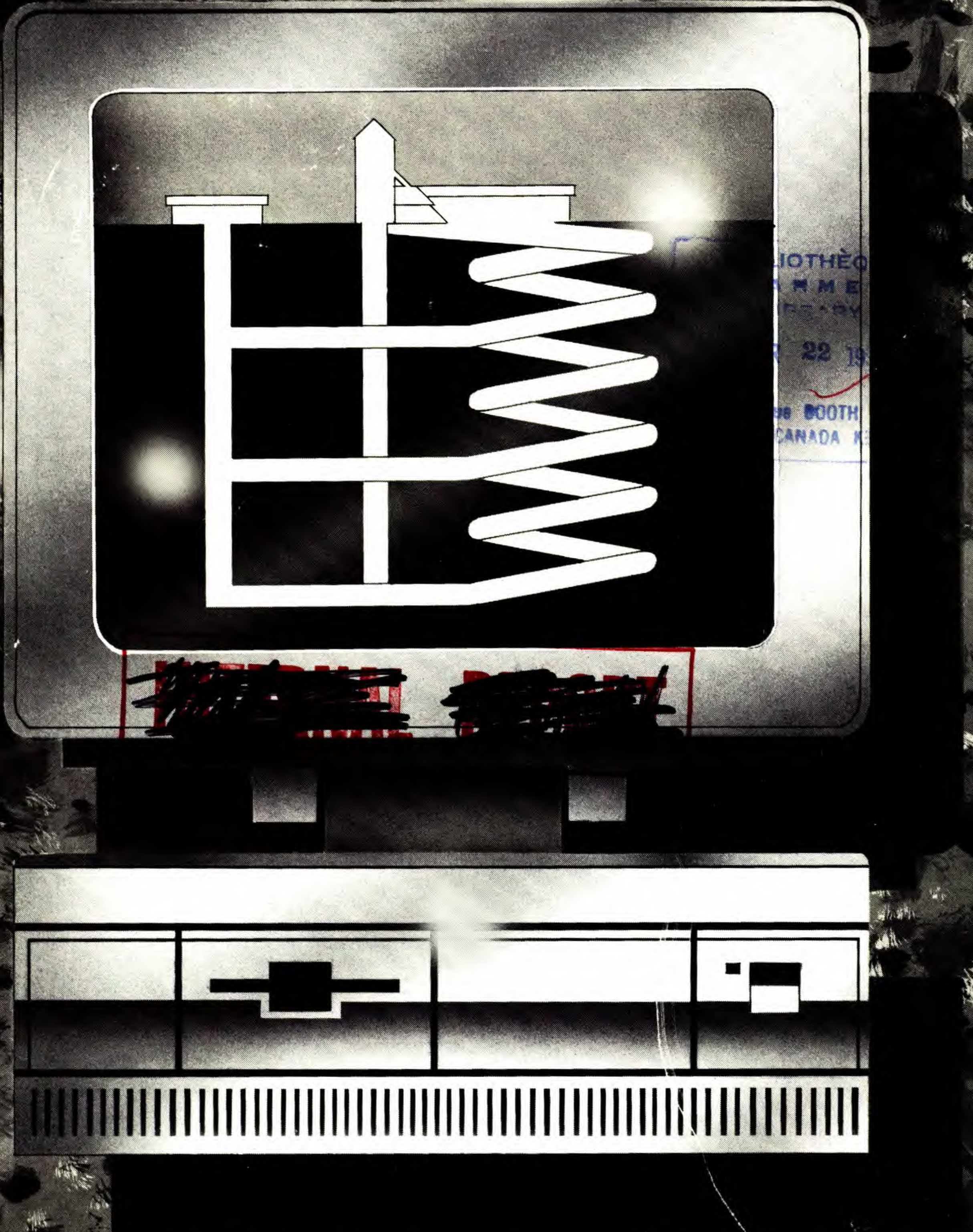
INFORMATION TECHNOLOGY IN MINING



Edited by: W.G. Jeffery, J. Pathak and M. Clapham

INFORMATION TECHNOLOGY IN MINING

A WORKSHOP FOR SENIOR EXECUTIVES

MARCH 8 AND 9, 1989 - TORONTO

THE FOUR SEASONS HOTEL
21 Avenue Road
Toronto, Ontario

CO-SPONSORED BY

- Mining Industry Technology Council of Canada (MITEC)
- Canadian Advanced Technology Association (CATA)
- Machinery and Equipment Manufacturers' Association of Canada (MEMAC)
- National Advisory Council for Mine Automation (NACMA)
- Canada Centre for Mineral and Energy Technology (CANMET)
- Industry, Science and Technology Canada (ISTC)

Foreword

J. Trevor Jubb
Director-General, Mineral Technology Branch
CANMET

The mining industry in Canada, aware of the competitive and cyclic nature of their industry, is taking every step possible to be even more competitive. New mining methods, better designed and more suitable equipment, increased mechanization and automation of individual equipment and mining systems, new computer applications and new operations management systems are being introduced and successfully used as a part of the mining process. The success that the mining industry is achieving in remaining competitive is important to Canada because of the key role the industry plays in Canada's economy.

To improve its competitive position a general consensus has developed within the industry that an assessment of its future equipment and information technology needs is required so that these needs can be discussed with industry suppliers. It is becoming increasingly evident that mine-wide communications systems permitting the transmission of large volumes of voice, video and data transmission to achieve longer-term goal of fully automated mines is central to the application of the new technology.

CANMET, as the research arm of Energy, Mines and Resources Canada, is pleased to have sponsored with the Mining Industry Technology Council of Canada (MITEC), the Canadian Advanced Technology Association (CATA), the Machinery and Equipment Manufacturers' Association of Canada (MEMAC) and Industry, Science and Technology Canada (ISTC), this Workshop on Information Technology in Mining. The real value of the workshop will be in its successful catalysis of partnerships in technology developments and future workshops which bring the ideas expressed in these papers to fruition.

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FOCUSING ON

- Creating and using information technology for competitive advantage in underground mining
- Strengthening linkages between users/suppliers
- Encouraging collaborative efforts in advanced information technology applications

TARGET AUDIENCE

- Mining industry management with the responsibility for strategic planning and operations in underground hardrock metal mines

- Senior executives from information technology companies and mining equipment suppliers, having the responsibility for strategic planning and new product development

INTRODUCTION

The mining industry faces increasing competition from developing countries, substitution, and volatile fluctuations in commodity prices, all of which shrink market size and make future planning difficult. The industry has recognized that one key element in reducing the impact of these adverse effects is through the adoption of information technologies.

The increasing use of information technologies is becoming a necessary corporate response to diverse economic swings, demands for product quality and the challenge of remaining competitive in difficult markets.

Based on a cluster of interrelated innovations in microelectronics, computers and telecommunications, information technology can be used in all sectors and all functions. Applications of this technology can create substantial productivity gains. Although many advances are being made in the application of this strategic technology there are still large gaps that offer tremendous opportunities for both the mining industry and information technology suppliers in Canada.

WORKSHOP OBJECTIVES

Based on the joint interests of the sponsors, the objective of the workshop is to bring together senior mining operators, mine equipment suppliers, and information technology experts to identify opportunities for companies to cooperate in filling gaps in the availability and effectiveness of information technologies used in the mineral sector.

Perspective of the mining companies:

- to enhance the competitiveness of the mining industry by accelerating the development and use of information technologies

Perspective of the mining equipment suppliers:

- gain a better understanding of the technological needs of the mining industry
- contribute to standardization among suppliers of improved products
- develop links with suppliers of specialized technologies

Perspective of the advanced technology community:

- gain a better understanding of the requirements of mining operations for current and emerging information technology needs
- strengthen linkages with the mining and mining equipment supply industries in order to increase their sourcing of technology from Canadian firms
- raise awareness of Canadian high technology capability.

While participants should be technologically knowledgeable, the discussion will focus on the business aspects of:

- the role of technology in enhancing productivity and competitiveness;

- structuring business relationships to augment the supply of technology into the mineral industry.

TECHNOLOGY APPLICATION FOCUS

The following four technology groups along with suggested applications and examples identify the types of information technologies that this workshop will focus on.

I. **Communications and Networking:**

- Underground data communications (fixed and mobile)
- Underground radio based voice networks

II. **Production Monitoring and Control:**

- Supervisory Control and Data Acquisition (SCADA): Computer-based monitoring and control of process and mine variables at a central site
- Vehicle and equipment diagnostics
- Automated environmental monitoring and control (eg. sensor technologies for gas monitoring)

III. **Automated Material Handling:**

- Remote controlled machinery and equipment (eg. radio and wire guided control)
- Computer controlled vehicles and equipment (eg. multi-dimensional vision sensor systems)
- Automated conveyer systems (ACS)

IV. **Design and Engineering:**

- Mine design for automation (Computer Aided Engineering-CAE)
- Computer modelling and Expert Systems (AI)

AGENDA

MARCH 8, 1989

1600	Check-in and registration
1630	Welcome and opening remarks

SESSION I - Executive Presentations

Chair: G. Poling, R&D Coordinator, Mining Association of B.C.

1645 Paper 1: The economic and practical impact of new developments in information technology - a supplier's perspective

W.G. Hutchison - President, William G. Hutchison Ltd.

1715 Paper 2: The development and sourcing of information technology within the mining industry - a user's perspective

B. Ferguson - Vice President (Mining), Falconbridge Limited and Chief Executive Officer, Falconbridge Gold Corporation

1830 Reception

1900 Dinner

Chair: R. Woodbridge, President, CATA

2030 Opening Address

H. Rogers, Deputy Minister, **Industry, Science & Technology Canada**

Keynote address: **Information technology - its profitable introduction to mining**

W. Curlook - Executive Vice President, Inco Limited

MARCH 9, 1989

SESSION II - Information Technology Innovation Applicable to Mining

Chair: G. Poling, R&D Coordinator,
Mining Association of B.C.

0830	Communications and Networking (user view)
	K.V.S. Meyer - Vice President, Mining, Cominco Engineering Services Ltd.
0900	Production Monitoring and Control (supplier view)
	B. Westhead, President, Westhead Associates
0930	Automated Material Handling (supplier view)
	T.B. Christie, General Manager, EMS Associates
1000	Coffee break
1030	Design and Engineering (user view)
	W. Bawden, Professor (Mine Design), Queen's University

SESSION III - Panel Discussion

Chair: P. Richardson - Queen's University, School of Business

1100 The panel will address questions from the floor on the following issues:

- Strengthening linkages between suppliers and end users of information technology.
- Measures that could be taken to develop the technological base in Canada, the development of a domestic information technology supply industry, and the needs of the mining companies for improved information technology systems.
- The economics and practicality of creating joint ventures or other forms of cooperation.
- The government's role in promoting cooperative ventures.

Participants:

H. Brehaut, Senior Vice President, Operations, Placer Dome Inc. and Chairman, MITEC

D. Letts, President, Continuous Mining Systems Ltd. and Vice Chairman of Mining Equipment Manufacturers' Section, MEMAC

L. Hurtubise, President & CEO, Ericsson Communications Inc. and Chairman, CATA

J. Nantel. Manager, Mining Technology Division, Noranda Research Centre and Chairman NACMA

T. Jubb, Director General, Mineral Technology, CANMET

1200 Cash bar

1230 Buffet Lunch

1315 *Chair: Ron Watkins, Director General Information Technologies Industry Branch, ISTC*

Luncheon address: Collaborative Approaches to Technology Innovations

G. MacNabb - President and CEO, PRECARN Associates Inc.

SESSION IV - Workshops

Chair: P. Richardson

1345 The challenge of the workshops - chairman's directives

1400 Break out groups by technology themes: **Plan of action for information technology applications of tomorrow**

- Where do we go?
- How to make it happen?
- Building bridges and partnerships between users and suppliers
- Strengthening the competitiveness

Workshop I - Communications & Networking: K.V.S. Meyer
Workshop II - Production Monitoring & Control: B. Westhead
Workshop III - Automated Material Handling: T.B. Christie
Workshop IV - Design & Engineering: W. Bawden

1500	Coffee break
1530	Summary of workshop reports
	Chair: P. Richardson
1615	Closing comments and adjournment
	W.G. Jeffery, Executive Director, ***Mining Industry Technology Council of Canada (MITEC)***

Workshop Organization provided by:

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The Economic and Practical Impact of New Developments in Information Technology: A Supplier's Perspective

William G. Hutchison
President, William G. Hutchison Ltd.

Thank you Mr. Chairman. Ladies and Gentlemen, it's a pleasure to be here today. Mr. Chairman, you gave a great flattering background of my activities. I thought I might put some of my supplier roles in perspective because for the past thirty years, I have been a supplier of information technologies and an advisor about the supply of them. In fact before Honeywell, I was with Bell Canada for three years designing data communication circuits. So I started on the supply side of communications and then the supply side of computers, and in fact, manufacturing computers. For the last thirteen years I have been advising on the use of them and sometimes helping users dig themselves out of holes that have been created.

In talking about the new developments in Information Technology, and I'm going to be talking about their impact from an economic and practical point of view, let me first define the Information Technologies as I see them. I would include here, digital computers, all the software that drives them, communication systems, the fibrotic technologies that are being used in computers and communication systems, electronics because computers are electronics, and all of the communications fields, including switching, transmission technology and satellite technology. All of these generally fall in what we call Information Technologies.

As we all know, the driving force behind these technologies is micro electronics. Ever since the development of the transistor we have witnessed process of miniaturization in manufacturing. That process allows us now to put two hundred and fifty thousand transistors on a chip. The effect is an increase in the amount of memory we can get in a computer, in a little computer, and also an increased amount of computing capacity.

When I started in the industry, the cheapest computer I could sell for Honeywell cost $500,000. So a $50 million company was the minimum sized one I could talk to about my wonderful product. Today for $4,000 you can buy, including the printer and all the discs and everything else you can put on your desk, a lot more power than my half a million dollar computer that I used to peddle around in those days.

Yesterday you may have seen that Unisys Canada announced their mainframe on a desk. They've taken their mid-sized mainframe, put it all on a chip, and put it inside a work station that can sit on your desk. That's where we are today. They are advertising it.

In everyday terms, if we try to translate the pace of these developments to the car and other things it becomes even more shocking. For example we now have the laser card. It is the size of a credit card but data is recorded using laser technology, not with a magnetic stripe. This is the same technique we have on our compact discs for music. You can store the equivalent of ten issues of the Toronto Star on this laser card. That has all kinds of implications. You can carry all your medical records in your pocket. It makes the idea of walk-in clinics now practical. Today if you go into a walk-in medical clinic your records are somewhere else and it becomes a little awkward. You could carry your medical records in your pocket on the laser card.

Optical discs are only one example. If the automobile had developed at the same rate as computers, we would be getting about a thousand miles per gallon. The price of the car today would be $5.00 and on and on. It just boggles the mind.

As we look at information technologies in mining there's a tendency to say that maybe the industry's getting saturated, that we're near the peak. Well, I'm here to tell you that if you equate this industry to the automotive industry, and most people feel that that's the only one you can equate computers and information in technology to, we're at about 1920 in equivalent terms. The Model A has just been announced. The Model T is equivalent to the PC. It's interesting that the historical time frames are even comparable. The horseless carriage was around for thirty years before the mass production unit, the Model T, came out. Likewise, electronic computers were around for thirty years before the PC came out. The next version of the PC, the Model A equivalent, is the MacIntosh. It's easier to use and offers new features as did the Model A. If you compare the growth curves and everything else, the computer industry and the automotive industry tend to match up in interesting ways.

So, if we accept that we're at 1920, and you then think of all the car companies that have all disappeared, merged and grown, a lot of changes have occurred. Even more important the auto infrastructure didn't really develop until after 1920. Back then you had the gas pump in your backyard. So it wasn't until there were lots of cars that you had gas stations on the corner. Highways only really started to develop after that. In a similar way the infrastructure that will accompany all this new computer technology is only now starting to develop.

What does this mean for the Mining Industry? Well obviously those who foresee the development of these other infrastructure characteristics and get ready for them, take advantage of them and use them in competitive ways, will have many advantages. Those who don't, of course, will be passed by. There are all kinds of examples of those that didn't use the new transportation developments.

With respect to impact, we need to talk about the developments of information technology that are relevant to the Mining Industry and what will result from these developments.

What are the applications? I'd like to suggest that we consider information technology as falling into three categories for the Mining Industry. The first category is production automation. This conference focuses mostly on production automation; automation of various functions, mostly in the mine or around the mine. But there are two other very important categories that need to be considered. One is information management; management of the information needed to run the business. The other is the development of information services located outside your company but available to you to improve your competitive position and your business development activities.

Production automation is really automation of the production process, drilling, digging, loading and moving material. Examples of information management include the collection of information from the customer. What does the customer want and what does the market want. The management of that information is what I'm referring to. What's going on in production, how much production, what's the flow, what can we do to adjust it? The bringinging together of all of that information is what I call information management.

Information services include the multitude of services you can dial into. Examples are major data bases around the world that provide engineering information to help you apply new computerized design techniques or mining techniques. There are information services now that will provide you with information about suppliers to different industries. The number of services is unbelievable.

I am going to talk today about information management and information services because I believe the conference program is going to deal mostly with the other part.

All three categories of production automation, information management and information services are relevant. They apply to Inco, they apply to Polysar, they apply to MacMillan-Blodell, they apply to General Motors, and they apply to the $10 million company down the street that's a piece part manufacturing Company.

Their use of computers and information technology broadly falls into those three categories; they have automated production, and the management of information to do with there business or they are using outside information services.

Now if I look at information management, let me first of all say that I do have some background with the mining community. I was born just outside of Haileybury which is a good place to be born if you want to say you have any sort of background in the community. My father was active in the mining community, and I've designed and installed systems for large mining and natural resource companies. With those brief credentials I can tell you the mining industry is well behind some of the other industries in the information management field.

The good news is that there has been a big change in the last five to seven years in the mining industry's research, development and use of information technology for production automation. PRECARN is but one good example. Gordon MacNabb will be here later to talk about PRECARN and its collaborative approaches to research. There are a few companies here today, that are members of PRECARN, a new thirty-five company consortium, organized to conduct applied pre-competitive research and development focused on artificial intelligence and robotics and there are some mining companies involved in that, certainly Inco and Noranda.

Who would have thought ten years ago that the automotive companies would have been running "just in time" systems the way they are today. They used to believe in long production runs for production efficiency, but they ignored the cost of inventory and the lack of flexibility for the customer. Today the whole system is tuned to the point where the truck basically backs up to the door with the car seats that are going to be installed on cars in ten minutes as they come down the production line. The same is true for all of the other parts. The information systems required to control the parts flow are complicated and expensive. The North American car industry had to be kicked in the teeth by the Japanese car industry in order to implement them.

It hardly seems possible to have "just in time" mining. We are not going to start and stop drills and conveyors and everything else based on what somebody needs down the road. Well nobody thought they were going to do that in the car industry either and perhaps we're not going to get that far in mining. But the process of linking customer information and market information, managing the whole flow of production and product scheduling is going to continue to be refined more and more, not only in the mining industry but in other industries as well. The automotive industry today is merely one of the leaders in the new trend. "Just in time" systems are what information management is all about.

The flow of product and the need for more information management are going to be affected by free trade. Under the new free trade rule it becomes more practical to process our ore in Canada and to begin making products from the ore and shipping them across the border, than it was before. Duties on resultant products will be eliminated by free trade. As we begin to have a longer flow process and convert to product or more semi-processed forms, we will introduce more information management to monitor and manage the flow of ore and subsequent products.

Let me now talk briefly about information services and describe a couple of examples. In Britain there is a computer data base of British expertise in science and technology, not just in mining, but in all areas of applied science. Called the BEST system for British Expertise in Science and Technology, the system is sponsored by the British government and run by the private sector. Two hundred corporations pay $20,000 a year to access that information. You can track technology and identify everybody in Britain who is active and what they are doing in those areas right from a personal computer on your desk.

We could say, well today we'll get at that in Canada and get all the directories from all the Universities around the country - yes we could but no we don't because it's a real pain to do it, so we tend to have linkages going if we do have linkages with universities that are local to our office or to our engineering facility.

In France, industry can plug in and obtain all sorts of information that can help them. A good example is a trucker from Marseilles, who might be an independent trucker, who might drive up with a bunch of fish for the market in Paris. Once he gets rid of his load he goes over to a Minitel terminal, keys in and says - "I have a truck this big. Any loads need to go back to Marseilles?" - and he goes over and picks up a load. He doesn't have to be part of a transport firm or anything else.

The Minitel system in France was first implemented by the French government who basically put a small terminal in everybody's home and said we're not going to print the phone book anymore, you'll find it on you terminal. It was practical for them to do that - they couldn't keep the phone book up to date. It was always three years out of date. From a cost point of view it was practical as well, but they have built an information services business over there.

The BEST system in Britain gives an idea of an information service. Dow Jones is a form of information service and you can get electronic access to the stock market here, but there are a lot of other things you can use in your business when accessing these services and you may want to look at them. Anybody who isn't too familiar with this area, Bell Canada runs a service INET 2000 and you can subscribe to it and they give you a directory to all the data bases that are available. By going through INET 2000 - you can take out a subscription - you can access services all over the world.

That's indication of what is happening on the information.

The question I was asked to address is "what are the economic and practical implications of information technology?" I just talk about some of the trends and how we'll use them. On the practical point, some people might see a downside related to investment, retraining, job re-organization. A lot of middle management will start to lose their jobs because as the information management and information systems are installed and a lot of decisions can be made at the senior level and communications can be made with people on the floor and in the pit and you can eliminate a lot of middle levels of management. That will be one of the implications. But if we can compete successfully, our businesses will grow and they'll take up the slack. If we don't, of course our quality of life will drop. I always like to point out that 30 years ago New Zealand had the third highest standard of living in the world and today I think they have the 70th highest standard of living in the world, because they failed to adjust. So there's an opportunity if we do adjust and a real downside if we don't.

The economic impact of the new developments. What are they? Well, I didn't try to get into the cost of inventories and if you get a 10% improvement what does that mean? But on one hand the good news is that the cost of the new technologies is plummeting. It's coming down by about an order of magnitude every 7 or 8 years. Within 5 years optical discs will become practical and you'll pay a hundredth of the price to store your information. That's one aspect. You can for fifty cents send a message across Canada, a full page message through electronic mail, separate from a fax. These kinds of costs, compared to courier costs, compared to mail, are very practical.

The other good economic point is that you don't have to bet the company any more. It used to be that you studied it, you went out and bought the mainframe and you bet the company while the thing was being implemented for the next two or three years. Today, things can be implemented in small pieces on micros, on minis - step by step. Even tools that are available to help you generate computer programs are so much easier to use. You can track it as you go, and know if you're getting into trouble before you get there. There are many measures to the economic impact and many areas of improvement. I suggest that with good information management techniques, the cost of overheads can be reduced in the firm. There can be quality improvements. Service levels can be raised. Those are three of the key aspects. Ultimately lower product cost is the target that we are all after.

So, in summary, the good news is that the cost of information technology is coming down, and you don't have to bet the company in order to adopt its use. The automotive industry, I think provides a useful model for the use of information management in practical manner. Where the automotive industry has gone, the mining industry has gone, the mining industry will follow.

Well that highlights a few thoughts. I was conscious Mr. Chairman, before you started, that we want to run on time. There may be a few questions and I would be happy to take them. Thank you.

Any questions for Bill?

Q. I'll just ask one question of Bill, while I give others a chance to think. In terms of some examples that you know of, you're talking about procurement. Some of our northern mines now, like Polaris and Nanasivic, have procurement problems and information technology could fare where they have two to three to four week periods for shipping and everything else seems to come in by plane. It seems to me to put an additional onus on automating information systems for all sorts of things in northern development. Can you comment on that?

A. I think it just makes it that more critical. You are absolutely right. I think of communications to whomever they are dealing with, because of the small window, that they have and also of the fact that a tremendous amount has been done on the procurement side, purchasing systems. I think, it is suffice to say, that if anybody in that area really wants to improve - and I'm sure they are focusing on purchasing organizations because in those kinds of purchasing associations, they have tremendous focus on information technologies these days - the opportunities are here. The communication facilities are getting a lot better for communication with those northern points.

Any other questions?

Q. How critical do you think it is that the mining industry embark on a very serious way into this electronic age and the information age? Are we going to be left behind that badly if we don't embark on all the things that you outlined so well earlier in your discussion?

A. I think we would be left way behind. The thing about technology of course is that anybody can buy it so we can't say today that we're a little closer to technology and therefore our mines can use it better than newly industrializing countries can. Those countries that have lots of ore, lots of ability, lots of natural resources can buy the same technology that we can buy and they have lots of people too. They hire people if they don't have them. They hire them, bring them into the country and they have lots of people who have been out being trained in North America and other countries and they're going back. I think it's absolutely crucial that we do not assume that if we do a certain amount of automation here, we'll beat the other guys because they're still there with the pick and shovel and not much technology. Technology can be purchase all over the world. I've been involved in seminars in India and in other countries where I first thought, oh that's where you can ship the old technology. I can tell you that they are going to do it now. They are out there trying to leap frog the rest of the world. You know the countries where the Japanese have really penetrated. You look down in South East Asia, boy I'll tell you, you don't hear a lot about Fujitsu as a computer supplier. Here in Canada, you hear about their printers and their disc drive and things like that but not about their mainframes. I'll tell you they are all over those places and they are putting the latest technology in, so if we don't then we really lose the ball game.

Any other questions?

Thank you very much.

The Development and Sourcing of Information Technology within the Mining Industry: A User's Perspective

Brian A. Ferguson
Vice President, Mining
Falconbridge Limited

Ladies and Gentlemen:

First of all, let me say how pleased I am to be involved in this workshop on Information Technology in Mining and to help in launching it this afternoon. Both MITEC and Executive Director, Jeff Jeffrey are to be congratulated in bringing the various co-sponsors together and I am confident that the outcome will be to the benefit of all the participants. I think the holding of this workshop is particularly well-timed, if not somewhat overdue, as the industry begins to make its way more deeply into the information technology field.

I would be very surprised if the manufacturers and suppliers were not here in attendance in full force. I hope that the industry itself is equally well represented. I remember attending a somewhat similar CANMET-sponsored workshop some years ago related, I believe, to mining mechanization. At that meeting, I recall, MEMAC played a very active part in the proceedings. But industry was poorly represented. I hope that this workshop demonstrates the degree to which the industry has progressed since then.

As my remarks show, I believe strongly that technological progress in our industry comes from collaborative initiative between the industry and its suppliers. I trust that this workshop may spawn some new initiatives in the field of information technology in mining.

In re-reading the introduction in the Workshop Program in the light of current high metal prices, one might question perhaps its relevance. Nevertheless the challenge for the mining industry in Canada today remains quite clear. The development and application to our operations of both new technology and adaptation of technology already existing outside our industry is vital to our long term economic survival.

I do not regard myself as any sort of an expert in this field of information technology. But I do understand the mining industry and that to be successful, development and introduction of fresh technology and the pursuit of technological change in our industry must satisfy certain fundamental considerations. More on this later.

Perhaps to being with, and particularly for the benefit of those from outside our industry, I would like to review the past development of the industry and the influences that have led to the current high level of interest in information technology as evidenced by this workshop.

In the first place, over the last 25 years the industry has experienced a complete revolution in underground hardrock mining methods – the processes by which ore is extracted from the ground. It started in the Elliot Lane uranium mines in the mid 1950's with efforts to utilize trackless mining machinery from the coal mines, in these shallow dipping conglomerate beds. Trackless mining really took off with the introduction of the Wagner scoop tram to the steeply dipping nickel ore deposits in Sudbury in 1966-67. The impact of this machine concept on the industry has been truly revolutionary. It quickly led to the evolution of the decline ramp method of mine development and released mining practice from the straight jacket of fixed mining levels based on shaft station elevations to which the industry had been confined since ancient times. As a result, underground mining practice since has rapidly become highly mechanized and capital intensive. By way of example in 1989, Falconbridge Limited will have ongoing capital expenditures at their Sudbury operations of some $12.2 million on trackless mining equipment alone. Today, the successful application of a specific mining machine is straight forward, dependent on proper engineering design and justifiable on the basis of the defined potential cost or productivity benefit gained from utilization of the unit.

The second major influence on the industry which is demanding better information of what is going on in our mines is what I would term the cost-price squeeze. Operating profit margins per unit of metal product produced shrunk or even disappeared in some cases through the extended period of low metal prices that we recently experienced. Not withstanding the present levels of abnormally high prices, the Canadian underground mining industry is at an economic disadvantage to many producers in the third world because of the higher costs of labour. Preserving profit margins has become as much a business exercise as it is a production exercise. Mine operators continue to be as concerned as ever with maximizing production but they must now also be greatly concerned with the overall economics of their operations, with contributions to profit from each sub-operation and the return on investment in equipment and plant. The modern mine manager has become, first and foremost a businessman.

Thirdly, there is the growth and prominence of the electronics industry and our attempts, not always successful, in applying this new technology into our mines, essentially a comparatively hostile environment. In this process, we have sought out existing applications of electronic equipment outside our industry and have then attempted to adapt them to our own needs and situation. The results have sometimes been successful, but often have been unreliable and less than satisfactory.

What does it take to successfully introduce new technology into the mining industry?

It has been my experience that successful introduction must obey one of three laws:

1. It results in an increase in productivity usually accompanied by a reduction in the unit cost or an increase in unit revenue of existing production, or

2. It represents an investment in new production or in an increase in existing production with a well defined return on investment.

3. It brings about an improvement in safety or the quality of the working environment.

It would seem to me that the introduction of information technology must obey these same laws. The challenge therefore is to properly formulate applications and design installations so that these conditions are satisfied.

It has to be remembered that the mining industry is quite unique inasmuch as it has very little control over the price realized for its product. Unlike the contracting industry, to which it bears certain similarities, it cannot pass on the cost of new technology to its customers.

There was a time when the introduction of a new piece of mining equipment was entirely due to the equipment manufacturer's initiative. The manufacturer would attempt to perceive an industry need and then call on his design resources and experience to derive an acceptable product. He would then attempt to persuade a customer to try his new product which was often largely experimental. Introduction of the product was frequently unsuccessful or not widely accepted. There were the inevitable bugs in the design to be worked out, resistance to change and vested interests in existing technology, which would take several forms, and a lack of specific identification at the operator level with any of the laws that I referred to earlier.

The mining industry has always been perceived as a conservative industry, slow to change, and perhaps somewhat behind the times.

The reasons for this are not difficult to understand. There is a propensity to rely on tried and proven ways of doing things since any decision to change has lasting repercussions that can be literally carved in stone. But show the industry a successful new equipment application with demonstrable results, one that each decision maker can observe for himself, then the pace of introduction or conversion can be quite phenomenal.

This situation is currently changing, much for the better. With the drive to reduce costs and increase productivity and efficiency, the mining companies have begun to take management of technological development more into their own hands. They have done this by identifying potential opportunities for application of new equipment and presenting one or more manufacturers with an outline of what they are looking for. In some cases, mining companies and manufacturers have formed understandings and signed agreements to jointly seek out solutions to perceived equipment application problems and to form commercial joint ventures to design, manufacture and test prototype equipment to their mutual advantage. The advantages should be obvious. On the one hand, we have the mining company willing to share in the commercial risk, with a clearly defined objective and strong motivation for success and by good management able to mobilize its resources both technical and human to the achievement of the objective. On the other hand, the manufacturer has someone to share in the commercial risk and is assured of vitally interested customer. A demonstrable successful product can ultimately be portrayed in the best possible operating light.

What does all this discussion about the successful development and introduction of mining equipment have to do with the application of information technology? Simply, I think, the rules are the same and the road to success is the same.

The introduction of information technology into the mining industry is still in its infancy. In many ways the situation is very similar to where equipment mechanization was 25-30 years ago. There is one difference however, I believe that we are better prepared to accept the advantages that information technology can bring, ready to seek solutions to perceived problems and perhaps much more ready to accept change.

I would now like to be a bit more specific and review briefly the history, current experiences and future plans for information technology in my own corporation - Falconbridge Limited.

We pride ourselves at Falconbridge on our record of research and development effort into underground mining over the years. Mine research activities were established at Falconbridge in the early 1950's and there has been a strong mine research initiative ever since, fully supported at the corporate management level.

The realization that information technology could play a vital role in the management and control of our underground operations and contribute a significant improvement in cost, productivity and utilization of our capital plant and equipment came to us during the early years of the 1980's. As we were increasingly beset by lower metal prices and shrinking profit margins, like others, we began to cast around for solutions.

During this period we had conducted a study on behalf of CANMET into the availability and suitability of existing radio communication systems to underground mines and followed this up with a decision to install in our Lockerby mine a system that we had discovered to be operating successfully in a mine in Austria. Earlier, in 1980, we had installed at our Fraser mine a system for monitoring key stationary equipment. We were also installing at each of our mines microseismic monitoring systems to locate, measure and record ground movement activities as the result of increasing ground stress due to mining.

This process of trials of available technology culminated in the commissioning by management of an internal review entitled: "A Conceptual Study on the Application of Monitoring and Controlling Technology in Mining for Sudbury Operations".

This report was produced in March 1986. It outlined the full scope of monitoring and controlling the potential benefits from mechanization and automation and concluded that the technology for implementing these concepts was both proven and commercially available. See Figure A.

However, the report also predicted the necessity for changes in our organizational approach and the way "we do things". Such changes would have to overcome the inertia of the status quo that exists in every organization.

The report recommended the establishment of a Central Control Room at the Strathcona mine to monitor and control all hoisting and ore transportation and material handling operations within the Strathcona-Fraser mines complex. See Figure B. A conceptual depiction of the function of this control room is shown in Figure C.

The report also recommended that in the long term, monitoring and controlling technology should be built into the design and planning of all new mines and its quantitative benefits incorporated into the individual mine economics.

Finally, the report contemplated the setting-up of a management team to examine the implications of this technology on the organizational structure of our operations.

What has been our experience since that time?

The Strathcona control room has been established and the three surface hoists at Strathcona are operated, monitored and controlled from the control room. The new No. 3 underground production hoist is currently being commissioned and hoisting operations will be controlled at the outset from the central location on surface. The planned monitoring of ore pass and bin levels still awaits applicable and reliable technology to carry out this function.

The Lockerby mine radio system has met with mixed success. Here is a case where the existing physical layout of the mine pre-dates the modern decline ramp concept of mine

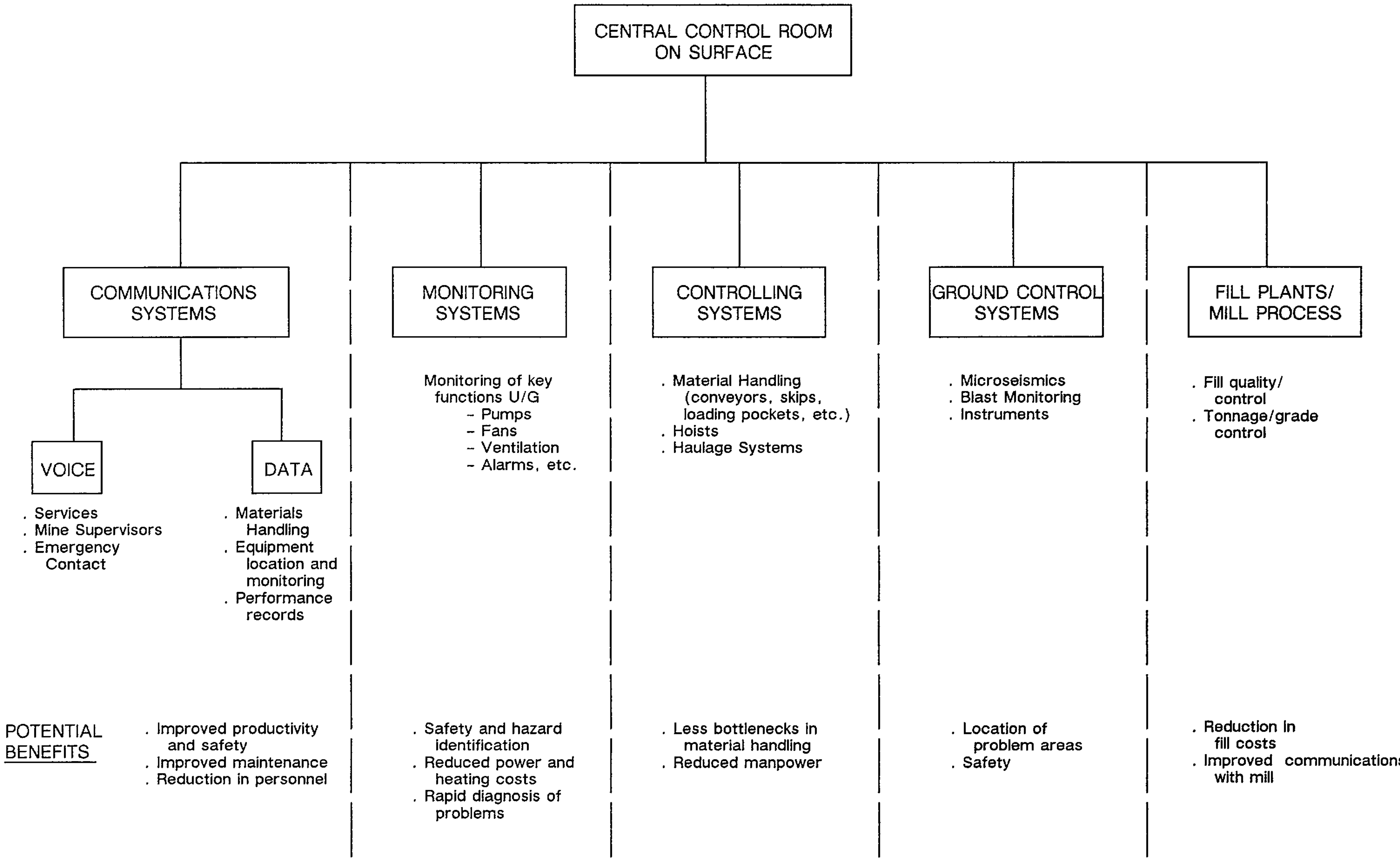

CENTRAL CONTROL ROOM ON SURFACE
COMMUNICATIONS SYSTEMS
MONITORING SYSTEMS
CONTROLLING SYSTEMS
GROUND CONTROL SYSTEMS
FILL PLANTS/ MILL PROCESS
VOICE
DATA
. Services
. Mine Supervisors
. Emergency Contact
. Materials Handling
. Equipment location and monitoring
. Performance records
Monitoring of key functions U/G
- Pumps
- Fans
- Ventilation
- Alarms, etc.
. Material Handling (conveyors, skips, loading pockets, etc.)
. Hoists
. Haulage Systems
. Microseismics
. Blast Monitoring
. Instruments
. Fill quality/ control
. Tonnage/grade control
POTENTIAL BENEFITS
. Improved productivity and safety
. Improved maintenance
. Reduction in personnel
. Safety and hazard identification
. Reduced power and heating costs
. Rapid diagnosis of problems
. Less bottlenecks in material handling
. Reduced manpower
. Location of problem areas
. Safety
. Reduction in fill costs
. Improved communications with mill

Figure A

ELEVATION VIEW — FRASER STRATHCONA — 1987 PLAN

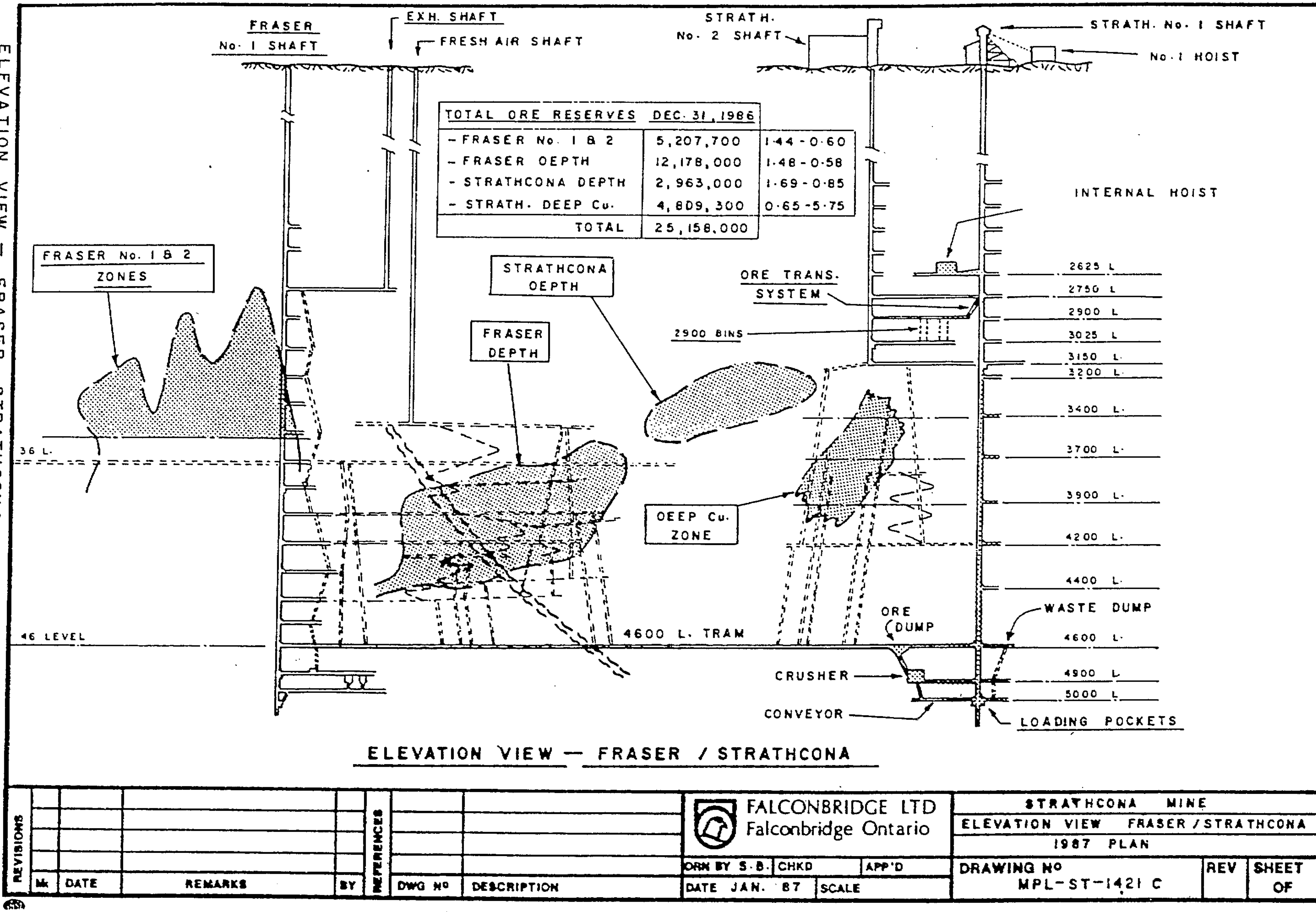
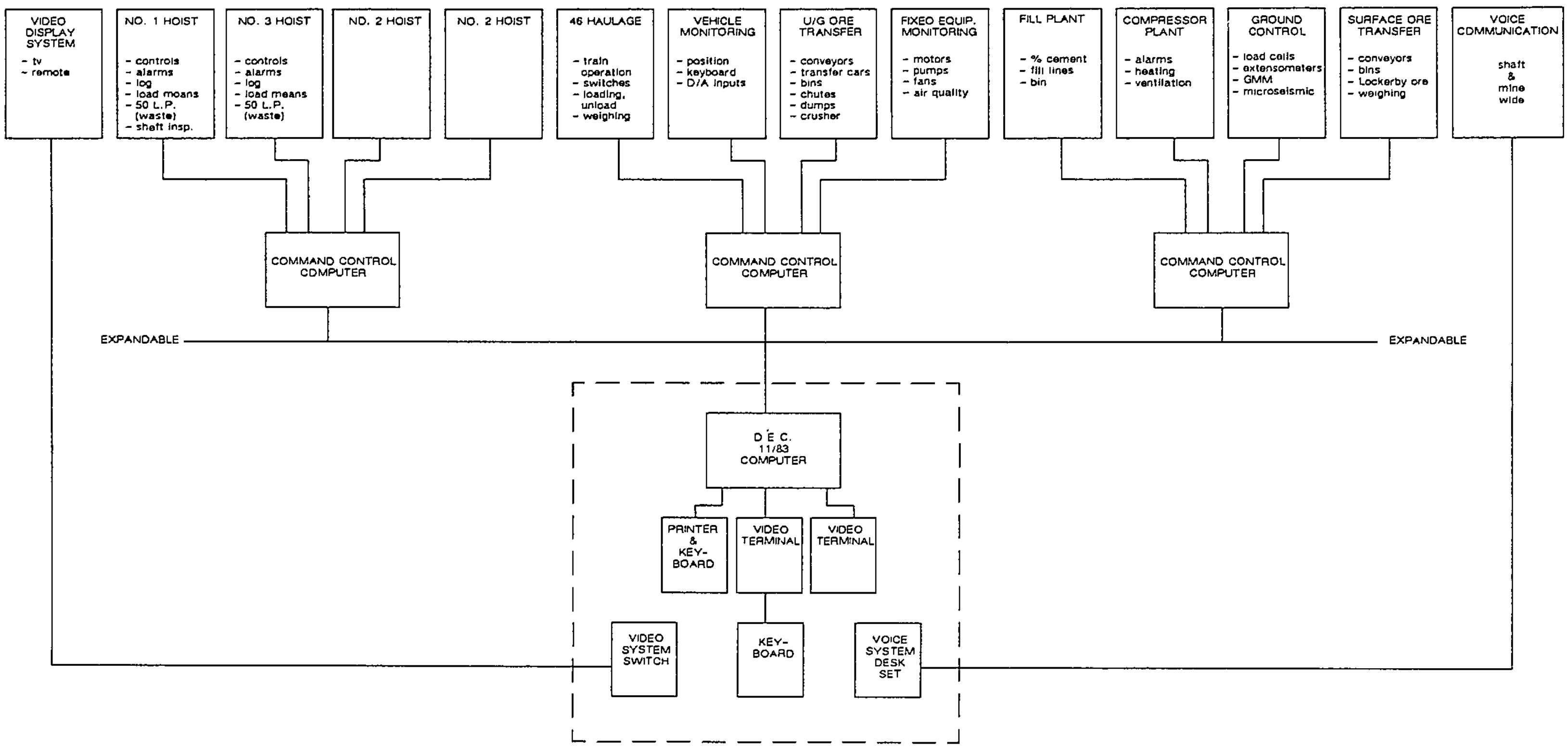


Figure B

FIGURE C

STRATHCONA MINE CONTROL ROOM CONCEPT



development thereby limiting the full benefit such a radio system can bring. The equipment was found wanting in the ruggedness required for our underground environment thereby limiting its reliability, servicing of the system by the foreign manufacturer was entirely inadequate and finally, it was perceived that insufficient effort had been directed to getting operations supervision to "buy-in" to the potential benefits of the system.

The monitoring/controlling system at the Fraser mine has provided valuable data to services personnel although its applications in production have been limited because of the lack of mobility and flexibility.

Microseismic monitoring has proved to be an outstanding success and is considered indispensible to our mining operations of today.

During 1987, a management review board was established to carry out the mandate of overseeing this new field of technological activity at Falconbridge, to formulate an implementation strategy for the introduction of this new technology and to provide a positive motivational influence to the process of change.

The following guidelines have been established and are being observed and acted upon:

1. All applications of this technology are to be based upon cost-benefit considerations only. No technology for the sake of technology.

2. The scope of the technology available is to be identified for consideration at all our mining operations.

3. Each mine is to:
   a. review its operations for appropriate applications of automation and control systems
   b. formulate a five-year plan for the adoption of appropriate applications
   c. identify and prioritize key projects for immediate implementation.

4. As a primary thrust of mine design:
   a. an appropriate level of central monitoring and control should be established at all mines
   b. the handling of ore and waste between the point of discharge into passes and exit from the headframe bin should ideally involve no operators.
   c. mining production equipment should be automated or remotely operated to reduce exposure of men at the working face and to improve the efficiency of operations.

To support these initiatives a resource committee was set up to provide the technical resources to the mines, as and when required, and to assist in the development and implementation of mine automation projects.

And so you can see that Falconbridge is poised and ready to make a big push forward in this field of automation and monitoring and control technology. We realize that much of the technology is already available but we are not convinced that it is in a form that can withstand the peculiar and rugged underground environment within which it must operate. This is vital if it is to achieve the level of reliability we demand in order to make economic sense of the investment required.

A field that I have not mentioned so far but nevertheless one we regard as equally important is that of computerized mine planning and design from geological ore reserve estimation through to rock mechanics, mine planning and actual operations. Over the last 10 years there have been significant developments in mine design and planning software based on PC's. Again, while this technology holds tremendous potential, it has a number of shortcomings that hinder its instantaneous acceptance and implementation throughout the mining industry.

1. Most supplier have not convinced the mining industry that they understand our needs and have a good understanding the engineering and mine planning process. Several software packages available today are somewhat superficial.

2. Unless enough emphasis is placed on training and education of the workforce, including our technical staff, acceptance of this technology is difficult at all levels.

3. With the serious cutbacks faced by the mining industry in the early 80's time allocated to training and education of the workforce has been limited.

Nevertheless, at Kidd Creek we have a highly effective mine planning and production control system that was born of necessity and developed collaboration between the mine engineering and geological staff and computer systems manufacturer.

At Sudbury, where our operations are quite diverse, we are still in the early stages of application of computers to mine planning. We have examined in some depth all the systems now available and have concluded that they offer insufficient facility to adapt to the particular requirements of the individual user. Here again we are forming an alliance with a CAD hardware and software systems supplier that will allow us to jointly develop our perceived needs in this area.

So you can appreciate that at Falconbridge we believe very much in working and collaborating with the suppliers to develop the means to improvement of our operations. These concepts apply equally to the industry as a whole. That is why I regard the organization of this workshop by MITEC as such a timely event.

We have heard much discussion during the past two-three years on the economic difficulties faced by our industry. We have heard that the solutions lie in the introduction of new technology and the stronger support and co-ordination of research and development efforts in the industry. I agree wholeheartedly with these ideas but I have had one serious problem. Insufficient attention, in my opinion, has been directed to the role of the manufacturers in this process, and I imagine that they feel left out and somewhat mystified as to our intentions. We have not spoken with a very coherent voice and we are just beginning to appreciate the difficulties of the equipment manufacturers in trying to deal with us. Perhaps this workshop will help to put this matter right. To the manufacturers I would say two things. Introducing new technology in mining is never easy. You need lots of patience and perseverance. Be prepared to be committed and work closely with us. There are rarely any shortcuts. There are, in the long term, excellent opportunities in automation and information technology in mining. In order for us to survive we will have to automate and become more efficient in communication systems and obtaining information in real time. I have said earlier that the process of change in our industry depends on building collaborative initiatives. I look to this workshop to promote this process.

Opening Address

H. Rogers, Deputy Minister
Industry, Science & Technology Canada

It is a great pleasure to be a part of the opening session of this important workshop. I am certain that I am not the first to congratulate you for putting this programme together but, first or not, I do wish to offer my sincere praise to those of you who conceived of and organized it.

Every industry in Canada, and indeed in the world, is constantly searching for something extra, something to supply it with a competitive advantage. The mining industry is no exception. The agenda you have put together for this evening and tomorrow, indicates that you are looking in the right direction. Technological sophistication and co-operative entrepreneurship are key elements in ensuring competitiveness in today's marketplace. Even a quick review of your workshop agenda convinces me that your conference organizers understand this and that what you're doing here is an important step in making the Canadian Mining Industry even more competitive.

As each of you in this room knows, the formula for industrial success has changed often and dramatically over the past thirty years or more. The days of staking a claim, extracting product and waiting for the world to beat a path to your order book, are virtually gone forever. Today, no market is guaranteed and no product is absolutely irreplaceable. Today, there is no such thing as a base price. If you can't produce it cheaper, watch out, someone else will.

Because the business world and business climate have changed so dramatically, a sense of real uncertainty has invaded a good many corporate boardrooms. That uncertainty is reflective of the instability that characterizes both the domestic and the international marketplace.

And, certainly, the world marketplace is an unstable place compared to what it was only a generation ago. Today, the very notion of captive markets is virtually an anachronism. The "global village" has become a reality and the structure of that village is unlike anything our fathers could have imagined. Our own Free Trade agreement is proof of that. So is the reincarnation of Europe (now officially scheduled for 1992) and so is the rise of our new Pacific Rim competitors, the so-called "Asian Tigers".

If the marketplace is in a state of re-definition, and it is, its metamorphosis is reflected in what is happening to traditional viewpoints on such things as product needs and industry definitions. New technologies have so altered available options that it is difficult to know from one day to the next who is your competition and what products are being touted as replacements for what you make.

Two simple examples tell the whole story. It used to be that the steel industry was guaranteed a certain share of the automobile parts market. After all, most of what went into cars had to be made of steel. That's no longer so. Now, steel producers face fierce competition; not only from aluminium, as announced this week but from plastics manufacturers.

Copper wire makers are being similarly pushed: not by aluminum wire but by fiber optics and satellite communications. Those industries believe that the best wire is no wire at all.

The end result is that it is no longer possible to find comfort in the traditional narrow definition of your industry and your competitors. No matter what you produce you must be constantly on the lookout for new competition. And, the impact of the new technologies makes it more than a little likely that the competition you face tomorrow will come from a product or a producer that wasn't even in the game yesterday.

The impact of this unstable world on senior executives is enormous. All work and no play is practically a way of life and the fear of "burn-out" is ever present. It's enough to make the average CEO want to chuck the whole thing, escape to the beach somewhere and write a best selling novel or something. Certainly, that's an option but it may not solve your problems. Even novelists live with pressure. Just ask Salman Rushdie.

Joking aside, we're not here to talk about giving up. You don't attend a workshop like this because you're a quitter. You take part in exercises like this because you're a fighter and you're looking for a new way to win. Things are tough, no doubt. Industry is being pushed closer to the edge every day by everything from international co-operation to exchange rates. But, as I hear you, you're not looking for a way out, you're looking for a way to get ahead.

At Industry, Science and Technology Canada, where I work, we've been mandated to help you find that way.

The Mulroney Government created my department for exactly the same reason that you are holding workshops such as this. The government is well aware of the climate of instability in which industry must operate, today. It is committed to helping industry adapt to the realities of a new marketplace, of new competitive challenges and of new production methods. The creation of my department was intended as a sign to industry of the depth of government commitment.

The key to understanding our mandate lies in our name: Industry, Science and Technology Canada. ISTC is the very embodiment of the government's belief that we must revise dramatically our approach to product development and international competitiveness. If Canada is to maintain and enhance her position as a world industrial force then everybody in every facet of production, from the laboratory to the shop floor, must work together in a spirit of dedicated co-operation.

This commitment to co-operation is not mere rhetoric. It is not political puffery. It recognizes the fact that the winning combination for this country lies in linking changes in government policies and practices to your needs and your priorities as you identify them. We can only forge these linkages if we work together.

Historically, this country's scientific, technological and industrial sectors have operated in virtual isolation from each other. There was no open hostility among the communities, no closed door policy, but, by and large, each had its own agenda, each pursued its own goals and each achieved its own remarkable successes.

In some senses, such independence is a wonderful thing. Each sector is master in its own house. No one feels obliged to march to the tune of anyone else's drum. Unfortunately, the independence so long enjoyed by the scientific, technological and industrial communities did nothing to prepare Canada for the competitive onslaught mounted by the new industrialists of post-war Japan.

The realities of rebuilding a war-shattered economy caused Japanese policy makers to become completely product-oriented. They had little time and no money for pure science and basic research and development. Laboratories and workshops had to be regarded as no more than way stations on the road from concept and. production to marketplace. In a dramatic experiment in demand-side economics, Japan looked for market niches and then poured all of its scientific, technological and industrial energies into filling them. The results are obvious.

In the past ten years Japan's share of world exports has doubled, Canada's has stagnated, the United States' has plummeted.

Our government has no intention of following our American cousins down. That's why it has made Canadian competitiveness a priority. It created my Department as one of many ways of serving notice that it wants Canadian industry to emulate and challenge the Japanese.

The way to do that is through co-operation. We must weld science, technology and industry into one market force to be reckoned with. The very spirit that underlies this workshop must become the hallmark of Canada's drive to secure an increased world market share. Science and Technology must become industry's partners or we cannot hope to succeed.

Your own industry provides any number of examples of how such a partnership can work. This meeting is not your first introduction to the value of information technology. The mining sector has been a leader in utilizing information technology to enhance control, productivity and safety. Examples include computer-based systems created specifically to monitor such things as equipment performance and underground environmental conditions.

It is important to stress that the government and my department are pursuing a goal of true co-operation, true partnership, among industry, science and technology. In no way are we suggesting that science and technology become industry's servants. What we are seeking is a truly symbiotic.relationship.

When your industry adopts high tech innovations it benefits. So does the high-tech industry. By enlisting information technology to gain a competitive edge you play a pivotal role in creating a new service industry. While you expand your own market, you become part of a new domestic market for Canadian information technology suppliers. As you use their products to sell your own, you open markets for them abroad. In short, everyone's a winner.

Just where does Industry, Science and Technology Canada fit into an industrial strategy based on marrying our different sectors? I suppose we are the marriage brokers. One of our jobs at ISTC is to act as the go-betweens, to facilitate the process of exchange and co-operation among these different sectors and between them and government.

Three of the new programmes we have underway at ISTC sound as if they were lifted straight out of your agenda. One programme is called "Support to Strategic Technologies". Another is "Support for Sector Competitiveness Initiatives". The third is called "The Provision of Business Information and Development Services".

I won't monopolize this evening's agenda by describing all three to you but I think you might be interested in a very short description of one of them. Our "Strategic Technologies Programme is intended to assist Canadian industry in developing, acquiring and applying a number of key technologies. One of those is Information Technology.

The goal of the programme is twofold. We want industries like yours to increase efficiency and competitiveness and we want to help build a strong domestic market for our Canadian suppliers of strategic technologies. Heavy emphasis is placed on increasing the number of firms working together in what, for them, may be new alliances in technological research and development. We're encouraging research and development that's targeted on industrial efficiency and that will result in improved industrial competitiveness.

Just as there is a lot more to mining than information technology, there is a lot more to my department than pushing co-operative enterprise. Our mandate, in the broadest terms, is to help make Canadian industries more competitive. We are doing that in a lot of ways.

We will provide you with information on just about anything from free trade and GATT to government programmes and international opportunities. We'll act as advocates helping you make your needs known in the corridors of power and, in turn, getting word out to you on government policies and programmes. Let me give you an example of the sorts of results this two-way communications strategy has already had.

In response to national concerns over the availability of highly qualified scientific and technical personnel, my department has launched three initiatives: we've established a "National Awareness Programme" intended to raise the Canadian consciousness of how important science is. This programme is aimed specifically at teachers and parents but, hopefully, will filter through to society as a whole. As well, we're helping to establish "Networks of Centres of Excellence" and we've put in place a "National Scholarship Programme". Each year 2,500 science and engineering students will receive direct government assistance.

To put it mildly, we've been busy. We intend to get a lot busier. As you know, developing a competitive edge, gaining a bigger share of world market, is more than a full time job. It's the challenge of a lifetime and it's a challenge we have to meet. The alternative is unthinkable.

I know that many companies simply don't have the resources to develop new technologies by themselves. That's where another aspect of the government's belief in co-operation and partnerships comes in. If you can't go it alone, form alliances. Work with universities, research institutes, other companies, even with competitors. The whole notion of competition, as we have understood it historically, may have to change.

They say politics makes strange bedfellows. So may the threat of losing that all important competitive edge.

Ladies and Gentlemen, I wish you every success in your discussions. They are vital to your industry and to Canada. Information technology demands that we look constantly and imaginatively forward. It is a tool that promises your industry exciting new advantages. Used well, it will yield new strategies, increased efficiency and profitable business prospects.

Good luck with your workshop and thank you, again, for inviting me to take part in it.

Summary of Dinner Speech by

Dr. Walter Curlook
Executive Vice President, Inco Ltd.

Dr. Curlook stated that he would present his observations on the recent history and immediate future of mining in Canada, and the impact and technology on the productivity and competitiveness of the industry. The decade of the 60's was one of strong world demand for minerals with high consumption rates to support industrial growth. This scenario gave rise to concerns over the long-run supply picture. In the 70's there were large capital expenditures in mineral supply projects, and the oil industry invested heavily in the mining industry. In the early 80's these developments created excess supply in a depressed world economy. Demand is now much stronger as we move to the decade of the 90's.

The outlook for the 90's is one of sustained and steady growth with emphasis on overall incremental growth. There will likely be fewer mega projects or extreme swings in the economy. The 90's will be a decade of high technology. There will be increased collaboration between industry, university and government, and between employer and employee. The accepted adversarial system will be modified. In the longer term the population of Asia will likely drive a demand boom for industrial goods and mineral production.

The Canadian mining industry has doubled productivity since 1981-82. Continued improvements will largely depend on the application of high technology.

Dr. Curlook then presented a comprehensive account of the Inco research effort over the last several years. The overall result is that the cost of producing nickel at the Inco operations is about the same as it was ten years ago. At the same time Inco has undertaken work training in new approaches such as fail-safe techniques. There are also teams of production workers who can interchange jobs. Lost time accidents have declined and turnover rates have dropped substantially. A profit sharing scheme which is related to the price of nickel has been introduced at all levels.

Turning to developments in the mining industry as a whole Dr. Curlook noted that the industry wishes to achieve more collaboration in research and to raise the quality of research. It is also desirable to have smaller industry members participate in shared research. Collaboration between different industry groups is also a goal such as took place at the workshop. All the advances put into place at Inco required other industries, other skills, other people.

Another wish is to promote better research between industry and university. The universities have vast research resources, not simply in mining, but in many other disciplines, which must be tapped. The main purpose of universities is to expand the frontiers of knowledge, but industry can assist in achieving that role.

Above all, it is important to bring together industry, university and government, both provincial and federal. Change is taking place and the people involved are cooperating more and seeking ways to work together. Industry is still looking for matching research dollars from government so that it will play its part in this new atmosphere of sharing. Understandably there are limits to the availability of funds, and the process of allocation has to be fair and equitable. It takes time, but there has to be ways to speed up the process so that the research can get started.

In looking ahead, more and more research is essential. More high technology has to be used. To get results everyone has to have a spirit of collaboration. Adversarial employer and employee relations have to be replaced. The technology pot is bubbling. The task is to keep it bubbling, stir and mix it some more and get results for the benefit of everyone and to advance our knowledge and skills.

Underground Radio Communications: A User's Perspective

K.V.S. Meyer
Vice President, Mining
Cominco EngineeringServices Ltd.

In my approach to this section of the Information Technology Workshop, I have borne in mind that a number of aspects are to be dealt with in the other 3 sections which follow.

Hence, my focus is on underground communications and networks and I think the best way to present a user's view is to essentially outline the somewhat successful experience that Cominco Ltd. has had in its mining operations and suggest the trend of future developments.

To that end, I propose to make extensive use of papers on the subject written by Hank Saunders and Martin Giles of Cominco's staff - both of these gentlemen having been directly involved in the development of our installations.

The most recent of these papers was presented a few weeks ago at an Electrical Mechanical Symposium organized by the B.C. Dept. o{ Mines in Victoria, BC., and with Martin's permission, I will quote liberally from this paper.

The inherent natural barriers to good communications in underground mines have long been a problem for mine operators. The increasing need for improved productivity to provide 'a competitive edge' highlighted the need for good communications.

Inadequate communications between personnel underground and surface facilities has led to less than perfect coordination between men and equipment. This can be particularly disruptive in trackless mining areas, where mobile equipment is constantly changing location, often in confined areas.

Since the early 1970's Cominco has installed VHF radio systems in its hard-rock mines; the Sullivan mine, Kimberley, B.C. and the Polaris mine, Little Cornwallis Island, N.W.T. The reliable communications afforded by these systems provides coverage to all key areas underground, surface areas and operational office locations.

History of U/G Radio Communications in Cominco Mines

The story for Cominco started in 1972. The copper mine at Benson Lake, Vancouver Island was the location of Cominco's first test of the use of radio underground,

This test was carried out using high-frequency (HF) radios provided by Marconi Ltd. An antenna system consisting of a single conductor was strung throughout a decline, drifts and sloping areas. With one radio connected to the long-wire antenna and another radio used as a test transceiver, the signal coverage in the mine was evaluated. The results were extremely promising; not only was coverage found in the areas equipped with the long-wire antenna, but also in areas where the antenna vas not installed. It was assumed the metal piping and electrical wiring acted as a passive antenna. It was also realized that the bulk and weight of the HF portable radios and their antennae made their use unacceptable as portable equipment underground.

After this early success further tests were conducted using very high frequency (VHF) radios supplied by Motorola Ltd. Instead of a single long-wire tests were carried out using balanced 300-ohm twin lead. The intent of these tests was to develop a system utilizing standard portable radio equipment that was compact enough to be reasonably carried by a miner all day without becoming a burden. The results were again very encouraging; clear, two-way communications was found to be possible approximately 40 meters off the sides of the twin-lead antenna and 90-120 meters off its open ends.

It was decided to replace an existing carrier-phone system on the Sullivan mine 3700 level haulageway. The proposal called for the use of 200-ohm twin lead (RG-86/UY) as the antenna system. As a result of the previous year's test, and the fact that other mining companies were also considering similar installations, the system was installed.

In 1974, another test using the VHF band was carried out, this time at the Pine Point mine, N.W.T. The Andrew Antenna Co. were experimenting with a leaky coaxial cable as an antenna called RADIAX (c), providing a continuous radiating antenna. With Pine Point anxious to investigate the application of underground radio, a system was installed using 600 meters of leaky coaxial cable, a 30-watt repeater and four portable radios. This system proved to be a success and during its lifetime the presence of dust, moisture and ice had no effect on the performance of the system.

While the Pine Point system was proving successful, dust and moisture on the twin-lead in the Sullivan mine haulageway was proving to be a real problem. Their combined effect on the cable dielectric significantly affected its characteristics increasing the attenuation in a disastrous and unpredictable way. It was also found that other users of this type of antenna system were also experiencing similar problems. The problems were so bad that regular cable cleaning was necessary to keep the system running. As the result o{ the success at Pine Point in 1977 RADIAX leaky coaxial cable was used to replace the twin-lead on the Sullivan 3700 level. The application of leaky coaxial antenna systems proved to be very successful, and Andrew RADIAX was adopted as the Cominco standard for leaky feeder cable.

Electric Blasting Caps and Radio Frequency Radiation

The possibility of accidental detonation of electric blasting caps has been of concern in mines considering the use of radio communications underground. The possibility exists that when blasting cap leads are uncoiled they may form an antenna such that in the presence of a radio transmitter sufficient radio frequency (RF) energy may be picked up to detonate the cap.

CSA Standard Z65-1966 was developed to protect personnel against radiation hazards. Clause 3 of this standard addresses electric blasting cap hazards from RF radiation. The standard has established minimum distances between radio transmitters and blasting circuits as well as detection and measurement techniques. For example, the minimum distance for a 10-watt mobile VHF transmitter from a blasting circuit is 10 feet.

Cominco carried out tests in the Sullivan mine in accordance with Clause 3.4 of CSA Z65-1966 and determined that based upon the criteria given:

1. There was no detectable hazard from the repeater/RADIAX portion of the U/G radio system.

2. A portable antenna had to be brought in contact with the test circuit to produce a hazardous situation.

3. A hazard may exist if a mobile antenna is parallel with and closer than 2 feet from a blasting circuit.

Case Study 1 - Sullivan Mine, Kimberley, B.C.

The Sullivan mine is located in south-eastern B.C. near Kimberley and is a lead and zinc mine which has been in production since 1909 and has been the principal supplier of ore to Cominco's plant in Trail; milling about 1.8 million tons of ore a year. Until the mid-1970's the Sullivan mine used conventional blasthole stoping mining techniques for the extraction of ore. In 1975 the conventional mining was augmented by trackless mining to extract the pillars left by the conventional stoping methods.

Ore extracted above the 3900 level is moved to the coarse ore bins and then to the 3800 level crushing plant, ore below 3900 level is moved to the crushing on a conveying system, both feed the fine ore bins for loading on a haulage system on the 3700 level which transports the ore to the concentrator some 6 km to the south.

3700 Level Haulageway/Concentrator

The first underground radio system at the Sullivan was on the 3700 level haulageway. The electro-magnetic interference from the mercury arc rectifiers supplying power to the electric locomotives was causing unacceptable noisy levels on the carrier phone system used by the haulageway operators. A VHF radio system was installed in 1973 to replace the trolley phone system. Conventional VHF portable, mobile and repeater radios were used, with a twin-lead antenna system. Unfortunately, as previously mentioned, the moisture and dust accumulation on the cable had a disastrous affect on the performance of the system, and considerable effort was necessary to ensure the cable was kept clean. In 1977 the twin-lead was replaced by RADIAX which proved to completely eliminate the problem associated with dust and moisture. The 3700 level haulageway radio system has since been extended to interconnect the two underground repeaters at the voice-frequence (VF) level with the surface repeater at the concentrator. This interconnection ensures that personnel associated with the haulage of ore, both underground and on the surface, are able to be in full contact at all times.

Two repeaters are installed underground connected to over 3000 meters of leaky feeder antenna. The 3 locomotives have mobile radios and approximately 15 portables have access to this system frequency. In addition, 11 remote desk sets underground and at the concentrator are connected to the system.

Mechanized Mining System

The introduction of the mechanized (trackless) mining operation brought with it the problems associated with trying to keep track of personnel and equipment. The success of the 3700 level system led to a proposal to install a leaky feeder based radio system in the mechanized areas. The system was designed by Cominco Engineering and installation was completed in 1979. Since that time the system has grown and changed in configuration. As working areas have changed, so has the layout of the system; including the recovery and re-installation in other locations. At the present time four repeaters are installed underground at the 3500, 3823, 3907 and 4250 levels and one is located in the surface warehouse. All five are interconnected at the VF level providing coverage throughout the trackless mining areas as well as on the surface, as a result supervisors and vehicles coming to the surface can remain in contact with underground.

3900 Level System

At the 3900 level it was a requirement that radio communication be available to permit single-man tramming. The 3900 level system operates on the same frequency as the mechanized system but is physically separate. It consists of one repeater connected to approximately 1200 meters of leaky feeder with four portables. Three remote desk sets are also connected to the system. It is proposed that the 3900 level system will be able to be temporarily connected to the Mechanized system by three rapid pulses on the push-to-talk button on a portable radio, the connection being automatically disconnected after a pre-determined time (of the order of minutes).

Crushing and Conveying System

One repeater connected to 1500 meters provides coverage in the crushing and conveying areas. It is not interconnected to the other radio systems and supports the operations and maintenance functions in these areas.

General Information

A total of more than 22 kilometers of underground radio coverage exists throughout the Sullivan mine. As previously mentioned, some of the underground systems are coupled with surface repeaters to provide wide-area coverage on the surface. In underground and surface offices remote desk sets are installed to provide access to each system by a selection switch.

The leaky feeder cable is supported by hangers from a 1/4" messenger wire which is attached to rock bolts in the roof or walls. All cable connections are made using standard UHF series connectors and fittings which are taped to ensure no ingress of moisture and dust. Depending upon the signal requirements the ends of the cable are either terminated in a 50-ohm terminator or a simple whip antenna.

The repeater base stations are WR Communications WR-194 units. The mobiles are 15 watt WR Communications WR-154 units which have been strapped or modified to produce a maximum of 10 watts output to comply with Provincial mine regulations. The mobile units are mounted in a special mounting designed by the Instrumentation department enabling the complete assembly, consisting of radio, helical antenna and microphone mount, to be installed and removed very quickly as one unit. The portable radios used are 2 1/2 and 4 watt Motorola HT-440 and MX-40 units, the latter being extremely rugged has proven to be suitable for the heavy usage in the Sullivan mine.

Case Study 2 - Polaris Mine, Cornwallis Island, N.W.T. (Figure 3)

Polaris is a lead and zinc mine located on Little Cornwallis Island, NWT, north of Resolute and close to the magnetic north pole, which makes it the western world's northernmost base metal mine. Concentrate shipping is limited to a lO-week season after the Arctic summer when the shipping lanes are open. In 1987 the mill treated approximately 1 million tons of ore.

The radio system was installed in 1982 when the mine went into production and is very similar to the Sullivan in design. The original repeater in the lunchroom has been supplemented by an additional repeater in the crushing area, with the leaky coaxial cable antenna extending through approximately 5600 meters of the mine.

Standard VHF radios are used throughout the installation, WR Communications WR-194 repeaters, Motorola HT-90/410 portables and MCX-100 mobiles.

The Sullivan and Polaris mines are excellent examples of the success of radio underground, and testimonials to the fact that radio can be integrated into the underground mining operation. Underground radio in these mines is not as common a requirement as electric power.

Costs

The costs of the original installation in 1981 at Sullivan are as follows:

3700 L System	$ 82,000
Mechanized Mining System	$172,000
Crushing and Conveying System	$ 64,000

These figures are in 1981 dollars.

Maintenance costs in the first year, were low as would he expected - $18,200. In the next year, there was a noticeable increase to $40,000, mainly due to reinstatement after blast damage plus preventative removal/reinstatement when close to blasting operations. Maintenance Costs have remained fairly constant since then.

Future Considerations

In recent tests at the Sullivan mine, 900 MHz portable radios were tested in workings withno leaky feeder cable. The results were extremely encouraging, point-to-point communications were obtained in excess of 300 meters around bends and down a man-way. This application of radio underground was in mine rescue. Typically, a portable base station with a high-gain antenna (small at 900 MHz) would be set up at the entrance to an area, working portable radios carried by rescue personnel. The radios used in these tests were GE portables.

Changes in mine operating methods, have in some cases increased the demand for circuits capable of carrying not only voice communications, but information relating to control of equipment within the mine. Rather than incur large capital costs to increase cable capacity. It may be more economical to consider multiplexing the information on existing facilities. Voice, data, closed circuit T.V., supervisory control and status monitoring information may be carried simultaneously on coaxial cable and with some exceptions on a pair of wires. Systems of this nature are in use at Cominco's Trail, B.C. Operations.

Fibre optics technology may see use underground. Immunity to electromagnetic interference and wide bandwidth characteristics makes it especially attractive as 'highways' for communication purposes. Relatively high cost is presently inhibiting its acceptance within the industry.

Conclusions

The cost/benefit advantage of communication systems can be very real provided original design is sound and application correct. Intangible benefits can be realized in improved safety and personnel comfort. No single system has all the answers, as is evident in the Sullivan mine experience. While this may be true for large mines, smaller operations are not so affected and may function well on one system.

Two-way radio communication systems are possible underground. Areas of maximum benefits are: shafts, conveyor systems, haulageways and mechanized mining.

Conventional systems have their place. Trolley carrier phones are more economical in long underground haulageways. Hardwired systems such as telephones, page/phones and light systems are better suited to fixed locations. Some mine page/phones are simplistic with low maintenance costs making them ideal for smaller mine operations. They may also be used as emergency back-up to more complex systems.

The introduction into the work place of sophisticated electronic PABX telephone switching systems, and the increased requirements for communications will further effect the integration of systems in mines.

I look forward to our Workshop sessions and the interchange of ideas between the users, suppliers and designers of Information Technology.

Production Monitoring and Control

B. Westhead
President, Westhead Associates

I will start by discussing organizational hierarchy and how Production Monitoring and Control impacts on the entire organization, from mine operations to the processing plant, and into the accounting functions. As soon as you install information technology, whether it's an IBM personal computer or a mainframe, someone back at corporate headquarters will want to tap into this network in order to gain access to information. We'll look specifically at where processing monitoring and control fits into the organizational hierarchy and then in discussing process monitoring and control we'll talk about the information hierarchy. That's one of the constants. I will talk about constants and variables. Dealing with human operators, for example is relatively constant, other things tend to be variables, like microprocessor technology. These are things that we can never get a grasp of in our industry because they are outside our control and changing too rapidly to get a fix on them. We will ask the questions, "who needs what information and when?"and what is the definition of real time. We should not forget the human side of our operations when we are designing information handling systems. We will look at the hardware available to implement different hierarchies within our corporate organizations and within our own mining automation information organization. What are some of the available technologies, the ones that are changing and the ones that are not.

First let's take a look at the corporate organization. At the bottom of the organizational structure is the process and cell control. Cell control is a term describing the control of more than one machine or more than one location. A cell may consist of all or a large segment of a conveyer, as opposed to one control station on the conveyer. So process and cell control is at the lower levels of the Computer Aided Manufacturing System (CAM). Other functions at this level, some applicable to mining, and some not, are process monitoring, inspection, quality control, material handling and maintenance. These functions feed to support the manufacturing control operation. Supporting the CAM planning is the business and accounting functions. At the engineering level is the computer aided design function. Once all this information becomes available on a network expectations increase to the size of network that can be accessed for management purposes.

Process monitoring and control is essentially dealing with information. Later on we will look at the sensor technology that delivers that information to us but when we are looking at monitoring today we are looking at computers. The technology today is a computer of some form or another, whether it is a personal computer or programmable controller, or dedicated machines controller, like a robot controller or a conveyer controller. All of these things are electronic. They all speak the language of electronics and they can be plugged into and connected to an information network. What do we do with the information, once we have collected it? One of the major issues, in any corporation, and we pay lip service frequently to this differential, is what is our most valuable asset, people or machinery? Most people would give this answer because they know that is what they are supposed to say. But inreal terms quite often our most expensive asset in mining, is not people, it is machinery. In reality, the one thing that is fixed in any process, including a mine, is the machinery. People are expendable, not all at once, but we are expendable and replaceable at any time. Machinery is fixed and this leads to the fundamental difference between automating an office and automating a mine or any other production environment. When you put a computer into an office the first notification comes out that we are computerizing our office, but don't anybody worry..you're job won't change, the computer is going to make it easier. Well the first thing we find from experience, is that the job changes almost immediately. Everyone in some way or another ends up adapting to the computer system because the computer system once it is in, is expensive to change. The implementers of the computer system never anticipates all of the details associated with the information flow between individuals in the office. So the individuals adapt because somebody decided to spend a million or a few million dollars on the computer and nobody is going to get in the way of making that thing unsuccessful, so the people adapt. Systems change when a computer goes into an office. The difference in production monitoring is that machines cannot adapt. If you put a computer into a mine, to control a conveyer,and the conveyer subsequently does not work then one of them is going to be thrown out. In this case it will be the computer that is tossed and not the conveyer. That is the key difference that we deal with in automating real production, or real manufacturing. The computers must adapt to the machines, the machines cannot be retrofitted to adapt to the computer. For one thing generally the machines cost more. This is the major difference to the office automation, accounting, planning, or even engineering design automation. In this case the machines we are trying to automate cost more than the equipment we are using to automate them, so they must adapt. This is the primary reason for having so much difficulty with them. You could throw a computer into an office, and after two years of turmoil, everyone who made the decision to buy the computer, says it went in like butter and it works fine. We cannot do that in a manufacturing plant, you put a computer in a manufacturing environment or production environment, and it gets in the way of production, the machine goes right out the door. This is because production is the companies bread and butter.

So let us take a look at the information. Fortunately one of the constants in the industry, is the type of information we are expected to display. Essentially there are four categories, graphics, alarms, trends and reports. This has been a constant, right through the sixties, seventies and eighties in dealing with very early computer automation technology. Graphics we use to display pictures and show what is happening in the process, on our conveyer lines. Alarms are used for safety information, diagnostic information, locating faults. Trends are used for watching whether production is increasing or decreasing. Reports are used for analyzing data and producing something like an hourly or shift report, that saves time and gives quick feed back on how production is going.

For example graphical information as displayed on a computer screen for use by operators, production supervisors and managers. This is real-time information. These numbers are changing on a second by second basis as production changes. The definition of real-time is another elusive concept. Most people at the machine control level, consider real-time to be milliseconds. A thousandth of a second can make a difference if you are looking at timing on a sophisticated machine.

When we are looking at real-time as it relates to operators, seconds are usually enough. Operators can wait a second or two for a piece of information to appear. In many cases if he doesn't know what happened twenty seconds ago he can wait for the information to appear. However this is not the case in a safety situation. If a button on the surface is activated it is unacceptable to wait twenty seconds before the computer informs the operator of the status. So if an operator turns something off on the surface, he expects it to be off quickly underground. In this situation seconds, or large fractions of a second is what an operator will consider acceptable as real time.

In terms of maintenance we will look a little bit at using computers for machine diagnostics in locating faults, and minimizing downtime. Real-time for maintenance is often in minutes. As long as we know within a minute or so what caused a fault, that is a lot better than having to send a crew underground to locate the fault. If we have enough sensors on a system underground, when it fails we can discover why it failed, and shut it down using safety interlocks. What is new is intelligent controllers that can communicate with humans. If a safety interlock fails, we can immediately shut down an entire conveyer. However the question is which one of the many interlocks shut down the conveyer. Machine diagnostics is when the computer can tell the operator which interlock was responsible for shutting the conveyer down. Once the operator can determine whether its an electrical or mechanical problem he will known which trade to send down the mine to fix it. So with maintenance issues, even minutes is a big improvement over sending a crew down to find out what the problem is. Then having to call back up to the surface for an electrician, who did not happen to be available initially.

In terms of production supervisors, hours are what he usually considers real- time. He is responsible for a shift, he might be happy to know on an hourly basis what his production's running at. In terms of a plant manager, probably the shortest time he wants to look at is an eight hour shift, so real time to him is getting information at the end of an eight hour shift. We can go on and on up to the shareholders who are happy to get a report once every ninety days, so to them real-time feedback, is a timely quarterly report. Real time can mean a lot of things to a lot of people. Most of the value of computers in todays production process is in report generation and data manipulation. In this case generally minutes or hours are acceptable. So computers don't always have to be fast at the microsecond speeds.

The other type of information we need quickly, is alarm information, and we need this primarily for safety reasons. Alarm information is something as simple as just a list of faults, the bottom of the list being the last alarm that came in. Usually it flashes until an operator acknowledges. Ideally the operator likes to record not only the time the alarm occurred, but the time the button was pushed to acknowledge the alarm. This action records the response time.

Production trends are another type of information that is required for planning purposes. The production manager has to determine whether production parameters are increasing or decreasing. Ideally he needs to look at these trends on a variable scale, and expand the scale to get a little more indication of to what's been happening. The other use for trends is timing analysis. Quite often if we have several machines working in tandem, as on a convey system. It is desirable to see which motors are running and when. Sometimes a motor like a sump is running normally then fails. Trend information can display this sequence and give management a good indication of what is happening in the process. The last type of information that is required by management is computer generated reports. We need to get some kind of display of a summary of information over a period of time.

Next I want to address a few human factors that require consideration when automating the production process. Today we can buy a computer for $4,000.00 or less and connect it with relative ease to a communications link and extract information. I want to stress that in other sectors such as manufacturing there is a tendency to implement automation too quickly without considering fully the human impact. However in the mining industry it tends to be the opposite, due to the cautious attitudes of mine management towards automation.

One factor that is often over looked is the designing of screen displays for ease of use by operators. When looking at pictorial information, the eye scans a picture, any picture, on a magazine page, or on a computer screen, from the top right, counter clockwise, around to the bottom right. So we want to put the most important information on the top right. If we put it at the bottom right, when the operator calls up the display, his eye will have to go around the screen to find the information he wants. The exception to this, of course, is text information, when we have to go to the top left and read from left to right. Something as simple as this is not a major factor because the eye takes fractions of a second to get around the screen. But knowing this can reduce what is called subliminal stress in an operator. If we design our screens poorly and make it difficult for the operator to look at, he is subjected to increased fatigue due to subliminal stress. This fatigue shows up as headaches which impedes the operators acceptance of the system.

Other factors such as colour assignments also impact operator fatigue. There are standard assignments for colours on computer screens. It's a good idea to stick to some standard such as red for alarm and yellow for warning and so on. Sensitivity of the eye to different colours also impacts the operators performance. The eye is more sensitive to green and yellow so we should put numbers and objects that require careful reading in colours like green and yellow. Avoid colours like violet and blue in combination, because they are at opposite ends of the wave length spectrum and it is difficult for the eye to focus on them simultaneously. It is also difficult to focus on red and blue simultaneously. Studies show that 8% of the male population suffer from some form of colour blindness hence one should avoid using certain colour combinations.

The next topic that I would like to discuss is hardware architectures. The basic architecture is the computer connected to a sensor. The next level up is some kind of central device that feeds several computers and a plant host. The link here being the link to the real time elements, whether they are programmable controllers, robot controllers or intelligent conveyer controllers. In terms of information we are collecting information from real time devices. Feeding this to a network and sending this information to terminals, operations and corporate computers for immediate assimilation. Examples of this information are the collection of daily production data.

The ideal organizational structure requires what we call a flat architecture. This is a network which uses a standard protocol such as Manufacturing Automation Protocol (MAP). However with such a varying number of protocols used by each computer manufacturer a flat architecture is quite elusive today. With all this different equipment being used by organizations the components at the machine controller level are not connected directly to the network. They require connections through intelligent boxes, which generically are called gateways. This is not flat information technology where ideally you have one cable, that goes right from the sensor level through the corporation all the way to the sales and administration computers. This level of integration really is difficult to achieve. This is the direction we are heading. From a sensor underground, ultimately up to some kind of a bus that gets us direct access to the corporate computers.

Let us now look at the some of the available technologies that can be used to automate the production process. Sensor technology, for example gas detection, is relatively constant. The sensor mechanics, the fundamentals of operation of the sensors are not changing. That is not to say that there are not new sensors being developed. It is the pace at which this technology is changing. In many types of applications in mining, manufacturing, etc., sensor technology is changing relatively slowly. A lot of the sensing problems we wished we could solve twenty years ago are still the same problems we have today. For example we do not have automatic or remote sensors. Progress is being made in the development of vision sensors, but not at the rate that was first anticipated. The main breakthrough in this area is in the packaging ofthese devices. We get gas sensors that are packaged in small robust units which are in turn connected to a computer.

This is a form of an island of automation. Sometimes we hear bad things about islands of automation. My feeling is that they are good, it's a good way to start. Small automation systems, this is an IBM personal computer or a clone connected to a number of gas sensors that form one of these islands of automation. The good thing about this is that it only does gas sensing, and the computer collects this information regarding this aspect of the operation. Then this information can be plugged into a larger network at a later date.

The next technology for discussion is unit controllers which are getting much more sophisticated. Relays are getting replaced with much more sophisticated and powerful programmable controllers, conveyer controllers and machine controllers. These are capable of doing what we call machine diagnostics and automatic activation of safety interlocks. The question of machine diagnostics comes down to, what happens when a machine stops. When a machine stops, production stops. The issue becomes what made the machine stop and how quickly can the fault be found and the machine repaired. Machine diagnostics, is one field that has undergone a large amount of technology development. This is due to the demands placed on automation in assembly plants, such as the automotive industry. This technology is also applicable to underground systems because of the difficulty in access by maintenance crews. Diagnostic packages inform the operator of the location and type of fault. From this information the right trades with the right equipment can be sent down the mine to do the repairs. The more sophisticated the diagnostics the more sensors are required to feed the machine information to the computer. The key to this system being effective is a combination of sensors, machine controllers and a computer to aid in analysis. This equipment can be obtained in industrial packaging. We can buy small computers or terminals, in good ruggedized packaging that are suitable for underground, exposure proof environments. This packaging is CSA approved for use in hazardous locations.

There are a couple more technologies of interest to our operations that may not be so evident. One is virtual graphics, this is an older form of technology, circular tracking recorders, and electrical calculators. The visual and data processing environment of thirty years ago. It is interesting to note that a lot of these panels with circular track recorders still exist in todays operations. Virtual graphics is a new technology which indicates the same information but in a very different format. Until recently this technology was only available in naval and other military installations. These virtual graphics operate in real time. The operator can grasp a knob on a touch screen and turn it, and a pointer will increase and decrease accordingly. You can actually take a control panel and put it on a computer screen in exactly the same pictorial form, right down to the piece of masking tape that might be on the panel with a label on it that the operator uses everyday. You can put that picture on the screen and you can turn the same knob on the screen, by grabbing the knob in the touch screen by turning ones hand. The knob will turn and the pointers will respond in the same way that the control panel does. This is a technology that can be introduced to operators in a mine environment.Finally a few references to technologies that are just becoming viable in production automation. Applications in the area artificial intelligence still have not made a significant impact on mining operations. A technology called "WORMS", a black box recorder. This is one wire going through the entire plant with a black box recorder attached which picks up every signal that passes along that wire. With this system, just like a VCR, we can replay the entire mine operation over a period of time, fast forward, stop, rewind. We can analyze a fault or a production stoppage and replay on the computer screen what happened.

Questions

1). Are there applications for using fibre optics? In your work, have you studied this use, particularly where the cost of the fibre optic cable is not the initial factor, ie what are other reasons for its use?

Fibre optics are being used in underground applications. The key reason for selecting fibre optic cable besides cost is the ability to carry more channels on one cable. This makes it a very practical communications medium for underground applications. The only difference between copper wire in terms of additional electronics is one extra box at the beginning and the end of the fibrotic cable that converts our electronic signals to light signals. The technology is available today and is easy to make use of.

2). Could you elaborate a little bit on some of the man machine interface problems that you presented earlier. For example, you were discussing how an operator can reach for a knob on a computer screen and change a parameter. Are operators finding this an easy transition? For example, in some of our process control applications and mineral processing plants, we are finding that the operators seem very reluctant to use the screen in that way, ie., they are really hesitating to use this screen as a true operating parameter, or operating control.

Yes when this system was first introduced we did observe these reactions. We started using touch screen in centralized control rooms as long ago as five years, and then it was a real issue. People did not want to even reach out and touch a screen. They had a lot of reluctance to touching the glass and getting involved that way.

Automated Material Handling

Ted Christie
General Manager, EMS Associates

Information Technology
(Overhead #1)

After agreeing to participate in these proceedings the first question I had to wrestle with was "What is information technology?" Very soon I came to realize that it was something with which I had been associated over the years, except I hadn't recognized it by that name.

Not too long afterwards I had a call from a gentleman named Richardson from Queen's University who mentioned something about a list of questions which I, at that time thought was something that I had to prepare. I now realize this was not really the case.

However, I dutifully prepared my list based on my own experience in bulk material handling systems. It may be interesting to repeat this personal list to you as, quite frankly, it was helpful to me in deciding what I might speak about today.

It is my intention, there, to refer to the following headings as listed on this overhead:

1. Basic Questions

2. Information Technology

3. Typical Bulk Terminal Installation

4. Operating Benefits

5. Automatic Guided Vehicle Systems (AGVS'S)

6. Marketing Considerations

7. User/Supplier Relationships

Basic Questions
(Overheads #2 and #3)

On these next two overheads are the questions which I first came up with on today's subject which, as I mentioned earlier may be interesting to review quickly.

1. Is the Adoption, or extension, of information technology in materials handling an already perceived need and is it appealing to the Canadian Mining Industry at large?

2. Do existing underground mining methods have to change to become adaptable to information technology?

3. Recognizing the possibility of conflicting interests between mining companies, is it possible to create a non-partisan approach in addressing a general industry need for improved mining methods including information technology?

4. If the creation of a non-partisan industry approach to further the development of information technology is a possibility, what role will the Canadian government play in these efforts?

5. Is financial and/or technological assistance available to the mining industry from the Canadian government for the advancement of information technology in Canada?

6. Canadian companies which are involved in both the engineering and production aspects of equipment and systems may find it increasingly difficult to justify the use of their engineering resources for the development of new products or technologies. Is there a solution to this problem?

7. Are there any programs in existence, or under consideration, which would allow tripartite cooperation between mining companies, suppliers and government for the development of new technologies in Canada?

8. Is the present educational system in Canada appropriate for the continuing advancement of information technology application in underground mining?

9. Economic pressures coupled with accepted purchasing practices often result in equipment or technology being procured from competent suppliers at very competitive levels. Does the availability of offshore equipment and expertise hinder, or even preclude, the perceived need for Canadian development of information technology in mining?

10. Could the existence of marketing relationships between mining companies and offshore clients act as a deterrent to the development of the technology in Canada?

11. Can non-Canadian corporate ownership of Canadian companies influence information technology development in Canada?

12. At what stage is the development of automatic guided vehicle systems (AGVS's) for application to underground mining?

13. What is the role of Canadian consulting engineering companies in developing information technology in Canada?

14. Is there, as a result of the current workshop sessions, an optimum and preferred option to be identified for the development of this and other technologies in Canada?

(Overhead #4)

A typical illustration of information technology as it is understood and presently applied in the bulk material handling industry is shown on this overhead.

This configuration is actually drawn up for a bulk terminal operation and as you can see in this case, a resource and information management system is made possible by the marriage of one or more programmable logic controllers with, usually, a super mini-computer.

This allows operating personnel to interact with the PLC through the system control panel for equipment status and control functions.

Information from the PLC is processed and/or stored in the memory of the computer which supports all other management systems functions that are important to overall facility management. These include, but need not be limited to, operations, scheduling, maintenance and financial control.

The adoption of such a complete system is, as you may imagine, quite costly. It is also understandable that the introduction of a complete system into an existing unequipped facility is a much more difficult decision to make as compared to that in the case of a new operation. This may be especially true in the case of an underground mining operation where the mining methods, perhaps, are not readily adaptable to its introduction.

The degree of sophistication, therefore, which may be appropriate in each case, can only be established after proper feasibility studies and cost/benefit analyses. This decision, however, should not be compromised by a sometimes natural tendency to downplay the disadvantages of the old at the expense of a newer, capital intensive unfamiliar alternative.

Typical Bulk Terminal Installations

(Overhead #5)

The degree of sophistication of automation and information systems for bulk terminals has grown over the years. Certainly much of this is associated with new terminals as they are developed, but it is also partly due to the much more exacting quality standards which are demanded by purchasers of bulk commodities such as is certainly the case with coal.

A fairly recent example of this is to be found in the coal handling system which was designed, supplied and installed by Stephens-Adamson Canada for the El Cerrejon Coal project at Puerto Bolivar in Colombia, South America.

Here the coal handling system at the port, as you can see, comprises:

- a train unloading station
- two bucket wheel stacker/reclaimers
- a large linear shiploader
- inter-connecting belt conveyors
- other ancillary equipment such as sampling system, weigh scales, metal detectors, etc.

This facility went into full commercial operation in early 1986 as many of you may know and it was financed in large by the Canadian Export Development Corporation (EDC).

The control and information requirements for the complete coal handling system at Puerto Bolivar are accomplished by means of a series of programmable logic controllers, one in each unit substation or electrical room and a main PLC in the Central Control Room (CCR) to provide communication with the other PLC's as well as to provide a means of indicating and printing all alarms.

The main PLC in the Central Control Room interfaces with the owner's host computer for all status and alarm signals, scale tonnage totalizers, rates of flow data and the position of all stacker/reclaimers and shiploader motion drives.

The control desk is located in the Central Control Room, facing the graphic panel and includes:

- a printer where all annunciated alarms anywhere on the conveying systems are recorded with the date and time of occurrence, as well as when each alarm reverts back to normal
- a CRT and data entry board, where the complete terminal, or parts of it, can be indicated in addition to the two most recent alarms
- a pushbutton control panel for the route and maintenance selection.

The installed cost of such a control and information system can amount to around four or five percent of the total handling system cost which represents a very significant capital investment. It is most important, therefore, but unfortunately not always the case, to have management dedication to using the system to its fullest capability to realize the potential benefits of the capital invested.

Operational Benefits
(Overhead #6)

For a variety of reasons it can be difficult to establish an actual documented assessment of the operating cost benefits resulting from a prior investment of both capital and learning inefficiencies in adopting some level of information technology. This notwithstanding, some operations have generally quantified assessments of the benefits to their specific operation.

Such is the case at Thunder Bay terminals, as one example, where the main bulk handling system generally comprises:

- rotary dump, train unloading
- coal crusher
- yard conveyor
- travelling, slewing, luffing stacker
- travelling, slewing, luffing B.W. reclaimer
- coal silo with four discharge feeders
- wharf conveyor
- travelling, luffing shiploader

The control and information system does not incorporate any PLC's but instead a multiplex system of control has been adopted between the control cabs, the motor control centers and the central control room. Alarms are annunciated and printed with time of occurrence at the central control room as well as weigh scale measurements. The scale readings are also made available to the operator on the deck of the ship.

All of the functions from reclaim through the yard conveyor, the silo and feeders, the wharf conveyor and the six-function shiploader are started with a single button by a single operator positioned on the deck of the ship. Shiploading continues under this operator's control from his portable control station and 30,000 DWT ships are being loaded in a period of only six hours.

Thunder Bay terminals figures that its investment in its control and information system, including a computerized planned maintenance program has realized operational cost and efficiency improvements totalling some 20 percent.

Another example which may be mentioned in passing, through further removed from mining, is related to self-unloading ships systems. In some ways these can be considered in a similar light, especially in coal service, in as much as large quantities of coal have to be conveyed at relatively volumes high capacities from tunnels under the ship's holds.

The environment at this point of the system is not entirely appealing and is governed by certain regulations for electrical control equipment in hazardous locations and explosion-proof requirements in hazardous locations and explosion-proof requirements for electric motors.

From the tunnel conveyors the material is transferred, usually to a sandwich belt, which in turn elevates it to a boom conveyor which then discharges it to the receiving location.

These systems used to require a tunnelman in each tunnel who was responsible for ensuring the correct flow of material from the ship's hoppers through hydraulically operated gates onto the tunnel conveyors using a system of indicating lights. Some vessels had three tunnels and hence three tunnelmen.

The introduction of a relatively modest level of automation on domestic vessels over the years has, for example, eliminated the absolute need for tunnelmen. In one ship operator's opinion the move to more automated self-unloading systems was brought about by a combination of operating efficiency and personnel safety considerations. It is estimated that the changes so far adopted have realized operating savings of some 10 percent.

The examples mentioned here relate specifically to bulk material handling and, for today's purpose, are general in their nature. Hence they are offered only as an indication of the cost effectiveness of employing some of the available technology.

It is recognized that mining methods involve other means of handling materials and that those methods are likely to make the implementation of information technology more of a challenge. Obviously, in considering some level of information technology at an underground mine location, the compatibility between the available technology and the mining methods has to be established and the cost/benefit relationship determined.

Automatic Guided Vehicle Systems

Automated Guided Vehicle Systems (AGVS's) have been employed very successfully in several manufacturing and warehousing facilities but this is a subject which must remain outside the scope of this presentation. It may be mentioned in passing that their application to underground mining has been very questionable because of the attendant environmental conditions. It is now understood, however, that at least one company in this field, namely FMC, have a conceptual project underway on AGVS's concerning their application to mining. The results of this will be looked forward to with some interest.

Marketing Considerations
(Overhead #8)

An objective of the current sessions is to promote not only the value and use of information technology in Canadian underground mining but to do so on a nationally sourced technology basis.

It would seem worthwhile, therefore, to consider some of the potential obstacles to the national aspirations of this objective.

The following are typical of some of the problems which may be encountered by Canadian suppliers in marketing bulk material handling equipment and systems in their domestic marketplace which may, or may not, have some relevance to the marketing of Canadian information technology.

Offshore Competition

In some competitive bidding situations, and despite apparently acceptable technical and commercial evaluation of a Canadian offer, business can be lost to a foreign competitor with a longer list of successful references.

Client/Owner Marketing Relationships

The possibility exists that marketing relationships between the client or owner of the commodity being produced and his customers can have some bearing on purchasing decisions for equipment and systems.

Non-Canadian Ownership of Canadian Suppliers

It is acknowledged that in certain cases Canadian companies may be part of larger non-Canadian companies or corporations. In such cases the technology source is most likely, and perhaps understandably, located outside Canada.

Government Assistance Programs

The Canadian government has some effective programs in place for export market development and financing arrangements which allow Canadian suppliers to compete quite successfully in overseas markets. It often appears most difficult, or even impossible, to achieve comparable success against the same offshore competitors in the Canadian domestic marketplace.

Education/Training

It appears in the bulk handling industry that it is becoming increasingly difficult to obtain experienced technical staff. The question is sometimes asked if the educational institutions could do more to alleviate this type of concern by improvements to the specific industry awareness level of academically qualified students entering the job market.

User/Supplier Relationships
(Overheads #9 and #10)

The working relationship between a supplier and his client is believed to be, more often than not, dictated by his client.

Client/Consultant/Supplier

A very common arrangement in bulk material handling systems is that the owner or user retains a consulting engineer who from then, at least up to the point of acceptance of the system, acts as an intermediary between user and supplier. Very often after this point a direct relationship develops between the user and the supplier for questions or problems which may arise from time to time.

This type of arrangement, although apparently necessary on large projects, can suffer up front from a degree of user/supplier isolation which can have certain negative effects on the project's final outcome.

In the post-acceptance period, all too often, the supplier has by necessity committed his resources to other jobs, possibly in other countries, and he may have difficulty in providing the sporadic requirements for his services from the user. This can and has been overcome to a degree in some recent cases by the user reserving supplier inspection and equipment survey services on an annual pre-planned basis.

(Overhead #10)

On larger international projects the protocol associated with user/consultant/supplier relationships can become quite staggering and difficult to manage. A recent example of this is shown for your interest.

User/Supplier

In some cases a supplier may be approached by a user to work directly together on a smaller project or assignment arrangement.

In most instances this would be on a regular contracting basis for equipment and/or services and in such cases the contractual arrangements are usually quite straight forward as is the implementation of the contractual obligation.

In other cases it may be for an equipment development project which has been pre-identified by the user as necessary for h is operation and within the supplier's particular area of expertise.

This type of direct working relationship is normally governed by some form of confidentiality agreement to protect the proprietary aspects of the user's initiative.

Again this type of user/supplier direct relationship has been found to work very well.

In summary, therefore, experience has demonstrated that in any relationship, there should be no more or no fewer participants than are absolutely necessary to complete the task on hand.

Experience has also shown that a direct user/supplier relationship is possible and works very well especially when it involves specialized equipment or a specific technology and this would appear to hold true in the case of information technology.

Overhead #1
Information Technology

Automated Material Handling

1. Basic Questions
2. Information Technology
3. Typical Bulk Terminal Installation
4. Operating Benefits
5. Automatic Guided Vehicle Systems (AGVS'S)
6. Marketing Considerations
7. User/Supplier Relationships

Overhead #2
Automated Material Handling

Basic Questions

1. Is the Adoption, or extension, of information technology in materials handling an already perceived need and is it appealing to the Canadian Mining Industry at large?

2. Do existing underground mining methods have to change to become adaptable to information technology?

3. Recognizing the possibility of conflicting interests between mining companies, is it possible to create a non-partisan approach in addressing a general industry need for improved mining methods including information technology?

4. If the creation of a non-partisan industry approach to further the development of information technology is a possibility, what role will the Canadian government play in these efforts?

5. Is financial and/or technological assistance available to the mining industry from the Canadian government for the advancement of information technology in Canada?

6. Canadian companies which are involved in both the engineering and production aspects of equipment and systems may find it increasingly difficult to justify the use of their engineering resources for the development of new products or technologies. Is there a solution to this problem?

7. Are there any programs in existence, or under consideration, which would allow tripartite cooperation between mining companies, suppliers and government for the development of new technologies in Canada?

Overhead #3
Automated Material Handling

Basic Questions

8. Is the present educational system in Canada appropriate for the continuing advancement of information technology application in underground mining?

9. Economic pressures coupled with accepted purchasing practices often result in equipment or technology being procured from competent suppliers at very competitive levels. Does the availability of offshore equipment and expertise hinder, or even preclude, the perceived need for Canadian development of information technology in mining?

10. Could the existence of marketing relationships between mining companies and offshore clients act as a deterrent to the development of the technology in Canada?

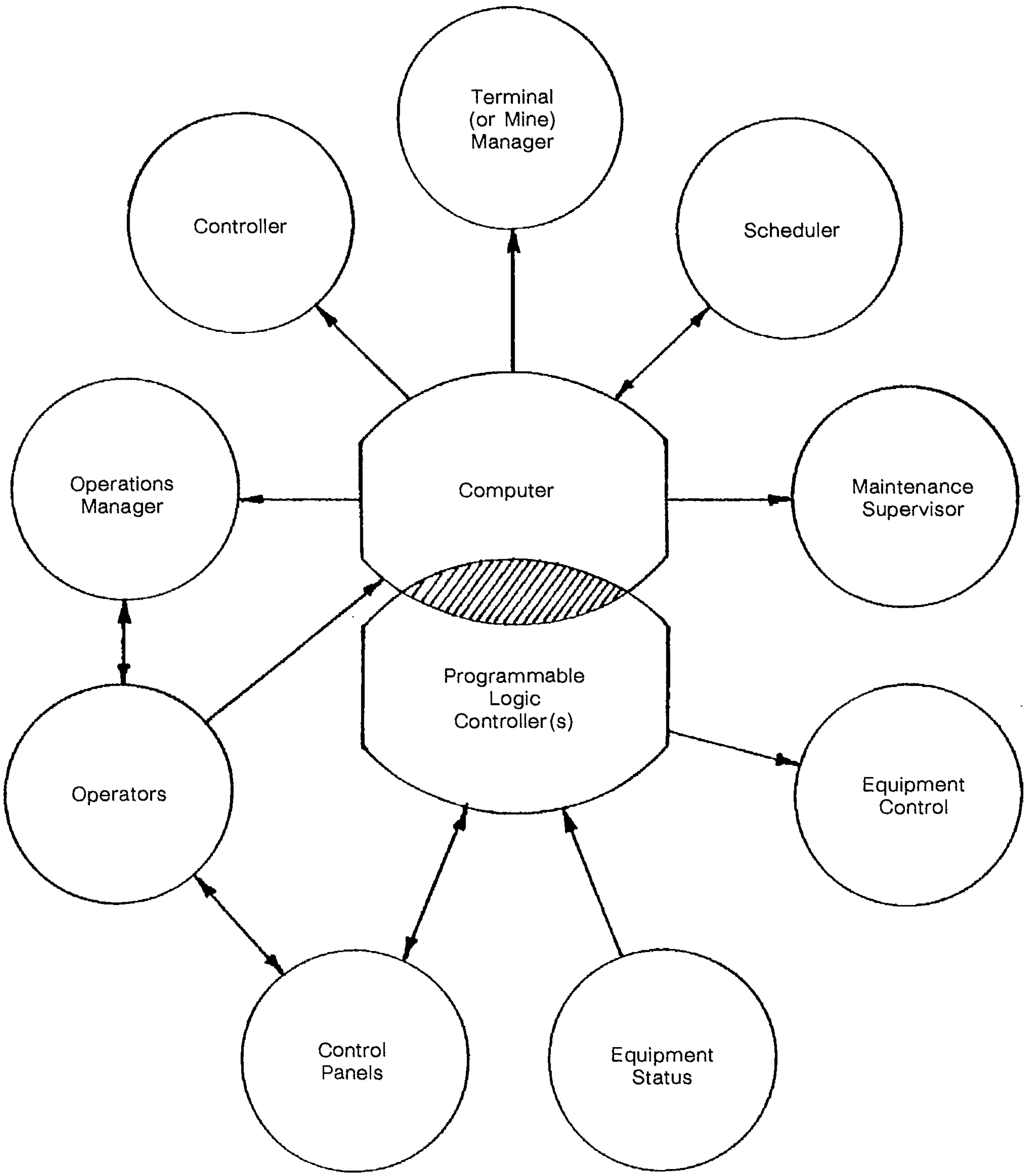
11. Can non-Canadian corporate ownership of Canadian companies influence information technology development in Canada?

12. At what stage is the development of automatic guided vehicle systems (AGVS's) for application to underground mining?

13. What is the role of Canadian consulting engineering companies in developing information technology in Canada?

14. Is there, as a result of the current workshop sessions, an optimum and preferred option to be identified for the development of this and other technologies in Canada?

INFORMATION TECHNOLOGY



O/H 5.

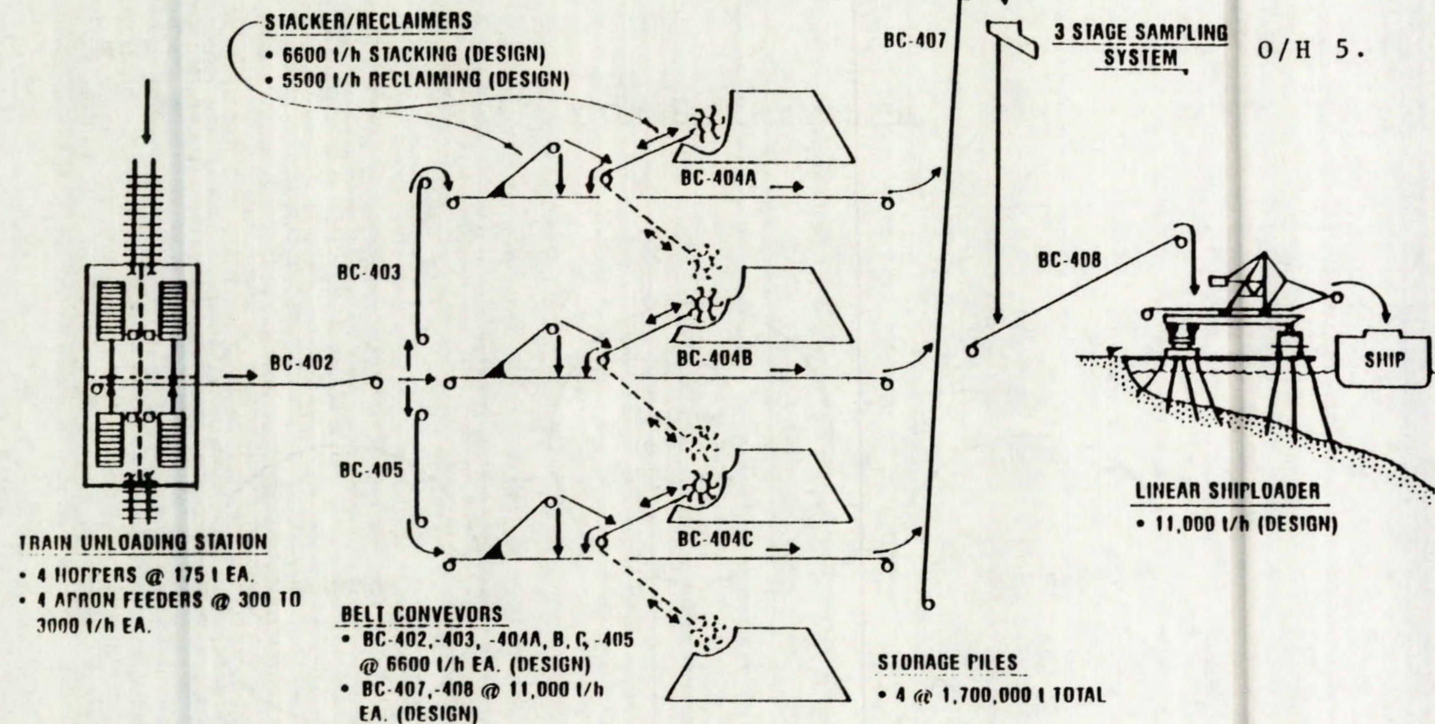
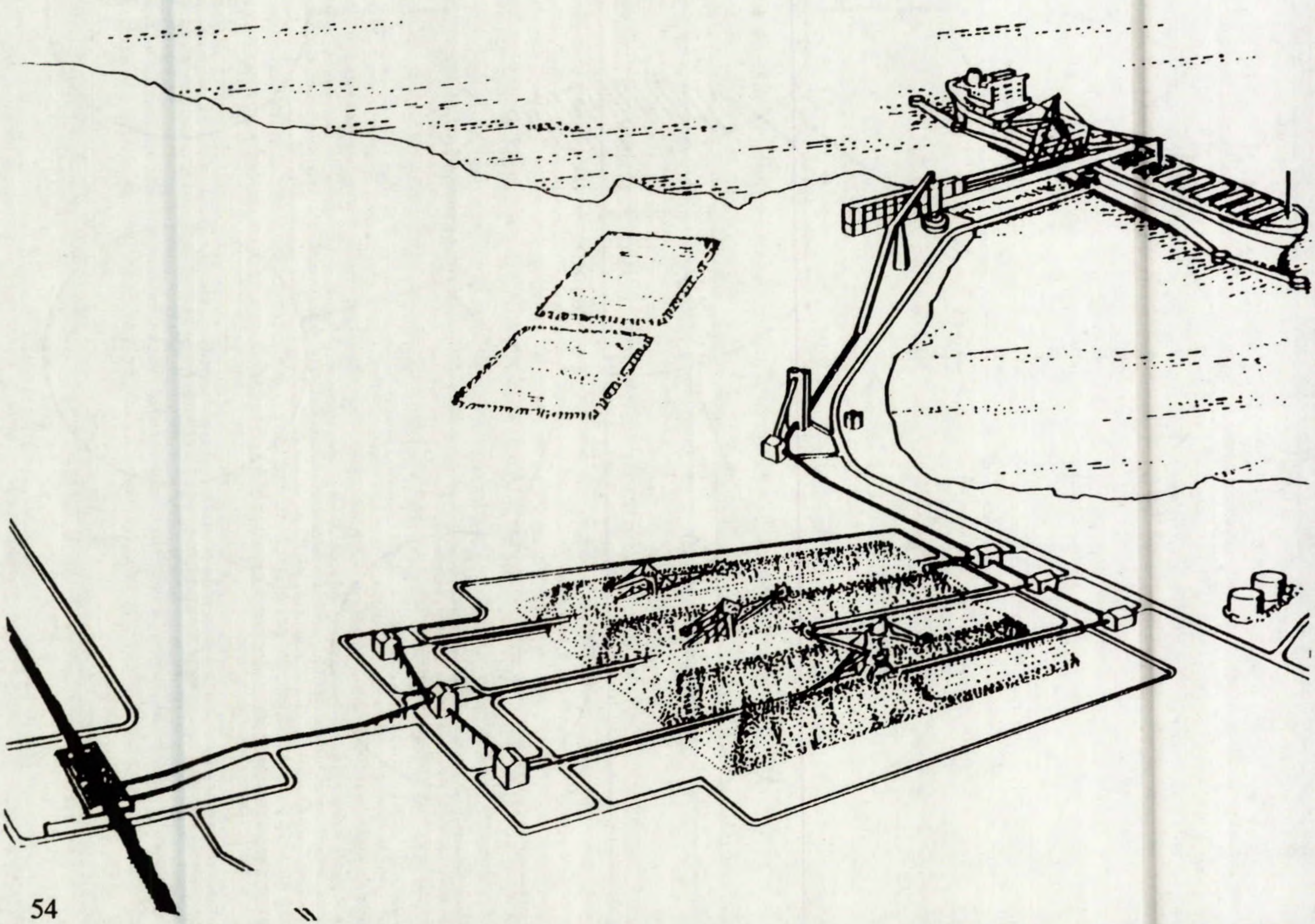
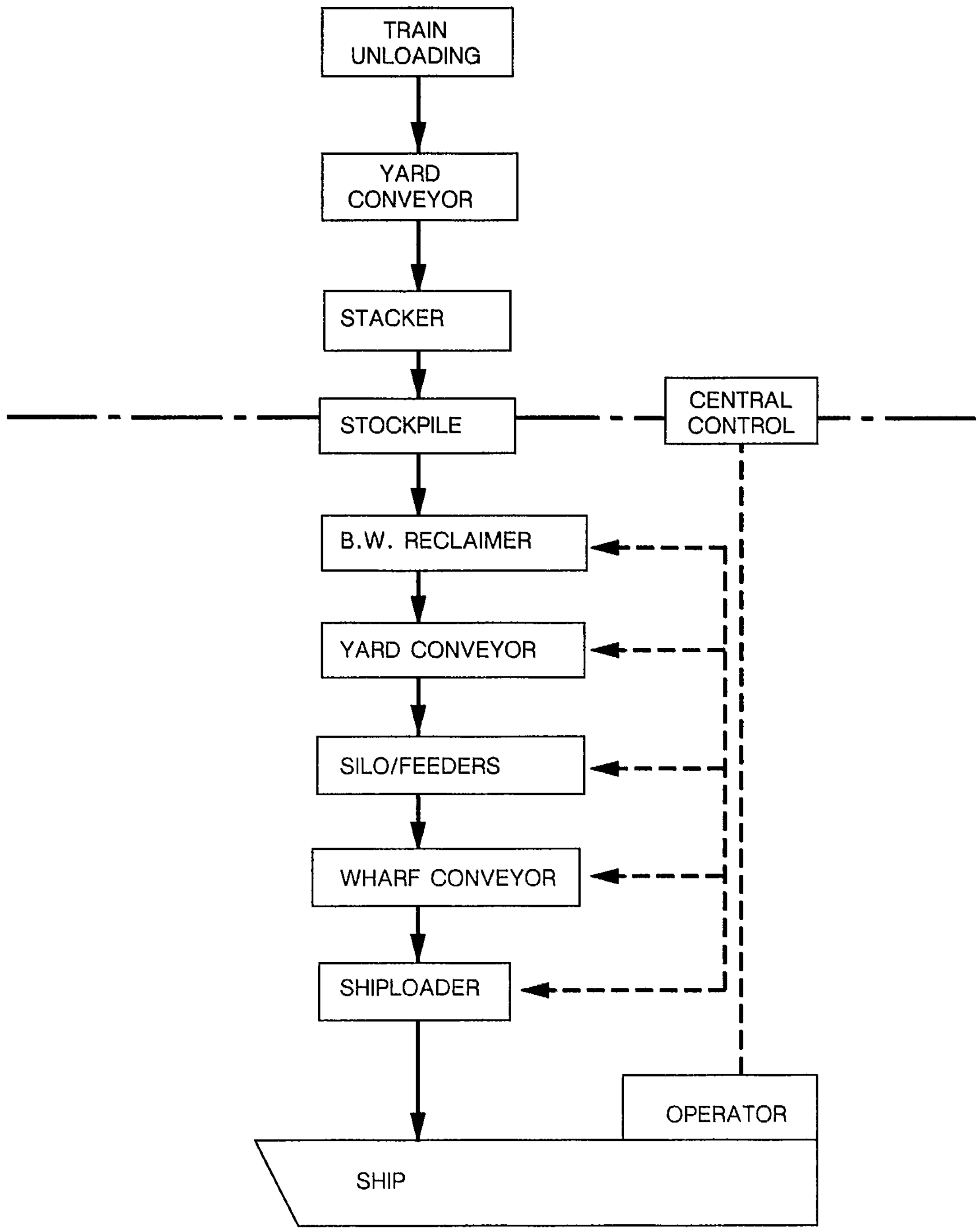


Fig 3 Port coal handling system flow diagram



COST BENEFITS



Overhead #8

Marketing Considerations

Offshore Competition

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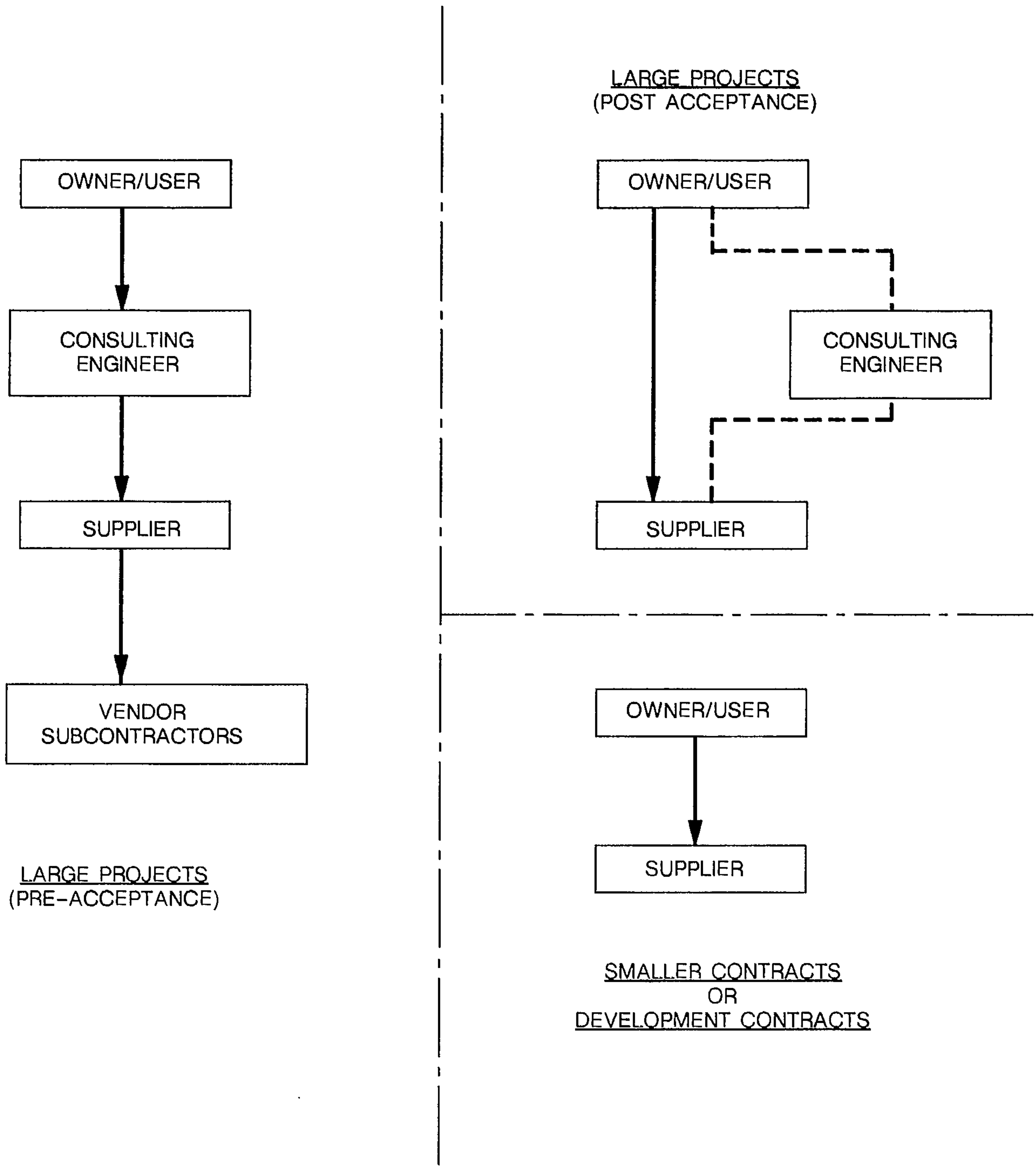
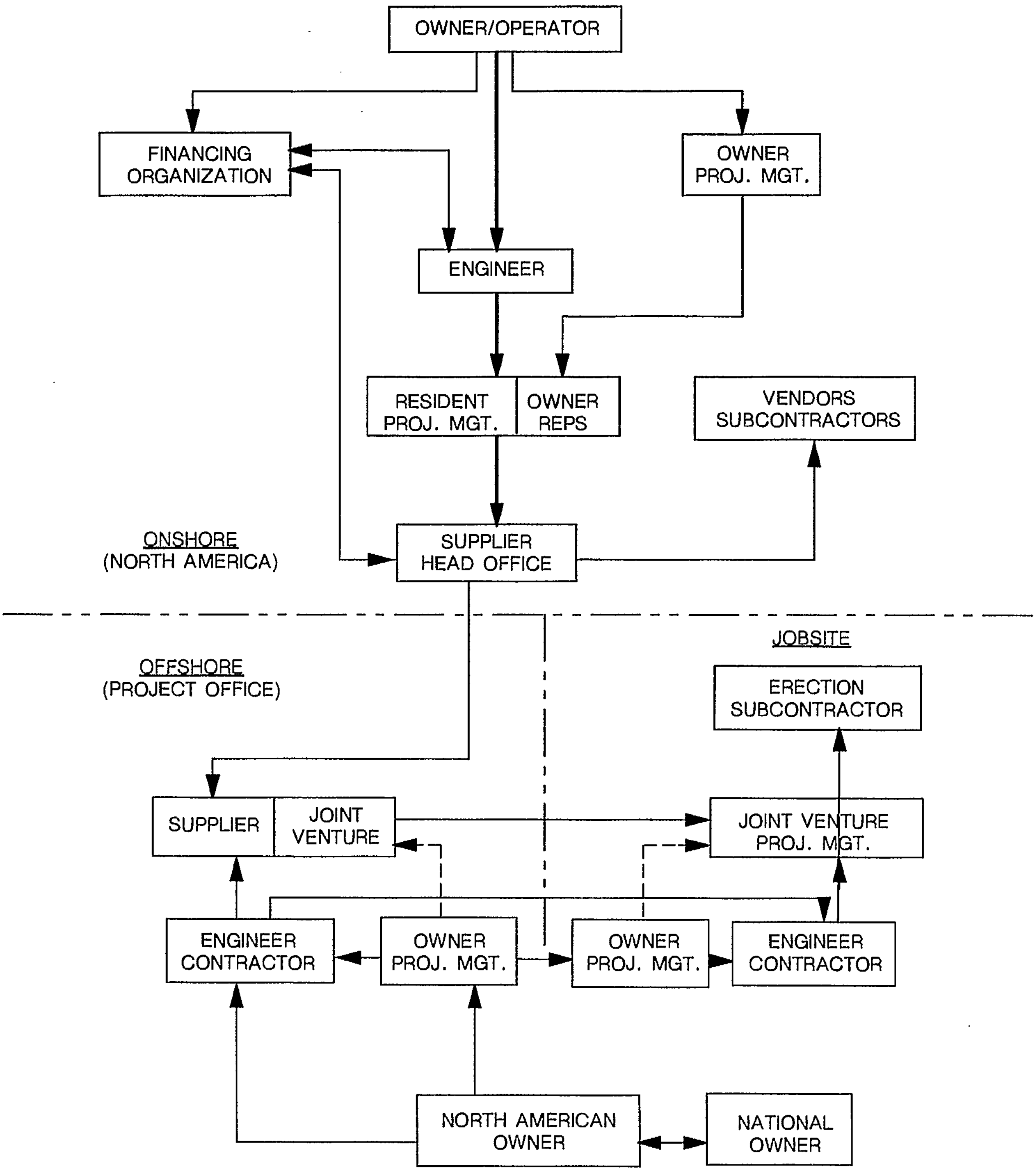
USER/SUPPLIER RELATIONSHIP



OWNER/SUPPLIER RELATIONSHIP
(OFFSHORE PROJECT)



Design and Engineering -- User View

Dr. W.F. Bawden
Mine Design, Queen's University

Components of mine design

To experienced mining engineers choosing a mining method and designing an open pit or underground mine still involves a large measure of judgement. The ability of the designer to access appropriate information and the confidence that can be assigned to such data critically affects the design process. As we shall see this can also critically affect the project bottom line. As we move into the "information age" the above will assume even more significance to all operations.

The key information areas influencing design are;

(1) Geological data to determine the configuration of the orebody: size; shape; dip; tonnage; grade; & metal distribution.
(2) Geotechnical data: competence of ore & host rocks; faults; fracture patterns; groundwater; in-situ stress.

(3) Economic data: value of the ore in the ground; grade throughout the orebody; metallurgical recovery.

A further piece of information vital to the design process concerns equipment;
- availability
- reliability
- degree of automation
- design and capability.

Both underground and open pit mining have undergone enormous change over the past 20 years. Very considerable productivity improvements have resulted, largely related to improvements in technology, (e.g. the introduction of large borehole drilling to sublevel mining, new mining methods such as VCR, etc.). New mining methods have traditionally evolved from advances in mining equipment technology and vice-versa. Method development and mechanization have been at the core of these productivity improvements since the beginning of the industrial revolution. Some of the ways improved mining equipment can result in new and novel mining methods are through;

(i) elimination of cyclicity through continuous operations,

(ii) the introduction of continuous on board monitoring, remote control, automation and robotics,

(iii) the elimination of some of the complexities of conventional mining practice, and

(iv) improved safety.

Information technology is playing an increasingly important role in the area of mining equipment innovation.

The future of the industry depends on our ability to continuously improve productivity and safety and hence lower, or at least maintain, unit costs. The very considerable improvement in productivity and rationalization that has occurred in the industry since the severe recession of the early 1980's suggests to me that we have not yet plateaued in possible productivity gains. The question rather is how to attain these?

In future, information technology will be central to many productivity enhancements, whether these are associated with improved equipment or elsewhere. The area of mine design is now, I believe, in a position to more actively contribute to future productivity improvements. It has been demonstrated that inadequate attention to design details, (i.e. the outdated philosophy that "this is how we did it at the previous operation so it should be suitable here"), can very negatively influence both productivity and profitability. Inadequate design can lead to;

(i) excess dilution of ore grades and loss of profitability,

(ii) safety problems resulting in problems with the work force morale and with regulatory agencies,

(iii) possible loss of reserves,

(iv) excess development costs, and

(v) excess support and rehabilitation, (i.e. maintenance), costs.

The increasing influence of design is a direct outgrowth of the ongoing revolution in computer hardware and software -- i.e. "information technology". Although at many operations today it still requires from 24 to 72 hours for an underground shift boss daily report to reach the chief engineer, I believe that we are poised at the verge of radical changes in this area of mining technology.

Mine Design and Information Technology

Mine design, particularly early in the mine life, generally falls into category of "data limited" problems. As extraction increases however an enormous volume of data becomes available to those who wish to make use of it. The task of mine design is intimately linked to our ability to obtain, access, manipulate and assimilate various forms of information. Mine design has traditionally been, and remains even more so today, an iterative process throughout the mine life. The mining engineer never has all of the information for the complete design when mining begins. In fact the information base is often at its minimum at that time. As mining progresses the information base rapidly grows. As more ground is opened vastly more data becomes available on the deposit geology, geometry, rock mass behaviour, etc. The mine wide database is thus continually expanding throughout the mine life. In order to be successful the designer must be able to access and assimilate widely scattered data from a large and diverse number of technology areas. It is this daunting task that has frustrated designers and management for many years.

Modern computing technology offers a potential solution to this problem. Large databases can now be stored and manipulated on mini's and more and more on micro computers. In many cases commercial database software can be used directly or modified for special mining needs. Alternately, when required, dedicated software can be developed for specialized needs.

With very large databases, at central design and research facilities servicing several mines, a Professional Database Management System, (PDMS), may be required to manage the volume and diversity of files.

An early version of a specialized database system was the DISCODAT system developed during the CANMET Pit Slope project in the 1970's. The relatively limited use of computers in the mining industry at that time and the specialized nature of the project resulted in limited usage. It was, however, an important direction to the future. The author is aware of two other database systems presently under development;

(i) a system being developed by INCO Manitoba as part of a CANMET MDA project, and

(ii) a database system being developed for Noranda Minerals Inc. by Noranda Technology.

There is no doubt that there is room in such developments for the specialized talents of the high technology community as long as the mining industry can adequately define its needs. Modern database systems allow the designer the option of interactively modifying his design criteria as the practical information base expands with increasing excavation.

Geometric Database

Let us look now more closely at one specific example of the potential for information technology to positively affect mine design. One of the largest, most complex and critical databases in the industry is the mine geometric database. Most orebodies are in themselves geometrically complex, (i.e. contact locations, waste inclusions, faults, etc.). The orebody geometry combined with service openings, permanent facilities, (shaft, ventilation raises, etc.), and production facilities including stopes, stope access, etc. become considerably more so. An additional complexity at many operations is that the economic ore reserve boundaries are not sharp but are rather grade/commodity price dependent. The geometric database alone involves gigabites of information in 3D spatial coordinates. Other databases such as numerical stress analysis output and microseismic databases can be equally large.

Attempting to visualize such complex 3D structures can be a daunting task, even for experienced engineers. To the novice or layman it is usually unintelligible. Never-the-less the geometric database is critical to every step in the design process and intimately affects the following;

(i) interpretation of basic geology and grade,

(ii) siting of permanent access facilities,

(iii) proper and optimal sequencing of stopes for extraction,

(iv) numerical stress analysis.

At the same time the geometric database is one of the most difficult to effectively and efficiently manage.

A modern computational tool called "Solid Geometry Graphics" is an information technology development that, although presently used almost exclusively for mechanical design, will in future almost certainly have a major impact on mine design, especially for underground mines.

Illustration

As an illustration let us consider a standard steeply dipping, tabular orebody typical of the Canadian shield. The particular example that I will use is Noranda's Golden Giant Hemlo deposit. In order to understand the complex geometric interrelationships between the various extraction and service openings engineers have traditionally used combinations of plans and sections. Figure 1 shows a longitudinal projection of the Hemlo deposit with the mine openings as developed to that time. Figure 2 shows a typical level plan showing the location of stopes, pillars and service openings, while figure 3 shows a typical transverse or cross section. From such two dimensional views the designer must develop a three dimensional image of the deposit on which he will base many fundamental decisions.

Solid geometry graphics offers an alternate and I believe superior method to obtain an accurate three dimensional representation of such a deposit. Computer solid graphics allows the creation of complex 3D geometric shapes using simple geometric primitives, (e.g. block, cylinder, sphere, etc.). Primitives are then combined using rigid motions and boolean operations to create the required geometry. This tool was used to develop an image of Block 1, the uppermost mining block, at Hemlo. This mining block is 100 meters high, up to 250 meters long and 25 meters thick in the ore zone. The block was developed on 4 levels, 25 meters apart vertically. Each 25 meter block was created as a solid and then these were joined together. The remainder of the mine could be similarly developed and added to this block. The image can now be rotated, viewed from any angle, etc, and the true complexity of the structure can be appreciated. Additionally two dimensional plan or section views are easily extracted when required.

Such a tool offers much more than simply improved visualization. Because the model is a solid it provides an accurate geometric database of the deposit and of the mine openings. This means that all areas, volumes, etc are correct. More importantly it also means that volumes at the intersection of openings, etc, are not double counted and that the geometries of such intersections are correct. The above two facts have considerable impact on the use of such tools for numerical stress analysis and for production planning.

Solid geometry software is now being linked to finite element packages for stress analysis. This will certainly be one of the most powerful uses of such tools in mine design. It would also seem logical that such tools could easily be modified for production planning purposes. In some cases however simple visualization of the orebody may be their most valuable use.

Illustration

Minnova's Ansil deposit has an extremely complex geometry. It can best be described as having an ellipsoidal, mushroom shaped upper zone with an elongated tail that dips off at about 50 degrees. Figures 4 and 5 show the deposit projected on a plan view with 10 meter contours and a section looking north respectively. Needless to say interpretation of this drawing is not immediate. Using a simple solid modeler however a much clearer picture of the deposit can be rapidly obtained. From drill hole data a series of solid sections along the orebody strike were created as solids and then joined to create the 3D orebody. In more advanced versions smoothing routines can be used to eliminate the steps between sections and make the final geometry more realistic.

Even the simple version shown here however allows a vastly improved appreciation of the orebody shape and complexity and hence provides a significantly improved tool for planning and design purposes.

Work is presently beginning on how to adapt these and other models so as to be able to present other complex 3D databases. For example in numerical stress analysis how can we visualize 3D stresses as mining progresses? The same question holds for microseismic monitoring data. Each of these databases may consist of gigabites of data and their manipulation, etc, is not trivial. The potential that such developments hold for the design process in mining however is enormous.

Summary

The above discussion represents one aspect where adaption of information technology into mine design may have significant influence. The solid model was presented here in terms of its use as an aid to production planning and stress analysis to help control dilution, minimize development, etc. It is easily imagined that such tools may be equally valuable to the explorationist in interpreting geology and planning exploration and to the geostatistician in attempting to extrapolate and predict grades. Ultimately the designer needs to be able to access all of these databases.

Other areas of information technology will also strongly affect future mine design work. A few examples are;

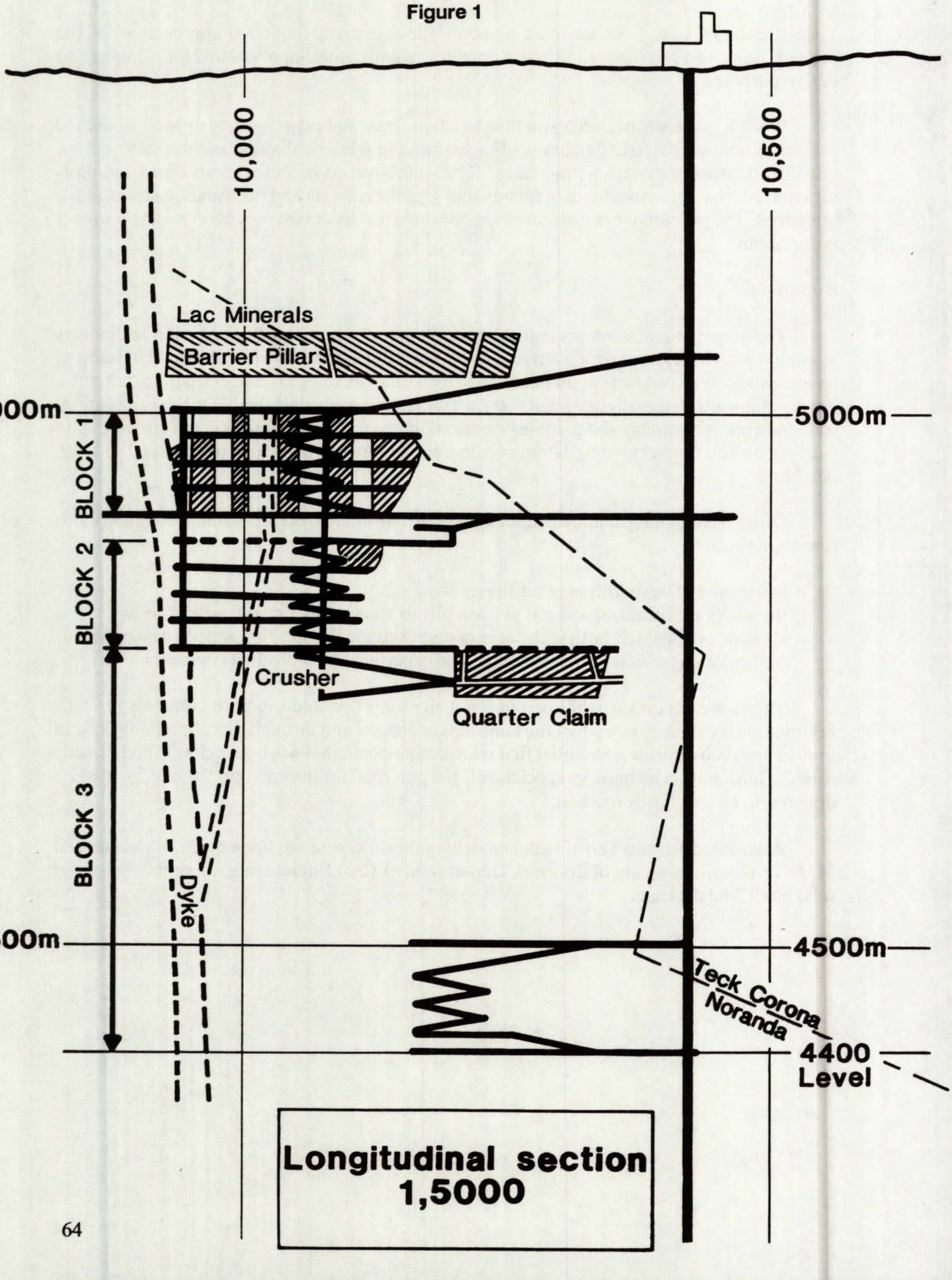
- automated 3D monitoring of pit slopes
- the use of robotized equipment in open pits to allow further steepening of walls
- artificial intelligence, both in the area of microseismic monitoring and as an integral part of the design process to help "extend" the experience of individual engineers.

The above discussion, while certainly not an exhaustive study, indicates one way in which information technology can affect the mine design process and through that the mining bottom line. In any such effort it is essential that mine design personnel work very closely and directly with the information technology specialists if the potential for information technology in mine design is to be practically realized.

Acknowledgement: The 3D solid modelling shown herein was done by Dr. J. Curram and Mr B. Corkum, University of Toronto, Department of Civil Engineering, using the Autosolid solid modelling package.

NORANDA Inc. HEMLO
GOLDEN GIANT MINE

Figure 1



LEVEL PLAN

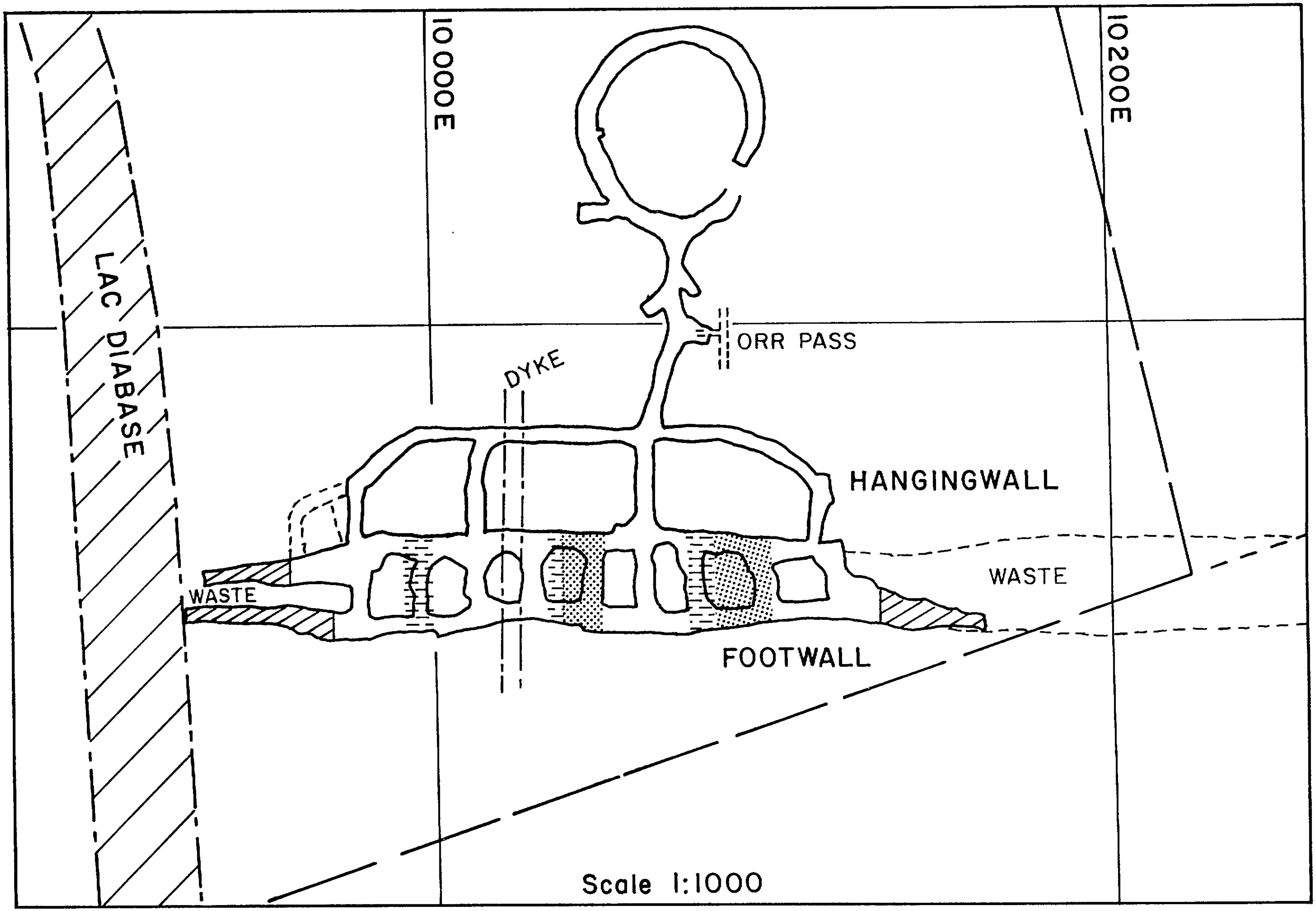
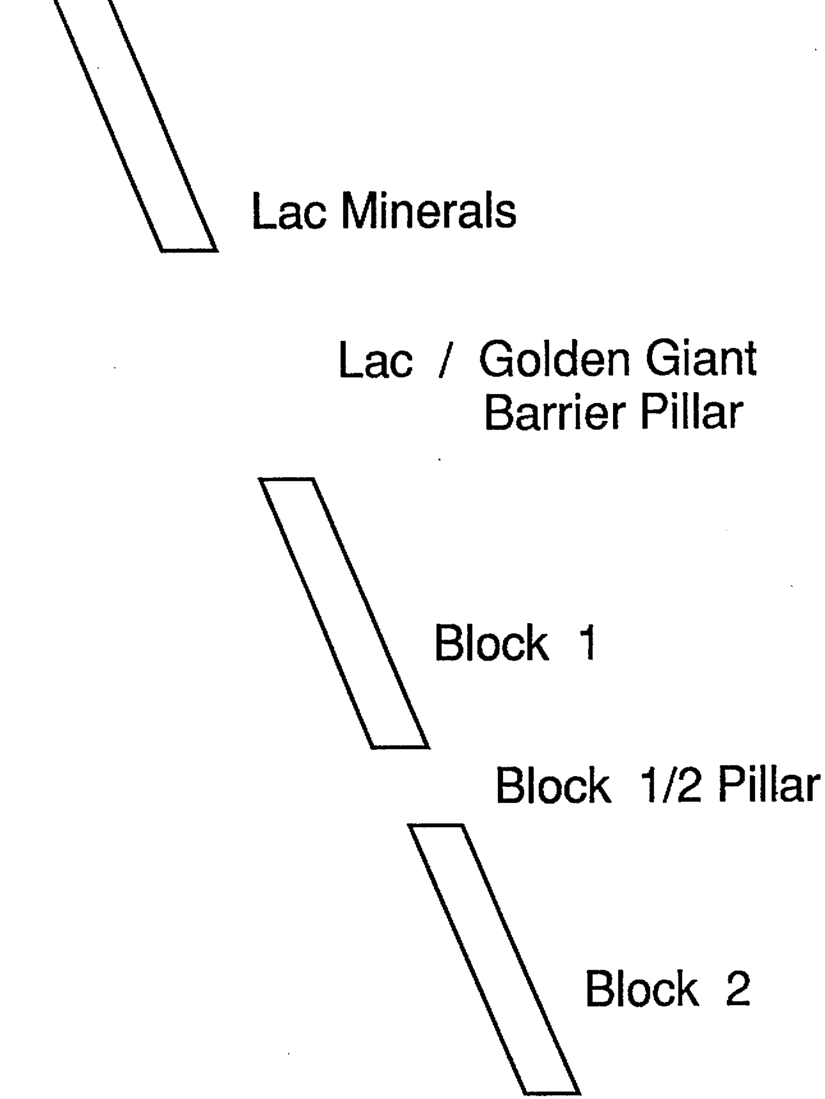


Figure 2

HEMLO GOLDEN GIANT
TRANSVERSE SECTION (GENERAL)



ORE MATERIAL PROPERTIES

m = 3.80

s = 0.400

UCS = 100 MPa

Figure 3

ANSIL PROJECT

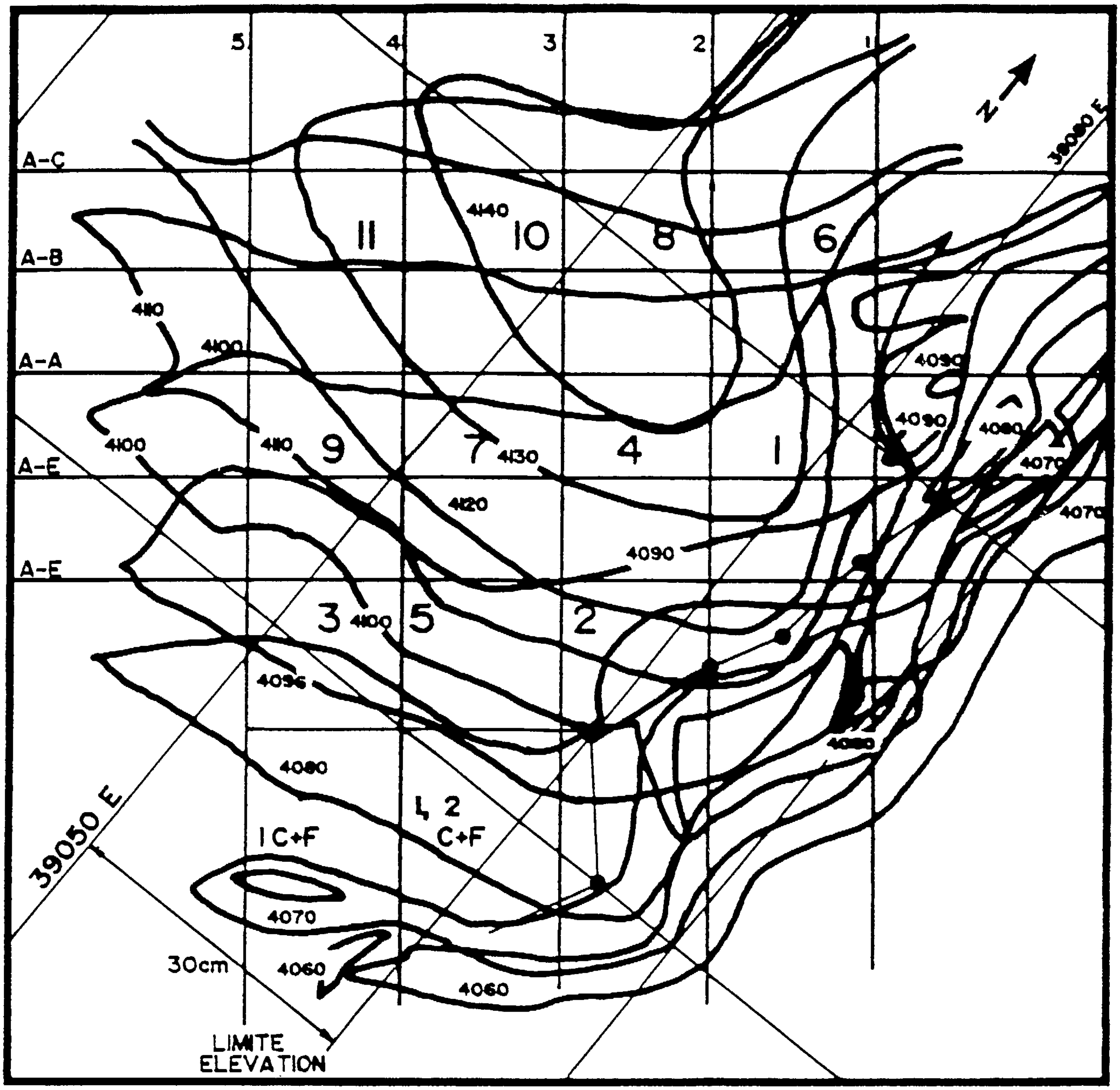


Figure 4

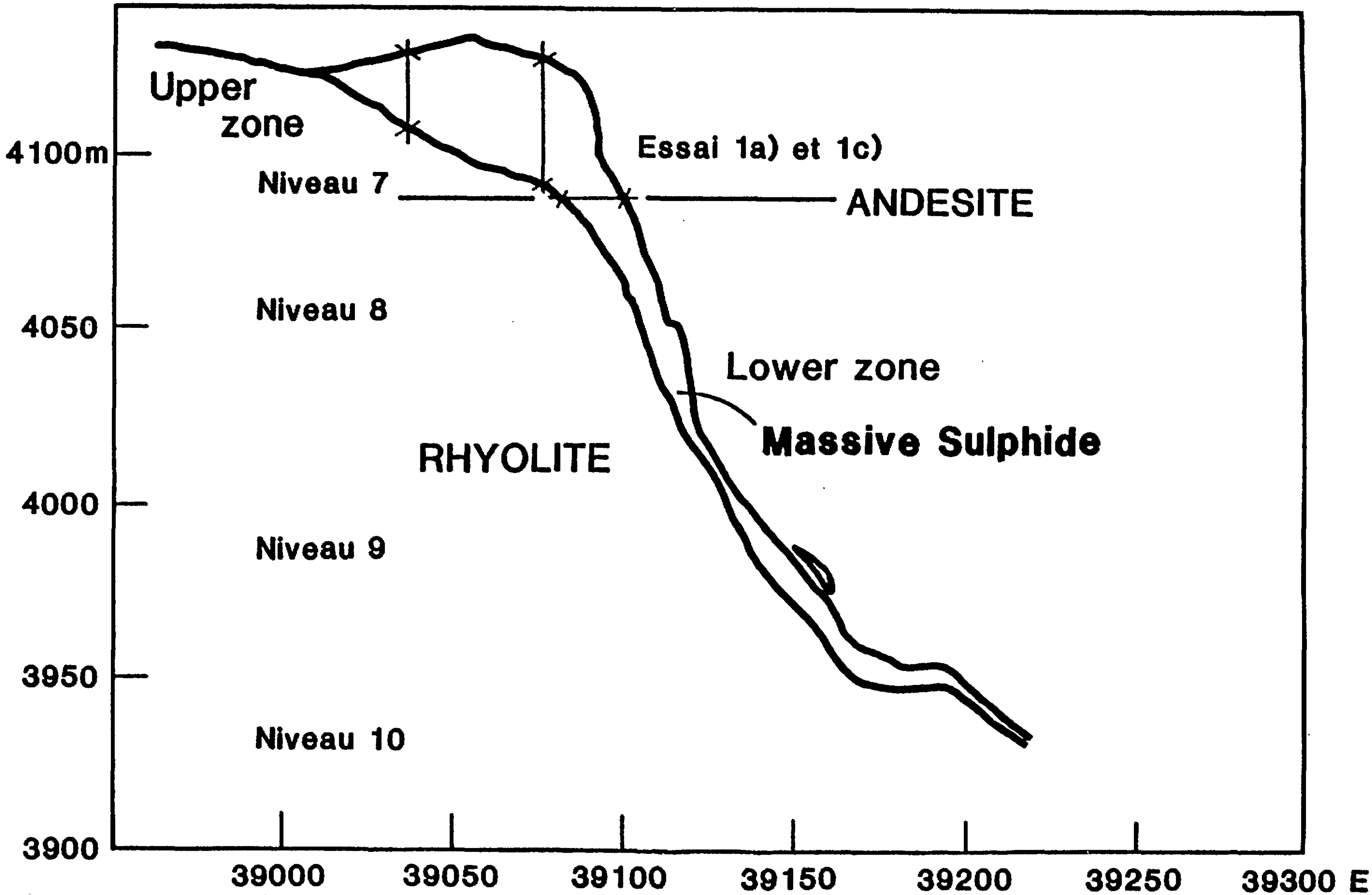

Upper zone
Essai 1a) et 1c)
Niveau 7
ANDESITE
Niveau 8
Lower zone
Massive Sulphide
RHYOLITE
Niveau 9
Niveau 10
4100m
4050
4000
3950
3900
39000
39050
39100
39150
39200
39250
39300 E

Figure 5

Panel Discussion

H. Brehaut, Senior Vice President, Operations, Placer Dome Inc. and Chairman, MITEC

D. Letts, President, Continuous Mining Systems Ltd. and Vice Chairman of Mining Equipment Manufacturers' Section, MEMAC

L. Hurtubise, President & CEO, Ericsson Communications Inc. and Chairman, CATA

J. Nantel, Manager, Mining Technology Division, Noranda Research Centre and Chairman, NACMA

T. Jubb, Director General, Mineral Technology, CANMET

Chairman (P. Richardson):

Welcome to this session on Information Technology and the panel. Let me introduce your panel: Henry Brehaut. Henry is a Senior Vice President at Placer Dome Inc. and the Director of the company and he is Director and Chairman of MITEC. Next to him Trevor Jubb. Trevor is the Director General of the Mineral Technology Branch of CANMET and is responsible for the mining research, minerals research and metals technology programs. Next to Trevor, Dale Letts. Dale is the President and General Manager of Continuous Mining Systems from Sudbury and he is the Vice President of MEMAC. Next to Dale is Lionel Hurtubise. Lionel is President of Ericsson Communications Inc. of Montreal. He was the founding president of the Ontario Centre for micro-electronics of Ottawa and currently he is the Chairman of CATA. Next to me is another former colleague from Queen's, who unfortunately got seduced by the wiles of industry to our regret, Jacques Nantel and Jacques is at the Noranda Technology Centre in Pointe Claire, Quebec. He formed the Mining Technology Division of the Technology Centre in 1982 and he is basically on a number of industry committees having to do with mining including MITEC and MIROC and a number of others that I won't go into.

There is one absentee and that is Dr. Akgun, who is the Director of the Communications Centre in Ottawa. Unfortunately he couldn't be with us today. Let me use a conversation I had recently with him to make a couple of introductory remarks. He wanted, if he had been here today, to get two points across on this information technology issue. The first of these is the need for long-term work. His perception is that much of the work that is currently underway is incremental in that it applies existing technology to the industry's problems. There is a larger issue of fundamental and basic research into some of the constraints to the use of information technologies in underground mines. For example the transmission of microwaves through rock. The second thing he wanted to talk about was the contribution that government can make in this area.

I think the long-term challenge of information technology in mining is a very interesting one. At Queen's University in the School of Business I teach Manufacturing Strategy as well as Strategic Management. Consequently, I am very aware of what is happening in North America manufacturing in general, and the introduction and the rate of application of C.I.M. or

Computer Integrated Manufacturing techniques. In manufacturing the "lights-out" factory is now a reality. It is a reality in Japan, it is a reality in North America. This is a factory where there are no direct workers on the shop floor. It has been made possible by the integration of hardware, software systems, logic controllers and cooperation between the suppliers of the technology and the users of technology. For those of you who are interested in the state of the art in C.I.M., there is a very good article in the January/February Harvard Business Review. It is an interview with Tracy O'Rourke who is the Chief Executive Officer of Allan Bradley which is a division of Rockwell International. He describes their building of the C.I.M. plant over the last 4 years and which has now been in operation for 2 years. They said we make electrical contactors for $16 and Ford competition make them for $8. If we want to stay in business we have to make them for $8. They studied the problem and found out there were only two ways they could meet the challenge. The first was to have no direct workers in the plant and the second way was to have no inventory, zero.

This article describes how they achieved it, what impact it has had on the company and the success they've had working with suppliers. My view is if we're going to be in the mining business in the year 2000 against companies that have $2.50 a day wage rates then we may have to look towards a "lights-out" mine. Such a mine would have no workers underground but a variety of highly sophisticated technologies working both on the surface and underground. Obviously Walter Curlook's talk last night indicated a movement in that direction. There are pressures in this industry from an economic perspective but also of course from a safety perspective. The safest way to run underground operations it to have nobody underground.

I would now like to start addressing questions to the panel. The first is a general question addressed to the entire panel. Maybe we could go along the panel starting with Jacques. The question to the panel is:

> *The pursuit of technology in Canadian mining is fragmented, uncoordinated and perhaps repetitive. For example, why are many operating mining companies simultaneously trying to apply and develop underground communications systems. Does the panel feel we are wasting resources following each other around and is there a better way to organize a better mechanism to utilize the resources of the industry to address common problem?*

Jacques Nantel:

I'm not sure that I have the answer, but I sit on all of these research organizations. Some are industry and some are government and some deal with manufacturers. Perhaps there seems to be a disorganized approach in the sense that we seem to be working on similar things. Talking with people in the industry I know, i.e. Ron Aelick of Inco, we all have made an exhaustive review, we are working on similar solutions to similar problems; hopefully we're going to find better solutions than they will. That's partly one approach to the problem. We cannot have a omnipotent body that would control who is to perform specific research. MITEC of course was supposed to fill a coordinating role and to be a kind of super authority. I'm not sure if it is working to be this way. People in individual companies are individualistic and we each have our ways to solve the problems. But if someone was to tell us that we have too many of these organizations, I think that's a good move. I don't believe we have too many. The converse would be pretty sad if we did not have any research going on. Perhaps it would be useful to form a club of research directors to meet once a year. I see some of these directors here. Perhaps we could have a meeting this afternoon and start the first one.

CANMET has done a pretty good job with the index of research projects* and that was at the instigation of the Advisory Council to CANMET. We get lots of inquiries from other companies, not only in Canada, asking us can you share any information on such and such research topics. That sort of exchange and that sort of centralizing of knowledge is going in the right direction.

* *The Index of Mining Technology Projects is an annual index of mining research projects which is prepared by CANMET in cooperation with the industry and universities.*

Lionel Hurtubise:

My reaction is to favour what we are doing here at this meeting. Networking is extremely important. The areas of the world that have made the greatest technological advances tend to be concentrated in small geographic areas. That's difficult for us in Canada, especially in this industry, so we try to concentrate in the Ottawa, Waterloo areas. We're trying to replicate that in Montreal. It's very important we not reinvent the wheel. Canada has too few resources; the only way we're going to meet the competitors will be by cooperating with each other. We see more and more of that now. Strategic alliances are becoming critical. I don't know the mining industry well, but participation by the various associations that are here today is a strong first step.

Dale Letts:

I agree with the comment that from a supplier's point of view the industry does seem fragmented and sometimes uncoordinated, but I think that's the nature of the business. The mining business is not a homogeneous industry. There are variations in ore bodies and from a supplier's point of view, the mines and customers come with different priorities and different concerns. The MEMAC organization tries to accommodate these variations and bring the ideas and the concerns of many different customers together. We meet regularly and try to put this seemingly uncoordinated deluge of information into some order. But the mineral industry is different and diverse, and other industry sectors, like MEMAC, try to address the needs of the industry. We don't think we should develop the equipment and you bend your needs to that equipment. We try to be reactive to the variations in the industry. Meetings like today and conferences like this will bring that information together. It certainly will help from a supplier's point of view.

Trevor Jubb:

From a CANMET point of view, we should take a look at what has been going on in Canada and elsewhere in the world. In Australia there is AMIRA, the Australian Mineral Industry Research Association which has operated for over 20 years. It has gradually worked to achieve an overall focus on projects and to assist industry working together. There's a similar effort in the Australian coal industry. In Canada the Saskatchewan Potash Producers Association has proposed a major eight million dollars research program over 5 years. The Coal Association of Canada is attempting a similar exercise. It takes time for people to work together, to understand the commonalities of the problems, to work out an overall focus, to look at the site-specific parts of the program, and to let people realize that with participation and collaboration there will be benefits for the individual company problem.

For instance to look at one particular project, the Canadian-Ontario Industry Rockburst Project has an overall focus: how do we deal with rockburst. But there are specific applications in say Elliot Lake, Falconbridge, or in Sudbury. I think that's how you have to organize these programs - identify the overall focus, obtain agreement and then apply the results to site specific problems.

Henry Brehaut:

I had an answer when I heard the question, but I have three answers now. I would first like to pick up on something that Trevor said on the Rockburst Research Project. This is well-organized as a cooperative effort between government on two levels, Ontario and Ottawa, and industry, six companies in Ontario. We know what we want to do, we have a vision, and our goals and they are well spelled out. The technical programs working towards those goals are going very well but there's a gap in the equipment and software support. We are using hardware and software, sensing devices and the microseismic system from the United States. We have made an attempt to try and develop a Canadian manufacturer but it hasn't been central to our purpose. This is a good example of how an industry group organized itself to achieve a research goal but left a business development gap. It's probably through MEMAC or in some other way that we have to find a better way of letting Canadian industry know our future needs. Perhaps through CATA or MEMAC we can, and not go to just one supplier or manufacturer. We need to spread the needs and have suppliers compete to develop the technology. The technology is moving faster than we can keep up to it and we need to have the information technology experts in close touch so that we can advance our capabilities more speedily.

The question put to the panel reflects some aspects of the presentations last night. I've seen the development in communication systems exactly as described in the question, and there's no doubt it's uncoordinated. Placer Dome had five underground mines, six now, and at one stage I said stop, nobody is to order any further communication systems. Each mine is visited by sales people extolling the benefits of their products, and each mine then wants to buy that system. I sensed that the CANMET study for Falconbridge brought things to a head. There was a watershed before '85 maybe, where developments were such that the industry should have taken notice of communication systems as a whole. That is when we should have developed our vision about what we wanted to achieve. At that stage if we had the vehicles to communicate we should have brought industry together to define our objectives for communication systems without any attention as to what existed. Then we could have gone to the next stage and sat down with the high-tech people working through CATA or with MEMAC. As someone said yesterday, you set up your wish list and then deal with the barriers or challenges. You set this out for everybody to work at and contribute to. There may be research to be supported and this is a chance for industry to work with the suppliers. A good idea can be brought to industry who may support to try it and if it works everybody can benefit from it. It's that kind of process that's been totally lacking. From our company's point of view as we looked at communications, there was a short-term and long-term wish list. We gave up on the long-term wish list and now have good systems that are meeting our limited goals. We also share with Eric Belford his broad list of goals that are working on at Kidd Creek and we are hoping to learn from how they have conceptualized the future. Perhaps we should try to get industry to develop this long-term wish list and then come back and work with Canadian suppliers. There is no doubt in my mind that production in Canada brings us our own economic benefits in addition to having the people close to us available to solve problems. One of the failings of the trials that we've worked on in our operations is that the key men were suddenly pulled out and there was nobody with the drive or the expertise to complete the job. That comes back to John's question that we don't have adequate educational facilities to cope with these advanced technologies when they first come into our operations. We learn with the help of our suppliers to apply that expertise over time, but in the introductory stage we do not have the ability to deal with these complex issues.

So we come to the third answer and in my view that's what MITEC is for. We're now going through the process of getting people to learn to work together and to share ideas and see that we can get benefit from doing so. We made one false start at trying to make some sense of the communication area about a year ago and perhaps it was too early in the process. Possibly MITEC didn't have the goals and how we could achieve them firmly in place. But we're in much better shape today, and this may be one of the challenges Jeff may have to go back and reactivate.

Chairman:

Thank you very much. I'm now going to address a series of questions to particular members of the panel. If other members of the panel wish to speak to the question they can do so.

The first is for Jacques Nantel. It relates to Brian Ferguson's talk yesterday with reference to the automation of boring machines, self-guided machines and continuous ore removal systems. The question is:

> *What is the perceived value of the ability to bore drifts per exact plans versus the cost of automation. Is it felt that this application may have merit in all mines or only those meeting certain criteria.*

Jacques Nantel:

Automation is a big word and I'm not sure if I'll see it fully applied before I die. We will have to learn how to crawl before we can start running as John Carrington (Minnova) indicated this morning. In the mining industry the level of expertise is still pretty low and we have to collectively try to raise our capabilities. Some companies already have automated drilling: Tamaroc and Atlas Copco are examples of that. As to cost, from the numbers I've heard, if a non-automated machine sells for example for $1, a machine that is fully automated will be about $1.5, so we're talking close to a million dollars for some of these machines. The statistics that we have show that they don't work in the automated mode all the time. You could do calculation and decide by yourself if you could afford that level of automation.

In some cases, if we leave production aside, there may be other concerns such as safety where we do not ask the economic question. We may want to have at least a portion of the machine that is automated, and we are willing to pay a little bit more for this feature.

This could be where conditions are hot or dangerous. The whole question of automation has to be addressed by the National Advisory Committee on Mining Automation (NACMA) which is composed of representatives of the mining industry, equipment manufacturers, academics and of course some people in government. NACMA has organized three symposiums in the past three years and it has generated a large awareness concerning automation in mines. However, there is a lot to do and the non-manned mine is not exactly ready to operated tomorrow.

While I have the floor, I'll be like a politician and talk about what I wanted to. I'm not sure if the first automated machine is going to be a drilling machine. Our first efforts may be by retro-fitting. At present Noranda and HDRK want to automate an LHD. People working in the space program tell us this is much more difficult then sending some ballistic device to the moon because for that you can calculate everything. Once you try to automate an LHD it is not that simple, the timing and conditions change constantly. But the spin-off effects of the research are going to be very important. It may turn out that eventually we won't have LHD's anymore. We'll have a continuous mining machine which won't resemble a tunnelling machine or a boring machine. It will be something new that will eliminate the drilling cycle and will lend itself to full automation much better then anything we have right now Noranda is putting a fair effort into this program with HDRK. We want to have a continuous mining machine for hard rock mines within ten years.

Chairman:

Do any other members of the panel have any comments?

No, then we'll go to the next question.

There's really two questions but they are somewhat linked. They are addressed to Lionel Hurtubise:

> *How important is the mining industry, as a customer, to information companies such as Ericsson and Nortel? How can we make those companies more interested in our needs and the opportunities in the mining industry?*

The second question is:

> Are there any hardware communication technologies that are currently confined to the military, that could be released or unclassified for use in the harsh, rugged mining environment?

Lionel Hurtubise:

Let me start with the last question. I can duck that one by saying it's classified information and I can't say anything. I don't know a lot, but I have a fairly good idea what we're doing in our defence business. However, I really don't have enough product knowledge to specifically answer the question. I doubt that there is any product that we can just transplant from the military and use it in the mining industry. However, I have no doubt at all that our technologists working with the challenges that we're facing in the military business could apply their knowledge in some fashion to your mining industry. The difficulty is how do we bridge the gap. These guys are building aircraft control panels and missile guidance systems. Some of them might talk to mining people, but they are operating in very different dimensions in terms of the problems to solve.

This leads to the second question, "How important is the mining industry to the information technology industry". I probably have to say it is not at the top of our list of priorities.

It is probably viewed by the Ericsson group and certainly by our Canadian operation as being a relatively small business opportunity for us. Therefore we haven't put too much effort into it. We may be totally wrong. Every company, Ericsson included, is always looking for new business opportunities. One thing I suggest is that the various associations represented here or other groups could put together seminars that demonstrate to our industry and our company that there is market potential. We would all be very pleased to send one of our representatives to do a little mining of our own for new business.

Chairman:

The next question is for Dale Letts.

Can a contract R&D, or engineering development organization, which works on a fee for service basis be successful in the Canadian mining industry. Would the operating companies or the equipment manufacturers be the most likely customers.

Dale Letts:

I believe the answer is yes. Expertise is needed that is not available in the mining equipment industry. So there is an opportunity for someone with such expertise on a fee for service basis to assist the mining equipment industry to develop better products in Canada, new technologies and related equipment for the mining industry. For example, computer-controlled mining equipment. Most mining equipment companies in Canada don't have enough expertise in this area. Some larger foreign companies have developed the expertise, but in Canada there is an opportunity for people with expertise in computer technology to work with equipment suppliers to adapt that technology to mining equipment and sell it to the mining industry. This probably applies to robotics as well. We might apply some of the robotics that have been developed for other industries, for example the automotive industry. The equipment manufacturers in Canada are fairly easy to identify through MEMAC.

Chairman:

The next question is for Trevor Jubb.

Is there room for government research facilities such as CANMET to approach and work directly with the information and the high technology and machinery companies in work directed to the mining sector?

Secondly, and related to that:

Does the government offer special encouragement to companies which contract for this source of expertise i.e. the fee for service expertise, developing technology for the industry?

Trevor Jubb:

The answer of course is yes. Let me give three examples as to how this can be done. CANMET does research work in-house but it also contracts out as well as contracts in. We also use unsolicited proposals through the Department of Supply and Services Canada and CANMET is a large user of NRC contributions e.g. IRAP Programs. The three projects will show how mining companies and fee for service operations and R&D contractors can take part in these programs.

First of all I was discussing with Tom Pugsley earlier about progress on the CUB, the Compact Underground Boring machine. About two years ago, Tom came to Ottawa to see how they could develop a prototype from the preliminary efforts at Kiena Mines, and what government programs were available. In this case CANMET really has not done any research.

CANMET has been able to help put the project together, together with Falconbridge, Borotec, Howden of Canada using our Technology Marketing Division. The program has obtained a million dollars from the NRC IRAP program. By August or September of this year, it is expected that the CUB will have been built and be ready for underground testing.

This is an example where CANMET did no work internally but we used the expertise from our mining division, our technology marketing group, and our knowledge of government programs to pull together four or five companies to assist the funding and management of the compact tunnel boring machine.

Another example is in the application of expert systems. We are not directly applying it in mining technology side presently but we are actively involved in mineral processing. We're not trying to develop new tools for artificial intelligence. We're in the business of trying to apply existing tools to the mineral processing industry and are seriously considering extending into mining research. We have internal programs where our scientists and engineers are working with companies to look at various processing problems. Companies have included Canada Cement LaFarge, Kidd Creek, Noranda and we have a major program with Syncrude using NRC IRAP programs. This last project is a two to three million dollar program looking at developing sensors for the Syncrude plant and in the application of expert systems.

My third example is in ceramic filter development. CANMET has worked for about ten years on a ceramic filter to remove soot from diesel engines. We coordinated that work with the mining industry and the United States Bureau of Mines with whom CANMET has a memorandum of understanding. If you saw Walter Curlook's slide last night of the Eagle Crusher which had been developed under a contract to USBM, our MOU with USBM facilitated the transfer of the crusher to Canada so that Inco could test it. Eventually Inco bought the marketing rights.

Through the NRC IRAP program again, we obtained funding for Engine Control Systems to commercialize the ceramic filter technology in applying the filter to the diesel emission soot problem. The filter has been tested at Brunswick Mining and Smelting as well as in Australia. Some of the development work was done by ORTECH Inc.

These are three examples on how CANMET can use other programs, our technical marketing capabilities, our inhouse work and our contract funds to assist in the development, transfer and commercialization of mining technology.

Chairman:

Thank you very much Trevor.

The last question is for Henry Brehaut:

Mining industry and R&D expenditures have dropped from a peak of $50,000,000 in 1981 dollars to about $37,000,000 in 1981 dollars in 1987. The decline appears to be continuing. The same is true for non-ferrous metals in general, excluding Alcan. I guess their R&D spending over the last decade had gone from about $36,000,000 to about $100,000,000 this year. And for non-ferrous metals it has declined from $42,000,000 to $26,000,000. The industry is talking more about R&D in recent years. The question is do you anticipate a real and long-term increase in our expenditures in *the foreseeable future and if so do you see it being concentrated in inhouse R&D or in joint cooperative ventures?*

Henry Brehaut:

I suspect that it is Margot Wojciechowski who asked that question. Ah! I see that I am right.

I have to give a speech at the CIM in Quebec City in May so I clearly must talk to Margot to get some more data from her to make the point that she has made in this question. It is a good point that we need to pay attention to.

I'd like to make a comment regarding the quality of research work. I worked for a number of years in major corporations of Canada that have large research programs. During the 70's I saw a great deal of research money going down the drain for no useful purpose. The $50,000,000 is a carry-over from that time. With the mining depression of '82 came a lot more realism about what research was trying to achieve and what was being spent. I have no doubt that the $37,000,000 in 1981 dollars that is being spent today is far more effective then the $50,000,000 in 1981. This is mainly because of the attention that the corporations have brought to their research effort. They now ask why are we doing it and make sure that the money is being spent in the right direction. I believe that there's a lot more money going into underground mining research. I suspect, without data, that it's at the expense of extractive metallurgy. Perhaps other panellists, such as Trevor Jubb, might have more information on such trends.

But having said that, the $37,000,000 in '81 dollars is still not enough to get us to where we want to go in the future. These major corporations are still the leaders. They are still doing what they should do as corporations and set a very good example for what the rest of us should do, Placer Dome included. We're just newcomers to research and being believers in research. There's a lot more talk than there is money but we're going to get the money up to an appropriate level. And by example, and by getting people into research consortia we hope to be able to interest the rest of the industry. What I don't know as yet, is whether the large firms are spending enough even though they are spending a lot more then the rest of the industry. In general, it would seem that the long-term goal has to be to get the industry in total up to a higher level of research effort.

The second part asked whether new research will be concentrated in-house or in joint cooperative ventures. To me, inhouse research will always be a part of the overall research exercise but I suspect it will be a lower percentage as time goes on. I think that will be true for inhouse government R&D as well. The gain from a shared relationship in today's complex world is so great that you can't afford to do it all yourself. The universities for example, offer a tremendous exposure to other disciplines. Contacts with the representatives who are here today offers tremendous payback. For example in the compact underground borer that Trevor mentioned, two companies, Placer Dome and Falconbridge have gone to a manufacturer and tapped into their expertise. IRAP is paying half the money; industry with Redpath is paying the other half, and we expect a product that will work. We're not in the venture to make money out of the producer. We're in there to make sure the product gets developed and we need the expertise of Borotec to help us get this done. We also need CANMET's expertise to put it together. And there are a number of examples, especially in expert systems applications where we need the expertise in the universities and the many disciplines that can be brought toward the solution. My view is that there has to be more and more cooperative ventures with whoever we can tap to give us the knowledge we need.

Chairman:

We now have time for a few questions from the floor. Please give your name, who the question is addressed to, and state your question quickly to the panel please.

Jacques Nantel:

I'd like to make a comment on some of the statistics that Margot threw at us. I'm not sure where you got your numbers Margot but I'm willing to challenge them. They don't sound right. Take Noranda and Inco. We were not doing any mining research in 1981 and now I would say we're doing about $5,000,000 worth of mining research, not metallurgical research, at the technology centre.

Will Bawden presented a challenge in his paper. Have productivities plateaued in the mining industry? I say not only have they not plateaued; I think we're just beginning. I would like to challenge everybody here that within ten years there's room for immense improvement in productivity using the measure that Peter Richardson has described in several papers on productivity in mining in terms of tons per person per shift. In the next ten years I think we could make increases by an order of magnitude. So if I quote 50 tons per person per shift right now, that should make many operators pretty happy, because I could say 10 and it would be closer to reality, for the total underground staff. We're starting to think in terms of a possible 500 tons per man shift. Some of the new equipment will have to be controlled from a distance but that's the sort of numbers there's room for and I hope to be around to see it.

Jeff Jeffery with MITEC

This is not so much a question but it occurred to me as I listened to this panel and their interesting comments and responses, that there's one constituency that is not represented fully here today and that is the universities. Of course Will Bawden comes from Queen's but he is here presenting one of the papers in his special area of knowledge. There is currently a strong movement in the universities to come together in the mining and engineering departments across the country. It has been driven by the Federal Government's announcement of a competition in Networks of Centres of Excellence. This has led to the nine departments that grant degrees joining together and MITEC has become a focus for putting in a proposal to that competition. We've passed through a number of hoops and shortly the proposed mineral research network will make a day-long presentation to a panel of experts. This comment is sparked by the statistical picture which Margot has raised and which I think bears a lot more examination by all of us in the mining sector. The submission will request centres of excellence funding for support to a research network. In addition, the proposed support which would come from industry, suggested in the budgets would comprise about 5% of what I think the major integrated mining companies are currently spending on R&D. Industry support would be requested for each research projects on its merit as seen by each company.

Chairman:

Thanks Jeff.

Herman Ruhl with Ruhl Machinery:

This is not a policy question but a practical application question. We have an inquiry from one of the mines on a problem which cuts across three of the subject covered. It has to do with information technology, with design and engineering and with material handling. It is a relatively simple problem. There is an American supplier, I wonder if there is anyone else available for it. If you have a mobile equipment and the mobile equipment has a boom that extends and is at different angles. The question is how do I measure and determine easily the load so I can use that further in information processing. We need that centre for one of the mines and the boom of course is prolonged but is hydraulically supported so one can measure the hydraulic force needed and can calculate and wonder if there is a practical solution than any gentlemen may know.

Chairman:

I would ask anybody who knows about that to talk to Mr. Ruhl after the session please.

Milt Jowsey with HDRK:

I'm going to direct this question to Jacques Nantel. I would like him to comment on the difficulty of actually developing long-range, cost-effective programs, versus the ability to raise money. In my estimation, money is easier than ideas. I would like you to comment please.

Jacques Nantel:

To give you an example as to how we proceed at Noranda and the way we finance mining research; the operations that would benefit from the findings are asked to take a very active part and also fund the research effort directly. So all mining operations have their say and are asked to input and to eventually use the technology. We find that this works quite well with short to mid-term projects where the mine superintendent or the mine manager sees the technology being used in the operation. Of course, we like to remind managers that when they close that particular mine they'll probably move to another one and carry these ideas based on our R&D to the new operation.

When some research is, let's say over five years and longer, that is financed mostly through corporate sources of funding. Of course it leads to a longer time frame. Some of the points you were making Milt as far as long-range corporate research policy; well at Noranda we have a mandate to develop methods and equipment to improve productivity all the time making sure that safety aspect are considered. We don't have a goal for example that we will revolutionize mining, per so. However, we assume that it will be evolutionary. We take a snapshot of 1989 practices and we estimate that operations in say 1999 will have progressed to a significant degree. That's the sort of approach we're taking.

Chairman:

We have to close off the discussion here.

In closing let me comment. One evident factor concerns the level of spending in mining research. The other factor is the effectiveness of the dollars that are being spent. I would echo the sentiment that the dollars are being spent in this area a lot more effectively now than they were ten years ago. One good example that I am familiar with is CANMET where there has been a tremendous attention to reorienting the scientific and technical programs toward industry needs and towards commercialization. In other words not just doing good technology but making sure these technologies apply. Trevor Jubb and his colleagues at CANMET are trying to foster joint ventures and other partnership efforts. I would urge companies to get behind CANMET in some of these efforts. There is a lot of good in that area.

Please join me in thanking our distinguished panel for their comments. We now adjourn for lunch and the speaker will be Gordon MacNabb of Precarn Associates. At 1:45 there will be a short briefing before the workshops. Of course the workshops are where we expect everyone to really get involved and give us you thoughts on where this whole area should go and what should be done.

Thank you.

Luncheon Address
Collaborative Approaches to Technology Innovations

Gordon MacNabb
March 9th 1989

Good afternoon ladies and gentlemen.

Before I get into my presentation I want to add my voice to those who have already congratulated the conveners, collaborators, for this session. It is just the type of thing that is needed, not just in this industry but certainly from my wanderings across this country, badly needed in other industrial sectors, some of them viewed as more high technology-oriented than the mining industry is, but in many ways you are ahead of those other industrial sectors.

Now to the experiment called PRECARN and it very much is an experiment. We've been working on it for two and a half years and as I will explain in a minute, our "High Noon", our first real test will come in a few months time. PRECARN means "Pre-Competitive Applied Research Network. It is an industrial consortium totally set up, managed and, so far, funded by the private sector. It focuses totally on artificial intelligence and robotics, long-term research. The words "intelligent system" encompass all of that.

So we are presenting industry with an opportunity to participate in a five to fifteen year time horizon collective research effort.

In the time available I am going to touch briefly on why we exist, who we are, and what we are doing at this time. And in so doing I will be commenting on some of the reactions that I have received across the country from both industry and government.

So, why do we exist? We have our roots in the Canadian Institute for Advanced Research. Many of you may have heard of Fraser Mustard's initiative to set up a network of our top academic experts in Artificial Intelligence (AI) and Robotics about six years ago. But after four years of operating that network there was concern that perhaps they were on a futile mission of improving the capacity of our universities in this field because of the lack of a receptor capacity for the knowledge in Canadian industry. My mandate was to develop a team of industrial receivers for this knowledge that is emanating out of our academic network.

That was a task that I embarked upon late in 1986. I wasn't that optimistic, quite frankly, about the chances of success, but the area had a very high potential for bringing a group of companies together. Unlike MITEC and PAPRICAN and other groups that are all industry sector initiatives, we were setting out to try to build a consortium around a technology as opposed to an industry. And we were dealing with a technology that was very generic by nature. In fact, it is hard to think of any major sector of our economy that isn't going to be impacted to a very considerable extent by intelligent systems of some kind.

Another reason for doing it was that a lot is happening around the world in other countries in terms of consortiums in this same field. There is the ALVEY initiative in the UK, and Eureka and Esprit in Europe, and they are not talking of just a few million dollars; they are talking of hundreds of millions of dollars in this specific area. We also felt, and I feel it even more now having watched the evolution of the Centres of Excellence programs, that there had to be a mechanism to bring the academic researchers and the industrial researchers physically together on a common research project. Not simply one party being the funder and the other party doing the research. One of the greatest needs this country has is to increase the number of people within the industrial community that understand these technologies; that work hand in hand with the academic specialists and then can take the results of that pre-competitive research and move it up towards more developmental stages. That is why we exist.

Who we are? What's the vehicle? We had our beginning almost two years ago now in a meeting where eleven people sat down around a table and talked about whether or not we should move ahead and establish a research consortium. When we left that evening we had our first eight members. Three of those eight came from the mining industry. We had Inco on board, we had Noranda and we had Lac Minerals. Since then two other mining companies have joined, Falconbridge and Minalta Coal. So that was the start; each company would be making a contribution into a common pool and we would go from there.

By February of 1987, when we were looking at developing the first round of research projects, we had thirty-five members.

We incorporated by May of 1987 as a not-for-profit Research and Development Corporation. In January 1988 we put out the call for research proposals. We selected seven out of twenty-eight responses and are currently embarked upon six month feasibility studies on all those seven projects. The membership that we have now is fascinating. It has been rewarding to watch this mix of people from the resource industries, from the "high-tech" industries and the manufacturing sectors etc., small, medium, and large, sit around the same table talking about a technology and suddenly realizing that the problems were not unique to them; that each could benefit from the experience of others and perhaps tackle longer-term research problems that had widespread application. That was the first benefit we got from PRECARN, the realization that there was a broader community that you could talk to about intelligent systems applications.

In the course of last year we selected the seven feasibility studies, and also negotiated a membership agreement. It deals with the question of intellectual property. Quite frankly we are not overly concerned with who owns what; the bottom line is that in anything that we support our full membership must have full access to the resultant technology at reduced or zero royalty rates. The membership of PRECARN gets access to all the knowledge that emanates out of the research programs through regular briefing sessions as well as through participation in the programs. If there is something that is protectable as intellectual property at the end, members have a guaranteed right of access to it at reduced royalties.

The membership agreement that was developed last year had to go by thirty-two legal departments, one in each member company. Then it spent four months in front of the Bureau of Competition Policy. Over the course of last summer we negotiated contracts for the seven feasibility studies which got under way about September. We had a mid-point briefing session in January of this year attended by about one hundred people. The first final reports will come in about April of this year.

PRECARN is putting $100,000 into each of those studies. On average they probably cost about $200,000 and the participants are putting in the balance. Three of them relate to real time expert systems for the control of continuous processes. One is being led by Ontario Hydro. The shell of that expert system, if that project is proceeded with, should be applicable to any continuous process; whether it be a petrochemical operation, a mining operation, etc.

Another expert system study is being led by MPB Technologies in Dorval. Noranda is participating and is using one of its mineral processing operations as a test bed. There is one other study headed up by Hydro Quebec, that is specific to the electrical utility industry.

There are three studies relating to robotics, or more precisely telerobotics, where the human is still involved to a large extent in the circuit. Two of those relate to the better use of telerobotics in very hostile environments, and that certainly should be of interest to the mining community. One is being led by MPB in Dorval along with CAE Electronics and the expertise that exists at McGill. Another one is being led by Ontario Hydro, plus others.

The final one is an effort by SPAR in cooperation with Canadian Marconi and Bristol Aerospace to capture in a computer not just the final design, but the whole thought process that led to that final design. So if you lose your designer you have not lost the whole benefit of his or her experience. I am told that half the community say it has already been done. And the other half says it can't be done. So it is going to be an interesting project.

Looking ahead our first real test of this experiment will come about May or June of this year. At that time, we will have the results of these feasibility studies and perhaps we will have also launched one or two more.

My personal target is a change in the currant funding of long-term, pre-competitive research, which up to now had been funded almost 100% by government. It is realistic to think that the industry's share of that long-term funding should be in the range of 25-30%, yet, to date governments always approach joint program with a fixation on 50/50 funding. My target is to try to achieve a 25% industry contribution in cash and in-kind, and bring forth funding from government sources for the balance.

Far better to have industry contributions at 25-30% coupled with industry know-how, and with industry needs represented at the table, than to revert to the way government has been doing it in isolation.

We have a commitment from the National Research Council under their IRAP program for $1 million a year over five years. We have had a proposal into MOSST and ISTC now for 22 months. Hopefully we will have a positive response there for $10 million over five years. And we have a proposal in front of the Technology Fund of Ontario for $10 million.

The problem throughout this fund raising is that PRECARN is unique. Fortunately, NRC has sufficient flexibility in the IRAP program to fit us in, but Industry, Science and Technology had to design an entirely new program for strategic alliances to get the funding from government. So you can appreciate the delay when they had to design a program, get it through all the levels of government, get it approved and get the funding for it. Hopefully that process will conclude successfully.

With the Ontario Technology Fund we don't fit at all. We certainly fit the objectives of government as proclaimed by the Premier for the Premier's Technology Fund, but our problem is that we are so different in all other ways that there is just no mechanism in place to access the funding.

I am very optimistic that those three sources will come together and therefore we are looking at something like $25 million over 5 years plus the private sectors contribution. That will get us going. We will digest that and come back to government with other projects in our hip pocket, looking for an increase at a later date.

PRECARN has also sponsored a Centre of Excellence proposal to the Federal Government at the request of the university community. There are some twenty projects from tactile sensing and vision systems through the use of very large sophisticated knowledge base right through to applications in robotics. There are some 123 faculty involved from coast to coast. PRECARN will manage the Centre, but all the funding will go into the academic research program. However, the program will be subject to the same management controls by PRECARN as if it were one of our own projects. What is amazing is that the academic community is willing to accept that. It suggests a degree of trust between the two parties that did not exist a couple of years ago. Planning is one thing however, successfully implementing it is another thing, if we are successful.

The reactions of industry, when I have gone door to door like a brush salesman, have been varied. At that first meeting, eight of eleven senior executives said "Yes, this is something we should be doing", and they carried that commitment back to their companies with them. But, we are asking them to do long-term research and development, a thought that is totally foreign to most of them, and we are asking them to do it as a pre-competitive project along with some of their competitors.

Of those challenges the greatest one is the long-term nature. To ask companies to go from that next quarter mentality to something five to ten or fifteen years in the future is asking a lot. But in talking to them you try to convince them of the longer-term benefits by showing them that there will be short-term benefits as well. In a lot of these cases the companies are already beginning to work with expert systems. And they are struggling with the early applications of robotics. What we offer to them is a forum where they can sit down and discuss with others, in other sectors of the economy, how the same problems have been encountered and overcome. So, after you spend about an hour with them they suddenly begin to realize that it is not just all long-term, there are some immediate benefits available in terms of becoming part of this community that is dealing with intelligent systems.

The other thing that they see fairly quickly is that a lot of them are looking forward to a very considerable turnover of their professional and technical staff in the next decade. They are worried about how they are going to find replacements with the qualifications of the people that they now have. They realize that while they have these people at the present time, they better be doing their best to capture their expertise in an expert system that will help to train the new ones coming in. That challenge brings home the importance of this technology to them in the immediate future.

The PRECARN membership fee is $25,000 a year regardless of the size of the company. The differential that I expect to see in contributions will come at the project stage where larger companies will participate in the projects. But even $25,000 is very difficult to find for many companies. So some Provincial governments are setting up programs to assist small companies to join us.

So it has been an interesting exercise, we have certainly been pioneers, we have certainly paid the price of most pioneers in terms of running into unexpected barriers. But, we have been proud of the fact that over the first 2 - 2· years it has all been done by industry. There has been about $2.5 million of investment in cash and in kind put into this process to date by industry. The amount we have received from government so far has been $25,000. That was an "accidental" contribution by the Ontario Government who thought that MITT could join as a member. We had to tell them "No, this is an industry operation", and they turned it into a welcomed grant.

So my parting message to you, and I have listened to some of your discussion with a great deal of interest, is to certainly pursue what you are doing through MITEC and other mechanisms in the mining industry. But recognize that when you come to some technologies, such as some aspects of what you have been talking about in the last day, that there is a much broader community out there that is sharing the same challenges with you and you should try to relate to them and benefit from their experience.

Of course, membership in PRECARN is the ideal way to do it. I have approached Jeff and suggested to him that there may well be projects that PRECARN and MITEC can jointly sponsor. I have made the same offer to the Space Station Group in Ottawa but I believe that the type of challenge and return on investment will be far greater in the mining industry than it will be in the Space Station.

Thank you very much.

Results of Workshop Discussions

The following four seminars were very different in content and style. This point has been raised to emphasize the importance of the chairman in controlling the direction of the workshop discussions. In such a diverse group with very different perspectives it is difficult to maintain focus. For anyone considering a workshop of this type, special attention is required when selecting the seminar chairmen.

Communications and Networking

Communications is considered the backbone of automation in underground mining. If the level of automation through increased robotics is to be achieved it is essential that the communications network have the bandwidth to handle the large amounts of data generated for monitoring and control of equipment. Another element of productivity gains that can be achieved is an enhanced voice network that is reliable enough to eliminate the buddy system that currently exists in underground mining operations. To ensure safety standards are maintained these communications systems have to be fail safe not just in normal operating environments but also under emergency situations.

The current leaky feeder transmission cable is considered adequate to handle the increased data produced from voice and data signals generated in modern mining operations. The leaky feeder system has a bandwidth of 9600Bd and is capable of handling data from fixed/mobile equipment and voice simultaneously. With the greater bandwidth requirements for video signals, the additional data transmitted over the leaky feeder system was considered impractical. A separate data link was deemed more appropriate for the high volume of data that video transmission generates.

The issue of stray electromagnetic signals which could prematurely detonate blasting caps was raised. The general consensus was that using modern leaky feeder cable did not pose any problems in this area. However it was also agreed that electrically isolated blasting techniques would be advantageous to ensure complete isolation from stray electromagnetic signals.

There was some disagreement on the cost of maintenance of a leaky feeder system. In the first year of operation it was agreed that maintenance costs were at an acceptably low level. However due to stress caused by blasting some participants were of the opinion that maintenance costs rose by a factor of two in the second year and progressively got worse over time.

The use of fibre optic cable in underground operations was also discussed at some length. The advantages of fibre optic cable were primarily two fold; the bandwidth was large enough to accommodate voice, data and video on one cable, and there were no stray electromagnetic signals.

The cost of installing fibre was considered higher than other transmission mediums but the life costs appear to be lower. There are however some technical limitations. Firstly multiplexing is difficult and costly. Secondly fibre is fine for point-to-point communications but is currently impractical for mobile transmission.

The Fully Automated Mine

The feasibility of not having any humans underground was debated. The general consensus was one of skepticism (if it was possible, it was many years away). However, there are definite areas for advancement in the short and long term.

Short Term Goals:
- Reductions in the cost of transmission mediums
- Reductions in the cost of maintenance
- High data flows from fixed to mobile equipment
- Increased use of video for monitoring
- Personal radio equipment designs to be even lighter (specifically in the area of the power pack)

Long Term Goals:
- Transmission medium without wires
- Video systems for vehicle guidance
- Fibre optics for mobile equipment
- Replacing stench gas for evacuation (research in low frequency signals through rock).

Production Monitoring and Control

Technology Need vs. Product Fit

This group felt that a communications gap exists between the mining industries need for technology and the suppliers of information technologies ability to address these needs. This can be demonstrated by larger mining and equipment supplier companies doing their own in-house R&D in the application of state-of-the-art information technology. However using this approach to information technology adoption has two problems:

1) Adoption and dissemination progress has been sporadic due to the inability to attract and keep good technical people in a mining environment.

2) Although there has been some co-operation between competing mining companies there has still been a high degree of duplicated effort.

As a result of these two factors the mining community does want to develop relationships and market possibilities for information technology companies especially in specialized niche areas. A number of forums were suggested that could facilitate this happening:
- Symposiums and workshops to strengthen the networking process and to identify areas of mutual co-operation.
- The use of centres of excellence to facilitate information technology development and applications
- Consortia, joint ventures and partnerships to share cost, spread risk and pool expertise.

Limitations to Implementation of IT

The question was raised about the lack of sensors as an impediment to greater monitoring and control of the production process. It was agreed by all of the group that this was not the case and that sufficient advances in sensor development and implementation offers many opportunities to further develop information technology applications to improve productivity in the production process.

At the corporate organizational level both mining and technology companies do not recognize the "need to know" issues related to technology development and implementation. For this reason technology often is secondary in an overall mining corporate strategy. Market analysis aimed towards the technological needs of mining is down-layed or ignored.

In many cases a mine has a short life and any expensive, risky technology venture is not considered worthwhile.

The mining industry is subject to wide swings in mineral prices which can produce a feast or famine situation in technology development and implementation.

Information Supplier Perspective

The need was identified that the supplier has to look for ways in which it can make the mining industry aware of new technology that has not had exposure in that sector.

New products are usually specified by the mining industry without supplier input. Then the mining industry will seek out a "best fit".

Mining industry has many problems with off-the-shelf technology.

Mining industry not interested in standoffs.

Very few high technology companies are knowledgeable about mining or the technology requirements.

It was pointed out that in countries such as Sweden, West Germany and Finland it takes five years to implement a new technology initiative into resource industries such as mining.

Conclusion

The Canadian mining industry may now be in a strong position with the climate created by high metal prices to increase the adoption and diffusion of information technology through in-house R&D and joint ventures.

Recommendation

1) Federal government consider programs to promote improved productivity in mining through greater adoption of information technologies.

2) Associations be encouraged to encompass mining equipment suppliers as well as mining companies.

Automated Material Handling

The concern for this group was that the adoption or extension of information technology is a real perceived need in the Canadian mining community. Although smaller mining companies were not well represented at this session it was felt that the degree of information technology adoption between large and small operations, was very different. The issue for the smaller operations was primarily one of cost.

The group also considered whether mining methods had to change to become more adaptable to information technology. The feeling was that as a short term goal this was not feasible. However as new advances are made in continuous mining systems, information technology should be an integral part of the new system development, ie. it was felt that it is not cost effective to adapt existing equipment to accommodate information technology.

The feasibility of mining companies forming joint ventures to develop and implement information technology applications was debated. There were no definite conclusions on how this type of endeavour could be achieved. Although it was recognized that groups already existed, and some progress has been made in formalizing this type of initiative.

The role the Canadian government plays in assisting industry in adopting information technology was discussed. It was felt that there were several possibilities, but no definite ideas tabled in what form they might take. It was pointed out that CANMET provides industry with a list of projects that are being performed by them. It was felt that more of this type of awareness should be provided by government. The group felt that the biggest single problem is lack of industry knowledge of what currently exists.

One comment that did come from one of the seminar members was the acknowledgement that government assistance is available. However in this particular case the applicant was frustrated when trying to find the individual that knew how to make the process happen.

Design and Engineering

1) Areas of advantage

3-D visualization is critical to:

- modeling
- improved mine production planning
- improved material flow design
- improved mining practice
- improved safety

The foundation for the above is there, and is available.

2. Problem: The equipment is very complex

- need highly qualified people to handle the equipment
- generally not available in Canadian mines (e.g. in Chile even the shift boss is an engineer)
- mining is not keeping pace with IT technology development

3. Computer programs need to he made much more user friendly

- this still requires an experienced engineer for interpretation

4. Data Base

- considered critical element
- need standardization of data handling aspect such that can develop communication between mines and potentially between companies

5. The mining industry should look at what other industries such as manufacturing are doing in terms of handling data.

   - a lot of expertise exists in this area at NRC/CANMET

6. Role of universities

- how should mining engineers be trained to handle IT applications
- should an interdisciplinary program be developed?
- how can we, the industry, most effectively combine the two different kinds of talents?
- need to set-up programs to retrain industry people on regular basis

7. Mine operations personnel have their hands full with mining
- how can you combine other (e.g. IT) talents?

8. In IT

- hardware costs - decreasing
- software costs - increasing

How can we define our general needs such that each new software development does not have to be unique?

9. There is a need to set up better, more regular forums for IT/mine industry communication

Appendix A

Evaluation of the Workshop

Michael Clapham, Information Technologies Industry Branch
Industry, Science and Technology Canada

Delegates at the workshop were asked to fill out an evaluation form which is to be used in planning future workshops and seminars. The compiled results with resulting observations and comments are summarized in the attached charts.

The following is a summarized analysis of these results:

Number of workshop attendees;	88	
Number of evaluation returns;	22	(25%)

In order to easily identify each of the three industry groups and the government participants the identification badges were colour coded. Also at the dinner on the first evening participants were p]aced at tables in order to gain maximum mix of different industry groups. Although this may appear at first to be a minor detail, the effect on networking proved to be very effective and crucial to the overall effectiveness of the workshop.

Alternative Workshop Structures

A number of points came out from the participants on how the workshop structure may be improved as follows:

- The length and technology focus of the workshop was generally acceptable, however it was felt that the whole workshop could easily have been more focused on just one technology topic.

- This type of workshops must not be too broad or it will not be possible to focus on specific issues related to the user/supplier relationships.

- The presentation of focused papers is required but not at the expense of substantive interactive discussion.

Summary

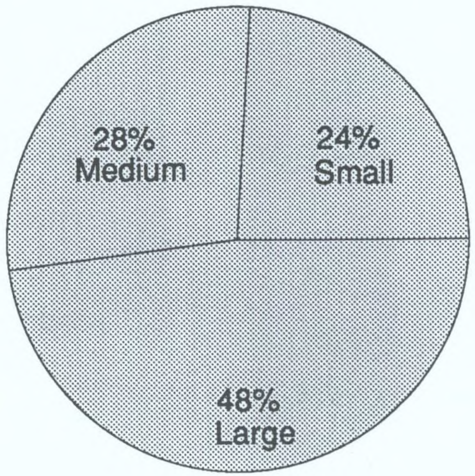
This case study showed that there were very real issues both long and short term that needed discussion. More time at the seminar level will be required to further bring out the issues and plan ways in which solutions can be implemented. The choice of chairman/moderators at these seminars is crucial to keep the discussions on track so that meaningful results can be achieved.

The majority felt that this type of endeavour was worthwhile and more should be carried out in the future. The need to gain an understanding of each other's business and the need for mutual co-operation is something that requires a forum such as this.

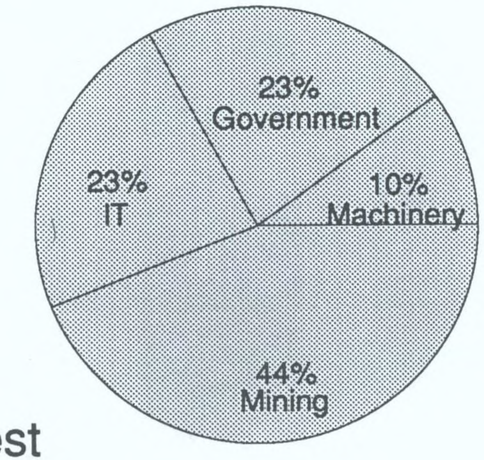
Follow-up was considered by most to be essential. It is anticipated that follow-up will be in the form of a questionnaire sent to all participants asking for general information on possible business activities resulting from the workshop. The time frame for this is estimated to be September 1989.

PROFILE OF RESPONDING DELEGATES

Size of Company



Area Represented



Primary Interest

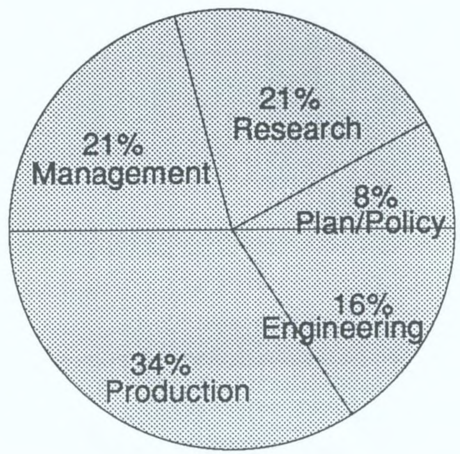


CHART 1

PRIMARY REASONS FOR ATTENDING WORKSHOP

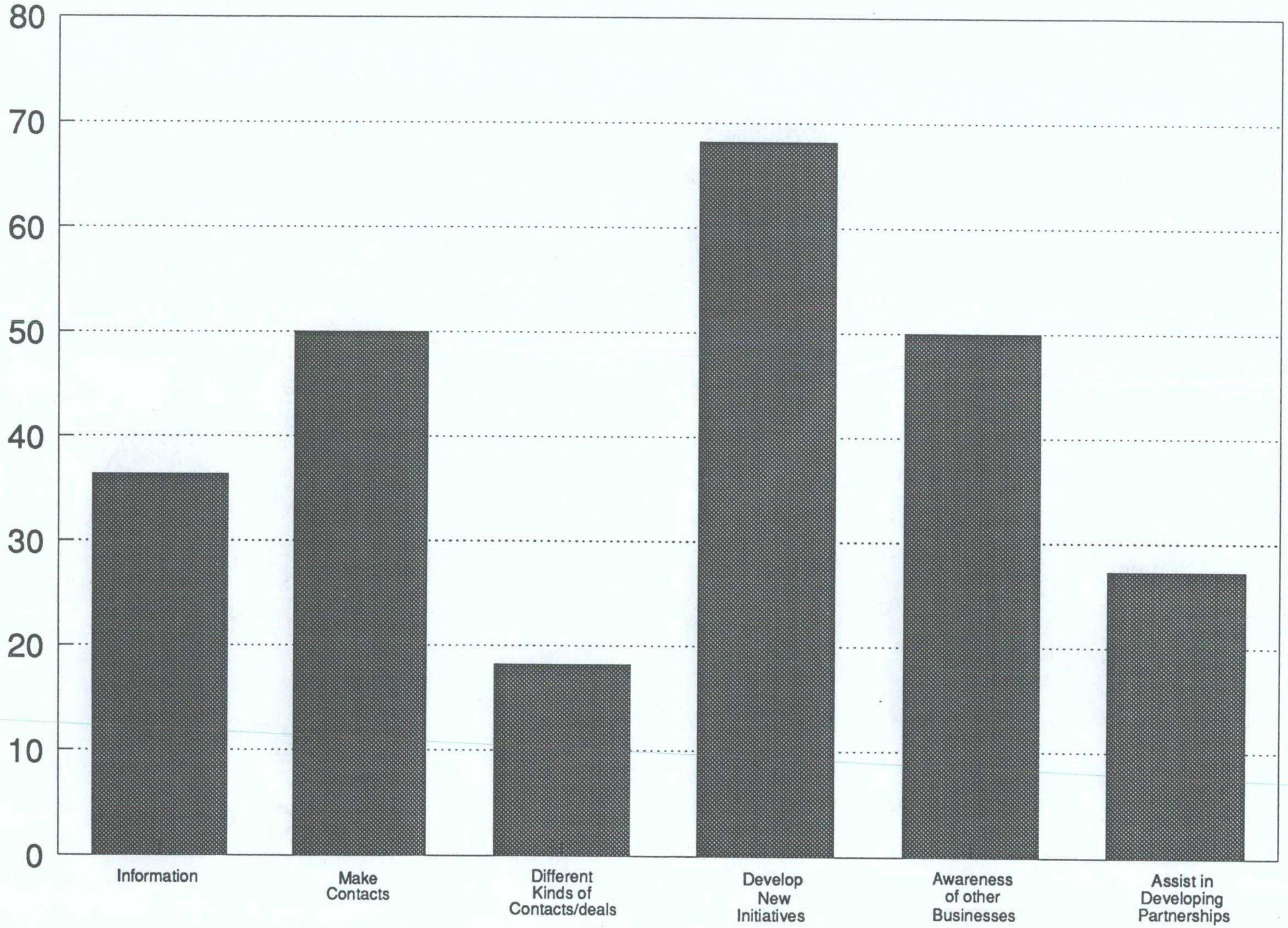


CHART 2

SUMMARY OF WORKSHOP ASSESSMENT

QUALITY		YES
1)	Was it worth your time?	90%
2)	Were the workshops on the whole as good as anticipated?	73%
3)	Were the speakers on the whole as good as anticipated?	68%
4)	Did the overall meeting format and content meet your expectations?	91%
5)	Was the discussion relevant to your business?	95%
6)	Was it worth the money?	95%
7)	Was the mix of industries valuable?	100%
VALUE		
1)	Would you be interested in a follow-up to this work?	86%
2)	Would you recommend a similar format?	77%
3)	Would you recommend a similar mix of industries?	86%
RESULTS		
1)	Were you able to make new contacts?	100%
2)	Might these contacts be useful in future business dealings?	100%
3)	Do you see any potential for future deals?	77%
4)	Do you anticipate some technology initiative developing because of this workshop	68%
5)	Did you gain new insights into the potential application of technology?	68%

CHART 3

ASSESSMENT OF THE QUALITY OF THE WORKSHOP

QUESTION	YES	COMMENTS
1) Was it worth your time?	90%	
2) Were the workshops on the whole as good as anticipated?	73%	Individual workshops too short. Many participants wanted longer to discuss specific issues.
3) Were the speakers on the whole as good as anticipated?	68%	
4) Did the overall meeting format and content meet your expectations?	91%	I liked the late afternoon start and the full day to follow - very acceptable for busy industry people (Engineering participant)
5) Was the discussion relevant to your business	95%	More time, more organized discussion groups. More "meaty" papers, more focused papers. Provide advice to research groups for long-term work. (Research organization).
6) Was it worth the money?	95%	
7) Was the mix of industries valuable?	100%	Good ratio of industry to government to university, i.e. highly industry focused. Could have had a few more university participants (Engineering participant).

CHART 4

ASSESSMENT OF THE WORKSHOP RESULTS

QUESTION	YES	COMMENTS
1) Were you able to make new contacts?	100%	Networking was successful.
2) Might these contacts be useful in future business dealings?	100%	A few indicated that there may be a possibility that technology initiatives will develop.
3) Do you see any potential for future deals?	77%	As a result of the workshop two IT companies have indicated that they have potential future business deals. One in data communications, the other in expert systems for equipment diagnostics.
4) Do you anticipate some technology initiative developing because of this workshop?	68%	Advanced communications systems (Research Organization).
5) Did you gain new insights into the potential application of technology?	68%	This was specifically true for IT companies that had not been involved with the mining industry in the past.

CHART 5

ASSESSMENT OF THE VALUE OF THE WORKSHOP

QUESTION	YES	COMMENTS
1) Would you be interested in a follow-up to this work?	86%	Continued development of present themes. Full day discussions - results of this workshop required reading (Research organization).
2) Would you recommend a similar format?	77%	Future workshops should have a narrow focus (Machinery/Equipment Engineering)
3) Would you recommend a similar mix of industries?	86%	Should be more industry representation. Need a forum for mining industry and manufacturers to sit and discuss specifics of industry needs (Mining Production/Engineering)

CHART 6

INFORMATION TECHNOLOGY IN MINING

c/o Events Management Inc.
4 Cataraqui St., Suite 209
Kingston, Ontario K7K 1Z7
Phone: 613-547-5093 / FAX: 613-547-6859

EVALUATION FORM

Please take the time to fill in this Evaluation Form. Your input will provide feedback for the Organizing Committee and information for future planning.

1. Profile of the Delegates

Size of Company: Small ☐ Medium ☐ Large ☐
Area represented: Mining ☐ IT ☐ Mining Machinery/Equipment☐ Government ☐
Primary interest: Research☐ Management☐ Production☐ Engineering☐ Planning/Policy☐

2. Why did you attend the Mining Workshop?

	Very Important	Important	Not Important
For information on the topic offered	☐	☐	☐
To make contacts	☐	☐	☐
To make business deals	☐	☐	☐
To make a different kind of business contact or deal	☐	☐	☐
For information to develop new initiatives	☐	☐	☐
For better awareness of other related businesses	☐	☐	☐
To assist in developing partnerships	☐	☐	☐

3. Assess the quality of the Workshop.

	Yes	No
Was it worth your time?	☐	☐
Were the workshops on the whole as good as anticipated?	☐	☐
Were the speakers on the whole as good as anticipated?	☐	☐
Did the overall meeting format and content meet your expectations?	☐	☐
Was the discussion relevant to your business?	☐	☐
Was it worth the money?	☐	☐
Was the mix of industries valuable?	☐	☐

4. Assess the results of the Workshop.

	Yes	No
Were you able to make new contacts?	☐	☐
Might these contacts be useful in future business dealings?	☐	☐
Do you see any potential for future deals?	☐	☐
Do you anticipate some technology initiative developing because of this workshop?	☐	☐

If yes,elaborate: ______________________________

____

	Yes	No
Did you gain new insights into the potential application of technology?	☐	☐

5. Assess the value of future meetings.

	Yes	No
Would you be interested in a follow-up to this workshop?	☐	☐
Would you recommend a similar format?	☐	☐
Would you recommend a similar mix of industries?	☐	☐
What topic would you suggest for a future meeting?	☐	☐

6. Other comments:

____

____

____

____

____

____

7. Optional

Name: ____

Company: ____

Please deposit this form in the box provided at the Registration Desk, or send to the address at the top of this form.

Thank you!

Appendix B

Information in Mining Technology Attendee List

Last Name	First Name	Company
Aelick	Ronald	Inco Ltd.
Ahopelto	Erkki	Normet Industries Canada Inc.
Baiden	Gregg	Inco Ltd.
Bawden	William	Queen's University
Beaton	Tom	ISTC
Belford	Eric	Kidd Creek Mines
Black	Malcolm	Blackbox Controls Ltd.
Blackery	Andrew	Falconbridge Ltd.
Bodell	Richard William	MITT
Bosch	Johann	Boart Canada Inc.
Brehaut	Henry	Placer Dome Inc.
Bunce	Andrew	John T. Hepburn, Ltd.
Carrington	John	Minnova Inc.
Cervenan	Martin	Alberta Laser Institute
Chowdhury	Ash	Digital Equipment
Christie	Ted	EMS Associates
Clapham	Mike	ISTC
Clark	Robert	MPB Technologies Inc.
Clow	Graham	Nanisivik Mines ltd.
Curlook	Walter	Inco Ltd.
Dixon	Mike	Motorolla Ltd.
Dubois	Andre	ISTC
Dumville	Bruce	Brunswick Mining & Smelting Corp
Dunham	Lloyd	Falconbridge Ltd.
Ferguson	Brian	Falconbridge Ltd.
Gardner	John	ISTC
Garlick	Arnold	MEMAC
Gow	Gordon	Ontario Ministry of Northern
Gregg	Lauri	Falconbridge Ltd.
Hackwood	James	El-Equip Inc.
Harris	Tony	Comdale Technologies Inc.
Hawkes	William	Inco Ltd.
Hayward	James	Gellman Hayward & Partners Ltd.
Hepburn	James N.	John T. Hepburn, Ltd.
Hepburn	John F.	John T. Hepburn, Ltd.
Hershtal	Zev	Vadeko International Inc.
Holmes	Warren	Falconbridge Ltd.
Hurtubise	Lionel	Ericsson Communications Inc.
Hutchison	W.G.	William G. Hutchison & Co. Ltd.
Imrie	Craig	Mattabi Mines
Jeffery	W.G.	MITEC
Jowsey	Milton E.	HDRK Mining Research Ltd.
Jubb	J. Trevor	CANMET, Energy, Mines and Resources

Last Name	First Name	Company
Jullian	Michel	OCM Technology Inc.
Kidder	John	Coldswitch Technologies Inc.
Kirby	Maurice	Hudson Bay Mining
Kossatz	Eric	Inco Gold Management Inc.
Kreimes	Walter	FMC
Lacroix	Rick	Potash Corp. of Saskatchewan
Laurie	Gordon	Hatch Assoc. Ltd.
Letts	Dale D.	Continuous Mining Systems Ltd.
Lo	Peter	Relcon Inc.
Lumb	Chris	Alberta Research Council
MacNabb	Gordon M.	Precarn Associates Inc.
Merrick	Lou	Noranda Inc. Information Serv.
Meyer	Keith	Cominco Engineering Services Ltd
Morissette	Fernand	ISTC
Mungall	Robert	Mine Radio Systems
Nantel	Jacques H.	Noranda Inc.
Nenonen	Leo	National Research Council
Orr	Stephen	Motorolla Ltd.
Pathak	Jay	CANMET
Pelton	Earl	ISTC
Poling	George	Mining Association of B.C.
Pugsley	Thomas	Falconbridge Ltd.
Quesnel	William D.	Boart Canada Inc.
Raleigh	Patrick J.	Falconbridge Ltd.
Richardson	Peter	Queen's University
Robertson	Brian	Placer Dome Inc.
Rogers	Harry	ISTC
Ruhl	Herman	H. Ruhl Machinery Co. Ltd.
Sibbald	Cory	TECK Corporation
Smith	Russell	Foundation Instruments Inc.
Sodhi	Ajit	Securiplex Systems Inc.
Thomas	Bill	Datem Ltd.
Vieira	Walter	Natural Sciences and
Volker	Michael	BC Advanced Systems Foundation
Walker	Edward	Motorolla Ltd.
Watkins	Ron	ISTC
Westhead	Barry	Westhead Industrial Systems Corp
Wiatzha	Gerd	Noranda Inc. Information Serv.
Wilk	Stan	National Research Council
Wojciechowski	Margot	Queen's University
Woodbridge	Roy	CATA
Yates	Edward	Falconbridge Ltd.
Young	Doug	Ramsey Canada