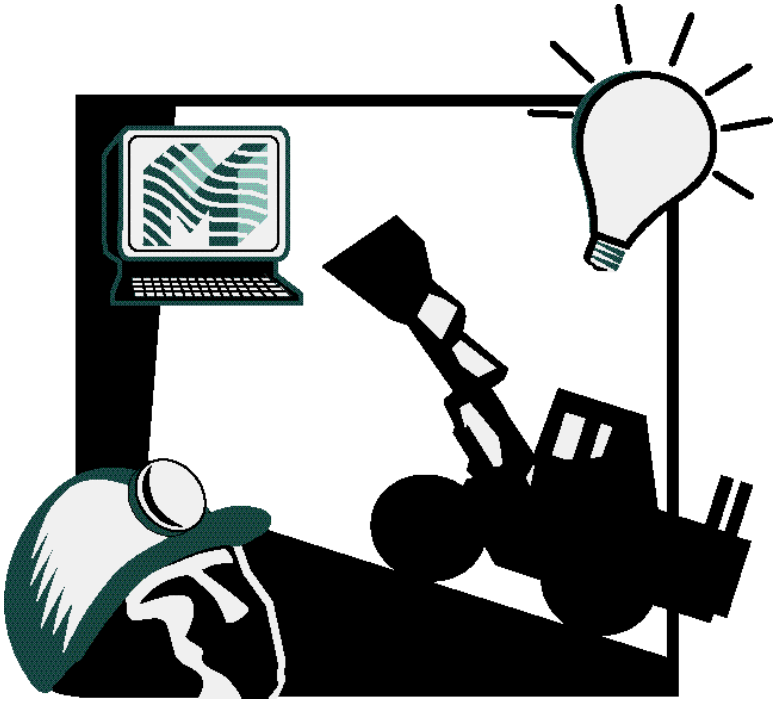
Education Roadmap for Mining Professionals

December 2002



Mining Industry of the Future

FOREWORD

In June 1998, the Chairman of the National Mining Association and the Secretary of Energy entered into a compact to pursue a collaborative technology research partnership, the Mining Industry of the Future. Following the compact signing, the mining industry developed *The Future Begins with Mining: A Vision of the Mining Industry of the Future*. That document, completed in September 1998, describes a positive and productive vision of the U.S. mining industry in the year 2020. It also establishes long-term goals for the industry. One of those goals is:

> "*Improved Communication and Education: Attract the best and the brightest by making careers in the mining industry attractive and promising. Educate the public about the successes in the mining industry of the 21st century and remind them that everything begins with mining.*"

Using the *Vision* as guidance, the Mining Industry of the Future is developing roadmaps to guide it in achieving industry's goals. This document represents the roadmap for education in the U.S. mining industry. It was developed based on the results of an Education Roadmap Workshop sponsored by the National Mining Association in conjunction with the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. The Workshop was held February 23, 2002 in Phoenix, Arizona.

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INTRODUCTION

A profitable and stable mining industry is vital to U.S. economic and national security. Exhibit 1 provides just a snapshot of the important role of mining in the United States. Leaders from the U.S. mining industry have a positive and productive vision of the state of the industry in the year 2020. This *Vision* rests on achieving the following goals:

- ***Responsible Emission and By-product Management:*** Minimize the impact from mining activities on the environment and the community by fully integrating environmental goals into production plans. Support the development of technologies to reduce carbon dioxide emissions to near zero and sequester additional emissions.

- ***Safe and Efficient Extraction and Processing:*** Use advanced technologies and training to improve the worker environment and reduce worker exposure to hazards that reduces lost time, accidents and occupational diseases to near zero.

- ***Superior Exploration and Resource Characterization:*** Develop ways to find and define larger high-grade reserves with minimal environmental disturbance.

- ***Low Cost and Efficient Production:*** Use advanced technologies to improve process efficiencies from exploration to final product.

- ***Advanced Products:*** Maintain and create new markets for mining products by producing clean, recyclable and efficiently transportable products and form cooperative alliances with the processing and manufacturing industries to jointly develop higher-quality and more environmentally friendly products.

Exhibit 1. Mining: A Vital U.S. Industry[1]

Mining plays a vital role in our national economy, national security, and in our society:

- Each year, nearly 47,000 pounds of materials must be mined for each person in the U.S. to maintain their standard of living.
- Processed materials of mineral origin account for nearly five percent of U.S. gross domestic product.
- U.S. electricity costs are among the lowest in the world due to the availability of low-cost coal.
- Coal accounts for 51 percent of all electric power generated in the U.S.
- In 2000, the value of shipments of mined materials processed domestically was $429 billion.
- More than 320,000 people work directly in the U.S. mining industry.
- Indirect employment, in manufacturing, engineering, environment, geology, and others, accounts for nearly three million additional jobs.

- ***Positive Partnership with Government:*** Work with government to reduce the time for resource-development cycle by two-thirds. Achieve equitable treatment for mining compared to other industries that produce materials and energy relative to international competition by making the legal and regulatory framework rational and consistent.

- ***Improved Communication and Education:*** Attract the best and brightest by making careers in the mining industry attractive and promising. Educate the public about the successes in the mining industry of the 21st century and remind them that everything begins with mining.

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1 Estimates developed by National Mining Association based on data from US Department of the Interior, US Geological Survey, Mineral Commodity Summary (mineral consumption); US Department of Energy, Energy Information Administration, Monthly Energy Review (coal energy consumption); US Department of Commerce, Bureau of Census (population).
http://www.nma.org/fastfacts.html#anchor208017.
Mining Engineering, Annual Review, May 2001.
Mine Safety and Health Administration, Worktime Quarterly Reports. 2001 data are preliminary. Updated: April 2002.

The Mining Industry of the Future is striving to achieve each of these visionary goals.

The first technology roadmap supporting this *Vision*, the *Mining Industry Roadmap for Crosscutting Technologies* < http://www.oit.doe.gov/mining/visions.shtml >, was published in February 1999. That roadmap focused on technologies that could impact the processes for all products of the mining industry.

The second roadmap, the *Mineral Processing Technology Roadmap* <*http://www.oit.doe.gov/mining/visions.shtml*>, was published in September 2000 and addresses those technologies leading to mineral processing improvements that may apply to one or multiple mining product areas.

The third roadmap, the *Exploration and Mining Technologies Roadmap*, currently in draft, focuses on process and technology advances that will improve the exploration for, and extraction of, ore from the earth.

This document, the *Advanced Education for Mining Professionals Roadmap,* addresses the vision goal of "Improved Communication and Education." The term "education" includes mining- and mineral-related education in grades K-12, undergraduate, and graduate programs, continuing education, and public education.

These strategies are recommendations based on the inputs received from the participants and can be used as guidance to meet the needs of the mining industry. Some of these strategies can be implemented through demonstration projects, pilot programs and other activities involving teams of industry and academia. Other challenges would require more fundamental changes and may be beyond the scope of individual industry-academia projects.

This Roadmap outlines strategies that the industry can implement, many in partnership with the education community, to improve education, communication, and interest in mining and mineral related fields. Specifically, it outlines strategies in three areas:

1. Flexible Curricula
2. Outreach
3. Career Opportunities

Each of these areas is described more fully in the following sections.

FLEXIBLE CURRICULA

OBJECTIVE

To develop flexible curricula that can adapt to societal needs.

BACKGROUND

The Accreditation Board for Engineering and Technology (ABET) is a federation of 31 professional engineering and technical societies. Since 1932, ABET has provided assurance of quality education programs through accreditation actions. ABET accredits more than 2,500 engineering, engineering technology, computing and applied science programs at over 550 colleges and universities nationally. Currently ABET has accredited 15 programs for mining engineering, 15 for geological engineering, 2 for geophysical engineering, and 2 for mineral engineering in the United States as shown in Exhibit 2. Many of these programs are struggling with enrollment and more mining related programs are expected to close.

Exhibit 2. ABET Accredited Programs Related to Mining

Mining Engineering	Geological Engineering	Geophysical Engineering
1. University of Alaska Fairbanks	1. University of Alaska Fairbanks	1. Colorado School of Mines
2. University of Arizona	2. University of Arizona	2. Montana Tech
3. Colorado School of Mines	3. Colorado School of Mines	
4. University of Idaho	4. University of Idaho	Mineral Engineering
5. University of Kentucky	5. Michigan Technological Institute	1. Michigan Technical University
6. Michigan Technological University	6. University of Minnesota-Twin Cities	2. New Mexico Institute of Mining and Technology
7. University of Missouri-Rolla	7. University of Mississippi	
8. Montana Tech	8. University of Missouri-Rolla	
9. University of Nevada-Reno	9. Montana Tech	
10. Pennsylvania State University	10. University of Nevada-Reno	
11. South Dakota School of Mines and Technology	11. New Mexico State University	
12. Southern Illinois University at Carbondale	12. University of North Dakota	
13. University of Utah	13. South Dakota School of Mines and Technology	
14. Virginia Polytechnic Institute	14. University of Utah	
15. West Virginia University	15. University of Wisconsin-Madison	

The Society for Mining, Metallurgy and Exploration, Inc. (SME) sets the curriculum for mining and related fields, including:

- *Geological Engineering* - the application of geologic data, techniques, and principles to the study of naturally occurring rock and soil materials or ground water for the purpose of ensuring that geologic factors affecting the location, planning, design, construction, operation, and maintenance of reengineering, structures, and the development of ground-water resources, are properly recognized and adequately interpreted, utilized, and presented for use in engineering practice. This work also includes site characterization, environmental remediation and protection, and geotechnical engineering.

- *Geophysical Engineering* - the application of measuring a physical property of the rocks and interpreting the results in terms of geologic features or the economic deposit sought during the exploration for minerals or mineral fuels. Physical measurements may be taken on the surface, in boreholes, or from airborne or satellite platforms.

- *Mining Engineering* - the planning and design of mines, taking into account economic, technical, and geologic factors; also, supervision of the extraction, and sometimes the primary refinement, of the raw material.

- *Mineral Engineering* - the application of modern science and engineering in the discovery, development, exploitation, and use of natural mineral deposits.

The engineers who venture down this path supply Americans with the basic materials needed to sustain their standard of living. However, the role of the mining industry in meeting these needs is often invisible. The majority of persons do not realize that over 30 minerals are used to build a computer.

Mining engineers and other mining professionals must balance the constant demand for low-cost materials to meet societal needs with additional societal demands for a clean and safe environment. Moreover, they must be able to adapt to unforeseen changes in markets, regulations, or other factors impacting the business of mining. An appropriate mining education should provide students with the skills needed to balance society's demand for diverse mined materials with a reduced environmental impact, as well as prepare them to adapt to future changes that may impact the industry.

There are a wide range of strategies - near, mid, and long-term - that can be incorporated into the curriculum for mining-related engineers. Curriculum changes should produce well-rounded employees that can adapt to future demands placed on the mining industry.

ACHIEVING OUR GOAL

To achieve the goal of developing flexible curricula that can adapt to societal needs, mining educators and industry have identified a number of activities that can be implemented over the near-to long-term. These activities fall into four basic categories:

- **Curriculum Development**
- **Continued Education**
- **Design Teams**
- **Industry, Academia, and Government Cooperation**

The following describes specific recommendations in each of these four categories. It should be noted that many of the strategies below already be implemented in some of the mining and mineral related programs in which case the strategies below can be used to reemphasize their importance.

Curriculum Development

There are many strategies to maintain, improve, and develop a more flexible curriculum. Students must be made aware of the diverse career opportunities available from mining and related fields. Similarly they must bring a variety of technical and non-technical skills to address the changing demands facing the industry. This is critical in attracting more students into mining and mineral-related programs. Recommended strategies include:

- **Mining Education Advisory Board** - Responding to the need for new training requirements, a high-priority strategy is to increase the interaction between Mining Education Advisory Boards and academia to design new core requirements for students. This could be accomplished with a committee that includes educators, industry, customers, decisions makers, and students. Once these new core requirements are established, each university should better maintain a dialog with industrial advisory board to guide and direct the educators to meet industry's needs.

- **Communicate Diverse Opportunities in Mining and Mineral Engineering Curriculum** - Currently, the definition of mining engineering is perceived to be narrow. However, a student trained in mining engineering actually possess skills that can be applied in a wide variety of industries, including civil engineering, oil and gas, defense, and others. Mining engineers must be expert in many of the techniques critical to activities in these industries such as tunneling, slope stability, drilling, and other processes. Mining education should communicate the diverse career paths that mining engineers have available. Mineral engineering students possess skills that can be applied to chemical, materials, ceramic engineering, and related fields.

- **Comprehensive Curriculum** - Universities should maintain and develop a flexible and comprehensive mining program curriculum that allows students to grow professionally and technically in a variety of mining-related career paths. Some universities may already incorporate training in management, sustainable development, foreign languages, and/or international business issues. Curriculum should continue to be diverse and include coal, hard rock, and industrial minerals.

    - Curriculum should incorporate sustainable development concepts into course work, including environmental and natural resource courses to support mine planning, development, management, and reclamation.
    - Curriculum should include communication technologies, business and management, and foreign language training.
    - Curriculum should incorporate Web-based training tools to adapt to student learning styles.

    A comprehensive curriculum better prepares students for the increasingly diverse demands facing today's mining professionals including the need to operate in foreign markets, respond to environmental regulations, and apply new technologies.

Continued Education

To remain flexible and adaptive both professionally and technically, continued education is needed after a person enters the industry. Web-based and other distance learning tools should be developed to increase the availability of continued education. Examples of recommended strategies include:

- **Internet-based Education** - A high-priority strategy among industry and university representatives is low-cost Internet-based education and use of other electronic tools to make education more accessible to employees in remote locations.

- **New Courses** - Courses should be developed to help engineers grow and expand their knowledge of the latest technologies, mine management strategies, and other aspects of mining and minerals-related fields. These courses can be distance-learning opportunities to modify "on-campus" education requirements.

- **Management Training** - Management-training programs that many companies have eliminated can be re-instituted.

Design Teams

Increased interaction with multidisciplinary design teams can educate students in a wide variety of skills. These teams should include experts in the areas of political science, economics, accounting/finance, and journalism. To assist in these teams, adjunct professorships and faculty sharing between universities can provide more diverse perspectives. Also, summer employment of educators in industry will keep them up-to-date on current industry practices, techniques, and needs. Also, equal tracks for research and teaching in universities for professors was

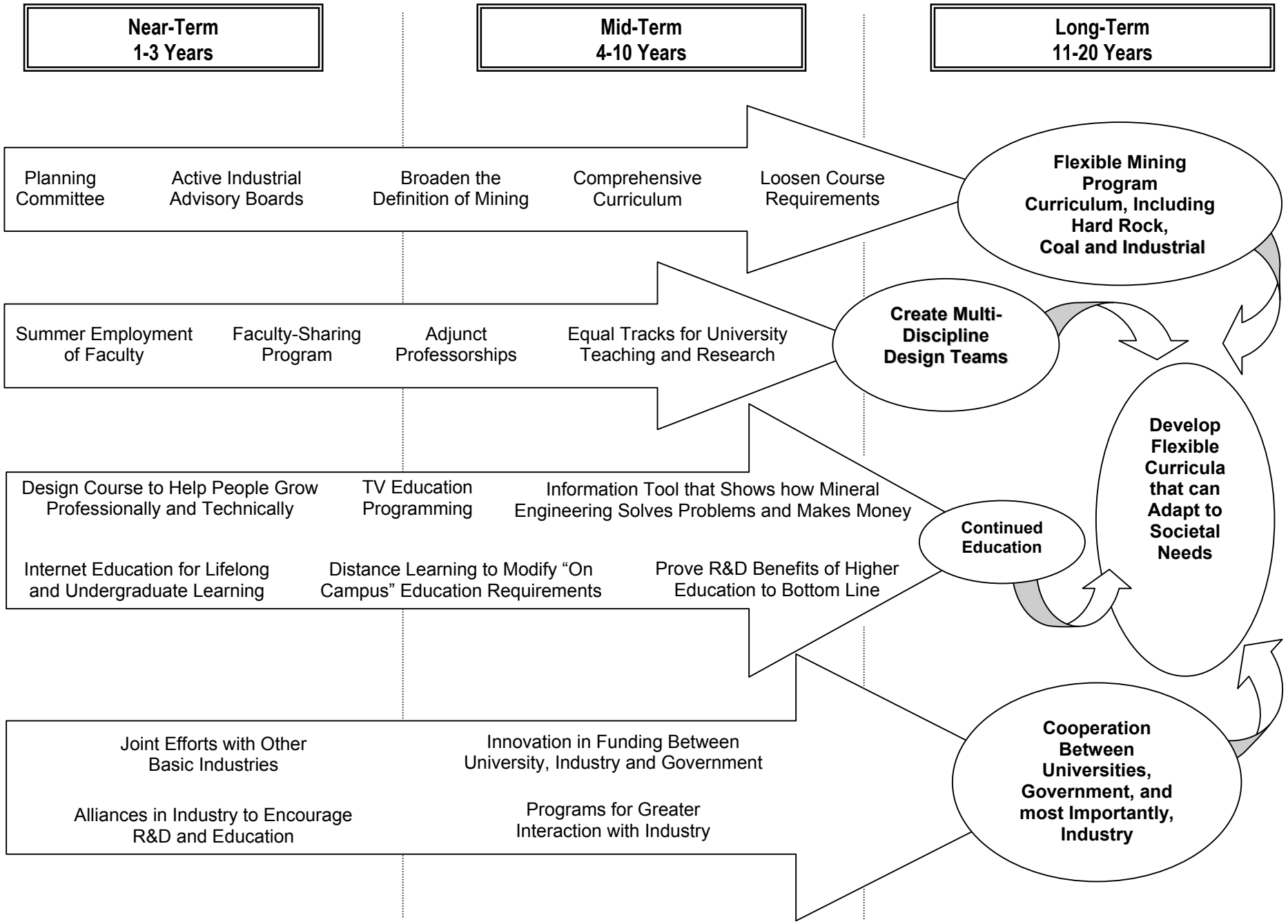
recommended. This will allow educators to focus more on education issues, rather than research.

It was suggested that the European education system be used as a model for such a multidisciplinary design team. The European system is organized so that students rotate from different universities where they are taught mineral-related classes in the areas where that university excels. It should be noted that this system is heavily subsidized in Europe.

Industry-Academia-Government Cooperation

To accomplish these strategies, cooperation between university, government, and most importantly industry, is required. Some strategies to stimulate cooperation are joint efforts with other basic industries such as agriculture and oil and gas. These industries are known to have similar problems in attracting well-trained students. R&D is a high-risk venture. Cooperation allows that risk to be shared. Also, high-risk research can result in large successes, which can be a powerful tool in attacking attention to the industry. R&D results that help to improve production can be a powerful tool, but everyone must share the risk involved. In addition, co-involvement of students and mining engineers in research and development that produces successful results that demonstrate the value of industrial R&D to the industry. At the same time, it exposes students to the industry while working on the research. It will also help in disseminating R&D to industry. Innovative funding mechanisms between university, industry, and government are needed to allow all three to share the risk and meet each other's needs. Continued interaction with industry is key to maintaining a well-designed curriculum.

Exhibit 3. Flexible Curricula



OUTREACH

OBJECTIVE

To educate the public, university level, and secondary level about the modern image of mining.

BACKGROUND

One challenge to the industry's efforts to recruit is the misperception that the industry operates in a state similar to that of a century ago. For instance, some view the mining industry as having a dangerous work environment, even though the overall nonfatal injury and illness rate for mining is lower than any other industry category with the exception of finance.

This misperception must be overcome to improve the public's image of the industry and to encourage more students to pursue mining-related careers.

ACHIEVING OUR GOAL

To overcome these misperceptions, the mining industry must undertake outreach in three main areas:

- **Public Outreach -** A number of outreach strategies can be implemented by industry and associated industry societies that could improve the image of mining and enable the industry to meet its recruiting and other goals.
- **University Level Outreach -** Within the pool of available engineering undergraduates, there is considerable potential for outreach activities to encourage students to explore the offerings of the mining disciplines.
- **Secondary School Level Outreach -** Participants pointed out that there were a number of activities that the mining industry and those interested in the field could undertake to cultivate interest in the field by students.

Public Outreach

One challenge to effective outreach to the general public is the lack of a single, clear, defined and articulated message that could be “the face of mining”. It has been suggested that the mining industry pattern itself after other trades that have achieved success in getting their message out to the public. Ideally, a concerted advertising campaign would present the message.

At a minimum, incremental steps can be taken to improve the image of the industry. The challenge is communicating the current reality of a thriving and high-tech modern business enterprise. In the near-term, a small, well thought out series of outreach measures, such as a consistent and clear industry message would go a long way in replacing the outdated images with a more positive picture. This would lay the foundation for a longer-term message, where the industry can highlight the job flexibility available to the modern mining student and professional.

- **Communicate the Benefits of a Career in Mining** - Some of the best ambassadors to the public in general and potential mining students in particular should be the people currently involved in mining. In some cases, current employees can be tapped as a resource to identify the many positive aspects of a career in mining, why they chose a career in mining, and the personality traits that make a strong mining professional. Similarly, the industry and educators can communicate this information to potential employees and students.

- **Encourage Employee Outreach** - Companies should encourage employees to take part in outreach activities by incorporating such activities into their incentive structures.

Employees should be encouraged to discuss their professional experiences of students in classrooms, or to the general public in any forum that invites speakers, such as social clubs.

- **Develop Media on Mining Careers** - For those who cannot be reached by direct personal contact, companies can develop materials that replace old stereotypes with the modern image of a dynamic and technology-driven industry. These materials, such as CD-ROMs, Websites, games and other interactive media, could be accessed by target audiences that might not be reached by other means such as speakers, and would go a long way in improving interest in the industry, particularly as a potential career.

- **Participate in Fairs and Expositions** - The industry can support science fairs and engineering competitions, which often draw considerable attention from students exploring scientific careers. It would be relatively easy to take this process a step further and reach out to students by inviting high school groups to events such as the Industrial Energy Efficiency Expo, the SME Annual Conference and Expo, and MINExpo.

- **Community Relations** - In some cases, mining employees and individuals living in mining communities are reported to discourage young people from entering the industry. The industry needs to identify and resolve the issues that create these attitudes.

In addition to a concerted public relations effort, some adjustments in current practices and policies could raise the profile of the industry, improving its message and encouraging more young people to explore mining as a potential career. These include simple steps like forging partnerships with government agencies, e.g. the U.S. Department of Energy, whose interests converge with those of the industry, or developing models for classroom demonstrations on mining and processing, enabling students to experience the industry hands-on to increase their interest in the field.

The latter should involve an explicit effort to showcase the mining industry, with outreach activities such as tours, demonstrations of equipment, and modern blasting techniques. These can reach even larger audiences by encouraging media interest such, for example inviting the Discovery Channel, sponsoring PBS specials on the role of mining in society, and even obtaining recognition for outstanding engineers in the field by encouraging high profile awards such as the Nobel prize.

Ultimately, the success of these and any other suggestions is dependent on the acceptance and implementation of these plans by higher-level industry executives and other key influential players.

University-Level Outreach

There is a need to improve outreach in higher education to eliminate misperceptions about mining careers and to communicate the opportunities available from a career in mining.

- **Communicate Flexible Curriculum** - To remedy the misperception that mining is not a highly sophisticated and technical industry, one option is that mining departments reach out to other departments to maintain and create flexible curricula that conveys to students the nature of the modern mining profession as well as the ethical, responsible nature of a modern corporate career in the mining field. A comprehensive curriculum, developed and administered in conjunction with departments like environmental resources, could not only alleviate the misperceptions that surround the industry but could also offer greater flexibility and career path choices to mining students.

  A specific example of this is to stress the technological nature of mining. The training that mining engineers undergo is rigorous and comprehensive enough that a mining engineer

is qualified to undertake many other jobs, such as mechanical engineering. This flexibility should be emphasized, both to students and to employers that recruit them.

- **Establish Web Sites for Students and Recent Alumni** – A networking Web site could be created to establish connections between current students and recent alumni. Alumni could provide highlights of career activities, as well as information on career opportunities for students. Students can help keep the alumni engaged with the college or university.

- **Improve Recruiting** – Mining companies can host regular dinners or receptions with students and recent graduates to begin the outreach process and to help students get to know more about opportunities in the industry.

- **Communicate "High-Tech" Nature of Mining Careers** - The high-tech nature of mining, has not been exploited to its maximum potential due to restrained public relations efforts on the part of those involved in mining education and industry.

- **Joint Industry-University Research** - There is the possibility for collaborative research efforts between the mining industry and mining departments across the nation. Bringing higher education into research efforts in the mining field could be beneficial not just for academia, but also for industry. It would also provide a high degree of return on their research dollar.

Secondary-Level Outreach

There are several specific opportunities to build bridges to educators and guidance counselors in grades K-12. There is a large potential for outreach activities that could effectively bring the message of mining to this critical demographic group. This population of younger students represents potential entrants into industry, but also a target audience for outreach that can be reached relatively economically with a consistent energy message.

- **Educational Materials** - One key point is educational materials that depict the benefits of a mining career as well as the many favorable aspects of the industry. It would be relatively easy for industry to develop diverse materials, and then disseminate them to grade K-12 science and mathematics teachers who are always on the lookout for fresh and innovative ways to excite students about their subjects.

- **Science Standards** - It would be fruitful if national industry societies incorporated their input into school curriculums by participating in the development of science standards. The industry should certainly participate in standards science implementation and development.

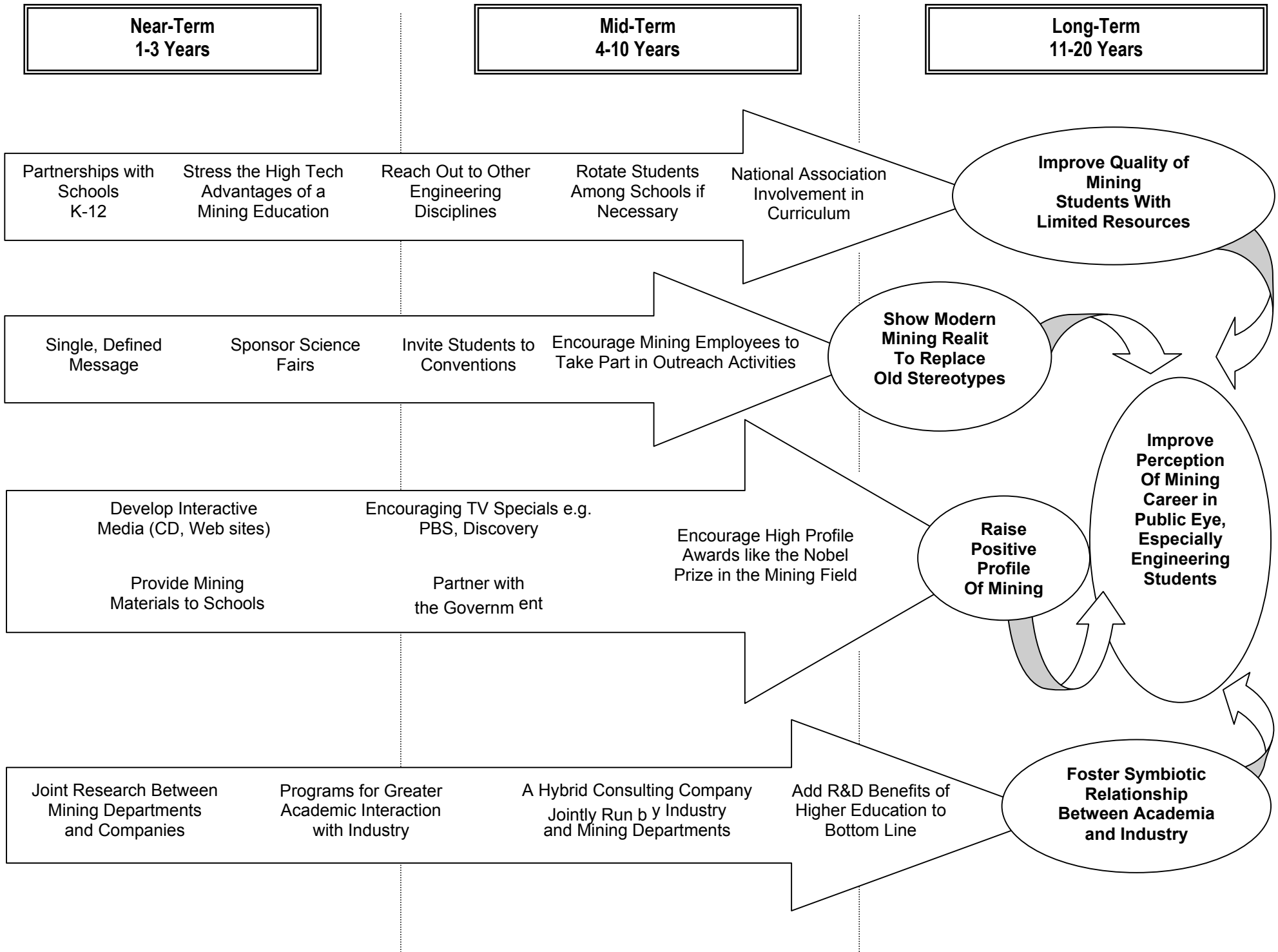
- **Educate Teachers and Counselors** - The industry could arrange for interested K-12 teachers and counselors to take "mining in society" courses, which could provide them with the point of view of the mining industry, as well as make them more likely to encourage their students to explore mining as a career choice. In fact, the industry could invite high school science faculty to work in the industry for summer sabbaticals as a way of cultivating goodwill. A similar system could be extended to high school students. The industry should foster programs that enable high school students to take capsule courses or summer credit at universities. The industry could encourage these programs by providing financial aid, encouraging colleges to grant credit, issue certificates, or offer summer employment in conjunction with academic study.

- **Summer Mining and Geology Camps** - One- to two-week geology and mining camps can be designed (similar to computer and other camps available to children) to provide

children with hands-on education in the exploration, production, and application of the Earth's minerals.

Increased outreach at the secondary level can encourage high school students to consider vocational or university-level training related to mining upon high school graduation.

Exhibit 4. Outreach



CAREER OPPORTUNITIES

OBJECTIVE

To develop and maintain flexible, challenging, well-paying and rewarding careers.

BACKGROUND

One of the major challenges currently facing the U.S. mining industry is the ability to attract and retain a strong workforce in both technical and non-technical fields. A number of factors have contributed to this situation, including lack of awareness of the diverse opportunities available in mining as well as misconceptions that fail to recognize the many technological, safety, and environmental advances that have occurred in the U.S. mining industry. Also, many mining companies have reduced the size of their engineering staff. Much of the research and technological development has diminished and their effort is more focused on production. Increasingly, support activities, such as mine planning, development, maintenance, and other support operations are being outsourced.

Many in the mining industry have asserted that they have found their careers in mining to be extremely interesting, offering many intellectual challenges. The mining industry now uses many cutting-edge technologies in exploration, extraction, and processing. These involve computer-based analysis, and advanced sensors and other equipment. However, most students do not associate the mining industry with the application of these advanced technologies. Nor do they realize that the flexibility of mining-related curricula, which includes mining engineering, geophysics, and other related studies will offer them diverse career opportunities. These career opportunities will extend throughout the mining industries and to related industries such as oil and gas, construction, space exploration, and others.

Other factors causing fewer students to consider careers in mining are due to the nature of the mining industry itself. Mines are often located in remote areas requiring either relocation or extensive travel. This may cause a lack of interest among potential students and workers. In addition, students interested in becoming entrepreneurs will have difficulty due to the large capital requirements associated with competitive mining operations. Due to increasing environmental and other regulations as well as international competition, students and workers may perceive the future of the U.S. mining industry with uncertainty and be less willing to pursue a career in the industry. Also, the globalization and consolidation of the industry is resulting in a small number of very large international companies.

Finally, the mining industry must maintain its economic health to ensure an adequate supply of well-paying careers. This involves improving industry profitability and performance, identifying markets for mining byproducts, reducing operating costs, addressing trade issues which impact competitiveness, and other solutions which may be outside the scope of this roadmap. Addressing technology challenges which impact the industry's economic health may be possible via other Mining Industry of the Future roadmaps, as well as through individual industry initiatives.

ACHIEVING OUR GOAL

To achieve the goal of developing and maintaining flexible, challenging, well-paying and rewarding careers, mining educators and the mining industry have identified a number of activities which can be implemented over the near- to long-term. These activities fall into four basic categories:

- **Outreach**
- **Industry-University Joint Activities/Partnerships**
- **Industry Coalitions**
- **Ensuring a Stable and Profitable Future for Mining**

The following describes specific recommendations in each of these four categories.

Outreach

A number of outreach activities can be pursued to communicate the fact that the mining industry currently offers challenging and rewarding careers. Outreach activities should focus upon the fact that the mining industry requires many types of expertise such as engineering, geology, finance, mathematics, and other fields. It also offers flexible and diverse career paths.

Again, outreach activities may include increased efforts to recruit at local schools and universities to both communicate career opportunities and to support local economies and communities. It may also include industry visits to schools, educational and promotional campaigns, and other activities. Outreach should target high school and college guidance counselors, science teachers, and career services staff at universities. Outreach activities are discussed in more detail in the Outreach section of this report.

Industry-University Joint Activities/Partnerships

An increase in the quantity and quality of interaction between industry and academic institutions and students will result in several important benefits. It will help educators to be more aware of the mining industry's workforce requirements – the types of skills and attributes required of mining industry employees. It will help to communicate the current state of the industry to educators and students alike, communicating the rewarding and technically exciting nature of a career in mining.

A high priority for industry in the near term is to create a better exchange of communication and information between universities and industry. Examples of activities that could be implemented to achieve this include:

- **Industry Visits** – Local mining companies can visit area universities and high schools and give presentations on the industry and career opportunities. In addition, local companies could offer field trips for students to see first hand how mining operations work. These would have the dual benefit of dispelling misconceptions about the industry while introducing students to technical career opportunities.

- **Seminars** - Mining companies can provide seminars at local universities on topics such as the mining industry in general, technologies used in mining, environmental restoration in mining, and other topics of interest. These would help to educate students on the industry as well as create interest on diverse career paths that could be pursued.

Cooperative research and business relationships between universities and the industry can also be established and/or expanded. For example, students can participate as interns or apprentices. In addition, cooperative research centers can be established with students participating directly in the research. Each of these activities will provide students with direct exposure to the industry as well as provide an avenue for job opportunities upon graduation.

In addition, industry should increase its recruiting activities at local high schools and universities to both educate and create new interest among students. By focusing on obtaining employees locally, it will have the added benefit of supporting local economies in the mining community.

Industry Coalitions

Several strategies can be employed to improve education in mining on a more focused basis. This includes the development of industry coalitions or advisory groups. These coalitions can address specific topics such as developing and maintaining rewarding careers, or they may focus on other key topics as well.

One example of such an activity includes convening a panel of mining company executives to address the need to ensure a sufficient and well-prepared workforce for the future of the industry. The panel should include industry decision makers that can affect change and can implement specific activities to

address the need. Similarly, corporate roundtables can be established to focus on topical needs related to education in mining and to ensure positive career opportunities. A similar strategy is discussed the in the section on Flexible Curricula.

Ensuring a Stable and Profitable Future for the Mining Industry

Fundamental to maintaining challenging and rewarding careers is the need to maintain the economic viability and profitability of the industry. An industry that is perceived as having economic opportunity – a source of a well-paying and stable career – will be more enticing to students. Many of the activities to make this a reality are outside the traditional scope of improving education in mining; however, several strategies identified include:

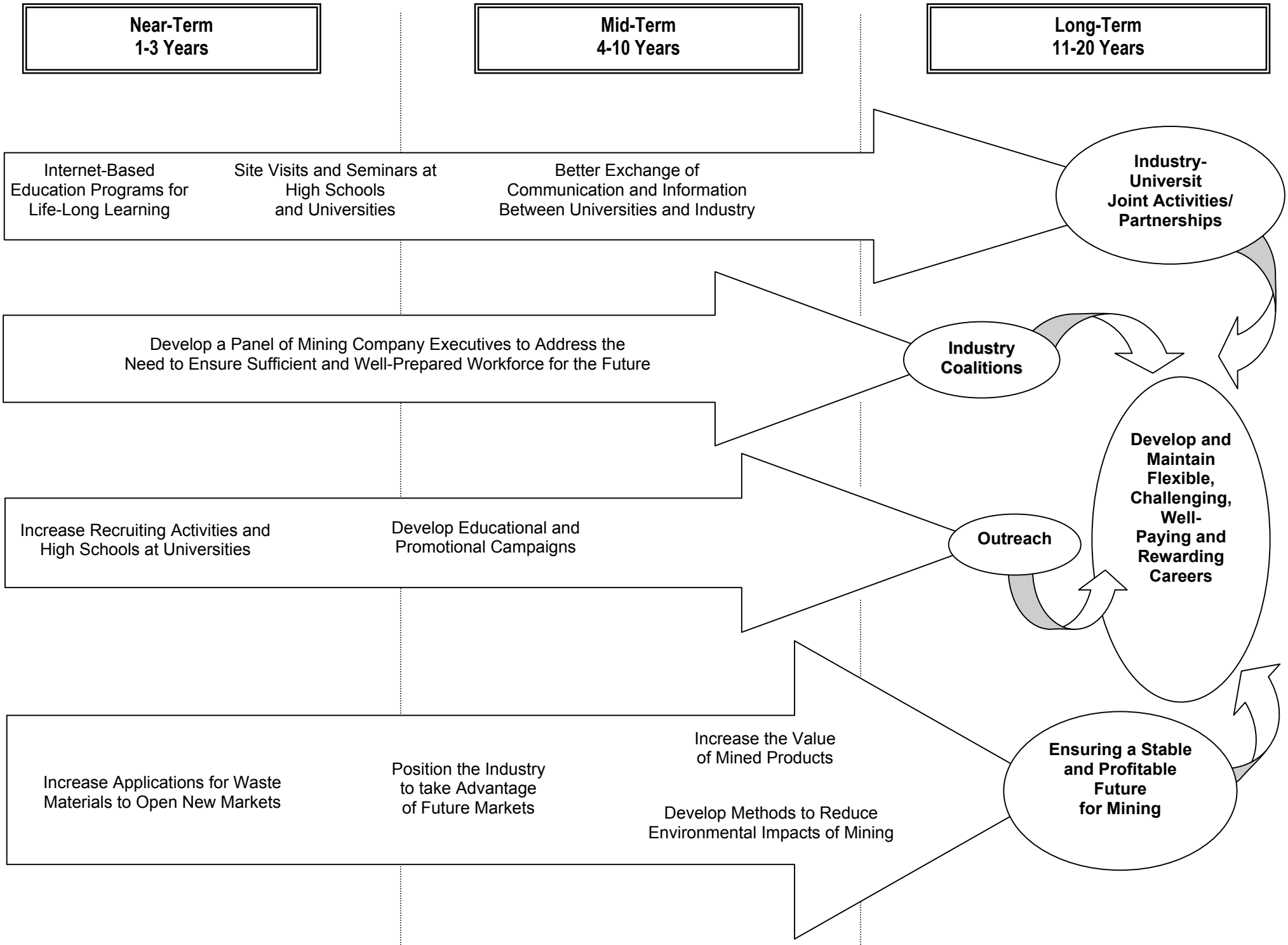
- Developing increased applications for waste materials generated in mining. This will generate additional income and reduce waste management requirements and costs.

- Increasing the value of mined products to command a better price and to open new markets. This may involve engineering material properties of mined commodities to add value.

- Identifying methods to reduce the environmental impacts of mining, thereby reducing the environmental costs of mining and improving overall profitability.

- Positioning the industry to take advantage of future market demands. This will require conducting R&D that is anticipatory and not reactionary – R&D that is directed to where the market is going to be in the future

Exhibit 5. Career Opportunities



ACHIEVING OUR GOALS

Through the successful implementation of activities charted in this roadmap the mining industry seeks to achieve important objectives in three focus areas:

- *To develop flexible curricula that can adapt to societal needs.*
- *To develop and maintain flexible, challenging, well-paying and rewarding careers.*
- *To educate the public, university level, and secondary level about the modern image of mining.*

These goals will be achieved only through continued partnerships between industry, government, and academia. For these partnerships to remain strong, it is critical that each member of the partnerships understands the others' priorities and values. A major purpose of this roadmap is to demonstrate the dependencies and highlight the interrelationships among them. Also, achieving these goals will result in attracting more students to mining and mineral related careers.

Within the discussions of these three objectives, two key factors are continuously stressed. The first is flexibility. Flexibility is needed to meet the changing needs of society. Societal demands range widely from material needs for maintaining the standard of living to environmentally friendly practices. Mining professionals must have the flexibility in their education and careers to meet all of society's needs. Flexibility is also a key component to maintaining career opportunities. Career flexibility for mining engineers allows them to participate in all aspects of mining from exploration and mining planning to mineral extraction, processing and finally mine closure. It also allows mining engineers to branch into other areas of mining such as business issues or to work in foreign markets. Flexibility is also a strong highlight for the outreach campaign. Flexible curriculum and careers are selling points in mining outreach activities.

The other factor continuously stressed is cooperation. Cooperation between government, educators, and, most importantly, industry is necessary to meet the objectives in this roadmap. There are many examples in this roadmap of suggestions as to how the mining industry can better cooperate. Without cooperation from all entities in the mining industry the objectives for this Roadmap will not be successful. Through this effort to map out its own education strategy, the U.S. mining industry has provided the means for the entire mining community to find applications for many efforts to improve education of students, workers, and the public. ABET has already started in this process by developing new criteria that expects curricular managers to develop a continuous dialogue with industry and professionals resulting in program goals to producing professionals ready to meet industries needs. The mining industry's unique compact size will help establish this dialogue.