compression of Condensed Matter, June 26 – July 1, 2011.

Memberships:

Society for Mining, Metallurgy, and Exploration (since 1997), International Society of Explosives Engineers (since 1997), Institute of Electrical and Electronics Engineers (since 2000), Reviewer/Referee for IEEE Transactions on Plasma Science, American Institute of Aeronautics and Astronautics (since 2000), Directed Energy Professional Society (since 2000), American Physical Society (since 2005).

Honors and Awards:

2006 Tibbetts Award for SBIR Excellence, 2008 SAME "Engineers Make a World of Difference" Award, 2008 Army Achievement Award.

Institutional and Professional Service:

Mining Promotion and Tenure Committee, 2012, Faculty Advisor to the Missouri S&T Student Chapter of the National Stone, Sand and Gravel Association, 2002 – Present, Faculty Advisor to the Missouri S&T SME/NSSGA Student Design Contest Team, 2005 - 2011. Faculty Advisor to the Missouri S&T chapter of Pi Kappi Phi fraternity, 2004 – 2011.

GILLIAN M. WORSEY, Ph.D., M.Sc. B.Sc. (Hons)

Adjunct Assistant Professor, Department of Mining and Nuclear Engineering
Missouri University of Science and Technology October 2012

Phone #: 573-341-4317 Email: worseyg@mst.edu

Education

University of Bristol

B.Sc. (Honours) Physical Geography, Class Iii, 1978

University of Newcastle upon Tyne

M.Sc. Civil Engineering, 1982

Advisor: Mr. David Silcock

Thesis Title: An Investigation of Statistical Relationships Between Accident-Rates and Road and Traffic on Two Urban Routes.

University of Missouri - Rolla

Ph.D. Civil Engineering, 1986 GPA 4.0 Advisor: Dr. Charles Dare

Dissertation Title: An Investigation of Signs for Median Crossovers.

Other Qualifications and Training

Member Chartered Institution of Highways and Transportation (MCIHT) 1987 – present

Member Missouri Valley Chapter International Society of Explosives Engineers 2009- present

MSHA Underground Metal and Non-Metal Safety Training Certificate, 2009-present

ATF Responsible Person Clearance, 2003-present

Blaster's Training Oct. 2008, Dec.2008, Dec. 2009, April 2010, Jan. 2011, April 2011, April

2012 Basic Blasting Course Fall 2006

Advanced Blasting Course Fall 2006, July 2010

Work Experience

Transport Operations Research Group, Dep. of Civil Engineering, University of Newcastle upon Tyne

Junior Research Associate (1979-1980)

Observed drivers and reported hazards while they were driving a specific route in Newcastle upon Tyne.

Research Associate (1980-1981)

Collected and organized data, performed statistical analysis and wrote report.

University of Missouri – Rolla / Missouri University of Science and Technology

GTA (1982-1986)

Graded papers and taught in professor's absence.

Post-Doctoral Researcher (1986-1988)

Researched new technologies, tested transportation computer software and wrote newsletter articles for Missouri Department of Transportation technology transfer project.

Adjunct Assistant Professor (1995-1999 and 2011-present)

Taught two sections of the basic transportation class in fall and spring semesters (1995-1999)

Taught two sections of the explosives regulations class in summer and fall semesters (2011-present)

Incubator Technologies Inc.

Principal Investigator (1987)

Oversaw Small Business Innovation Research contract and wrote reports.

Technology Development Inc.

Consultant (1991-1993)

Performed statistical analysis and wrote reports.

Worsey and Associates Inc.

Company Secretary (2000-present)

Reports, accounting, taxes and all paperwork required to comply with blasting and security regulations.

Awards and Honors

Thomas J. Seburn Award for Outstanding Contribution in Transportation Engineering, Institute of Transportation Engineers Missouri Valley Section, October 15, 1984.

Honorable Mention 1984 Student Paper Award, Institute of Transportation Engineers, Sept. 25, 1984.

Winner 1986 District 4 Student Paper Award, Institute of Transportation Engineers District 4, 1986.

Teaching Experience

Classes at MST

CivEng 211 – Transportation Engineering

GTA 1983-1986

Adjunct Assistant Professor 1995-1999

ExpEng 408 Regulatory Issues for the Explosives Industry

Adjunct Assistant Professor 2011-present

Research Experience

Risk, A.W. and Shaoul, J.E. "Driver Behaviour in Relation to Safety," Transport Operations Research Group, Newcastle upon Tyne for UK Transport and Road Research Laboratory, Junior Research Associate, September 1979 – August 1980.

Worsey, G.M. "Relationships Between Accident-Rates, Road Characteristics and Traffic on Two Urban Routes," Transport Operations Research Group, Newcastle upon Tyne for Rees Jeffreys Road Fund, Research Associate (P.I.), September 1980 – December 1981.

Worsey, G.M. "Investigation of Warning Signs for Median Crossovers," Traffic Safety Research Division, Office of Safety and Traffic Operations Research and Development,

FHWA, Research Fellowship, May 1985-September 1985.

Dare, C.E. "Transportation Technical Assistance Office," University of Missouri – Rolla, Department of Civil Engineering for Missouri Department of Transportation, Post-Doctoral Researcher, September 1986 – February 1988.

Worsey, G.M. "Technical Assistance in Dual Purpose Initiator Research," Incubator Technologies Inc., Rolla for Department of the Army Harry Diamond Laboratories, P.I., July 1987 - December 1987.

Worsey, P.N., Wulfman, D. and Sitton, O. "Automated Explosives Handling Facility and Explosives. Testing," Technology Development Inc., Rolla for Office of Naval Research, Consultant, April 1991 – January 1993.

RICHARD L. BULLOCK

Professor Emeritus

Education:

Doctor of Engineering Degree, Mining Engineering, 1975 - University of Missouri-Rolla
Master of Science Degree, Mining Engineering, 1955, Missouri School of Mines & Metallurgy
Bachelor of Science Degree, Mining Engineering, 1951, Missouri School of Mines & Metallurgy

Service:

Hired as Endowed Robert Quenon Professor, in Mining Engineering, January 03, 1997
Promoted to Endowed Robert Quenon Chair in Mining after endowment was fully funded in 1998.

Retired from University of Missouri-Rolla, May 2002

Continued Teaching on campus as Professor Emeritus until December 2003

Continued Teaching off campus as Professor Emeritus Distance Learning, 2002-Present

Corporate Experience:

1995 – Present Behre Dolbear & Company (USA), Inc., Senior Associate

1994 – 1995 TRW and Department of Energy, Consultant, Yucca Mountain Project

1986 – 1994 Raytheon Services Nevada/Fenix & Scisson, Project Manager/Technical Project Officer, Yucca Mountain Project

1977 – 1986 Exxon Minerals Company, Vice President, Engineering, Technology, and Research; Project Executive, Project Executive, Los Bronces Expansion Project;

1955 – 1977 St. Joe Minerals Company, Director, Corporate Mine Development and Research; Division Superintendent-Fletcher Division; Mine Superintendent-Viburnum

1952 – 1954 U.S. Army Corps of Engineers, Pit and Quarry Instructor;

1951 – 1952 New Jersey Zinc Company, Gilman, Colorado, Mine Surveyor; Mine Safety

Consulting:

Performed Due Diligence Study on the following mineral properties: Stillwater Mining Co.; seven mines, Hunan Prov., China; massive rutile deposit, Shanxi Prov., China; three metal properties in Tibet, China; three copper properties, Inner Mongolia Prov., China; three base metal properties & three coal properties in Qinghai Prov., China; A base metal property in Sichuan Prov., China; Pea Ridge iron mine, Missouri; Coos Bay black sand project in Oregon; Hollister gold mine in Nevada. Preliminary study for manganese deposit in Hidalgo, Mexico. Mine Geomechanical study of copper mine in Sonora, Mexico.

License and Certification:

Professional Engineer License in Missouri, Nevada, New York and Tennessee. He is a Certified Qualified Professional in Mining and Ore Reserves by Society of Mining and Metallurgy of America, for due diligence and feasibility study analysis in United States, Canada, South Africa, Australia, China and most countries in Europe.

Publications:

- “Stillwater Mine Due Diligence Mine Reserve Report”, Stillwater Mining Company, completed for SEC requirements, 2003. Repeated in 2005, 2006, & 2008
- “Summary of the Mining, Milling and Chat Operations of the American Zinc, Lead and Smelting Company in the Tri-State, Picher Mining Fields of Oklahoma”, Legal document for Blue Tee Corp., Goldfields Mining, Tri State Zinc, and American Zinc, 2004.
- “Independent Technical Review of the Mining Properties of Hunan Nonferrous Metals Company Limited Hunan Province the Peoples Republic of China”
- Due Diligence Study of Seven Mines in China, for IPO Listing on Hong Kong exchange. 2005
- “Independent Technical Review of a Massive Rutile Deposit in China”, for Innomaxx, 2006.
- “Independent Technical Review of the Mining Properties of Western Mining Company Group in China”, for IPO Listing on Singapore stock exchange. 2006.
- “Milpillas Mine Geomechanical Review of Post Pillar Cut and Fill Mine Plans”, for Penoles Cia Miñeria, Mexico. 2006.
- “Letter Report on the Meyer’s Manganese Mining Concession in Hidalgo/San Luis States, Mexico”, a prefeasibility report for ESL International, 2007.
- “Due Diligence Report on the Hollister Gold Mine” for the Great Basin Gold Corporation, to meet qualification of the 43-101 Canadian Stock Exchange for GBG listings. 2007.
- “Due Diligence Review of Prefeasibility of Reopening the Pea Ridge Mine”, for Minmetals of China, 2007.
- “Preliminary Due Diligence of the Coos Bay, Oregon Black Sands Project”, for a fatal flaw study for Credit Suisse investment. 2008.
- “Chapter 7, Underground Mining”, for book on Human Performance in Extreme Environments, to be published by Ashgate Publishing Ltd, Gower House, Ed. Jason Kring, 2009.
- Author of Seven Chapters of Mineral Property Feasibility Study Handbook, also Co-Editor, to be published by Behre Dolbear in 2009.
- Author of Three Chapter and Associated Editor of ongoing SME Mining Engineer Handbook to be published in 2012.

Memberships:

Society of Mining, Metallurgical and Exploration; International Society of Explosive Engineers; Mining & Metallurgical Society of America; and Underground Construction Association.

Honors & Awards:

- University of Missouri-Rolla Outstanding Teaching Awards, 2000, 2001, 2002, 2003, 2005, and 2006; MSM-UMR Alumni Outstanding Student Advising Award 2001; and UMR Outstanding Distance Learning Teaching Award, 2006 and 2007;
- Distinguished Member of SME in 2003;
 - Pittsburg Coal Mining Institute & SME McCann Excellence in Teaching Award, 2002;
 - Missouri School of Mines-University of Missouri-Rolla Alumni Merit Award- 2001;

- Legion of Honor status in 2000 of SME;
- Elected to the Missouri School of Mines and Metallurgy Academy, 1996 (At the time, only 15 of approximately 6000 living graduate so honored).
- Received 1991 Distinguished Service Award from the M & E Division of SME;
- Honorary Professional Engineer of Mines Degree, 1986 - University of Missouri-Rolla.

Institutional and Professional Service:

Retired from University of Missouri-Rolla, May 2002, so no longer active on campus.
Associate Editor of Society of Mining Engineering Handbook.

Percentage of Time Available for Research:

Not applicable since I'm retired and living in another state.

Percentage of Time Committed to the Program:

10 hours per week, or over 500 hours per year.

SEOKBIN (BIN) LIM, PH.D

Associate Professor

Department of Mechanical Engineering, New Mexico Tech

801 Leroy Place, Socorro, NM 87801

Phone: 575 835 6589

Email: lim@nmt.edu

Expertise

Energetic material science/technology/safety, shock physics, computational modeling/design of energetic materials and systems, shaped charges, EFPs.

Education

Ph.D. Mining Engineering – Energetic Material (EM) emphasis, Missouri S&T (formerly University of Missouri-Rolla), Rolla, MO, May 2006

Dissertation title: *Investigation of the Blade Formation Process of Linear Shaped Charges*

Advisor: Dr. Paul Worsey

M.S. Mining Engineering – Energetic Material (EM) emphasis, Missouri S&T (formerly University of Missouri-Rolla), Rolla, MO, December 2003

Thesis title: *Investigation of the Characteristics of Linear Shaped Charges used in Demolition*

Advisor: Dr. Paul Worsey

B.S. Mechanical Design Engineering. Chungnam National University, South Korea, February 2000

Employment history

May 2013 ~ Current Associate Professor, Department of Mechanical Engineering
New Mexico Institute of Mining Technology, Socorro, NM

Jan 2008 ~ May 2013 Assistant Professor, Department of Mechanical Engineering, New Mexico
Institute of Mining Technology, Socorro, NM

Aug 2006 ~ Dec 2007 Research Assistant Professor, Department of Mechanical Engineering,
New Mexico Institute of Mining Technology, Socorro, NM

Course Instruction

Teaching/Development of explosives engineering/science classes (basic to advanced level) for the staffs in nearby national labs (Sandia, Los Alamos national laboratory) and national defense-related governmental agencies (U.S. Nuclear Regulatory Commission, Department of Defense, etc.) in both Undergrads and Graduate levels

MENG 545 (EXPL 311): Introduction to Explosives Engineering

Introduction to the broad field of explosives science and technology covering the following topics: Basic organic chemistry, decomposition reactions, properties of explosives,

thermodynamics of explosives, shock wave theory, detonation theory, initiators, Gurney equations, blast effects and demolition

MENG 549 (EXPL 412): Shockwave Propagation

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions.

MENG 550: Advanced Explosives Engineering

The detonation of non-ideal explosives, shaped charge effect and explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications.

MENG 553: Numerical Modeling of Detonation

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation.

MENG 586 (EXPL 418): Special Topic - Shock Physics and Structural Response to Blast

Introduction to the shock physics in air and structural response under strong air blast loading. An understanding of the basic shock propagation behaviors depending on the air properties variation, air blast formation, shock reflection (normal vs. oblique shock), and fundamentals of structural systems and evaluation.

MENG 586L: Special Topic -Explosives Science and Application Lab

Introduction of the multi-disciplinary fields of engineering hands-on knowledge of explosives including chemistry, mechanics and applications of explosives. Based on multi-disciplinary areas of engineering of explosives, students can learn more in-depth and hands-on based explosives application and science, providing different levels of achievement, starting with the basic science and moving toward more advanced engineering applications.

Recent Research Activities

I have been involved with multiple on-going research efforts and industrial contract research projects as a lead researcher or an active participant.

Cumulative funding received as PI since 2008: \$737,252

Cumulative funding received (as PI and Co-PI) since 2008: \$937,186

10/09-Present Office of Naval Research (ONR) funded "Development of Novel Methodological Approaches for the Rapid Creation of Expedient Tactical Entry Holes in Typical Urban Wall Systems (Phase I ~ III)" (Oct, 2009 ~ current). PI

06/09-Present Sandia National Laboratory (SNL) funded "An Engineering Design of Linear Shaped Charges Driven by Electro-magnetic Forces (Phase I ~ III)" (June, 2009 ~current). PI

- 09/08-Present Department of Homeland Security (DHS) funded "DHS Homeland Security Science, Technology, Engineering and Mathematics Career Development Grant (CDG): New Mexico Tech Explosives Engineering HS-STEM Program" (Sep, 2008 ~ Sep, 2012, No-cost extended). PI
- 05/08-08/11 National Science Foundation (NSF) funded "Course Curriculum, and Laboratory Improvement (CCLI): Explosives Engineering Laboratory for Undergraduate (EELU)" - Phase I (May, 2008 ~ Aug, 2011). Co-PI
- 05/07-03/08 Development of an innovative excavation (deep drilling) system utilizing exothermic amplification of pulsed electromagnetic power (EAPERD project) - Phase I (Sep, 2007 ~ Mar, 2008, Co-PI), funded by Boyer & Associates, Lombard, IL 60148. Co-PI
- 11/06-05/07 Participated in the preliminary development of military vehicle protection system, (APS: Active Protection System) from incident RPG attack using Linear Shaped Charges technology - Project title: "DARPA iron curtain project". Consultant

Recent Journal Publications

- Lim, Seokbin. "Acceleration profile of a flat flyer driven by detonation isentrope" *Propellants Explosives Pyrotechnics*, 38(3), 410-418, 2013
- Lim, Seokbin, "Jet Velocity Profile of Linear Shaped Charges Based on the Arced Liner" *Journal of Energetic Materials*, 31(4), 239~250, 2013
- Matthew Johnston & Seokbin Lim. "Numerical observation of the jet flight patterns of linear shaped charges". *Appl. Sci.* 2(3), 629~640, 2012.
- Lim, Seokbin, "Steady State Equation of Motion of a Linear Shaped Charges Liner" *International Journal of Impact Engineering*, 44, 10~16, 2012
- Lim, Seokbin, "A Steady State Analytical Equation of motion of LSCs Jet Based on the Modification of Birkhoff Theory" *Appl. Sci.*, 2(1), 35~45, 2011
- Indeck, J. and Thompson, A. and Lim, Seokbin, "Numerical Analysis of Damage Propagation for Shaped Charge Jet Impacts into a Concrete Target" *I-Manager's Journal on Civil Engineering*. Vol. 1. No 2. 55~62, 2011

ANDREAS ECKERT

Department of Geological Sciences and Engineering
Missouri University of Science and Technology, Rolla, MO, 65401
Phone: (573)-341-4876; email: eckertan@mst.edu

A. Professional Preparation

Karlsruhe Institute of Technology (Germany)	Geophysics	Diplom (M.S.) (2003)
Karlsruhe Institute of Technology	Geophysics	PhD (2007)

B. Appointments

2008-2010: Assistant Research Professor (Petroleum Eng.), Dept. of Geological Sciences and Engineering, Missouri S&T
2010-Present: Assistant Professor (Petroleum Eng.), Dept. of Geological Sciences and Engineering, Missouri S&T

C. Publications Relevant to this Proposal

- Yang, F., Bai, B., Dunn-Norman, S., Nygaard, R., Eckert, A., 2013. Factors Affecting CO₂ Storage Capacity and Efficiency with Water Withdrawal in Shallow Saline Aquifers. *Journal of Environmental Earth Sciences*. In press.
- Eckert, A. Constraints on minimum horizontal stress magnitudes using numerical MEMs in extensional stress regimes. Submitted to *International Journal of Rock Mechanics and Mining Sciences*.
- Amirlatifi, A., Eckert, A., Nygaard, R., and Bai, B. An Explicit Partial Coupling Approach for Simulating CO₂ Sequestration. Submitted to *International Journal of Greenhouse Gas Control*.
- Amirlatifi, A., Eckert, A., Nygaard, R., Bai, B., Liu, X., and Paradeis, M.: Role of Geometrical Influences of CO₂ Sequestration in Anticlines. The 46th U.S. Rock Mechanics/Geomechanics Symposium, Chicago, IL, June 24 – 27, 2012.
- Akpan, I.C., Govindarajan, S., Nygaard, R., Eckert, A., Baojun, B.: Shared Earth Models Give Model Consistency In Simulations; Application At a Shallow Carbon Dioxide Sequestration Site. The 46th U.S. Rock Mechanics/Geomechanics Symposium, Chicago, IL, June 24 – 27, 2012.
- Paradeis, M.A., Eckert, A., Liu, X., 2012. Influences of Anticline Reservoir Geometry on Critical Pore Pressures Associated With CO₂ Sequestration. Paper presented at the 46th US Rock Mechanics / Geomechanics Symposium held in Chicago, IL, USA, 24-27 June 2012.
- Amirlatifi, A., A. Eckert, R. Nygaard, and B. Bai: Coupled Reservoir and Geomechanical Modeling to Predict CO₂ induced Caprock Failure. Paper presented at the 10th Annual Conference on Carbon Capture & Sequestration, May 2-5, 2011, Pittsburgh, Pennsylvania.
- Lee, M., Eckert, A., and R. Nygaard, 2011. Mesh optimization for finite element models of wellbore stress analysis. Paper presented at the 45th US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, 2011.
- Eckert, A., and P.Connolly, 2007. Stress and fluid-flow interaction for the Coso Geothermal

Field derived from 3D numerical models, GRC Transactions, Vol. 31.

D. Past and Current Research Support

Generic MEMs for typical reservoir settings: Lead PI (100%); Funded by Chevron ETC for \$48,651; Period of performance: May 2009 – August 2010

Numerical Modeling of Geomechanical Processes Related to CO₂ Injection within Generic Reservoirs: Lead PI (50%); Co-PI: Runar Nygaard (50%); Funded by Department of Energy (DE-FE0001836) for \$299,114; Period of performance: Dec 2009 – May 2013

Geomechanical Simulation of CO₂ Leakage and Cap Rock Remediation: Co-PI (33%); Lead-PI: Runar Nygaard (34%); Co-PI: Baojun Bai (33%); Funded by Department of Energy (DE-FE0001132) for \$1,257,532 (DOE share: \$917,937; \$89,000 match from City Utilities of Springfield); Period of performance: Sep 2009 – Aug 2012

Structural Development of Fractured Anticline Formations: Lead PI (100%); Funded by Chevron ETC for \$ 179,294. Period of performance: Dec 2011 – Nov 2013

E. Synergistic Activities

1. Member of the Geological Society of America (since 2004), American Geophysical Union (since 2002), Society of Petroleum Engineers (since 2008).
2. Taught as a member of the combined (Geology and Petroleum Engineering) Missouri S&T field trip which won the Exxon excellence award in 2011.
3. Reviewer of Geodynamics (Elsevier)
4. Missouri S&T ITTC Committee 2012-present
5. Missouri S&T Outstanding Teaching Award 2011

F. Collaborators and Other Affiliations

1. Collaborators and Co-Editors

Peter Connolly (Chevron ETC), Thies Buchmann (Chevron ETC), Jozina Dirkzwager, (Chevron ETC), Oliver Heidbach (GFZ Potsdam), Birgit Mueller (KIT), Runar Nygaard, Baojun Bai, Amin Amirlatifi, Matthew Paradeis, John Hogan, Mohamed Abdelsalam (all Missouri S&T)

2. Graduate Advisors and Postgraduate-Scholar Sponsors

(1) M.S. thesis – Peter Connolly (Chevron ETC)

(2) Ph.D. Dissertation - Peter Connolly (Chevron ETC)

3. Thesis/dissertation Advisees

current: Amin Amirlatifi (PhD), Nevan Himmelberg (MS), Xiaolong Liu (MS), Deepak Gokaraju (MS), Aravind Prabakhar (MS), Mengke Li (MS)

past: M. Lee (MS), Matthew Paradeis, MS, Chevron ETC

GENDA CHEN, PH.D., P.E., Fellow ASCE, Fellow SEI

Department of Civil, Architectural, and Environmental Engineering

Missouri University of Science and Technology (Missouri S&T)

Phone: (573) 341-4462; E-mail: gchen@mst.edu; URL: www.mst.edu/~gchen

(a) PROFESSIONAL PREPARATION

Dalian University of Technology, Dalian, China B.S. in Civil Engineering, 1978-1982
Dalian University of Technology, Dalian, China M.S. in Civil Engineering, 1982-1985
State University of New York at Buffalo, NY Ph.D. in Civil Engineering, 1989-1992
National Center for Earthquake Engineering Research Postdoctoral Fellow, 1992-1993

(b) APPOINTMENTS

Sept. 2007 – present Missouri S&T (formerly University of Missouri-Rolla); Professor
July 2007 – present Mid-America Transportation Center; Associate Director
July 2006 – July 2011 Center for Infrastructural Engineering Studies; Interim Director
Aug. 1996 – Aug. 2007 University of Missouri-Rolla; Assistant Professor, Associate Professor
May 1993 – July 1996 Steinman, Boynton, Gronquist and Birdsall; Senior Engineer
July 1985 – Jan. 1989 Dalian University of Technology, Dalian, China; Assistant Lecturer

(c) PUBLICATIONS (10 out of over 250 publications)

1. G. Chen, H. Mu, D. Pommerenke, and J. Drewniak., "Damage Detection of Reinforced Concrete Beams with Novel Distributed Crack/Strain Sensors." *Structure Health Monitoring*, 3(3), pp.225-243, 2004.
2. G. Chen, R. McDaniel, S. Sun, D. Pommerenke, and J. Drewniak, "Distributed Crack Sensors Featuring Unique Memory Capability for Post-Earthquake Condition Assessment of RC Structures." *Smart Structures and Systems*, 1(2), pp.141-158, 2005.
3. G. Chen, N. Anderson, R. Luna, R. Stephenson, M. El-Engebawy, P. Silva, and R. Zoughi, *Earthquake Hazards Assessment and Mitigation: A Pilot Study in the New Madrid Seismic Zone, Final Report Prepared for FHWA, No. CIES07-073, Aug., 2005.*
4. G. Chen and K. Karim, "Damping-enhanced Strengthening: a Unique Way to Normalize the Seismic Performance of RC Bridges for Multiple Objectives." *Proc. 6th National Seismic Conference on Bridges and Highways, July 28-30, 2008, Charleston, South Carolina.*
5. M. Fakharifar, Z. Lin, C. Wu, S. Mahadik-Khanolkar, N. Leventis, and G. Chen, "Microstructural Characteristics of Polyurea and Polyurethane Xerogels for Concrete Confinement with FRP System." *Advanced Materials Research*, 2013.
6. P. Silva, M. Lubiewski, and G. Chen, "Seismic Retrofit of Cast-in-Place Steel Shell Columns to Bent Cap Connections." *ACI Structural Journal*, 106(6), Nov.-Dec. 2009.
7. P. Silva, N. Ereckson, and G. Chen. "Seismic Retrofit of Bridge Joints in Central U.S. with Carbon Fiber-Reinforced Polymer Composites." *ACI Structural Journal*, Title No. 104-S22, pp. 207-217, Mar.-Apr., 2007.
8. P. Yen, G. Chen, M. Yashinsky, Y. Hashash, C. Holub, K. Wang, and X. Guo, *China Earthquake Reconnaissance Report: Performance of Transportation Structures During the May 12, 2008, M7.9 Wenchuan Earthquake, No. FHWA-HRT-11-029, Feb. 2011(a).*
9. P. Yen, G. Chen, I. Buckle, T. Allen, D. Alzamora, J. Ger, and J. Arias, *Postearthquake Reconnaissance Report on Transportation Infrastructure Impact of the February 27, 2010, Offshore Maule Earthquake in Chile, Publication No. FHWA-HRT-11-030, Mar. 2011(b).*

10. X. Ying, G. Chen, P. Silva, R. LaBoube, and P. Yen, "Thin Steel Sheet Wrapping on RC Columns and Steel Plate Strengthening on Beam-Column Joints for Seismic Ductility and Capacity Improvements." Proc. 8th National Conference on Earthquake Engineering, San Francisco, April 17-21, 2006.

(d) SYNERGISTIC ACTIVITIES

Executive Member of US Panel on Structural Control and Monitoring, Associate Editor with ASCE Journal of Structural Engineering, Past Chair of ASCE Performance-Based Design of Structures Committee, Control Member of ASCE Structural Control and Sensing Committee, and Member of TRB AFF50: Seismic Design and Performance of Bridges Committee

Delegates to 7 NSF international workshops in the area of smart infrastructure and 4 Federal Highway Administration (FHWA) international workshop in bridge engineering, and invitees to the ASCE/SEI "Enhancing Bridge Performance" Workshop and 3 FHWA post-earthquake reconnaissance teams

Members of 20 national and international conference organizing/steering committees, including track co-chair of 2006 ASCE Structures Congress: Materials, Advanced Materials and Methods, St. Louis, and directed the geotechnical and bridge seismic design workshop: New Madrid Seismic Zone experience, 2004, and chairs of 29 sessions in national and international conferences and workshops

NSF proposal reviewer for PATH, CAREER, BRIGE, IRES, NEESR & three unsolicited initiatives/programs. NSF NEESComm equipment site reviewer.

Presenter for 8 lectures to K-12 students as part of the NSF Scientists and Engineers in the School Program and for the "School Day at the K" project by FOX News meteorologists for over 20,000 school kids, and supervisor of 7 female graduate students and 5 female undergraduate students

(e) COLLABORATORS AND OTHER AFFILIATIONS

Collaborators and Co-Editors (off campus)

Dr. A. Nanni from University of Miami, Dr. M. Barker from University of Wyoming, Dr. P. F. Silva from George Washington University

Graduate Advisors and Postdoctoral Sponsors

Professor T.T. Soong in the State University of New York at Buffalo

Thesis Advisor

Y. Huang (Ph.D., 2012), Z. Wang (Ph.D., 2011), W. Wang (Ph.D., 2007), Y. Xin (Ph.D., 2006), X. Ying (Ph.D., 2006), X. Huang (Ph.D., 2005), C. Chen (Ph.D., 2003), H. Mu (Ph.D., 2002), X. Yang (Ph.D., 2001), J. Wu (Ph.D., 2000), L. Rathe (M.S., 2012), I. Muchaidze (M.S., 2010), R. Mullapudi (M.S., 2010), K. Karim (M.S., 2009), M. Wang (M.S., 2008), B. Wood (M.S., 2008), M. Brower (M.S., 2007), L. Kindervater (M.S. 2006), C. Courtright (M.S., 2005), R. McDaniel (M.S., 2004), S. Eads (M.S., 2004), M. Gebhardt (M.S., 2003), D. Smith (M.S., 2003), G. Garrett (M.S., 2002), P. Thebeau (M.S., 2001), E. Bothe (M.S., 2000).

Postgraduate-Scholar Sponsor

Post doctor supervised: Z. Lin, D. Yan, B. Xu, M. El-Engebawy, C. Chen

Visiting professors:

H. Yin, D. Pan, Z. Zhou, J. Li, Y. Sun, M. Lou

J. DAVID ROGERS, PH.D., P.E., P.G., C.E.G., C.HG.

Karl F. Hasselmann Chair in Geological Engineering Missouri University of Science & Technology

J. David Rogers grew up in the grading and excavation business in southern California. He received his B.S. degree in geology from the California State Polytechnic University in 1976, and was named Outstanding Graduate in Geosciences. His presentation of his senior research thesis at the 106th Annual Meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers was recognized by the society's Best Presentation Award for 1976. After graduation he worked as a field geologist for U.S. Borax in the Great Basin prior to enrolling in graduate studies in geological engineering at the University of California at Berkeley.

During graduate school Rogers cut his teeth working on an array of research projects, which included the post-failure assessment of the Teton Dam failure, Shasta High Dam feasibility studies, and developing field instruments to measure and differentiate slope creep on natural and landslide-prone slopes. After completing his master's degree in civil engineering in June 1979 he began consulting on slope stability problems for the mining industry and geotechnical engineering firms. This work funded his doctoral research in the evolution of secondary joints and their impact on rock slope stability, which he completed in May 1982.

In August 1982 he joined Alan Kropp & Associates geotechnical consultants, becoming a professional engineer in 1983. In May 1984 he formed Rogers/Pacific, Inc., a consulting firm specializing in the evaluation and mitigation of natural hazards, with particular emphasis on emergency mitigation of infrastructure failures, mostly for government entities. In 1986 he became a General Engineering Contractor and started Rogers-Caulfield, a construction management firm focused on designing and building slope stability repairs using new technologies, such as mechanically-stabilized embankments, cast-in-ground caissons, and soilnails.

By 1994 Rogers/Pacific had offices in the San Francisco and Los Angeles metropolitan areas and possessed a diverse range of specialists, which included geologists, geophysicists, civil, geological, geotechnical, and structural engineers, hydrologists, hydrogeologists, surveyors, and environmental planners. Along the way the firm gained an enviable reputation for pioneering research in seismic hazards evaluation, through research contracts with the National Science Foundation, U.S. Geological Survey, the California Department of Transportation, and the Federal Highway Administration.

In 1984 Dr. Rogers began teaching short courses on geologic hazards and engineering mitigation techniques for the Universities of Wisconsin, Michigan, California, Northeastern University, and the Georgia Institute of Technology. In 1989 he developed a new short course on Practical Slope Restoration Methods for the University of Wisconsin Extension program, which was taught across the USA. He also taught short courses on slope stability mitigation for the International Conference of Building Officials, U. S. Navy, U.S. Forest Service, Association of Bay Area Governments, City of Los Angeles, and Counties of Los Angeles and Santa Barbara, between 1989-99. In 1993 his efforts in educating decision makers was recognized by the Award of Merit in Environmental Education by the Association of Bay Area Governments in Oakland, California.

In 1992 Rogers published an article titled Recent Developments in Engineering of

Landslide Corrections: (Chapter 10 in Reviews in Engineering Geology, Volume IX, Landslides/Landslide Mitigation: Geological Society of America), which drew considerable attention as one of the finest articles on that subject. This led to the development of a national slope stability and landslide mitigation course. In 1994 he developed a week-long short course with Prof. Sunil Sharma (Univ. of Idaho) on advanced methods of slope stability analysis and mitigation for public agency transportation engineers across the United States. This became the FHWA Advanced Slope Stability Course, taught in all 50 states. This course included case studies to familiarize course participants in field techniques used to explore and evaluate slope stability problems. Between 1998-2003 he taught a module on mitigation of slope stability problems for the short course titled "Evaluation and Mitigation of Seismic Hazards," sponsored by University of California Extension in Los Angeles and San Francisco.

His 1992 article titled Reassessment of the St. Francis Dam Failure was recognized by the E.B. Burwell Award of the Geological Society of America and the Rock Mechanics Award of the National Research Council for 1994. In 1994 his novel design of "blind reinforcement" for a troubled cliff face in the City of San Francisco was recognized by the Distinguished Project Award of the American Public Works Association. After publishing his first book, titled A Man, a Dam and a Disaster in 1995, his contributions to the emerging field of geoforensics were recognized by the 1996 R.H. Jahns Distinguished Lecturer in Engineering Geology Award, which allowed him to deliver 56 lectures in 31 states. In 2006 he received a Presidential Citation from the Association of Environmental & Engineering Geologists for his leading role in investigating the levee failures that occurred during Hurricane Katrina for the U.S. Geological Survey and the National Science Foundation.

His named lectureships have included: 1999-2001 Sigma Xi College of Distinguished Lecturers; 1999 ASCE GeoExpo Queen Mary Lecture; 2001 Trent Dames Civil Engineering Heritage Lecturer of the Huntington Library & Trust; 2002 California Water Colloquium Lecturer sponsored by the University of California; 2005 Distinguished Lecturer from the Kentucky Geotechnical Engineering Group; the Roy B. Hunt Lecture in Applied Geology for the Institute in Environmental Studies at the University of Pennsylvania, and the George Riveschl, Jr. Lecture in Applied Sciences at the University of Cincinnati. Dr. Rogers has also provided numerous keynote presentations for technical society meetings, including the Keynote Address for the Golden Anniversary meeting of the Association of Environmental & Engineering Geologists in 2007.

Professor Rogers served as a Lecturer in Engineering Geology in the Department of Civil & Environmental Engineering at the University of California, Berkeley from 1994-2001. He taught courses in engineering geology, environmental geology for planners, and introduction to civil engineering practice. In July 2001 Dr. Rogers accepted the Karl F. Hasselmann Missouri Chair in Geological Engineering at the University of Missouri-Rolla, now the Missouri University of Science & Technology (MS&T). This is the only endowed chair position in engineering geology or geological engineering in the United States.

Since coming to MS&T Professor Rogers has supervised more than \$1 million in research projects funded by the U.S. Geological Survey, National Geospatial Intelligence Agency, Federal Highway Administration, Department of Defense, National Science Foundation, as well as state and local agencies. He has served as a consultant on slope stability problems for a dozen federal agencies, more than a dozen different state agencies in CA, OR, HI, LA and MO, and dozens of local agencies.

Governor Matt Blunt appointed Rogers as the geology representative to the Missouri Seismic Safety Commission in 2005. He was appointed to the National Science Foundation's Independent Levee Investigation Team in 2005-06; and the Coastal Louisiana Recovery Panel of Environmental Defense in 2007. Rogers was also selected by the State of Louisiana as the only out-of-state instructor for their inaugural Flood Protection and Ecosystem Restoration Professional Development Program in 2007.

Dr. Rogers is a registered civil engineer, geologist, engineering geologist and hydrogeologist in California and a Certified Professional Geologist in several other states. He is the author of over 100 technical papers and articles, many of which deal with slope stability and landslide issues, world-wide. Most of his recent work is posted on his website at www.mst.edu/~rogersda

Dr. Rogers joined the Marine Corps Platoon Leader Corps in 1974 as an E-5, and matriculated through Officer Candidate School at Quantico, VA. He received his wings as a Naval Aviation Observer and transferred into the Naval Reserve as an air intelligence officer in 1984. He was re-called to active duty stints on five occasions, between 1987-91. He resigned from the Naval Reserve in June 2002.

DR. JOSHUA L. ROVEY

Assistant Professor of Aerospace Engineering
Department of Mechanical and Aerospace Engineering
Missouri University of Science and Technology
Rolla, MO 65409-0050
Phone: (573) 341-4613; Fax: (573) 341-4607
E-mail: roveyj@mst.edu ; <http://campus.mst.edu/aplab/>

Professional Preparation

University of Michigan-Ann Arbor Aerospace Engineering B.S.E., Dec. 2002
University of Michigan-Ann Arbor Aerospace Engineering M.S.E., May 2003
University of Michigan-Ann Arbor Aerospace Engineering Ph.D., May 2006

Professional/Academic Appointments

Assistant Professor Missouri S&T 2008-present
Propulsion Research Engineer Starfire Industries, LLC 2006-2007

Research Interests

Advanced space propulsion, plasma aerodynamics and flow control, hypersonics/re-entry body plasma interactions, plasma physics and rarefied gas dynamics, plasma-based medical devices.

Honors and Awards

2012 Missouri S&T Research Award
2012 AIAA Plasmadynamics & Lasers Best Student Paper (Student: Timothy Nichols)
2011 AIAA St. Louis Section Young Professional Award
2010 Missouri S&T Outstanding Teaching Award (2009-2010)
2010 Missouri S&T Academy of Mechanical & Aerospace Engineers Faculty Excellence Award
2010 Air Force Office of Scientific Research Young Investigator Award

Professional Societies

American Institute of Aeronautics and Astronautics, Electric Rocket Propulsion Society, Sigma Gamma Tau, American Society of Engineering Education,

Select Journal Publications (19 total)

1. Heckman, A.J.*, Rovey, J.L., Chandrashekhara, K., Watkins, S.E., Stutts, D.S., Banerjee, A., and Mishra, R., "Structural Health Monitoring Data Transmission for Composite Hydrokinetic Turbine Blades," *Advanced Shipping and Ocean Engineering*, accepted May 3, 2013, in press.
2. Nichols, T.G.* and Rovey, J.L., "Surface Potential and Electric Field in the Aerodynamic Plasma Actuator at Low Pressure," *AIAA Journal*, Vol. 51, Issue 5, pp. 1054-1065, May 2013.
3. Berg, S.P.* and Rovey, J.L., "Assessment of Imidazole-Based Ionic Liquids as Dual-Mode Spacecraft Propellants," *Journal of Propulsion and Power*, Vol. 29, Issue 2, pp. 339-351,

Mar-Apr 2013.

4. Berg, S.P.* and Rovey, J.L., "Decomposition of Monopropellant Blends of Hydroxylammonium Nitrate and Imidazole-based Ionic Liquid Fuels," *Journal of Propulsion and Power*, Vol. 29, Issue 1, pp. 125-135, Jan-Feb 2013.
5. Hu, Jing* and Rovey, J.L., "Experimental Investigation of Formation Time in Single-Gap Pseudospark Discharge," *Journal of Physics D: Applied Physics*, Vol. 45, No. 46, pp. 465203, Nov. 21, 2012.
6. Meeks, W.C.* and Rovey, J.L., "On the Delayed Gas Breakdown in a Ringing Theta-pinch with Bias Magnetic Field" *Physics of Plasmas*, Vol. 19, No. 052505, May 2012.
7. Zidar, D.G.* and Rovey, J.L., "Hall-effect Thruster Channel Surface Properties Investigation," *Journal of Propulsion and Power*, Vol. 28, No. 2, Mar-Apr. 2012.
8. Hu, Jing* and Rovey, J.L., "Faraday Cup with Nanosecond Response and Adjustable Impedance for Fast Electron Beam Characterization," *Review of Scientific Instruments*, Vol. 82, No. 073504, July 2011.

Select Conference Publications (33 total)

1. Meeks, W.C.* and Rovey, J.L., "Optical Emission Spectroscopy of Initial Plasma Formation in a Heavy Gas Theta Pinch Coil," 40th IEEE Conference on Plasma Science, San Francisco, CA, June 16- 21, 2013.
2. Pahl, R.A.* and Rovey, J.L., "Magnetic Field Probe Calibration at Relevant Field Magnitude and Frequency," 40th IEEE Conference on Plasma Science, San Francisco, CA, June 16- 21, 2013.
3. Watkins, S.E., Robison, K.E., Nicholas, J.R., Taylor, G.A., Chandrashekhara K., and Rovey, J.L., "Damage Assessment of Hydrokinetic Composite Turbine Blades Using Fiber Optic Sensors," Paper 86742B, Proceedings of the SPIE Vol. 8694, Smart Structures/NDE Conference, San Diego, CA., Mar. 10-14, 2013.
4. Miller, S.W.*, Prince, B.D., and Rovey, J.L., "Capillary Extraction of the Ionic Liquid [Bmim][DCA] for Variable Flow Rate Operations," AIAA-2012-3738, 48th Joint Propulsion Conference, Atlanta, GA., July 30 – Aug. 1, 2012.
5. Meeks, W.C.* and Rovey, J.L., "Numerical and Experimental Efforts to Explain Delayed Gas Breakdown in Theta-Pinch Devices with Bias Magnetic Field," AIAA-2012-3929, 48th Joint Propulsion Conference, Atlanta, GA., July 30 – Aug. 1, 2012.
6. Heckman, A.J.*, Rovey, J.L., Chandrashekhara, K., Watkins, S.E., Mishra, R., and Stutts, D.S., "Ultrasonic Underwater Transmission of Composite Turbine Blade Structural Health," Paper 8343- 23, SPIE Smart Structures/NDE Conference, San Diego, CA., Mar. 11-13, 2012.
7. Robison, K.E., Watkins, S.E., Nicholas, J.R., Chandrashekhara K., and Rovey, J.L., "Instrumented Composite Turbine Blade for Health Monitoring," Paper 8347-93, SPIE Smart Structures/NDE Conference, San Diego, CA., Mar. 11-13, 2012.

Other Publications

Rovey, J.L., "2009 Electric Propulsion Year in Review," *AIAA Magazine Aerospace America*, Vol. 12, pp. 52-55, 2009.

Synergistic Activities

AIAA Plasmadynamics & Lasers Technical Committee Member and Secretary

Session Chairman Plasmadynamics & Lasers, Joint Propulsion Conferences

Reviewer for scientific journals, such as Journal of Propulsion and Power, Physics of Plasmas, Journal of Applied Physics, Review of Scientific Instruments, Plasma Sources Science & Technology

Collaborators & Other Affiliations

1. Collaborators and Co-Editors:

H. Pernicka, C. Castano, S. Usman, J. Kimball, D. Riggins, S.N. Balakrishnan, R. Mishra, A. Banerjee, K. Chandrashekhara, S. Watkins, D. Stutts, M. Leu (Missouri S&T)
S. Kovaleski, S. Baker, G. Baker (Missouri-Columbia)

2. Graduate and Postdoctoral Advisors: A.D. Gallimore (University of Michigan)

3. Thesis Advisor and Postgraduate-Scholar Sponsor:

Graduate Students (Graduated 1 PhD, 10 MS): J. Ferry, B. Donius, J. Gaither, D. Zidar, A. Satonik, A. Heckman, S. Berg, T. Nichols, J. Hu, S. Miller, R. Pahl, W. Meeks, M. Emanuel, P. Friz; Total number graduate students currently advising: 4 PhD and 1 MS

DR. LESLIE GERTSCH

Professional Preparation

Graduate: Colorado School of Mines	Mining Engineering	Ph.D. 1989
Undergraduate: Colorado School of Mines	Geological Engineering	B.S. 1982

Appointments

Deputy Director for Rock Mechanics – since May 2009

Sr Research Investigator – since 2003

Rock Mechanics & Explosives Research Center, Missouri University of Science and Technology

Adjunct Associate Professor – since Aug 2009

Adjunct Assistant Professor – 2006-2009

Mining Engineering Program, Missouri University of Science and Technology

Associate Professor – since Aug 2009

Assistant Professor – 2003-2009

Geological Engineering Program, Missouri University of Science and Technology

Assistant Professor – 1998 - 2002

Mining Engineering, Michigan Technological University, Houghton, MI

Assistant Professor – 1996 - 1997

Mining Engineering Department, Colorado School of Mines, Golden, CO

Research Assistant Professor – 1990 - 1996

Excavation Engineering and Earth Mechanics Institute, Colorado School of Mines, Golden, CO

Mining Engineer – 1988 - 1990

Spokane Research Center, U.S. Bureau of Mines, Spokane, WA

Recent Publications

Abu Bakar, M.Z. and L. Gertsch, in rewrite to incorporate review comments. "Evaluation of fragments from disc cutting of dry and saturated sandstone," Rock Mechanics and Rock Engineering.

Iai, Masafumi and L. Gertsch, 2013. "Excavation of lunar regolith with large grains by rakes/rippers for improved excavation efficiency," Journal of Aerospace Engineering, Vol 26, No. 1, Jan, p 97-104.

Abu Bakar, M.Z. and L. Gertsch, 2013. "Evaluation of saturation effects on drag pick cutting of a brittle sandstone from full scale linear cutting tests," Tunneling and Underground Space Technology, Vol 34, Feb, p 124-134.

Abu Bakar, M.Z. and L. Gertsch, 2012. "Disc cutting tests on dry and saturated sandstone: Muck as a performance estimator," Society of Mining, Metallurgical, and Exploration Engineers Annual Meeting, 20-22 Feb 2012, Seattle, WA, preprint 12-104.

Gertsch, L.S., 2008. "Extra-terrestrial mineral production: Multiple aspects of sustainability," invited plenary paper, XXIV International Mineral Processing Congress, Beijing, China, 24-28 Sept 2008.

Gertsch, Leslie, Jason Baird, and Paul Worsey, 2007. "Blast designs for NEO destruction and deflection," paper and poster presentation at the 2007 Planetary Defense Conference,

Washington DC, 5-8 March 2007.

- Gertsch, Leslie, 2007. "Percussive penetration of unconsolidated granular media in a laboratory setting," presented at 5th Symposium on Space Colonization, of the Space Technology and Applications International Forum (STAIF-2007), Albuquerque, NM, 11-15 Feb 2007, published in AIP Conference Proc 880, American Institute of Physics, p 854-862
- Gertsch, R., J. Rostami, and L. Gertsch, 2007. "Disc cutting tests in Colorado Red Granite: Implications for TBM performance prediction," International Journal of Rock Mechanics and Mining Sciences, Vol. 44, No. 2, February, p 238-246.
- Gertsch, L.S. and D.A. Summers, 2006. "Disc cutting of low-strength brittle rock," presented at GoldenRocks 2006 (42nd U.S. Symp on Rock Mechanics), 17-21 June, Golden, Colorado.
- Boucher, Dale, Jim Richard, Leslie Gertsch, and Richard Gertsch, 2004. "A continuous method for mining regolith on the Moon or Mars," presented by D. Boucher at 3rd Symposium on Space Colonization, of the Space Technology and Applications International Forum (STAIF-2004), Mohamed El-Genk (ed), Albuquerque, NM, 8-11 Feb, AIP Conference Proc 699, Am Inst of Physics.

Synergistic Activities

Courses Taught

Advanced Mine Planning
Advanced Rock Slope Engineering
Asteroid Mining
Discontinuity Analysis for Rock Engineering I, II
Geological Engineering Capstone Design
Geo Engineering Senior and Graduate Seminar
Introduction to Mining Engineering
Introduction to Physical Geology
Introduction to/Fundamentals of Rock Mechanics
Materials Handling
Measuring and Modeling in Geomechanics
Mine Cost Engineering
Mining Health and Safety
Mining Methods
Rock Mechanics in Mining
Statics and Mechanics of Geological Materials
Statics/Dynamics
Subsurface Exploration
Surface Mine Design
Underground Hard Rock Mine Design

Affiliations and Activities

American Assoc for the Advancement of Science
American Geophysical Union
American Institute of Aeronautics & Astronautics
American Rock Mechanics Association
American Society of Civil Engineers
Engineers Without Borders
Geological Society of America
Missouri DNR Land Reclamation Commission
Society of Mining, Metallurgy, & Exploration
Space Resources Roundtable

(underlined = taught during preceding 12 months)

Collaborators & Other Affiliations

Collaborators and Co-Editors in Fields Related to Rock Mechanics

Abu Bakar, M. Zubair

Darling, Peter

Handewith, Howard

Selimoglu, Oyku

Asbury, Brian

Eloranta, Jack

Orobona, Michael

Summers, David

Awuah-Offei, Kwame

Ge, Yu-Ning (Louis)

Rancourt, Ken P.

VanDelinder, Peter R.

Baiden, Greg

Gertsch, Richard E.

Robbins, Richard

Worsey, Paul

Baird, Jason

Iai, Masafumi

Rostami, Jamal

Graduate Advisors

William A. Hustrulid, Miklos D.G. Salamon

Graduate Advisees

6

Postdoctoral Scholars

none

Present Affiliations of Former Advisees

Axelspace Corporation, Tokyo, Japan

Lahore, Pakistan

University of Engineering & Technology,

NORBERT H. MAERZ

EXPERIENCE

- 2006-Present Program Head, Geological Engineering; Program Administrator, On-line M.E. in Geotechnics, Dept of Geological Sciences and Engineering; Senior Investigator, Rock Mechanics and Explosives Research Center, Missouri University of Science and Technology
- 2004-2005 Associate Professor, Dept of Geological Sciences and Engineering ; Senior Investigator, Rock Mechanics and Explosives Research Center, University of Missouri-Rolla
- 1998-2004 Assistant Professor, Dept of Geological and Petroleum Engineering; Senior Investigator, Rock Mechanics and Explosives Research Center, University of Missouri-Rolla
- 1995-2006 President, WipWare Inc.:
- 1996-1997 Sessional Lecturer, Dept. Of Earth Sciences, University of Waterloo:
- 1990-1997 President, N. H. Geo Consulting Limited:
- 1985-1992 Geological Engineering Consultant, Franklin Geotechnical Ltd.:

EDUCATION

- 2005-2010 M.Sc. (Engineering Management) at the Department of Engineering Management, Missouri S&T
- 1985-1990 Ph.D. (Engineering Geology) at the Department of Earth Sciences, University of Waterloo.
- 1982-1985 M.Sc. (Engineering Geology) at the Department of Earth Sciences, University of Waterloo.
- 1977-1981 B.Sc., Honors Earth Sciences (Geography Option) Department of Earth Sciences, University of Waterloo.

PROFESSIONAL ASSOCIATIONS

American Rock Mechanics Association
Association of Professional Engineers of Ontario
International Society for Rock Mechanics
Society for Mining, Metallurgy, and Exploration
Association of Engineering Geologists

PUBLICATIONS – Recent

- Maerz, N. H., Youssef, A. M., Otoo, J. N., Kassebaum, T. J., and Duan, Y., 2013. A simple method for measuring discontinuity orientations from terrestrial LIDAR images. Accepted for Publication, Environmental and Engineering Geoscience, June 2012.
- Maerz, N. H., Kassebaum, T., Williams, D., Shea, K., Duan, Y., Xi, Y., Li, X., 2013. Visualizing and modeling interior spaces of dangerous structures using LiDAR The International Journal of Safety and Security Engineering, Vol. 2, No. 4, pp. 1-21.
- Youssef, A. M., and Maerz, N. H., 2013. Overview of some geological hazards in the Saudi Arabia. Online first, Environmental Earth Sciences, March 2013, 16 pages.

- Otoo, J. N., Maerz, H. H., Li, X., and Duan, Ye., 2013 Verification of a 3-D LiDAR viewer for discontinuity orientations. *Rock Mechanics and Rock Engineering*, 12 pp.
- Youssef, A. M., Maerz, N. H., and Al-Otaibi, A. A., 2012. Stability of rock slopes along Raidah Escarpment road, Asir area, Kingdom of Saudi Arabia. *Journal of Geography and Geology*, v. 4, no. 2, pp. 48-70.
- Youssef, A., and Maerz, N. H., 2012. Development, justification and verification of a rock fall hazard rating system. *Bulletin of Engineering Geology and the Environment*. Online first, v.71, pp 171-186.
- Youssef, A. M, and Maerz, N. H., 2009. Slope stability hazard assessment and mitigation methodology along eastern desert Aswan-Cairo Highway, Egypt. *Journal of King Abdulaziz University Earth Sciences*, vol. 20, no. 2, pp. 161-179.
- Youssef, A. M., Maerz, N. H., and Hassan A. M., 2009: Remote sensing applications to geological problems in Egypt: Case study, slope instability investigation, Sharm El-Sheikh / Ras-Nasrani Area, Southern Sinai. *Landslides*, 10.1007/s10346-009-0158-3, 8 pp.
- Youssef, A. M. and Maerz N. H., 2008. Slope stability hazard assessment and mitigation methodology along the Eastern Desert Aswan-Cairo highway, Egypt. Submitted to *Journal of geological engineering*, King Abdel Aziz University, Saudi Arabia, September 2008.
- Youssef, A. M. and Maerz , N. H., 2008: Remote sensing applications to geological problems in Egypt: Case study, slope instability investigation, Sharm El-Sheikh / Ras-Nasrani Area, Southern Sinai. Submitted to *International Journal of Landslides*, August 2008,
- Youssef, A., and Maerz, N. H., 2008. Development, justification and verification of a rock fall hazard rating system. Submitted to *Environmental and Engineering Geoscience*, May 6, 2008.
- Youssef, A., Maerz, N. H., and Qinfang, X., 2007. Rocksee: Video image measurements of physical features to aid in highway rock cut characterization. *Computers & Geosciences*, v. 33, no. 3, pp 437-444..
- Maerz, N. H., Youssef, A., and Fennessey, T. W., 2005. New risk-consequence rock fall hazard rating system for Missouri highways using digital image analysis. *Environment and Engineering Geoscience*, v. xi, no. 3, pp. 229-250.
- Maerz, N. H., and Palangio, T. W., 2004. Post-muckpile, pre-primary crusher, automated blast fragmentation sizing. *FRAGBLAST, The International Journal For Blasting and Fragmentation*, v. 8, no. 2, June 2004.
- Maerz, N. H., 2004. Technical and computational aspects of the measurement of aggregate shape by digital image analysis. *Journal of Computing in Civil Engineering*, v. 18, no. 1, pp. 10-18.
- Latham J-P, Kemeny , Maerz , Noy , Schleifer , Tose , 2003. A blind comparison between results of four image analysis systems using a photo-library of piles of sieved fragments. *FRAGBLAST - The International Journal for Blasting and Fragmentation*, Vol. 7., No. 2, pp. 105-132.
- Zhou, W., and Maerz, N. H., 2002. Implementation of multivariate clustering methods for characterizing discontinuities from oriented boreholes. *Computers & Geosciences*, v. 28, no. 7, pp. 827-839.

- Matana, M., Galecki, G., Maerz, N, and Nanni, A., 2005. Concrete substrate preparation and characterization prior to adhesion of externally bonded reinforcement. Proceedings of the International Symposium on Bond Behavior of FRP in structures, 7pp.
- Maerz, H. H., and Zhou, W., 2005. Multivariate clustering analysis of the ECRB cross drift discontinuities, Yucca Mountain Project. Alaska Rocks, Proceedings of the 40th US Rock Mechanics Symposium, Anchorage Alaska, June 25-29, 2005, 10 pp.

CONTRACTS – recent

- Leica/UTC, UMR, Acquisition of a LIDAR unit, 2007, PI, \$200,819, 100%
- NSF, SGER/Collaborative Research: 2008 Midwest levee Failure Investigation, 2008, \$42,969, 20%
- Leonard Wood Institute, Visualizing and Modeling Interior Spaces of Dangerous Structures, 2008, \$395,643, PI, 50%
- MODOT/UTC, Transportation Geotechnics Research Program, 2008, \$1,625,000, 12.5%
- NSF, Extracting 3-D Fracture Orientations for Rock Failure Analysis by Combining Optical Imaging and LIDAR Scanning technologies, \$2009, \$289,915, PI, 50%
- MODOT/UTC, Geophysical Surveys Along the New Route 50 Alignment, 2010, \$10,000, PI, 50%.
- UM Research Board/UTC. Development of a Quantitative Model for the Mechanism of Raveling Failure in Highway Rock Slopes and Cuts, 2011, \$38,699, PI, 50%.
- TOYON, Visible Electro-Optical (EO) System and LIDAR Fusion for Low Cost Perception by Autonomous Ground Vehicles, 2012, \$47,000, PI, 100%.
- TOYON, Visible Electro-Optical (EO) System and LIDAR Fusion for Low Cost Perception by Autonomous Ground Vehicles, Phase 2, 2013, \$150,000, PI, 100%.
- MST, Acquisition of a LIDAR Scanner, 2013 \$62,017, PI, 100%.
- MODOT/NUTC, Bridge Hydro-Demolition Thickness Measurements, 2013, \$7,500, PI, 100%.

DR. RUNAR NYGAARD

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Missouri University of Science and Technology
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POST SECONDARY EDUCATION

01.1997-10.2004 PhD in Geomechanics. University of Oslo
01.1995-06.1996 MS in Geology/geotechnics. University of Oslo
08.1990-12.1994 BS. Natural science/Geology University of Oslo/
University of Bergen

EMPLOYMENT

10.2007- Assistant Professor in Petroleum engineering, department of Geological sciences and Engineering and Research associate Rock mechanics and Explosives Research Centre, Missouri University of Science and Technology
Conducts research in; Long term wellbore integrity and wellbore leakage from injection wells, Wellbore stability, fluid losses and wellbore strengthening, Improving drilling efficiency and bit design, and Drilling optimization and drilling automation

Total external research funding at S&T as is more than 2.25 M USD (more than 4M USD total in career)

Currently published more than 60 technical papers in journal and conferences and 20 technical reports and supervised 10 graduate students

Teach totally five undergraduate and graduate courses in petroleum engineering

04.2006-09.2007 Research Associate, Schulich school of Engineering, Chemical & Petroleum department, University of Calgary

Developed algorithms and software for real time decision systems for e-drilling centres

Assessed risk for leakage of geological stored CO₂ through abandoned wells and shales

Evaluated sands and sandstone geomechanical behaviour during production

Taught undergraduate and graduate courses in drilling engineering

10.2004-04.2006 Associate, McKinsey & Company, Business Technology Office, Oslo, Norway

Created innovative price models and deal mechanisms to reach a joint value sharing for

major IT outsourcing deals

Facilitated price and service management outsourcing negotiations between a consumer goods company and IT provider which resulted in total a total cost reduction of 1 billion CAD over the 7 year contract period

Made market plans, identified takeover targets and developed implementation plans for a private equity company to restructure the Scandinavian BPO market

07.2000-10.2004 General Manager and Geomechanical Specialist, Drops Technology AS, Oslo, Norway

Co-developed Drops drilling software to successful sale to Pason Drilling systems and Lyng Drilling, A Schlumberger subsidiary

Transformed a start-up with almost no income to become a \$ 500,000 profitable company
Managed research and consultancy projects for numerous oil and gas customers, including be a part of establishing the first small Norwegian oil company – OER Oil – which started the revitalization of the Norwegian oil sector by small oil companies

01.1997-02.2000 Norwegian Research Council Scholar, University of Oslo/ Norwegian Geotechnical Institute, Oslo, Norway

Established new theories of how shales develops strength and fluids flow on fractures in shales by conduction laboratory experiments on deformation and flow measurements in different high pressure – high temperature laboratory setups

10.1998-04.1999 Visiting Scholar, University of Waterloo, Ontario, Canada

Researched on pore flow in shales by conducting laboratory measurements of high and low frequency permittivity

01.1995-12.1998 Consultant, Saga Petroleum ASA, Baerum, Norway

Studied petroleum geomechanical of wells, reservoirs and basins in planning and day to day follow up for offshore exploration wells

MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Association of Drilling Engineers (AADE), Member (2009-present)

American Rock Mechanics Association (ARMA), Member (2007, present)

IEA Greenhouse Gas R and D Programme - Risk Assessment Network, Member (2008-2010)

Member of IEA Greenhouse Gas R and D Programme - Well integrity network, Member (2008-present)

Society of Petroleum Engineers (SPE) Member (2002-present)

SERVICE

Missouri S&T AADE student chapter Faculty advisor (2012-present),

Missouri S&T SPE student chapter Faculty advisor (2008-present),

SPE Drilling and Completion Journal, Technical editor (2008-present)

SPE PetroWiki, drilling and completion geomechanics moderator (2012-present)

Reviewer - ASCE Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Environmental Geology Journal, Journal of Canadian Petroleum Technology, Journal of Natural Gas Science & Engineering, Ocean Engineering, Natural Sciences and Engineering Research Council of Canada, The Arabian Journal for Science and Engineering

AWARDS AND HONORS

Norwegian research council personal PhD scholarship (1997-2000)

Lester Birbeck Chair in petroleum engineering (2007-2009)

Marquis Who is Who in America (2009-present)

SPE faculty support program awardee for the Mid-Continent Region (2011)

Mines & Metallurgy Academy Young faculty award (2012)

SERHAT HOSDER, PH.D. (BIOGRAPHICAL SKETCH)

Assistant Professor of Aerospace Engineering
Department of Mechanical & Aerospace Engineering
290B Toomey Hall, Missouri University of Science and Technology
400 W. 13th St. Rolla, MO 65409-0500
Phone: 573-341-7239
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A. Research Interests

Aerodynamics, uncertainty quantification (UQ), gas dynamics, hypersonic flows, computational fluid dynamics (CFD), multidisciplinary design and optimization (MDO) of aerospace vehicles, aerospace systems design, flow control, robust design, numerical methods.

B. Professional Preparation:

Ph.D. Aerospace Engineering	Virginia Tech (2004)
M.Sc. Aerospace Engineering	Virginia Tech (2001)
B.Sc. Aeronautical Engineering	Istanbul Technical University (1997)

C. Appointments:

Assistant Professor of Aerospace Engineering, Department of Mechanical and Aerospace Engineering, Missouri S&T, Rolla, MO (2007-present)
Postdoctoral Associate, Department of Aerospace and Ocean Engineering, Virginia Tech, Blacksburg, VA (2005-2007)
Principal Research Engineer, Techsburg, Inc., Blacksburg, VA (2004)
Graduate Research Assistant, Department of Aerospace and Ocean Engineering, Virginia Tech, Blacksburg, VA (1998-2004)

D. Awards and Honors:

2012 Missouri S&T Faculty Research Award
Listings in Who's Who in America and Who's Who in Science & Engineering since 2011
1st (out of 60) rank in the graduating class of Aeronautical Engineering and 4th (out of 2332) among the graduates from all faculties of Istanbul Technical University in 1997

E. Selected Publications:

(* : graduate students supervised)

- [1] T. West*, S. Hosder, and C. Johnston, "A Multi-Step Uncertainty Quantification Approach Applied to Hypersonic Reentry Flows," accepted for publication in AIAA

- Journal of Spacecraft and Rockets (2013).
- [2] S. Gulli, L. Maddalena, and S. Hosder, "Variable Transpiration Cooling for the Thermal Management of Reusable Hypersonic Vehicles," accepted for publication in *Aerospace Science and Technology*. (2013).
 - [3] Y. Zhang* and S. Hosder, "Robust Design Optimization Under Mixed Uncertainties with Stochastic Expansions," accepted for publication in *ASME Journal of Mechanical Design* (2013).
 - [4] S. Hosder and B. Bettis*, "Uncertainty and Sensitivity Analysis for Reentry Flows with Inherent and Model-Form Uncertainties", *AIAA Journal of Spacecraft and Rockets*, Volume 49, Number 2, pp: 193-206, March-April 2012.
 - [5] S. Hosder, "Stochastic Response Surfaces Based On Non-Intrusive Polynomial Chaos for Uncertainty Quantification", *International Journal of Mathematical Modeling and Numerical Optimization*, Vol. 3., No. 1/2, pp: 117-139, 2012.
 - [6] B. Bettis* and S. Hosder, "Efficient Uncertainty Quantification Approach for Reentry Flows with Mixed Uncertainties," *AIAA Journal of Thermophysics and Heat Transfer*, Volume 25, No. 4, 2011.
 - [7] S. Adya*, D. Han* and S. Hosder, "Uncertainty Quantification Integrated to CFD Modeling of Synthetic Jet Actuators," *International Journal of Flow Control*, Volume 3, No. 2, September 2010, pp. 169-181.
 - [8] S. Hosder, R. W. Walters and M. Balch*, "Point-Collocation Nonintrusive Polynomial Chaos Method for Stochastic Computational Fluid Dynamics," *AIAA Journal*, Volume 48, No. 12, December 2010, pp. 2721-2730.
 - [9] S. Hosder and D. Han*, "Inherent and Model-Form Uncertainty Analysis for CFD Simulation of Synthetic Jet Actuators," 50th AIAA Aerospace Sciences Meeting and Exhibit, Paper No. AIAA-2012-0082, Nashville, TN, Jan. 2012.
 - [10] Y. Zang*, S. Hosder, L. Leifsson, and S. Koziel, "Robust Airfoil Optimization Under Inherent and Model-Form Uncertainties Using Stochastic Expansions," 50th AIAA Aerospace Sciences Meeting and Exhibit, Paper No. AIAA-2012-0056, Nashville, TN, Jan. 2012.
 - [11] S. Hosder, L. T. Watson, B. Grossman, W. H. Mason, H. Kim, R. T. Haftka and S. E. Cox, "Polynomial Response Surface Approximations for the Multidisciplinary Design Optimization of a High Speed Civil Transport," *Optimization and Engineering*, 2, No. 4, Dec. 2001, pp. 431-452.
 - [12] S. Hosder and R. W. Walters, "Non-Intrusive Polynomial Chaos Methods for Uncertainty Quantification in Fluid Dynamics", 48th AIAA Aerospace Sciences Meeting, Paper No. AIAA-2010-0129, Orlando, FL, Jan. 2010. (Invited Paper)
 - [13] B. Bettis*, S. Hosder, and T. Winter, "Efficient Uncertainty Quantification in Multidisciplinary Analysis of a Reusable Launch Vehicle", 17th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, Paper No. AIAA-2011-2393, San Francisco, CA, April 2011.
 - [14] S. Hosder, J. A. Schetz, B. Grossman, W. H. Mason, and R. T. Haftka, "Computational-Fluid-Dynamics-Based Clean-Wing Aerodynamic Noise Model for Design," *Journal of Aircraft*, Volume 47(3), 2010, pp. 754-762.
 - [15] S. Hosder, R. W. Walters, and M. Balch*, "Efficient Uncertainty Quantification Applied to the Aeroelastic Analysis of a Transonic Wing", 46th AIAA Aerospace Sciences

- Meeting and Exhibit, Paper No. AIAA-2008-729, Reno, NV, Jan. 2008.
- [16] S. Hosder, R. W. Walters, and M. Balch*, "Efficient Sampling For Non-Intrusive Polynomial Chaos Applications With Multiple Uncertain Input Variables," 9th AIAA Non-Deterministic Approaches Conference, Paper No. AIAA-2007-1939, Waikiki, Hawaii, April 2007.
- [17] S. Hosder, B. Grossman, R. T. Haftka, W. H. Mason, and L. T. Watson, "Quantitative Relative Comparison of CFD Simulation Uncertainties for a Transonic Diffuser Problem," *Computers & Fluids*, Volume 35, Issue 10, pages 1444-1458, December 2006.

F. Teaching:

AE-369: Introduction to Hypersonic Flow (Re-Developed/Structured the course in Fall 2008)
AE/ME-330: Applied Computational Methods (New course developed in Spring 2009)
AE-271: Aerodynamics II (Re-Developed/Structured the course in Spring 2008)
AE-231: Aerodynamics I (Re-Developed/Structured the course in Fall 2007)

G. Professional Society Memberships:

Senior Member, American Institute of Aeronautics and Astronautics (AIAA)
AIAA Non-Deterministic Approaches Technical Committee (NDA-TC) Member
Professional Member, American Society for Engineering Education (ASEE)

WILLIAM P. SCHONBERG, PhD, PE

Fellow, ASCE; Fellow, ASME; Associate Fellow, AIAA
Civil, Architectural, and Environmental Engineering Department
Missouri University of Science and Technology
1401 N. Pine Street 211C Butler-Carlton Hall
Rolla, MO 65409-0030
573-341-4787

Dr. William P. Schonberg, P.E., is Professor and Chair of the Civil, Architectural, and Environmental Engineering Department at the Missouri University of Science and Technology. Dr. Schonberg has over 25 years teaching and research experience in the areas of shock physics, spacecraft protection, hypervelocity impact, and penetration mechanics. He received his BSCE from Princeton University in 1981, and his MS and PhD degrees from Northwestern University in 1983 and 1986, respectively. The results of his research have been applied to a wide variety of engineering problems, including the development of orbital debris protection systems for spacecraft in low earth orbit, kinetic energy weapons, the collapse of buildings under explosive loads, insensitive munitions, and aging aircraft.

A significant part of Dr. Schonberg's research is dedicated to improving the safety of long-duration spacecraft and of personnel involved in space flight and operations. His research is unique in that it considers a number of significant parameters typically omitted in the analysis and design of damage-resistant spacecraft. Dr. Schonberg's international reputation has been earned primarily through the publication of refereed journal articles. To date, Dr. Schonberg has published over 65 papers in refereed journals on these topics, and has presented over 65 papers at a broad spectrum of international scientific and professional meetings, including several invited papers and presentations. To date Dr. Schonberg has received over 35 contract and grants from a variety of federal, state, local, and private funding agencies, including NASA, AFOSR, ARO, Sandia National Laboratories.

At Missouri S&T, Dr. Schonberg continues to teach a variety of graduate and undergraduate courses in civil, mechanical, and aerospace engineering. As an academic leader, Dr. Schonberg has been department chair at two different universities and served one year as Interim Dean, guiding the various engineering departments in the School of Engineering as the campus reorganized into a Dean-less administrative structure. In 2007 Dr. Schonberg was honored to receive the Manuel T. Pacheco Award from the President's Academic Leadership Institute (PALI). This award honors an academic administrator who exemplifies outstanding academic leadership at one of the four institutions within the University of Missouri System.

Recognition for Dr. Schonberg's scholarly and technical accomplishments has come through numerous honors and awards bestowed upon him by his peers. In 1995 Dr. Schonberg received the AIAA's Lawrence Sperry Award for his work on the design of spacecraft protection systems. In 1998, Dr. Schonberg was promoted to the membership rank of Associate Fellow in the AIAA and in 2000 was selected to receive the Charles Beecher Prize for one of his recent

papers on orbital debris protection systems from the Aerospace Sciences Division of the Institute of Mechanical Engineers in England. In 2003 and 2005 he was promoted to the member rank of Fellow of the American Society of Civil Engineers and the American Society of Mechanical Engineers, respectively.

In recognition of his technical expertise and standing within the orbital debris community, Dr. Schonberg has been invited to serve on six (6) national committees charged with reviewing key technical issues related to the nation's space exploration programs, including three (3) NAE/NRC committees. In 2007 Dr. Schonberg received a Friedrich Wilhelm Bessel Research Award from the Humboldt Foundation in Germany. This award enabled him to spend 7 months at the Fraunhofer Ernst Mach Institute in Freiburg, Germany working on advanced protection systems for satellites and developing preliminary designs for safe lunar habitats using in-situ materials for protection against meteoroid impacts. Dr. Schonberg has also been a Summer Faculty Fellow at NASA/JPL (2006), Eglin AFB (1992/93), and NASA/MSFC (1987/88, 1994/95).

Appendix F – New York Times (Science Times) Article July 3, 2007