

**CONCEPTUAL DESIGN FOR A RADICALLY SMALLER,
HIGHLY ADAPTIVE AND APPLICATION-FLEXIBLE
MINING MACHINE FOR UTILITY AND
DEVELOPMENT WORK**

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Final Technical Report

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ABSTRACT

The aim of this research project was to develop a preliminary “conceptual design” for a radically smaller, highly adaptive and application-flexible underground coal mining machine, for performing non-production utility work and/or also undertake limited production mining for the recovery of reserves that would otherwise be lost. Whereas historically, mining philosophies have reflected a shift to increasing larger mechanized systems [such as the continuous miner (CM)], specific mining operations that do not benefit from the economy of the large mining equipment are often ignored or addressed with significant inefficiencies. Developing this prototype concept will create a new class of equipment that can provide opportunities to re-think the very structure of the mining system across a broad range of possibilities, not able to be met by existing machinery.

The approach involved pooling the collective input from mining professionals, using a structured listing of desired inputs in the form of a questionnaire, which was used to define the range of desired design specifications. From these inputs, a conceptual specification was blended, by the author, to embody the general concurrence of mission concepts for this machine.

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1.0 INTRODUCTION

1.1 Background and Historical Prospective

Deep coal mining in the United States has progressed through a continuous and varied evolutionary trend that has sought to increasingly mechanize and automate a process, in an industry whose roots have epitomized the struggles of a historically labor-intensive pursuit.

Traditionally, underground coal operations have involved staffing levels that challenged the imagination to envision the disproportionately large (by today's standards) mass of workers deployed in underground workings in all manner of both face-mining applications and outby support activities.

Productivity for the mine owners was achieved through a mix of exploiting the availability of cheap labor, minimizing the requisite complexity of the necessary capital equipment, standardizing the training and support logistics and fully exploiting both the economic and social limits of a permissive and under-regulated industrial environment. Adopting a technological utilization approach that required the actual work of mining to occur across a multitude of separate working sites (active faces) within the mine, allowed for an overall decentralization of the operation and reduced the contributory importance of any one production site or individual.

Operating many autonomous units, collectively, allowed greater latitude in the management of the mining operation. All that was required was only a broad and often very simplified plan for the development of the reserve. The criteria for engineering decisions were principally involved with the limits and the constraints of just the human factor. At the relatively slow rates at which mining advanced the limits of the workings, time was available to assess and react to economic and geologic changing conditions. This allowed the development of the mine to be modified as the need of the changing conditions required. Within this adaptive framework, main haulage roads were logically developed to provide optimal grades (downhill) for loaded rolling stock. Main and subheadings were oriented to facilitate the coal cutting at the working faces. Panels were pitched to keep the faces self-draining and the geometry of the operation itself was scaled and configured to the minimum dimensions adaptable to the worker when it was necessary to contend with adverse conditions in localized areas of the mine.

As a response to changing economic and social conditions, mining was required to contend with (or succumb to), the same changes that swept most other heavy production industry. The most notable were a shift to more capially intensive and increasing mechanized equipment. With the availability of a broad range of advances rapidly being developed in other industrial arenas, the inevitable shift was to a technology that could provide great labor-saving operations. Initially, the mechanization approach within the mining industry was one that sought to replicate mechanically and in close kind, the human activities that they were envisioned to replace.

In the conventional room-and-pillar operations, the coal faces were drilled, undercut, explosively shot and then hand loaded. Individual machines were developed that were designed to replicate and automate these familiar operations. Automated drilling replaced hand/breast auger drilling. The laborious hand pick-work gave way to the mechanical ripping of the necessary under-cuts or

side-cuts. Equipment was developed to mechanically scrape the bottoms and load the muck pile into waiting cars to be hauled by electric locomotives instead of the physical drudgery of hand labor. These mechanizations were readily adopted and incorporated with little change to the mining plan, initially trading productivity for people. What was lost in the selectivity of the old process was gained by adopting the overwhelming economy of scale that came with the application of new technologies. Traditional methods of mining coal seams of undulating and pitching thickness and of variable roof competencies resulted in a mine plan whose maps could be readily interpreted to deduce the geologic influences that were at work. This gave way to rigid systems of uniform lattice-works that unvaryingly plowed to the limits of their intended (and economic) reach by often just bulling through the changing conditions as they came.

This trend toward an increasing reliance on an automated mining methodology in the face areas ultimately evolved into the various forms of the continuous mining machine (CM). The CMs represented a radical philosophical departure, and left behind the “conventional” manual mining methods. These machines embodied an aggregate of the finite and separate attributes of the former highly specific smaller and lighter equipment, with those of one whose function incorporates the individual tasks in a single unit. With the ability and requirement to tram from several alternating mined locations now within a “face area”, it could cut, load, augment ventilation and even support the roof with an array of integrated appendages that added capability, complexity, size, weight and cost.

By trading hand labor for horsepower, the CM changed the way mine reserves were exploited. The mine evolved from a low-tech “collective hive” of effort, to an individual focus of highly directed development around the needs of the CM. Each CM unit within a mine recovered its own apportioned domain of reserves at the cost of directly trading mechanization for flexibility. The objective was increased productivity in an attempt to optimize profits. However, in mine development planning, one is constantly faced with the understanding that the optimization of profitability via productivity may do so at the expense of both the overall recovery of the available reserves and/or the ultimate potential life of the operation.

It is the inherent loss of the flexibility in operational control that is the basis for this investigation. This flexibility has been eroded across many fronts to the degree that the CM dictates what, where, and how reserves can and will be recovered. The functionary role of the operation itself becomes one of direct support and facilitation for the process.

Mine planning becomes a process of assessing the economic viability of the venture based less on the geologic and societal conditions that prevail and more on the engineering mechanisms and requisites that must be satisfied.

It would be foolish to advocate that the economy of scale and the inherent safety aspects of the CM should be disregarded. However, it should be recognized that a sacrifice was made to achieve a technologic and economic end. The application of CMs allowed the industry to deal with a changing market place that continues to evolve in deference to various constraints. The technological revolution in mining has moved on to increasingly embrace the longwall (LW) philosophy with the even greater productive gains, and increasing losses in system flexibility and recovery.

Regardless of how mechanized and technically complex an operation becomes, it is worthwhile to remember that it still just a coal mine. This means that it continues to share with the technologic generations that have preceded it, a commonality of mission, of environment, and of geology. At the fundamental level, a wide range of various basic operational and often mundane needs must be met on a daily basis as in the past. These needs are often made more acute by the inability to readily recover lost reserves. In many cases it is important to reflect that they were in fact not lost, they were traded.

Forced to be tethered to the demands of its hydraulic and electric components, CM mines and now longwall (LW) mines (and their support equipment) have become an evolving complex network of power distribution systems. Power demands are constantly shifting toward higher and more efficient voltages requiring increasingly complicated, mandated and regulated ancillary and support equipment. Workers, which at one time could be readily shifted to start-up a new mining section in a mine within a few days, can today take weeks to establish a new CM section, and potentially months for a LW mine.

When looking at a mine as a whole, it is first and foremost a business, which at the forefront is principally involved with the process of cutting coal and rock. To that end it has increasingly vested and centralized this function within the domain of a single class of machine. Although supported by a myriad of ancillary and specialized equipment, the CM (and certainly the LW) is fundamentally in the business of wholesale extraction, within a necessary economy of scale that precludes, inhibits and/or prevents its use in other than its primary mission.

From time to time, (as it always has in coal mines) is the need for general utility cutting, selective mining, trimming, excavation, grading, cutting and loading or trenching of coal, roof or bottoms at removed sites (or those intentionally passed by) the active working places. To do so would require the repositioning of a CM to an outby location (to handle those issues), which could be cost effective and/or logistically possible.

Self-propelled mechanized scoops and transports have bridged the gap to eliminate a range of manual labor. However, applications involving utility cutting/selective mining needs (as cited above) are often ignored. To meet these needs the operation is required to resort to using misapplied equipment, throwback technologies or antiquated equipment with their inherent inefficiencies and safety risks.

1.2 Technical Approach and Scientific Method

The concept that was proposed under this research was to develop a preliminary “conceptual design” for a radically smaller, highly adaptive and application-flexible mining machine, to meet the needs for performing general utility work. In addition it would be potentially able to perform limited development or secondary recovery work in coal mines. In so doing it would increase the overall recovery of reserves that would otherwise be lost.

The objective is to develop a machine that will support innovative and alternative mine design(s), augment recovery capability and/or permit the performance of utility applications not able to be met by existing machinery. It was not envisioned to be a cost-competitive substitute

for CM mining equipment, but rather an attempt to broaden the collective equipment operational envelope.

In the mechanization process in underground mining, productivity increases have resulted from optimizing standardized machine capabilities within efficient mining methodologies. The trend has generally been toward larger equipment, greater mechanical availability, increased power and higher total throughput capability. These operations, in turn have become increasingly reliant on the need to operate in relatively thick and uniform condition coal seams.

The logistical equipment constraints of the CM directly controls the specific mine geometry of entry widths, minimum seam heights, entry intersection spans, turnouts and necessary roof support considerations. More importantly, it also dictates where within the mine the equipment can or can't be deployed. These constraints include; power availability; cable distance limitations; the need to stay in production cycle and the required quality criteria of reserves. As an indirect result, the operating constraints also limit what roles are relegated to the function of a CM no matter how immediately pressing the need. These include; outby utility work such as cutting sumps or overcasts; trimming rib and top for beltlines; and taking bottoms for roadways or cleaning roof falls.

What has been traded away is operational flexibility that would permit a responsive adaptation to a range of changing conditions and constraints. Current economic and societal pressures are requiring a second look to mining thinner coal seams. Where the practicality of implementing LW systems is not justified, the potential role of conventional CM mining scenarios has again come to consideration. Where the practicality of implementing CM systems is not justified, a viable alternative is lacking.

Although the mining industry has an extensive professional technical experience base, mining equipment manufacturers who have met the demands of the recent industry trends, may be ill prepared, to meet the downscaled design requirements of this changing economic environment. The deliverable sought to be developed from this project is a conceptual mining machine design that will be the first highly flexible concept-design that could directly lead to the production of a prototype.

The study methodology involved pooling the collective input of a broad base of qualified opinions garnered from a cross-section of mining professionals using a highly structured question/feedback process. The process was crafted to draw upon a range of individual expertise, and designed to assess and elicit responses to questions that were developed to focus directly on, and stimulate innovative thought and problem solving.

The following concepts were incorporated in the development of the questionnaire:

1. The range of applications or objectives currently not met with conventional CM equipment.
2. The state of development and/or availability of alternative technologies.

3. The required ideal performance criteria to meet the technical parameters.
4. An assessment of immediate applicability and projected use.
5. The projected impact in the industry as the “concept” equipment gains widespread acceptance.

The initial responses were compiled into a “preliminary design-concept”. A follow-up interview with respondents was considered to elicit strengths and weakness of the aggregated design concept but this effort met with limited success.

A final design concept was then developed along with supporting documentation of the approach, reasoning and evaluative methods of the project. To that end the following tasks were performed:

1. Preliminary research to acquire background data on the “state-of-the-industry” by investigating mining trends, current methods, strategic plans and current R&D.
2. Identify current industrial and operational philosophies to identifying the range of “drivers and constraints” that would support or impede technologic implementation.
3. Identify the participants and strategy for optimizing feedback contact and effectiveness.
4. Structure and define the overall approach, the issues, and the applications, define the query scenarios to be developed, formulate the questionnaire, and analyze inputs into a composite of the industry viewpoints.
5. Develop and implement the follow-up interviews.
6. Prioritize the findings and compile the resultant design-concepts and design-criteria.
7. Author the final report as required and make recommendations on prioritized topics of subsequent research, equipment development, utilization strategies and implementation/market opportunities.

1.3 Energy and Economic Benefits

Underground coal mining is an energy intensive process whose economic viability is impacted by how much of the expended energy expense per unit cost can be shifted into alternative and lower cost methodologies.

This has traditionally been met with the evolution toward larger CM mining systems that incorporate increasing economies of scale. These larger systems require increasingly consistent geologic roof and bottom conditions, uniform seam characteristics, and favorable environmental

conditions to assure a high confidence for production projections. When challenged to adapt to a shift in these conditions, the logistical limitations and the inherent “inertia” of these “large” systems directly impact their competitive abilities. This is the current condition in the mining industry, a condition that has dramatically occurred several times in the 1900’s.

The benefits afforded by developing a radically smaller, highly adaptive and application-flexible mining machine for utility and development work in coal mines will be an important outcome of meeting the objective of this study. It will create a new class of equipment that can provide opportunities to re-think the very structure of the mining system. The opportunities include:

1. The ability to potentially mine new and/or under-utilized coal reserves within an existing mine at locations where coal thickness vary suddenly and/or excessive rock would have to be taken to economically recover. Trying to do this today overstresses equipment, keeps it from more profitable utilization, and it increases downstream separation costs. Often these areas and the recoverable coal that lay beyond it are excluded from development and become permanent unrecoverable reserves. Having the ability to permit the mining cycle to by-pass these areas and relegate recovery to a more selective process, would optimize resource recovery.

It is estimated that over 13 billion tons of “sacrificed reserves” in the U.S. could be mined, if afforded the ability to utilize the utility CM miner envisioned in this study.

2. In CM operations the ability to reposition the CM unit to a location other than the immediate mine faces at which it is scheduled to work, involves onerous logistics. Required utility work has to be planned for “on advance” with few opportunities to redirect mine plan considerations if conditions dictate. Having the ability to deal with changes adds flexibility in adapting the overall mine plans, and the ability to efficiently perform tasks such as localized mining, cutting sumps and ditching, trimming ribs for beltlines, taking up bottoms for roadways and cutting overcasts, etc.
3. The actual overall recovery of coal tonnages that exist within the mined areas developed using CM operations typically ranges only from 50-55% even in mines that employ full pillar recovery. Although coal is required to be left intentionally for surface support considerations, some of the loss is a function of logistical inefficiencies that prevent economic recovery with conventional equipment. With the ability to maximize recovery using innovative secondary recovery techniques, mine life would be extended, operating unit costs would be reduced and the overall recovery efficiency would be increased. It is estimated that if overall recovery of CM mines in the US could be increased by only 1% with an adaptive mining system, it would translate to 1.75 million tons each year of saleable reserves.
4. CM mining advance rates is the primary goal to meet critical schedule milestones (as in developing headgate and tailgate entries to support the development of a

LW panel). The volume of coal required to be mined per foot of advance and the production capability of the CM unit dictate the daily advance rate. If varying entry sizes could reduce the volume of mined coal required per foot of advance, the overall rate of advance would be increased. This could be achieved by minimizing entry widths and heights within the limits of conventional CM equipment to achieve the desired rate of advance, while permitting future entry geometry modifications to be performed by the utility equipment at a less critical point in time.

By permitting entry geometries that utilize the ability to contend with non-uniformity, the productive losses associated with delaying the “critical paths” of high output production units can be reduced.

5. In conventional CM mining, vast numbers of entries and intersections are required to be created whose dimensional control dictates the roof support requirements. Where appropriate, the ability to reduce entry widths and intersection spans by a utility miner would reduce the unit cost for roof support and ventilation controls and provide for improved health and safety as an indirect benefit.
6. The ability to provide and stimulate new commercial opportunities, sales volumes and the creation of downstream businesses and support services

Overall, the development of this unique mining machine with the application of appropriate strategies will serve to enhance industry competitiveness, increase recovery of coal reserves, reduce the unit cost of production and stimulate downstream business and support services.

The concept should provide a range of capability and mission potential beyond that which is currently used or supported by current operating practices and/or is available using the commercial equipment capabilities deployed across the range of deep mining coal operations.

This concept machine will support innovative, alternative mine design(s) and/or utility applications not able to be met by existing machinery over as broad a segment of the varied mining operations and operating practices as possible within the current industry. It is intended to stimulate the development of reserves not routinely recovered. The unit will be able to be deployed without the usual logistical problems encountered in recovery work. The deliverable of this project is a design specification that will be a highly flexible concept-design that could lead to production of a prototype.

2.0 EXECUTIVE SUMMARY

The concept that was proposed under this research was to develop a preliminary “conceptual design” for a radically smaller, highly adaptive and application-flexible underground coal-mining machine, to perform general utility work and/or undertake limited production mining for the recovery of reserves that would otherwise be lost. Often these reserves and the potential coal that lay beyond it are excluded from development and become permanently unrecoverable reserves. It is estimated that if overall recovery of CM mines in the US could be increased by only 1% with an adaptive mining system, an additional 1.75 million tons of saleable reserves each year would be realized.

Historically, mining philosophies have reflected a shift to both capitally intensive and progressively mechanized equipment that incorporate increasing economies of scale. At the fundamental level, a wide range of various basic operational and often mundane mining and cutting needs must be met on a daily basis, often made more acute by the inability to be readily addressed with existing equipment. To meet these needs, the mine operation often resorts to using either misapplied equipment that overstresses machinery, keeps it from more profitable utilization, increases downstream separation costs or uses throw-back or antiquated equipment with its inherent inefficiencies and safety risks.

Developing this prototype concept will create a new class of equipment that can provide opportunities to redesign the mining system across a broad range of possibilities. This machine could support innovative and alternative mine design(s) thereby augmenting recovery capability and provide utility applications not able to be met by existing machinery. The latter would include the recovery of under-utilized coal reserves, achieve rates of mining advance, reduce costs for roof support and ventilation and, provide improved health and safety conditions. This would in the end stimulate downstream business and support services.

The approach involved the design and development of a questionnaire, which sought to define industry applications or objectives currently not met, the availability of alternative technologies, specific performance criteria, the range of applicability and the projected industry impact. The pooled collective input of responses to this questionnaire, by mining professionals, was used to define the range of desired design specifications. A conceptual specification was blended to embody the general concurrence of mission concepts for this machine by the respondents as well as the author's.

The conceptualization depicts the prototype as an exceedingly low, but robust machine, along the lines of a familiar but scaled-down continuous miner (CM). The design would utilize a conventional drum and bit cutter technology, complete with gathering arms, integral conveyor and the ability to be operated by remote and wireless control. The unit would tram on exceptionally wide track caterpillar-type treads, be provided with directional dust suppression and air moving sprays and be equipped with an integral scrubber. The similarity to a familiar CM configuration is believed to reflect both the operational familiarity and reliability confidence in the contemporary configuration of CM machines by the respondents.

However, notable variants from conventional CM equipment are the potential load-out capabilities utilizing three separate modes of operation. These are: i) the use of a conventional articulated conveyor boom to meet the high production capabilities envisioned for the machine when used in the normal production cycle; ii) the utilization of a readily adaptable, light and extensible conveyor system that would be used to meet less demanding operations; and iii) the ability to discharge into a self-towed bucket-type haul cart to meet low-demand mining.

A similar departure from a conventional CM is the potential for this equipment to be energized by two separate modes. One mode would utilize 1000-volt ac trailing power cables, with the ability to be easily disconnected, both mechanically and electrically, to facilitate machine transport and switch input feeds from alternate power sources. When desired, for tramming and limited cutting, the equipment would be energized by utilizing self-contained batteries. Additional design provisions could be incorporated, that would allow for easy charging and/or battery module change-out. Multiple auxiliary battery modules, to be carried by the haul cart, could be similarly adapted, to provide a greater capacity and/or extended run times.

The desired operating performance built into the concept includes capabilities to take 10-foot box cuts with a 10-foot reach, deep cutting to 35-40 feet and throughput production approaching 15 tons/minute. The prototype would also have limited capabilities to self transport within the mine, have no automated temporary roof support system or integral bolters and require only a one-man crew for operation. A payback period of less than 5 years at a rate of return of 15 – 25 % would also be desirable. A conceptualized drawing, incorporating these salient attributes, is included with this report even though it was not requested as part of the scope of work.

3.0 EXPERIMENTAL

3.1 General Approach

In an attempt to meet the general needs of this research, and in so doing develop the questionnaire, Advanced Technology Systems, Inc. (*ATS*) performed the following:

1. Researched and categorized the potential range of usage for an ultimate design specification(s) based on experience and familiarity with the problems to be resolved. To that end, efforts were directed toward the following tasks:
 - a. Identified the limiting logistical and environmental constraints with respect to:
 - i. Geologic conditions to be encountered
 - ii. Environmental constraint
 - iii. Safety considerations
 - iv. Operational requirements
 - v. Logistical issues
 - vi. Commercial requirements
 - vii. Ideological issues
 - b. Became familiar with current mining practices
 - c. Reviewed historical mining practices
 - d. Researched historical equipment
 - e. Identified current equipment resources
 - f. Investigated legal requisites, restrictions and/or impediments
2. Structured a direct comprehensive questionnaire that sought to address issues and requirements related to:
 - a. Mining new and/or under-utilized coal reserves
 - b. The ability to easily relocate the unit.
 - c. Addressing the potential for secondary coal recovery.
 - d. Identifying the critical rates of advance.
 - e. The potential to impact the unit cost for roof support and ventilation controls.
 - f. The potential for improved health, safety, and business and support services.
 - g. Applications or objectives currently not met with conventional CM equipment.
 - h. The state of development and/or availability of alternative technologies.
 - i. The required ideal performance criteria(s) to meet the technical parameters.

- j. The level of immediate applicability and projected use.
 - k. The projected impact, as the “concept” equipment gain widespread acceptance
- 3. Organized, and assimilated application specific ideas within the mining industry and ultimately pooling the collective input of a broad base of qualified opinions using a highly structured mining oriented question/feedback/interview process.
 - 4. Assimilated the data from the above to arrive at a workable preliminary (and ultimately a final) design specification within the framework of restrictions imposed by these tasks.

3.2 Questionnaire Development:

To address the research requirements of this project, the general issues and requisites that have been identified and outlined above were systematically reviewed and then organized in a comprehensive format that ultimately evolved into a questionnaire. This document underwent several internal revisions in content and formatting intended to facilitate the coding of the response, and was accompanied by a cover letter (See Appendix Item A) intended to elicit a desire to participate in this research.

Overall, the questionnaire (See Appendix Item B) was structured and organized to address an array of issues that sought to gain input in the following areas:

1. Geology

At issue were the desired type and condition of in-seam materials that would need to be cut with specific considerations as to material hardness, seam heights, in-seam conditions and the uniformity of conditions.

2. Environmental

At issue were the desired specific environmental controls that were of principal importance to be included and control operating dust levels and methane liberation.

3. Safety

At issue were the desired specific roof support considerations that would need to be addressed, including how best to incorporate the operator interfaces for the machine (e.g. manual/remote). What integral safety systems should be designed into the unit and the range of operating voltages/pressures?

4. Operational

At issue were the desired utilization operating parameters needed for the unit that included crew size, where in the mine and for which jobs it was foreseen to be used, how it might be powered, how it should be able to be transported within the mine and the anticipated cutting technology.

5. Logistical

At issue were the desired functionary role for the machine as fundamentally either a utility or a production unit and the equipment mission and optimization goals, the physical size, operating and performance envelope, ancillary capabilities in loading conveying capability and overall flexibility (adaptable for multi-functionary purposes or purpose-built for unique applications).

6. Commercial

At issue were the desired commercial considerations that would impact areas of financial returns, their drivers and the suitability of available equipment alternatives.

7. Ideological

At issue were the concerns related to the anticipated marketplace need, market desirability of the product, how quickly it might be expected to gain applicability and what industrial or operational philosophies might be expected to either drive the project or impede industry-wide implementation.

3.3 Questionnaire Database

Considerable efforts were made to identify individuals with the necessary experience base required for polling on this research. To that end various attempts were initially investigated that included, a wide offering of commercially available database lists, registered internet groups of coal mining professionals, trade and industrial groups, lists that had been identified as associated with various industry sponsorships, technical and periodical publication lists of subscribers and various industrial manufacturer listings.

Several of these databases were unfortunately found to be significantly deficient in that they lacked critical information or completeness concerning either the individuals or organizations that were deemed necessary to meet the logistical requirements of the project.

Other commercial databases were being offered on a purchase-basis, at unreasonable rates, with little assurance that they would satisfy the project needs. Others were restricted from external release by the organizations that controlled them due to standing membership agreements, privacy or commercial restrictions.

It was also found that some organizations (which controlled databases of definite significant interest), were reluctant to otherwise participate in discussions that might be construed as involving conflict of interest due to their line of business

It was ultimately decided that the most reasonable, efficient and cost-effective approach, was to primarily solicit input from the coal mine operations themselves. The coal mines were recognized as having more of a vested interest in the outcome of this research and could potentially contain the largest assemblage of mining professionals at known addresses.

To that end, several different databases that could potentially yield the information on both the current active mine operations and those critical individuals within those organizations that could be queried were investigated. Recognizing that overlap and thus duplication were possible (and inevitable), several large national commercial and governmental databases were identified, and purchased. These were then assembled into one master listing. This master listing was sorted against (and by) key fields such as mine type, mine permit number, regional location, corporate entity and key individual(s) or points of contact.

These databases were ultimately uploaded into a formatted master database, which could accept the range of available input fields. The master database underwent multiple cross-sorting into various preliminary listings, which in turn were then compared to other compiled listings of similar formats. The intent was to eliminate redundancies, internal errors, and non-applicable records and maintain a reasonable confidence as to accuracy of information. As a result, approximately four-hundred (400) contact recipients were identified. These contacts were nationally represented and associated with direct involvement at active deep coal-mine operations.

4.0 RESULTS & DISCUSSION

4.1 Summary of the Resultant Questionnaire Responses

On review of the responses to the questionnaire, abstracts of the information were organized into desired specification criteria relating to the design of the prototype-mining machine. These data were then assimilated and responses grouped into the category criteria of the questionnaire and are presented below:

1. Geology

As anticipated, little agreement was found among respondents as to the desired capabilities in addressing variant in-seam coal geology, maximum and minimum seam thicknesses, anticipated cutting hardness's and/or the need to make allowances for cleat orientations. This variability was attributed to the fact that the interests expressed reflected one that was associated with the respondents own operation which could reasonably be expected to vary from mine to mine as it varies from commercial seam to commercial seam. The range of response was felt to be consistent with this variability of the operations, which in turn are dependent on reasonably competent and stable commercial conditions for a mine to exist profitably in the first place. As such, competent slate strata were anticipated for the immediate roof and as bottom strata, the machine would also have to contend with wet or soft bottoms at times, but that conditions overall were anticipated to be somewhat uniform.

2. Environmental

The specific environmental controls that were identified of principal importance to be included were those associated with the need to impact and control operating dust levels. It was seen that water suppressions systems were favored to be used in conjunction with conventional brattice controls, supported by on-board integral scrubber capabilities.

Issues concerned with methane liberation considerations were not held as a necessary component capability for the prototype and the use of diffuser sprays were not deemed important in deference to conventional ventilation controls.

3. Safety

The desired specific roof support considerations that would of course need to be addressed were not of interest as auxiliary capabilities of the machine. Integral bolting capability was not desired in deference to using a separate bolting, stoppering, posting or cribbing operations. The unit was clearly seen as a stand-alone unit in this regard and an Automated Temporary Roof Support (ATRS) capability was similarly rejected.

In terms of the desired operator interfaces for the machine (e.g. manual/remote), the overwhelmingly response was to have the unit remotely operated. The sole provision for operating the prototype was somewhat split among either control by means of a wireless remote,

utilizing an umbilical remote and/or having provisions for a combination of both. Provisions for an on-board operator's position were clearly not desired.

The potential for utilizing the prototype at the active working face of a production section was in full accordance with the respondents. This clearly recognized the need for full permissibility compliance. The power would be supplied at 1000 volts / ac (presumably the available face voltages for the respondents operations). The working hydraulic pressures that were desired were found to be consistent with the common 3000-4000 psi mid-range working pressures.

4. Operational

Although not a direct design criteria of the equipment, respondents were split as to the question of crew size and reflected the potential need for a helper in addition to that of a sole operator.

In terms of outby utility work, responses were varied, but were believed to reflect the specific operations needs for utility work. As an example, manholes (as mandated by law) are needed in coal mines in rare and often unique instances. The elected choice to construct an undercast (similarly rarely seen) in deference to overcast can be one of judgment philosophy. Negative responses in these instances were construed to reflect lack of previous occurrence or experience. The similar negative response to address the more common widespread need to perform roof scaling revealed a need for more fundamental design criteria, as it was expressed in the responses. It was indicated that the principal outby utility work that was envisioned for the prototype would be in addressing such issues such as cleaning up falls, construction of overcasts, digging sumps and to a limited degree, roadway maintenance and construction. The roof-related issues were not deemed important at all and maintaining escape-ways while constructing manholes and undercasts (as above) and trenching showing only a slightly greater need.

Surprisingly, the prototype was seen to have little desired applications for stand-alone and removed mining locations (such as driving air connections). It was overwhelmingly desired that the machine be capable of being utilized in the production cycle for both high advance rate mining as well as secondary recovery at active face areas. This desired ability to participate in the production cycle at sustained levels of elevated throughput (a true production machine) could conceivably offer an opportunity to provide for a variant prototype more aligned with production capabilities than principally utility requirements.

Although battery power for the prototype was envisioned as a desirable option, the extended run capabilities that were cited as desired were those commensurate with sustained levels necessary for production shift work. To meet these demands, respondents similarly identified equipment as requiring removable battery packs to achieve this capability. However, it appears that a dual mode of energizing the prototype was also envisioned. The need to afford the equipment with trailing cables of 800-1000 feet (in conjunction with battery operation) were deemed as a necessary practical function and wanted them supplied with load-center ac voltages of 1000 volts (as cited above). Surprisingly, alternative means of powering (e.g. diesel variants) were overwhelmingly cited as not desired.

The ability to be self transportable from place to place (as opposed to loading and hauling or towed) was only of moderate importance. Self-tramming capabilities were envisioned, with caterpillar drive seen as the most favorable over tires or skids.

In terms of the anticipated cutting technology to be incorporated, mechanical rotating systems of drums and bits was the favored scenario, with some consideration given to the potential for ripper chain cutting. There was expressed almost no interest for alternative and/or variant innovative technologies such as percussive or water jet cutting.

5. Logistical

As cited above, principal desired interest of the prototype was envisioned to be both in and outside of the production cycle at active face areas and to be capable of being operated in outby areas as well. In addition the “equipment mission” was clearly depicted as being desired to be broadly flexible. The design would not limit one arena of potential optimization (e.g. overall recovery of reserves) over that of another desirable optimization function role (e.g. that of throughput production). It is interpreted that the desired functional role for the machine is as both a utility and a production unit with inherent overall flexibility i.e. adaptable for multi-functional purposes rather than purpose-built for unique applications.

To achieve that end, there was good agreement that, minimum cutting height would be required to be slightly less than 3 feet. Surprisingly a fair spread in the maximum reach seen as desirable approached 10 feet, but there was very close agreement that cutting below grade capability did not need to exceed 1 foot.

When deployed in sump cuts, a minimum limit of approximately 10 feet was deemed practical with capabilities to take deep box cuts to 35-40 feet consistent with conventional CM equipment.

Overall machine dimensions envision the height of the machine to be slightly above 2 feet, with a width approximately 10-12 feet with less specific and highly variable estimates given in overall weight (tons) and ground loading (psi).

Desired production rates as anticipated were variable and dependent on the intended use philosophy of the respondent, but overall reflected desirable production rates that averaged about 15 tons per minute in active mining

Tram speed was not a focus of respondent attention, but there were definite interest in considering mucking, conveying and loading/transport issues for which gathering heads in conjunction with an integral chain conveyor coupled to an extensible bridge would be required.

6. Commercial

Commercial responses indicated that the prototype would definitely be considered a significant component of profitability and not relegated to an overhead expense to be borne by the operation. Desired payback periods and rates of return on invested capital were projected at

levels consistent with principal mining production capital equipment with the prototype assuming a similar functionary role.

7. Ideological

Overall, the anticipated marketplace need was seen as being of desirable consideration whose ultimate value would be driven by the financial constraints or incentives that might present themselves in the coal market.

The prototype was viewed as having significant merit in its potential to expand the envelope of capabilities of existing equipment, which are recognized as being limited in some regards. The time required to gain acceptance was tied to the future direction of the industry, the government and the price of coal.

4.2 Summary of Resultant Design Specifications

This area summarizes the responses outlined in an attempt to conceptualize the specific design specifications for the prototype unit. These criteria are:

1. A very low machine with clearance heights of approximately 2 feet and minimum cutting height of lightly less than 3 feet with a width of 10-12 feet capable of operating in uniformly low conditions with competent roof and bottoms.
2. Undercut capability to 1 foot, but above grade reach to be adaptable to 10 feet.
3. Wireless remote control with the potential for a hard-wired umbilical back up.
4. Powered by 1000 volt ac supplied using 800-1000 feet of trailing cable, but with the capability of being battery powered for limited mining use and/or tramming utilizing on-board chargeable and replaceable battery modules.
5. Hydraulic systems to operate at 3000-4000 psi.
6. Onboard dust suppression sprays with and integral dust scrubber provided with rear exhaust.
7. Wide tread caterpillar drive to minimize ground pressures and deal with wet bottoms.
8. Drum and bit cutter drum.
9. Gathering arms mucking.
10. Integral chain conveyor.
11. Load out capability using articulated boom, extensible bridge conveyor or towed self-unloadable haul cart.
12. Minimum depth of box cuts to 10 feet, with desired deep cutting to 35-40 feet.
13. Active mining throughput production approaching 15 tons/minute.

14. Limited capabilities to self transport.
15. No ATRS systems, no integral bolters.
16. Crew consisting of operator and possibly helper (at times), but potential to operate without a helper.
17. Payback periods under 5 years and rates of return 15 – 25 %.

4.3 Description of the Conceptual Illustration

In an attempt to depict an approximate rendering of the machine, consistent with the criteria that had been developed, several design concepts were blended to produce the resultant drawing. This drawing attempts to embody the general concurrence of the study concepts for the machine, into a workable and cogent package. To arrive at the concept drawing, several compromises were necessary to ensure that plausible and non-conflicting ideas were represented in a single rendering. See Appendix Item C

It should be understood that this is a conceptualization and is presented for diagrammatic purposes only. No attempts have been made to predict the operability and/or functional design of the various aspects presented. This would require an engineering analysis, substantive design calculations and technical feasibility analyses. These efforts would be relegated to a scope of work related to preliminary engineering design and feasibility study.

In describing the machine it was necessary (and intended) to show the prototype as an exceedingly low, but robust machine that would be built along the lines of a scaled-down drum-type continuous miner. This similarity and reliance on a conventional pre-existing design, reflects both the operational familiarity and reliability confidence in the widespread contemporary configuration of CM machines by the respondents.

The design would incorporate a conventional drum and bit cutter technology that would be provided with gathering arms, an integral conveyor and would be operated remotely utilizing familiar wireless controls. The unit would tram on wide track caterpillar-type treads, intended to lower the loading of the machine to cope with wet and/or soft bottoms. It would similarly be provided with directional dust suppression and air moving sprays and equipped with an integral scrubber

A notable variant from conventional CM equipment would be the potential load-out utilizing three separate modes of operation. These are as described below:

1. Utilize a conventional articulated conveyor boom for direct loading into a shuttle car, hopper or feeder or to a ground stockpile. This capability would be used to meet the high production capabilities envisioned for the machine when used in the normal production cycle.
2. Utilize a transfer from the boom directly onto a light extensible bottom-mounted conveyor system, which would be easily coupled to the mining machine. The

extensible conveyor would have only a limited reach and would itself be powered directly from the prototype. This capability would be used to meet less demanding mining and clean-up operations, where limited transport is required.

3. Discharge into a readily coupled (and uncoupled) bucket-type haul cart that would be provided with steerable wheels and the ability to self-discharge once loaded. To facilitate an even loading into the cart, the boom could be provided with a retractable skid plate. This capability would be used to meet low-demand mining and clean-up operations where small quantities of material could be acceptably handled and limited transport is required

A similar desirable departure from conventional CM mining equipment that would be provided is the ability to energize the equipment via two separate modes. These are described below:

1. Utilize conventional 1000-volt ac trailing power cables fed from power load centers that are relocated as necessary to provide the necessary reach. The power cable would be terminated at the machine with the gland and strain couplings, but additionally it would be provided with the ability to be easily disconnected. This would permit the unit to be essentially disconnected and reconnected to facilitate machine transport. This capability would be used to meet the high production capabilities envisioned for the machine when used in the normal production cycle.

Energize by self-contained electrical batteries during tramming and cutting when or when trailing power cables are undesirable. It is recognized battery power sources would limit some of the machine operations. This could be offset with design provisions that would allow for quick battery module changing-outs. The following options would be considered:

- i. Spent individual battery modules could be dropped to the bottom from a rear-mounted under-slung battery compartment. The prototype would be able to tram rearward over a charged battery module to load it into the battery compartment.
- ii. On-board battery modules would be charged during period of ac trailing cable operation. They could then provide sustained power output levels for limited time intervals.
- iii. Multiple auxiliary battery modules could be carried by an attached haul cart in order to provide a greater capacity and/or extended run times when operating away from AC sources.

5.0 CONCLUSIONS

The findings from this investigation identified a need for a small production machine of modest throughput capabilities.

An effort was made to incorporate this need in the conceptual design submitted. However scope for this project did not include engineering considerations that would have supported the theoretical design issues presented. This work would have required a substantive engineering analysis and supporting design calculations in order to present the operability design and performance envelope for the prototype. These efforts are of necessity relegated to a scope of work that would permit a preliminary engineering design and feasibility studies and usually associated with a Phase II performance of such a project.

As with the submission of any new idea, the hope here is that the conceptual design submitted will stimulate other creative derivatives that can have an impact across a spectrum of unforeseen applications. The concept prototype will hopefully permit a re-thinking of the basic structure of the mining system introducing a broad range of possibilities.

A production machine with the potential of shifting the criteria limits that separate recoverable and non-recoverable reserves, opens the potential for increased conservation; utilization and profit involving an economy of scale that stretches across the entire underground mining industry. The result would be longer mine lives, reduced operating unit costs and the potential of increased recovery of coal reserves

Overall, having a new opportunity to efficiently address mining requirements with the application of newly developed strategies could enhance industry competitiveness, improve health and safety while clearly stimulating new commercial opportunities, sales volumes and the creation of downstream businesses and support services

6.0 ACKNOWLEDGEMENTS

ATS would like to acknowledge the US DOE (NETL) for funding this study under Grant Award No: DE-FG26-03NT41935

September, 2004

Mr. A.B.C.
ABC Mining Company
P. O. Box 123
Anywhere, PA 12225

Dear Mr. A.B.C.:

The purpose of this unsolicited communication to you is part of a much larger industry wide research that has been undertaken with the specific intent of gathering qualified opinions from informed individuals within the coal-mining industry. The information and feedback you provide will be used in taking the first steps in potentially developing a new class of underground mining machines.

The mission envisioned for this “*conceptual design*” would be a **radically smaller and highly adaptive and application-flexible mining machine** that could be used for specialized utility applications and could potentially be utilized in limited development work in coal mines.

This research is being wholly supported by the Department of Energy – National Energy Technology Laboratory (DOE-NETL) and has no affiliation with equipment manufacturers, mining companies, or other vested interests within the industry.

It is hoped that through this effort, a preliminary specification could be developed by a “needs consensus” that would support innovative, alternative mine design(s) and/or utility applications not able to be met by existing machinery and permitting, such as:

- The development of reserves not routinely recovered
- The ability to operate at removed locations from the face
- The flexibility to be deployed without excessive logistical problems

Your participation in taking a few moments in responding to this inquiry is deeply valued and your expertise and opinions could directly contribute to a design specification for a production prototype.

Please provide input in any (or all) categories of the range of questions, which you feel you can best contribute. Your opinions and ideas will be kept in strict confidence and you can indicate if you would be available to directly discuss concepts in greater depth with the project staff.

September, 2004

Page 2

Thank you again for your input, or in redirecting this questionnaire to the appropriate party. We look forward with great interest to your input and assisting in moving the project to the next level.

Respectfully,

A handwritten signature in black ink, appearing to read "Andrew H. Stern", with a long horizontal flourish extending to the right.

Andrew H. Stern
Project Manager

AS/blm
Enclosures

ATS - CHESTER ENGINEERS

"Solving Tomorrow's Problems Today"™

DOE-NETL CONTRACT REF #DE-PS26-03NT417573

Questionnaire

A conceptual design for a radically smaller, highly adaptive, and application-flexible mining machine for utility and development work for use in underground coal mines.

The following questions will seek to identify the limiting constraints that would define the "design envelope" for a potential prototype.

Please check all applicable responses, which you would deem as a requisite for a potential prototype.

Your efforts are truly appreciated. If the need should arise, would you have objections to being contacted to discuss your responses?

☐ Yes

☐ No

NAME: _____

COMPANY NAME: _____

PHONE: _____

EMAIL: _____

Please return via mail in enclosed envelope

OR

Fax to (412) 967-1911

1. Geology

A. What in-seam materials would be desired to be cut?

i. In-seam bituminous coal

1. Cutting hardness

☐ Soft

☐ Medium

☐ Hard

2. Is cleat orientation a consideration

☐ Yes

☐ No

3. In-seam inclusions

☐ Sandstone

☐ Shale

☐ Clay

ii. Immediate roof

☐ Slate

☐ Sandstone

☐ Other

1. Competent and/or massive

☐ Yes

☐ No

2. Scaly with loose top

☐ Yes

☐ No

3. Heavily fractured and heavy

☐ Yes

☐ No

iii. Bottom material

☐ Shale

☐ Sandstone

☐ Slate

☐ Clay

B. What seam heights would be anticipated to be encountered?

1. Maximum Height

_____ Feet

2. Minimum Height

_____ Feet

C. In-seam conditions to be contended with?

☐ Good Bottom

☐ Wet Bottom

☐ Soft Bottom

D. How uniform would expected conditions be?

☐ Highly Uniform

☐ Somewhat Uniform

☐ Variable

☐ Highly Variable

2. Environmental

A. What specific environmental controls are of principal importance?

i. To control operating dust levels

1. Water suppression systems

☐ Yes

☐ No

2. Integral scrubber

☐ Yes

☐ No

3. Conventional brattice ventilation

☐ Yes

☐ No

4. Auxiliary face ventilation

☐ Yes

☐ No

ii. To control methane gas

1. Water spray diffusers

☐ Yes

☐ No

2. Conventional ventilation controls

☐ Yes

☐ No

3. Safety

A. What roof support systems to be utilized?

i. Place-change bolting / strapping

1. Separate bolting machine

☐ Yes

☐ No

2. Manual roof stopper

☐ Yes

☐ No

ii. Integral bolting capability

☐ Yes

☐ No

iii. Chocks, props, cribs

☐ Yes

☐ No

B. What mode of mining machine operation?

i. Manual operator controls

☐ Yes

☐ No

ii. Remote operator controls

☐ Yes

☐ No

1. Umbilical

☐ Yes

☐ No

2. Radio

☐ Yes

☐ No

C. What integral safety systems?

i. Built to permissible standards for following location use?

☐ Use at the face ☐ Intake Outby ☐ Return Outby

ii. Auxiliary ATRS

☐ Yes

☐ No

iii. Auxiliary ventilation controls

☐ Yes

☐ No

D. Maximum voltage

☐ AC _____

☐ DC _____

E. Maximum pressure (hydraulic)

☐ PSI _____

4. Operational

A. Desired crew size?

i. Single operator

☐ Yes

☐ No

ii. Operator and helper

☐ Yes

☐ No

B. Anticipated outby utility work?

i. Scaling roof

☐ Yes

☐ No

ii. Manholes construction

☐ Yes

☐ No

iii. Trimming rib for roadways and beltways

☐ Yes

☐ No

iv. Cleaning up falls

☐ Yes

☐ No

v. Driving small headings for air connections

☐ Yes

☐ No

vi. Digging sumps

☐ Yes

☐ No

vii. Taking up bottoms for rehabilitation

☐ Yes

☐ No

viii. Roadway construction

☐ Yes

☐ No

ix. Maintaining escape ways

☐ Yes

☐ No

x. Overcast construction

☐ Yes

☐ No

xi. Undercast construction

☐ Yes

☐ No

xii. Trenching

☐ Yes

☐ No

C. Anticipated recovery work?

i. High advance rate development work

☐ Yes

☐ No

ii. Limited secondary recovery

☐ Yes

☐ No

iii. Driving small headings during development for air connections

☐ Yes

☐ No

D. Equipment power considerations?

i. Electric

1. Battery powered

☐ Yes

☐ No

A. Operating charge duration

_____Hours

B. Recharge duration

_____Hours

C. Swappable battery packs

☐ Yes

☐ No

2. Medium Voltage DC – trailing cable

☐ Yes

☐ No

a. Cable length

_____Feet

3. Medium Voltage AC – trailing cable

☐ Yes

☐ No

a. Cable length

_____Feet

4. High Voltage AC – trailing cable

☐ Yes

☐ No

a. Cable length

_____Feet

- ii. Diesel with integral scrubbers
1. Straight diesel ☐ Yes ☐ No
 2. Diesel – electric ☐ Yes ☐ No
 3. Diesel – hydraulic ☐ Yes ☐ No
 4. Diesel pneumatic ☐ Yes ☐ No
 5. Other: _____
- E. Transport requirements?
- i. Self transportable ☐ Yes ☐ No
 - ii. Low-boy – track/wheel hauled ☐ Yes ☐ No
 - iii. Towed by auxiliary equipment ☐ Yes ☐ No
- F. Trimming capability during use?
- i. Self-trammed – caterpillar drive ☐ Yes ☐ No
 - ii. Self-trammed – mounted on skids ☐ Yes ☐ No
 - iii. Self-trammed – mounted on tires ☐ Yes ☐ No
 - iv. Non-trammable – uses auxiliary equipment to position ☐ Yes ☐ No
- G. Cutting technology utilized?
- i. Mechanical systems
 1. Drum and Bits ☐ Yes ☐ No
 2. Ripper chain ☐ Yes ☐ No
 3. Wheel cutter ☐ Yes ☐ No
 4. Percussive ☐ Yes ☐ No
 5. Other: _____
 - ii. Water-cutting systems
 1. Water jet
 - A. High pressure ☐ Yes ☐ No
 - B. Low pressure ☐ Yes ☐ No
 - C. Abrasive mixtures ☐ Yes ☐ No
 - iii. Other systems ☐ Yes ☐ No
 1. Other: _____
- H. Areas where desired to be used?
- i. Within active faces area ☐ Yes ☐ No
 - ii. Outby – intake air ☐ Yes ☐ No
 - iii. Outby – return air ☐ Yes ☐ No

5. Logistical

A. How is the machine envisioned to be used?

- i. Production work
 1. Development support
 - a. In the product cycle ☐ Yes ☐ No
 - b. Outside of the production cycle ☐ Yes ☐ No
 2. Secondary recovery support
 - a. In the production cycle ☐ Yes ☐ No
 - b. Outside of the production cycle ☐ Yes ☐ No

ii. Utility			
1. Active face areas	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
2. Active section	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
3. Outby areas	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
B. Equipment mission			
i. Optimize reserves	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
ii. Optimize recovery	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
iii. Optimize production rate	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
iv. Optimize manpower	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
v. Optimize mine plan	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
C. Cutting ranges desired to be achieved?			
i. Minimum height	_____ Feet		
ii. Maximum height	_____ Feet		
iii. Cut depth below grade	_____ Feet		
iv. Width of cut			
1. Minimum sump cut	_____ Feet		
v. Depth of cut from last permanent roof support?			
1. Manual control	_____ Feet		
2. Remote control	_____ Feet		
D. Machine dimensions desired?			
i. Maximum height	_____ Feet		
ii. Maximum width	_____ Feet		
iii. Maximum weight			
1. Total weight	_____ lbs		
2. PSI loading on bottom	_____ psi		
E. Desired tram speeds (if self-trammable)			
i. Transport speed	_____ Feet/Min.		
ii. Advanced rate (mining)	_____ Feet/Min.		
F. Desired production rate	_____ Tons/Min.	_____ Ft of advance/hour	
G. Mucking ability			
i. Gathering head	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
ii. Gathering arms	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
iii. Scrape and slush	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
iv. Other _____			
v. None needed	<input type="checkbox"/> None Needed		
H. Conveying capability			
i. Integral flights	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
ii. Integral chain conveyor	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
I. Loading / transport capability			
i. Direct load-out into shuttle car or scoop	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
ii. Removed conveying system capability	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
1. Extensible bridges	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
2. Mechanical transport	<input type="checkbox"/> Yes	<input type="checkbox"/> No	
3. None needed	<input type="checkbox"/> None Needed		

J. Degree of flexibility required

i. Highly application flexible

☐ Yes

☐ No

ii. Single purpose-built for unique application

☐ Yes

☐ No

1. Desired application _____

6. Commercial

A. Economic structure

i. Approximate cost

_____ To _____ Dollars (range)

ii. Desired payback period

_____ Years

iii. Cash flow rate of return

_____ Percent

iv. Required production tonnages to make viable

_____ Tons/Shift

B. Present competing equipment alternatives that are utilized

i. How well suited

ii. Range of applications not effectively met

C. What are the drivers for you to consider using this equipment?

i. Reducing staffing levels

☐ Yes

☐ No

ii. Increasing the recovery of reserves

☐ Yes

☐ No

1. By reducing permanent reserve losses

☐ Yes

☐ No

2. Reducing support operating costs

☐ Yes

☐ No

iii. Increasing production tonnage

☐ Yes

☐ No

iv. Increasing rate of advance (stay on cycle)

☐ Yes

☐ No

v. Safety mandates

7. Ideological

A. The level of immediate applicability

i. Immediate and pressing need

☐ Yes

☐ No

ii. Desirable consideration

☐ Yes

☐ No

iii. Not deemed required

☐ Yes

☐ No

B. The level of anticipated projected use?

i. It would gain industry-wide acceptance

☐ Yes

☐ No

ii. It has numerous utilization strategies

☐ Yes

☐ No

iii. There are widespread implementation/market opportunities

☐ Yes

☐ No

iv. There are limited applications

☐ Yes

☐ No

v. It would be redundant and not needed

☐ Yes

☐ No

C. Current industrial and operational philosophies

i. Which will drive the project?

ii. Which would constrain the development?

iii. Which will support or impede technological implantation? _____

ADDITIONAL COMMENTS (if any):

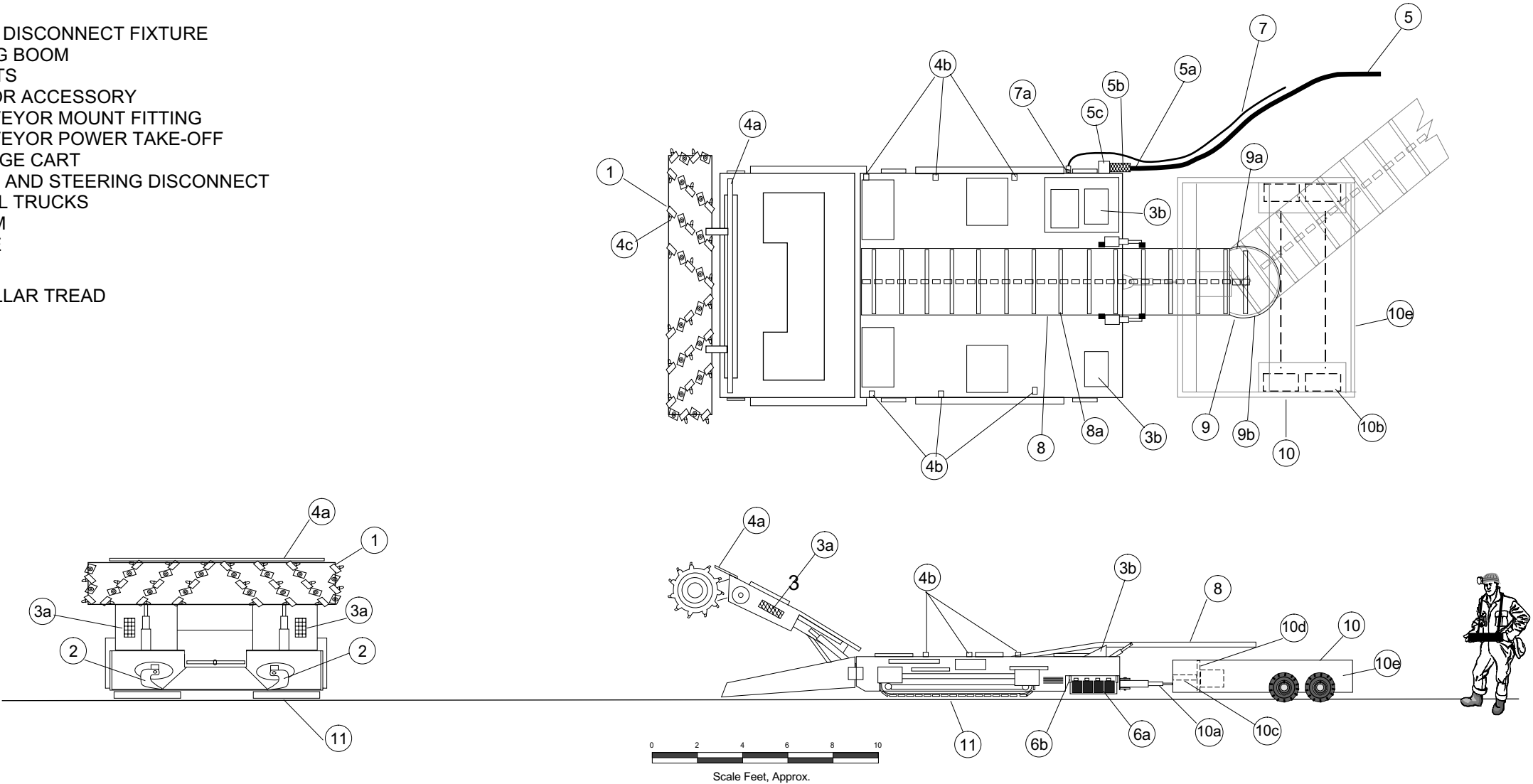
Thank you so much for your involvement.

PRINCIPAL COMPONENTS

- 1. CUTTER DRUM (CONVENTIONAL)
- 2. GATHERING ARMS (CONVENTIONAL)
- 3. PARTICULATE SCRUBBER
 - a. SCRUBBER INTAKE LOUVERS
 - b. SCRUBBER EXHAUST LOUVERS
- 4. DUST CONTROL SPRAY SYSTEM
 - a. DIRECTIONAL HEAD SPRAYS
 - b. BODY MOUNTED SPRAYS
 - c. SUPPRESSION SPRAYS
- 5. TRAILING POWER CABLE
 - a. ENTRANCE GLAND
 - b. STRAIN FITTING
 - c. POWER CABLE RAPID DISCONNECT FIXTURE
- 6. BATTERY MODULE COMPARTMENT
 - a. BATTERY MODULE
 - b. MODULE LIFT FIXTURE
- 7. WATER SUPPLY LINE
 - a. WATERLINE RAPID DISCONNECT FIXTURE
- 8. ARTICULATED LOADING BOOM
 - a. CONVEYOR FLIGHTS
- 9. EXTENSIBLE CONVEYOR ACCESSORY
 - a. EXTENSIBLE CONVEYOR MOUNT FITTING
 - b. EXTENSIBLE CONVEYOR POWER TAKE-OFF
- 10. DEMOUNTABLE HAULAGE CART
 - a. SWIVEL COUPLING AND STEERING DISCONNECT
 - b. STEERABLE WHEEL TRUCKS
 - c. TELESCOPING RAM
 - d. UNLOADING PLATE
 - e. TAILGATE
- 11. WIDE TRACK CATERPILLAR TREAD

GENERAL NOTES:

- 1. IT SHOULD BE UNDERSTOOD THAT THIS DRAWING IS PRESENTED AND INTENDED FOR DIAGRAMMATIC AND/OR DISCUSSION PURPOSES ONLY. IT DOES NOT CONSTITUTE A FINAL DESIGN.
- 2. IT IS TO BE CONSIDERED AS A CONCEPTUALIZED ARTIST RENDERING THAT WAS COLLECTIVELY DERIVED FROM SEVERAL SOURCES AND COMPROMISES WERE MADE TO ENSURE THAT PLAUSIBLE AND NON - CONFLICTING IDEAS WERE REPRESENTED IN A SINGLE RENDERING.
- 3. DETAILS ASSOCIATED WITH SPECIFIC FEATURES, CAPABILITIES AND/OR INTENDED CAPACITIES CAN BE FOUND IN THE ACCOMPANYING REPORT
- 4. NO ATTEMPTS HAVE BEEN MADE TO SUPPORT BY ENGINEERING ANALYSIS, SUBSTANTIVE DESIGN CALCULATIONS OR TECHNICAL FEASIBILITY ANALYSES AND THE OPERABILITY AND/OR FUNCTIONAL DESIGN OF THE VARIOUS ASPECTS PRESENTED.



FILE NAME	SCALE	DATE
Mining	NTS	12/10/04
PROJECT NO.	DE-PS26-03NT41757-3	

CONCEPTUAL DESIGN FOR A RADICALLY SMALLER, HIGHLY ADAPTIVE
AND APPLICATION-FLEXIBLE MINING MACHINE FOR
UTILITY AND DEVELOPMENT WORK

ATS CHESTER ENGINEERS		
DWN BY:	CHK'D BY:	APPR BY:
JS	AHS	AHS