DEPARTMENT OF MINING &GEOLOGICAL ENGINEERING
COLLEGE OF ENGINEERING

STRATEGIC PLAN

MINING & GEOLOGICAL ENGINEERING IN 2015

DRAFT

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STRATEGIC PLAN

NATURAL RESOURCES – PEOPLE - ENVIRONMENT

THE DEPARTMENT IN 2015

MISSION: Provide lifelong learning, service, leadership, and new knowledge of engineering and scientific principles applied to earth systems for the purpose of discovery and sustainable development of non-renewable resources, conversion of mineral resources into usable materials, safe construction of structures on and in the earth, and in situ characterization of volumes of earth materials with invasive and non-invasive techniques.

EDUCATING TODAY'S MINDS TO BUILD TOMORROW'S MINES

VISION: To be a world class center for mineral resource engineering through our core functions of technologically advanced education that emphasizes creative problem solving, leadership, and communication; innovative research that emphasizes leading technology to solve tomorrow's problems; and service to the profession to ensure mineral resources engineering remains a discipline valued by society.

VALUES: The department values and encourages the active participation of diverse faculty, professionals, and students in interdisciplinary teaching, research, service, entrepreneurial, and extracurricular activities at local, national, and international levels.

DIVERSITY: The department strives to create an environment where the contributions of faculty, staff, and students from underrepresented groups are respected, recognized, and rewarded.

> *"One of Arizona's greatest challenges in the twenty-first century will be to maintain economic growth and quality of life in the face of increasing environmental constraints." UA Strategic Plan 2009-2013*

THE MINE LIFE CYCLE AND SUSTAINABLE DEVELOPMENT

Societal expectations for the mining industry have evolved to focus on the concept of sustainable resource development and the mine life cycle. Sustainable development of mineral and energy resources provides the means for an ongoing reliable materials and energy supply to improve and maintain the desired standard of living for the world's population while preserving the ability of future generations to meet their needs. Sustainable development presumes the integration of positive economic activity, environmental stewardship, social responsibility, and effective governance systems. Mine life cycle analysis is an application of industrial ecology and requires that the consequences of developing a resource must be incorporated into the design process from exploration-stage data gathering through post-closure use of the land. Mining is a technology-intensive industry. New technology will help the mines of the future reduce their footprints, lower their water and energy consumption, preserve safe and healthy workforces and communities, and will lead to stronger economies in their communities during and after the life of the mine. Strong

interdisciplinary collaboration is fundamental to the education and research of mineral resources professionals.

> *Rising population and industrial growth are placing increasing strains on a variety of material and energy resources and the global environment. Understanding how to make the most economically and environmentally efficient use of materials will require an understanding of the flow of materials from the time a material is extracted, through processing, manufacturing, use, and its ultimate destination as a waste or reusable resource. It will also require knowledge of the environment and societal impacts of the flows. These considerations are key to the overall application of sustainable development in practice." Materials Count, National Research Council, 2004, p. 1*

STRATEGIC AREAS

Within the context of the University of Arizona Strategic Plan, the strengths of the MGE Department, the strengths of the University, and the global challenges of the mineral resources sector, we have defined key strategic areas. These areas identify with components of the mine life cycle but they also have important applications beyond mineral resources development which adds breadth to funding sources and employment.

While each of the priority areas listed below is currently covered in MGE's curriculum, we need to hire permanent faculty -on permanent funds – with expertise in mine design, health and safety, and environmental management and reclamation. For processing technology (extractive metallurgy), we will need to replace pending retirees in other departments with a hire in MGE. In order of hiring needs, our strategic areas are:

MINE DESIGN

Mine design is driven by the geology and economics of the resource, the local environment (including regulatory framework and community requirements), available technology, and the human capital necessary to design, develop, and produce the resource. Mine design should incorporate life cycle analysis. Mine design courses are capstone courses in our undergraduate curriculum as they draw upon all other technical aspects of mining. Mine design research will expand beyond operations research and will focus on decreasing the surface footprint, lowering energy and water consumption, and considering changes in design with incorporation of more automation and/or alternative haulage technology.

HEALTH AND SAFETY

The minerals industry in developed nations has made great strides to minimize the injury and illness rate of workers. In the past 30 years we have seen an 81% decrease in fatalities while production has risen 89%. Challenges remain in removing workers from the most hazardous environments, locating and communicating with underground personnel, monitoring the underground environment with enough lead time to mitigate hazards before they occur, and eliminating exposure to activities with long-term health consequences such as dust, noise, vibration, and gasses. Mine ventilation has become nearly extinct as a research area in mining engineering departments. Mine ventilation research needs to be revitalized, especially as more production extends underground and more civil infrastructure is developed underground.

Mine Health and Safety is a collaborative program with the College of Public Health Division of Community and Environmental Health.

ENVIRONMENTAL MANAGEMENT AND RECLAMATION

The development of new mineral resources is often constrained by concerns over potential environmental degradation. Delays in permitting have a significant impact on the economics of projects. Environmental management begins in the exploration stage with collection of data from mapping and drilling that helps inform the design process for minimizing environmental impact. Management of post-mining materials such as tailings, unmineralized rock, and leached rock is part of environmental management as is finding ways to minimize production of such materials, and finding alternative uses for such materials. Environmental management may extend to the recycling of processed materials at the end of their productive life or alternative ways to use a resource to minimize environmental impact. Continuous reclamation will become an important part of the mine design and environmental management process. Reclamation of legacy properties will be important as population in the western US encroaches on historic mined lands. Reclamation in harsh environments will require creative research solutions.

Environmental management and reclamation are very important new areas for the department and tie in with strengths at the UA in hydrology, soil and environmental science, plant science, environmental engineering, and more.

PROCESSING TECHNOLOGY

Mineral processing is usually the largest consumer of water and energy in the mining operation. In general, it includes the processes of crushing, grinding, screening, classification and separation (gravity, magnetic, electrostatic separation, flotation and hydrometallurgy). Modern process technology is being challenged to treat refractory ores at even greater efficiencies and lower costs. In addition, there is a requirement for 'clean' mineral processes with minimum impact on soil, water or air. Processing technology has application areas outside of mining, for example, recycling, dust control and waste water treatment.

Mineral Processing is a new area as of January 2007 with the hiring of the Douglas C. Yearly Phelps Dodge Professor of Mineral Processing. Processing technology faculty can collaborate with faculty in Chemical Engineering, Chemistry, and Materials Science.

PRODUCTION TECHNOLOGY

Automation will continue to make rapid advances in surface and underground mining. With more automation and operator assist technologies, the volume of information created will continue to present challenges. Organizing and using these vast datastreams in proactive ways will aid the planning process as well as the management of the mine. Information technology will extend from geoenvironmental to geometallurgical processes as we gain more and better knowledge of the mineral resource. An important component of production technology will be geosensing to develop more accurate ways to image orebodies and guide equipment.

Mine information and production technology is a relatively new emphasis area and has the highest student demand. Improvements in mine design, particularly underground mines, can be derived through improvements in mine technology. Mine information technology can collaborate with MIS, SIE, and ECE faculty. Production technology faculty can collaborate with faculty in mechanical, electrical, and systems engineering.

ROCK AND SOIL MASS CHARACTERIZATION

Geomechanics is fundamental to the mining process and to all human activities that require structures on or in the ground. Increasing environmental concerns will put greater emphasis on underground (as opposed to surface) mining where competent geomechanical analysis and design is particularly crucial. Even if all mining could be done with in situ leaching, the fracturing of the rock mass would be fundamental to providing permeability. Geomechanics research will need to focus on the science and engineering of deep excavations; more accurate prediction of in situ behavior using sophisticated mathematical models coupling mechanical, thermal, and hydrological system; and sophisticated geosensing of the mechanical properties of the rock mass. The same geomechanics research and teaching can serve the civil construction, energy, and mineral sectors and adds breadth of opportunity for our program.

Geomechanics has been an historic strength of the MGE department and will continue to be. The geomechanics program collaborates with faculty in Civil Engineering.

DELIVERING THE CURRICULUM

> *"The University of Arizona must provide students with a foundation for a lifetime of learning. The university must increase students' abilities to understand and work with people from other cultures, from Latin America to the Pacific Rim to Europe and the Middle East. We must take full advantage of our location on the US-Mexico border. And we must develop the diverse faculty that is essential to achieving this objective." UA Strategic Plan 2009-2013*

Coursework and practice in the department prepares students of all levels for professional careers with technically advanced subjects, leadership, business, life-long learning, and communication skills. The goal of our undergraduate program is to administer a curriculum that is outcome-based and leads to deeper and better learning through students and faculty working together toward shared significant academic goals.

In recognition of the increasing demand for mining engineers outside of traditional areas we have created three tracks in the underground curriculum: mining operations; geomechanics; and sustainable resource development (health, safety, and environment). The tracks were implemented in fall 2005. These tracks align with the department's strategic directions. They differ by approximately one semester of coursework. Most of the major courses (that are not skill-based such as mine surveying) are on-line through course management software. **Our undergraduate program will remain accredited by ABET under the program criteria for mining engineering.**

> *"The rapidly changing nature of modern knowledge and technology will demand, even more so than today, that engineers so educated must embrace continuous education as a career development strategy with the same fervor that continuous improvement has been embraced by the manufacturing community." The Engineer of 2020, National Research Council, 2004, p. 25*

At the graduate level we offer opportunities for study leading to the Post-Baccalaureate Certificate, Master of Engineering (MEng), the Master of Science (MS), and the Doctor of Philosophy (Ph.D.). We are formalizing a joint MS degree with the College of Public Health. A joint MEng-MBA program exists. We cooperate with the Lowell Program in Economic Geology

professional master of science degree. **All of our graduate courses have an on-line component and we will continue to develop effective methods of providing continuous education to working professionals around the world.**

UNDERGRADUATE CURRICULUM OBJECTIVES

From our ABET accreditation, 7 objectives of our undergraduate curriculum are:

A practicing mining engineer:

- Can tie the first principles of engineering with computer-based solutions to validate computer output, understand the difference between theoretical and practical solutions.
- Can conduct economic and risk analyses; understand a business plan and responsibilities to customers, stockholders, and stakeholders.
- Can stay current with technology and industry practices.
- Can effectively communicate with peers, front-line workforce, and management; possess the skills to be a team player.
- Takes safety and environmental concerns into consideration in designs.
- Can understand the human and social elements of a mining operation and its importance, dynamics, and sensitivity to internal stimuli as it drives the safety, costs, and productivity of the operation.
- Possesses the ability to organize, plan, and schedule projects to effectively manage resources and reach deadlines.

GRADUATE CURRICULUM OBJECTIVES

The objectives of the graduate program include a subset of the following for each degree:

- Possess a deeper knowledge from a baccalaureate degree of a sub-discipline within the general areas covered by the department
- Have a sufficient mathematical and computer background to formulate and solve practical problems in the discipline
- Access, analyze, and utilize available information from a variety of sources
- Use competencies associated with critical thinking and problem solving
- Demonstrate life-long learning skills including competencies associated with critical thinking and problem solving
- Possess an awareness of engineering ethics
- Demonstrate a commitment to the advancement of the profession

- Demonstrate the ability to communicate with a professional audience both orally and in writing including the ability to influence others.
- Possess a basic knowledge of business and/or socio-economic principles that impact the profession
- Demonstrate the ability to formulate and conduct a research project
- Demonstrate the ability to work effectively on a team
- Demonstrate quality of scholarship through the publication at least one significant paper

FACULTY: CURRENT STRENGTH AND FUTURE NEEDS

The tenure/tenure eligible (TTE) faculty strength in 2007 is 5 mining faculty (including department head) and 2 geological engineers. Professor of Practice (non-tenure track) positions contribute an additional 3 part-time faculty. One faculty member has been on loan from the Material Science and Engineering Department since 2005 but will return to MSE in June 2008. The ideal faculty size to deliver a world-class curriculum and conduct research and outreach is 8 TTE faculty in mining, 1 department head, and 3 part or full-time Professors of Practice. Hiring priorities are full-time TTE positions in mine design, mine health and safety, environmental management/reclamation, and extractive metallurgy. The Directors of the San Xavier Mine and the Institute for Mineral Resources should be full-time positions and could be included as Professors of Practice if teaching responsibilities are a significant part of the job descriptions.

CREATING KNOWLEDGE

> *"As a premier land-grant university, the UA plays a vital role in building a thriving state. The UA offers the highest quality education, excels in creating new knowledge that has worldwide impact, and provides leadership and collaboration to address the challenging issues facing Arizona, the nation and the world. To better serve future generations, the UA will be one of the 10 best public research universities." UA Strategic Plan 2009-2013*

The department balances applied and basic research and disciplinary with interdisciplinary work. The UA is one of the top-ranked research universities in the US with not only strong mining engineering and economic geology programs but also top-ranked colleges of public health, medicine, law, business, social sciences, science, optical science, and engineering. The current and future disciplinary strengths in the graduate program align with the strategic directions of the department and the research strengths of the University. Sustainable resource development is a growing interdisciplinary effort through the new Institute for Mineral Resources.

Success in creating knowledge depends on the faculty quality and quantity, access to funding, a pool of qualified graduate students, laboratory space and equipment, access to field sites, and industry support. **A high priority for the department is teaching assistantships to support graduate students in their first year of study.**

The department has been investing in upgrading laboratory facilities in geomechanics, mineral processing, and ventilation. Computer laboratories remain reasonably current for most research and teaching needs. **Priorities to support research include providing adequate IT personnel, a laboratory technician, and power and environmental controls for modern laboratory equipment.** The San Xavier Experimental Mine is an important laboratory teaching and research asset for mine ventilation, health and safety, and geomechanics. The ongoing priority for the mine is to provide a stable budget for management and operation so that its true potential can be realized.

Access to external research funding has been a challenge for mineral resources faculty since the closure of the US Bureau of Mines and more recently the closure of the DOE Mining Industries of the Future program. **We will continue to advocate for federal research support via the passage of the Energy and Mineral Schools Reinvestment Act or similar federal program.**

The Institute for Mineral Resources was conceived in 2004 and funding for a part-time director secured in 2007. The IMR will focus on difficult interdisciplinary challenges facing the mineral resources sector. Much like the Udall Center for Public Policy or the Institute for the Study of Planet Earth, the IMR will draw on faculty in existing departments and will provide a "neutral zone" for collaboration with minimal overhead. **For the IMR to achieve its potential it will need to secure a level of permanent funding.**

A stable operating budget, staff and faculty support must be secured.

SERVICE TO THE PROFESSION

Faculty provide service to the profession through leadership in professional societies, transfer of technology to the private sector including consulting, service on policy and reporting committees such as the National Research Council, and outreach to K-12, community college, and general public to create interest in and knowledge about earth science and engineering. Another important service activity for the department is the leadership and participation of professionals in department activities through the Industrial Leadership Board, seminars, guest lectures, research, and mentoring.

The department will continue to encourage faculty activities that improve our profession and the public's perception and understanding of our profession.

GOALS, OBJECTIVES, AND OUTCOMES TO IMPLEMENT THE PLAN

GOALS

A. Deliver a curriculum that is outcomes based and leads to deeper and better learning through students and faculty working together toward shared significant academic goals.
B. Diversify the curriculum to broaden employment opportunities for graduates and provide continuing education for working professionals
C. Generate knowledge by the conduct of scholarly research that is peer reviewed, advances the discipline, and educates students
D. Share the knowledge through publications, education, and outreach.
E. Increase the diversity and cultural sensitivity of students at all levels.
F. Provide vision, leadership, and participation in interdisciplinary scholarly activities at the local, national, and international levels.
G. Provide vision, leadership, participation in professional service, entrepreneurial, and governmental activities.

H. Foster a new model of alumni and industry participation in the department by encouraging industry to be stakeholders in academia and academia to be a stakeholder in industry; development is the process of cultivating partners not just patrons.

OBJECTIVES

A. Outcomes-based curriculum
    1. Define and measure outcomes for every course
    2. Provide a web component for every course
    3. Ensure every course requires some application of life-long learning skills
    4. Integrate leadership, business, and communication skills across the curriculum
    5. Maintain the goals of ABET for continuous improvement in the delivery of undergraduate education
    6. Increase industry sponsorship of courses
B. Broaden the curriculum
    1. Identify employment sectors that utilize mining engineering skills
    2. Use a broad range of applications in classes
    3. Take field trips to locations other than metal mines
    4. Invite guest lecturers from broad range of companies
    5. Develop short courses and distance learning courses for continuing education
    6. Emphasize professional development for students
    7. Emphasize communication, business, design, and leadership skills development
C. Generate knowledge
    1. Every faculty with a research component in their workload has externally funded research activity.
    2. Faculty members demonstrate internationally recognized expertise in chosen sub-discipline
    3. Faculty members conduct some research that has industry participation
    4. Undergraduate and graduate students are included in research projects
    5. Faculty members conduct some research that has an international component
    6. Research projects are incorporated into coursework
D. Disseminate knowledge
    1. Faculty members regularly publish peer-reviewed articles.
    2. Knowledge of the discipline is shared with those outside the discipline
    3. Maintain hands-on skill development and training capabilities at the San Xavier Mining Laboratory
E. Increase diversity and cultural sensitivity
    1. Recruit diverse students at all levels
    2. Inculcate the values of economic development, environmental stewardship, social responsibility, effective and ethical governance, cultural sensitivity, safety, and preservation of health
F. Participate in interdisciplinary activities
    1. Contribute to the formation and success of the Institute for Mineral Resources (IMR)
    2. Contribute to the success of the Cooperative Research Centre-Mining at UQ
    3. Continue collaboration with the College of Public Health
    4. Engage other engineering faculty and faculty across campus in research projects
    5. Engage in university sustainable development activities
G. Participate in service and entrepreneurial activities
    1. Faculty actively participate in and contribute to the leadership of professional societies

2. Faculty engage in governmental activities and decision making processes that impact the discipline
3. Faculty contribute to national and international development of support for mineral resources related needs
4. Faculty transfer technology generated through research and teaching activities to the private sector

H. Alumni and industry involvement
1. Actively engage members of the MGE Industry Leadership Board (ILB) in the department
2. Engage industry and alumni in the financial support of the department
3. Raise external support for faculty positions and operations

OUTCOMES

A. Outcomes based curriculum
1. Assess outcomes each year for undergraduate and graduate programs
2. Faculty meet annually to review curriculum and course content
3. ILB Audit Committee reviews courses
4. Develop web course delivery for every 400-level and higher course
5. 80 undergraduate MNE students
6. Submit essays to contests
7. Have practical projects, especially industry sponsored, in most classes
8. Share list of outcomes for each course with all faculty

B. Broaden curriculum
1. Inform students about 3 tracks in curriculum in MNE 200 and in advising sessions
2. Determine number of students in each track
3. Correlate student employment with their track
4. Document background of guest speakers and seminar speakers
5. Document breadth of field trips, locations, purpose
6. Establish need for short courses and distance courses and create and market them
7. Document professional development in summer internships, seminars, and industry-sponsored projects and senior design
8. Document improvement in communication skills, business component of curriculum, leadership opportunities in professional societies and at SX Mine

C. Generate knowledge
1. $150k/yr/faculty with 40-40-20 workload
2. At least 4 MS/PhD graduate students per faculty per year
3. 25 certificate and MEng grad students

D. Disseminate knowledge
1. 2 publications with some level of peer review per year per faculty member
2. Publish 1 or more conference abstracts and/or have research team members give 1 or more oral presentations each year
3. Participate in "Natural Resources Impact" publication with MFSW
4. Publish department newsletter each year with information on faculty research
5. Participate on committees outside of professional societies
6. Supervise shifts, support class projects and activities, give tours at the San Xavier Mine

E. Increase diversity and cultural sensitivity
1. Meet or exceed college average for women and minority students and faculty
2. Department participation in Engineers Without Borders
3. Invite seminar speakers with diverse backgrounds and opinions
4. Graduate students present their backgrounds in seminar

F. Participate in interdisciplinary activities

1. Fund IMR director position, establish interdisciplinary research and classes
2. Participate in research with CRC-Mining at the University of Queensland.
3. Participate in research and teaching with CoPH
4. Develop international collaboration in block caving and surface to underground mining transitions and mine of the future grand challenges

G. Participate in service and entrepreneurial activities
   1. Work with federal government to develop funding and programs to help mineral resources university programs
   2. Serve as officers, on committees, or boards for professional societies
   3. Transfer intellectual property to commercial entities
   4. Participate in consulting projects with commercial entities

H. Alumni and industry involvement
   1. Fund 5 faculty/teaching positions, IMR Director, SX Mine Director
   2. Fund the operating budget for the Department
   3. Keep SX Mine open with stable funding for director and operations
   4. Fund a base budget for the IMR
   5. Regular meetings with ILB