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Knowledge Intensive Service Activities (KISA) in Innovation of the Mining Technology Services Sector in Australia

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AEGIS

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November 2005

AEGIS is a Research Centre of the University of Western Sydney.

AEGIS

Acknowledgements

This report has been prepared by Dr. M.C. Martinez-Fernandez of the Australian Expert Group in Industry Studies (AEGIS). AEGIS is a research centre of the University of Western Sydney.

The cover artwork is credited to Monthalay Chanthapanya.

The study is part of an ARC Linkage funded project in partnership with Australian Government Departments DITR and DCITA (LP 0349167).

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The views expressed in this report are solely those of the authors and should not be attributed to the Department of Industry Tourism and Resources or the Department of Communications, Information Technology and the Arts.

ISBN 1 74108 109 2 print edition
ISBN 1 74108 110 6 web edition

Published by the University of Western Sydney, November 2005
http://www.uws.edu.au

M. C. Martinez-Fernandez (2005) *Knowledge Intensive Service Activities (KISA) in Innovation of the Mining Technology Services Sector in Australia*, University of Western Sydney: Sydney

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Executive Summary[1]

This report provides results of the investigation of Knowledge Intensive Service Activities (KISA) in the Australian Mining Technology Services (MTS) Sector. KISA can be defined as production and integration of service activities undertaken by firms in manufacturing or service sectors, in combination with manufactured outputs or as stand-alone services (OECD 2001, 2002). The results of the review of recent literature and surveys on the significance of the sector, semi-structured interviews with mining technology companies and case studies of MTS and mining companies are discussed.

Overview of the Sector

The MTS sector is comprised of companies, institutions, associations and other organisations that receive substantial portions of their revenue, directly or indirectly, from mining companies for the provision of goods and services based on specialised technology, intellectual property or knowledge.

The Australian Bureau of Statistics (ABS) does not collect data for the MTS sector. There is a minimum of 331 MTS companies in Australia as noted in the latest survey of the sector by ABARE. MTS is a critical component of Australia's largest export earner, the mining industry. Gross sales revenue in the MTS sector in 2004-05 is forecasted to be approximately AUD 4,430 million. The majority of the firms are SMEs employing 10 people or less with a total of 16,800 full time equivalent employees in 2003-04. The mining sector is estimated to contribute AUD 1.9 billion in high-technology exports in mining services, in particular to the East and South East Asian region but also to Central and South America, North America, Africa and Europe. The export revenue for 2004-05 is forecasted to be AUD 1,240 million.

Mining technology service firms are predominantly found in business centres and inner city locations. New South Wales, Victoria and Queensland have the highest number of mining technology companies. The sector has specific geographical features of clustering in the cities of Sydney and Perth, stressing the importance of network connections to corporate headquarters and other KIBS often associated with financial centres, especially in the case of Sydney.

Policies and Programs Supporting the Industry

In Australia there are no policies and programs specifically supporting the MTS sector or the supply or promotion of KISA in the MTS Sector. However, the current MTS Action Agenda provides the development environment for the sector. The Action Agenda is a cooperative dialogue between industry, Government and State Agencies, with the common aim of promoting sustainable economic growth. The Mining Technology Service Action Agenda was announced on the 6th of June, 2001. The Action Agenda focuses on five areas:

- Response to the globalisation change;
- Technology and research and development coordination;
- Improving industry market share and competitiveness;
- Education and training; and
- Promotion and marketing.

Case Studies: Key Findings

The case study analysis suggests that KISA performed by MTS have an important role to play in the transformation of the mining industry in Australia. KISA of high importance for both MTS and Mining Companies are:

- Exploration and other mining consulting;
- Design & Engineering consulting;
- Technical consulting services relevant to industry;
- Research & Development services;
- IP-related services; and
- Occupational Health & Safety (OH&S).

Services or expert contributions to KISA are largely sourced in-house, by KIBS or by a combination of both with exception of industry development advice which is mainly sourced from industry associations. The process underpinning KISA that is supplied and KISA that is purchased is different and seems to be linked to company competitiveness. Supply of KISA is increasingly happening in the form of 'packages' linking products and services such as maintenance, marketing or management services. Purchase of expertise is oriented to strengthening the core capabilities of the firm. These include KISA related to IT Consulting and Computer services, Management Consulting and acquisition of new skills or specialist skilled personnel. The purchase of services has a direct relationship with the capabilities firms wish to have in the future. These services are not static but subject to changes in the market and to the release of new knowledge as it emerges from R&D efforts and business practices elsewhere. Thus, access to international sources becomes an important feature of the competitivenes of the sector.

The process of KISA development by MTS firms is not dependent exclusively on formal contractual arrangements but on flexible interchanges and interactions across the network of companies in the 'innovation milieu' of the firm. Within this space, those in closer relationship to the 'product' constitute the main 'actors' with regard to source knowledge. The mix and match of internal and external expertise is usually done by project managers, product champions, and knowledge coordinators or by using formal platforms such as seminars and manuals. MTS companies seem to have more innovative solutions when it comes to knowledge management than mining companies despite the fact that mining companies are managing a significant number of contractors every day. MTS companies are highly dependent on the integration of knowledge they learn from each contract, as the application of new solutions is frequently based on their previous experiences. In this way, MTS companies act as transformers of the mining industry by transporting innovations from one mining site to the next one and by providing enhanced solutions based in previous solutions that worked well for other clients.

The case studies suggest the importance for mining sites as innovation intensive environments. Mining sites in Australia are often located in remote locations that are very rich in minerals which allows for a long-term exploitation and the formation of permanent settlements. Hundreds of contractors can be associated to the mine site having a significant impact both in the mining company where they operate and in other service businesses operating in town. In this respect mining sites are innovation intensive ecosystems that often lack the attention to the management of KISA as a value added to the organisational structure.

One of the main conclusions of the study is that KISA performed by MTS firms strongly impact innovation and competitiveness of mining firms. The frequency and diversity of these KISA are influencing the rapid transformation of the mining industry in the knowledge economy into a 'knowledge based techno-economic network' (KBTEN).

Emergent Policy Themes

• There is a need for governments to promote the awareness of the role of KISA in innovation. Specifically, it is important to focus attention on the different functions of internal and external knowledge intensive services for KISA and their relationships to firm competitiveness. For instances, sourcing external expertise to keep abreast with international technological innovations and solutions that internal experts might not have been exposed too. Thus, future capabilities might depend on increasing external contributions to KISA;

• The importance of knowledge management is growing in importance for the sustainability of the industry and government departments should attract attention to the fact that MTS firms have advanced knowledge management systems and practices that can be shared within the mining site environment;

• Significantly the findings of the study suggest that there is a need to see the MTS sector as part of a Knowledge Based Techno-Economic Network (KBTEN) together with mining companies. This network presents clustering features in mining sites and in financial business centres. Thus, policies and programs oriented to build and develop this network across mining sites and financial business centres would enhance innovation capability of both MTS and mining companies;

• There is a need for different government levels in Australia to increase the quality of transport infrastructure and urban logistics for the remote mining areas as an important part of the MTS sector development. An key feature feature of the sector is based in moving people to remote locations that lack the sophistication for network connections and development that existing urban areas have;

• Finally, the MTS Action Agenda could consider promoting or recommending initiatives to enhance KISA that is tailored to both MTS and mining firms as they are part of the same innovation ecosystem and their interactions are indeed of an intense nature.

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1. Introduction

This report gives an overview of Australian Mining Technology Services (MTS) outlining the industry context and major findings of the KISA MTS study. The KISA project is an Australian Research Council Linkage Grant investigating Knowledge Intensive Service Activities in the Software, Tourism and MTS industries.

Knowledge Intensive Service Activities (KISA) are defined as production and integration of service activities undertaken by firms in manufacturing or service sectors, in combination with manufactured outputs or as stand-alone services. KISA can be provided by private enterprises or public sector organisations. Typical examples include; Research and Development (R&D) services, management consulting, Information Technology (IT) services, human resources management services, legal services such as Intellectual Property (IP)-related issues, accounting and financing services, and marketing services (OECD 2001,2002).

The Mining Sector makes approximately 5.0 per cent of gross domestic product in contribution to the Australian economy.[6] Mining is the *nation's largest export earners;* in 2000-01, mining accounted for 26 percent of the total value of exports, principally from the coal, and oil and gas extraction industries.[7]

The significance of the MTS sector is linked to the contribution of the minerals industry to building national infrastructure throughout Australia. Entire towns such as Broken Hill, Mt Isa and Kalgoorlie developed around mines. Other cities such as Newcastle, Wollongong and Whyalla have prospered indirectly from mining. The Australian minerals industry as a whole contributed AUD 43.8 billion to Australia's economy in the year 1999-2000.

Mining technologies used by mining companies include exploration, extraction, mineral processing engineering and environmental technologies. Over the years, the mining technology services industry has become the world's leading producer of mining software and high-technology mining services.[8] The Mining Technology Services (MTS) sector has been defined as comprising of companies, institutions, associations and other organisations that receive a substantial portion of revenue, directly or indirectly, from mining companies for the provision of goods and services based on specialised technology, intellectual property or knowledge. 'Goods and services' include, but are not confined to, equipment, software, consulting and engineering services, and R&D. 'Mining' includes exploration, mining (extraction), quarrying and coal and mineral processing (including smelting and refining of metals and minerals).[9]

The report is divided into the following sections; the introduction, an overview of the MTS sector in Australia, key findings from the case studies and conclusions and policy suggestions. This introduction discusses the innovation and importance of Knowledge Intensive Services, the meaning of Knowledge Intensive Service Activities and the KISA study. Parts of this introduction are also part of the software and tourism reports of the KISA project. (Martinez-Fernandez et al, 2005a,b).

1.1 Innovation and the Importance of Knowledge Intensive Services

Recent research on innovation undertaken by the OECD and EU suggests that there are three principal 'lenses' useful for analysing innovative activities in a nation. In summary, these 'lenses' focus attention on understanding particular patterns of innovative activity seen in an economy as a function of the characteristics of the major players (institutions and organisations public and private), and the ways in which these link public and private sectors together. The players may link in different ways at different spatial levels (national, regional or local), through activities such as R&D provided through public or private enterprises, through the development and use of management and other business-related skills and expertise – seen in the rise of knowledge-intensive business service firms (KIBS) who provide skills and expertise to other players in the system – or they may link through their entrepreneurial activities as suppliers and customers.

Recent decades have seen a vast amount of investigative work, both theoretical and empirical, on the different aspects of the study of players and their interactions. Many studies have developed understanding of the *systemic* nature of innovation and the importance of all elements of a nation's innovation system – legal, scientific, training, business programs, for example – working well together. Much of the more recent work is summarised in OECD 1999, 2000, 2001a. (See also Edquist, 1997). The focus on *national* systems of innovation was subsequently complemented by recognition of the similar importance of regional and local innovation systems (eg Cooke, 2001). Work also progressed on sectoral or technological systems of innovation in specific industrial fields (Malerba, 2002; Marceau et al., 2001 and Marceau and Martinez, 2002) and more recently on the need to integrate the spatial elements of these systems (OECD, 2001b). There has also been important work on the growth of the services sector and the separate systems of innovation operating there (see eg. Anderson et al., 2000; Howells, 1999; Metcalfe and Miles, 2000) and on linkages between manufacturing and services in firms' competitive strategies (Marceau et al., 2001). Very recent work is bringing together theories about firms, institutions and organisations to provide a 'systemic' theory of innovation at firm level (Coriat and Weinstein, 2002).

Over the same period, the shift towards the 'knowledge economy' has seen the creation of KIBS as important private sector players in the innovation game (see eg. Miles et al., 1994; Gallouj and Weinstein, 1997. See also Muller, 2001 for interactions between KIBS and SMEs and Muller and Zenker, 2001) while public organisations, notably universities, have been encouraged to make their expertise widely available to business and community. The production and diffusion of knowledge via KIBS firms has become central to innovation systems in these countries. KIBS typically include legal and accounting but also, and more relevantly here, design and computer-related services, R&D consultancy, recruitment of skilled personnel, environmental services and technical and training services (Windrum and Tomlinson, 1999:393). KIBS play a twofold role in a country's innovation system – as providers of knowledge services to other firms and as a means of introducing internal innovations (internal consultancy).

Private sector experts, however, are not the only players in innovation. On the one hand, innovation expertise is also provided to firms by public sector research organisations and, on the other hand, by a range of government programs aimed at encouraging innovation in the private sector. Driving firms and organisations towards packing an ever-greater innovation punch through the use of the science and technology system and related policy instruments has become a major aim of government in Australia (see, for example, the series of measures gathered into 'Backing Australia's Ability' 2001), as elsewhere in the OECD (OECD, 2002a).

In contrast to the wealth of understanding about what knowledge-intensive public and private organisations can do, as indicated above, two aspects of the national innovation effort remain understudied. The first concerns the factors that trigger enterprises to decide on innovation per se. The second concerns how firms use the variety of sources of expertise available to innovating firms and companies and how they choose among several providers of similar services and seek different sources of assistance at different times and for different innovation project purposes. Nonaka and his colleagues, for example, have shown that innovating firms indeed draw on a range of providers of expertise (1995). Services available and used include R&D, testing, prototyping and other technical and engineering services, ICT, legal (especially IP-related), financial, marketing and training.

However critical questions remain about *how, when* or *why* firms choose to use *particular* different kinds of government and publicly and privately provided innovation programs or services among the variety available, why they choose x and not y or x and y but not z, or how and why these choices vary according to whether the innovation concerned is radical or incremental. Even less is known about how firms transform the innovation services they receive from outside to build capability and hence permit sustained innovation at firm level. As a result, innovation-related policies are still poorly targeted and often less effective than had been thought.

One of the most important aspects of the latest phase of international work on innovation at firm level has begun focusing on firms' development and use of the different sources of expertise available to them. Thus, for example, two projects funded by the European Union in recent years have focused on innovation in services and services for innovation. The first of these, the IS4S project, focused on innovation in service industries and specifically the development of services to support innovation by others. The second, the RISE project, focused on mapping the transformation of Research and Technology Organisations (RTOs) as they began to reach out more to private sector clients and to depend more on private sources of income (see Hales, 2001). The RISE project also began the investigation of how firms engage with external providers of innovation services, both public and private, at different stages of the innovation process and in different clusters (Hales, 2001; Hauknes, 2000; Preissl, 2001). In Australia, AEGIS ARISE project investigated the shifting landscape of RTOs, with a particular focus on the public-private hybridisation of major scientific organisations, including universities.

Taken together these studies have shed considerable analytical light on many aspects of the field. Results of the ARISE project; for example, have suggested strongly that three foci of research are now needed if government assistance for innovation in Australia is to be maximally effective. These are:

- better understanding of how firms interact with external providers of innovation services in order to develop innovation capability.
- better understanding of how firms mix and match their use of services at different 'stages' of their innovation project(s);
- better understanding of both the ways in which and the reasons why such mixing and matching varies according to the sector of principal activity of the firm.

The ARISE results thus suggest that *what is missing now from innovation analysis is how firms seeking to innovate mix and match their use of publicly provided assistance programs and private sources of expertise including their own in order to transform different kinds of knowledge inputs into sustained innovation.*

The Knowledge-Intensive-Service Activities (KISA) project, of which this report is a part,

addresses precisely this issue. The study is composed of several levels of analysis which provide the context for a firm-level analysis of innovation knowledge-seeking choices. The project involves detailed statistical description of the size and 'shape' of the industrial sectors selected for study and presentation of the policies available for firms in those sectors to use for innovation assistance. These two elements form the background for the empirical study of innovation at firm level. The results of this analysis for the mining technologies services sector are presented in this report. The report also presents key findings from an empirical study of mining technology services firms and mining firms in Australia intended to show the choices among providers of innovation expertise made by firms in the mining industry, to gain insights into the reasons for the choices made and to indicate how these firms mix and match the knowledge-intensive services used.

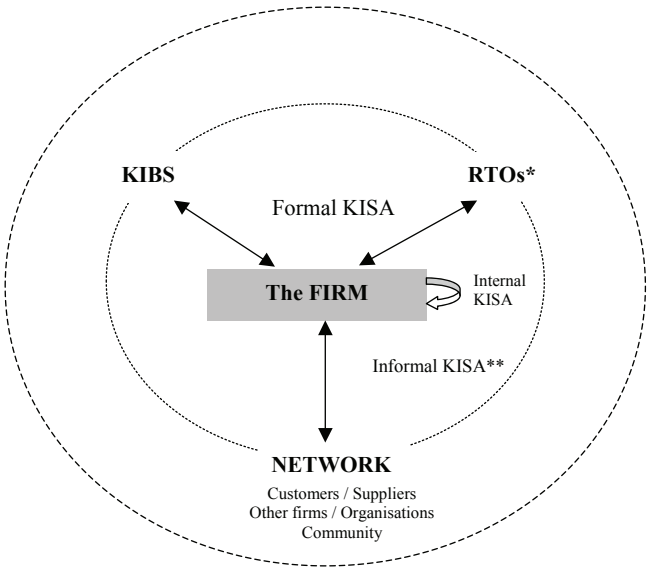
1.2 Knowledge-Intensive Service Activities (KISA)

KISA are the knowledge-intensive service activities that firms undertake in conjunction with external or internal experts to build capability in the multiple areas needed for sustained innovative activity. A range of knowledge intensive service activities can be identified as management and business service activities; consultancy services; legal; intellectual property and accounting services; recruitment and training activities; technology services such as IT; marketing services; research and development activities etc. (OECD 2001,2002). There are generic KISA, such as those generated by software firms or engineering consultancy firms, for instance, and specific KISA which are sector or industry specific. The experts concerned may be from public or private sector or research organisations or they may have been developed inside innovating firms as part of a strategic package of actions designed to build long-term innovative capabilities. The 'KISA' project therefore focuses from a firm level view on how such expertise is accessed, adapted, incorporated, refined, added to and transformed into innovative products, processes and organisational forms and the innovation capability needed for the future. It is hoped that the analysis of what firms do in different industries will then enable us to connect to other work so as to build up industry ('meso') level analysis. It is this firm and then industry-level focus that distinguishes the KISA project from work on KIBS and innovation in service industries themselves and from most existing literature.

The particular and distinctive ways firms access, acquire, produce and integrate knowledge are the 'KISA' firms undertake in their learning and innovation processes. Learning processes can be internal and external to the firm as an outcome of engagement activities inside the firm or with external organisations. This engagement is produced through the acquisition of knowledge intensive services to internal or external providers. The external providers are usually Knowledge Intensive Business Services (KIBS) but, increasingly, Research and Technology Organisations (RTOs) compete with KIBS as a result of changes in funding systems (Hales, 2001). Other important providers of expertise are competitors, customers and other organisations from the same or different industry sector and part of the network of firm. Inputs to KISA can come through networks and clusters via informal cooperation agreements.

The importance of the role of KIBS and RTOs might have been overestimated in the existing literature when we look in detail at how firms operate today within their learning space, especially in terms of their use of informal transactions for the co-production of knowledge. Figure 1 illustrates the learning space of the software firm and the role of the three 'vectors' of knowledge providing inputs to KISA: KIBS, RTOs and other organisations in the network space of the firm. The figure also shows where KISA are taking place in the firm and in which way, i.e. as formal transactions (eg contractual) or informal (eg sharing information) or as internal to the firm. The arrows in the figure indicate the engagement function of KISA and its dependence on interaction for the co-production of knowledge.

Figure 1 Elements in the co-production of knowledge of the firm



*RTOs-Research and Technology Organisations. Includes Government Departments that provides services such as research and development to firms/organisations.
KIBS-Knowledge Intensive Business Services.
**Although informal KISA can happen at any level they are more likely to appear while interacting with other firms/organisations of the network space of the software firm.

The activities that provide for the integration of KISA are important to building and maintaining a firm's innovation capability. For example, a firm sourcing providers in the marketplace to ensure that they get the optimum service. The firm engages in activities for sourcing, evaluating between service providers, assessing the services offered, the price, quality, and packages available. In this process the firm learns about the marketplace and acquires additional competences. Upon receipt of the service, there is further enhancement value to the firm as a result of the integration of the new service. Therefore the new service has added functionality and competence as well as providing new knowledge and learning abilities to the firm from the service provider's input. The process of the firm sourcing, obtaining, and mixing knowledge-intensive services are the activities accompanying the innovation process. This innovation process is positively affected in both sides of the interaction: the firm and the provider of services (Muller & Zenker, 2001).

KISA can vary according to the firm's own capabilities and innovation processes, the 'process of engagement' of the firm with external providers and the internal provision of knowledge intensive activities. Thus, KISA can be different in each firm and the activities that are more effective may indeed be the ones that differentiate a firm from its competitors. For example, company X, a manufacturing company focusing on advanced metal products, might require the latest technology and know-how in the application of cutting-edge machinery to maintain its position in the market. This particular activity will require a combination of expert services sourced externally and undertaken internally by the firm.

Understanding these innovation-related knowledge-intensive service activities – KISA – is important for governments because it relates directly to a set of issues which lie at the heart of policymakers' attempts to use public policy instruments to promote sustained innovation in all areas of the economy. KISA is also important for organisations providing innovation services

so that a better understanding of how their services work in practice, what areas needs to be improved in the range of service provision and the ways in which their services may be accessed and used is reached.

1.3 The KISA Study

The Australian KISA study focuses on three industries – software, mining technology services and tourism. The industries selected provide a contrast in scale and spread. The firms in each sector are mostly small, providing information on the constraints on policy services uptake faced by SMEs. The study is part of an OECD project examining different industries in several OECD countries.[10]

Mining Technology Services was selected for its relevance to the Australian economy both in term of exports revenue and in terms of innovation impact in the mining sector.

The Research Questions refer to the analysis of the role of KISA in firm innovation processes:

- What does KISA mean?
- What KISA are used by tourism firms?
- When are KISA used?
- Why is KISA used?
- How does KISA relate to firms capabilities?
- Who provides inputs for KISA?
- How are the different inputs to KISA mixed and matched by the firm?
- What are the policy implications of the role of KISA in innovation?

The focus of the MTS study is on the analysis of KISA in the Australian MTS sector utilising both quantitative and qualitative methodology. The research was carried out in two steps. Firstly a review of recent literature and surveys on the significance of the sector, including results of a previous AEGIS survey of mining technology companies. Second, in-depth 'case studies' of 6 MTS and mining companies and 2 related organisations were conducted.

Step 1. Literature review: major sources

The study includes data from the 2002 and 2004 Australian Bureau of Agriculture and Resource Economics (ABARE) survey of technology-based businesses that service the mining industry.

The study also includes results from the 2003 AEGIS survey of Mining Technology companies. AEGIS conducted 25 semi-structured interviews with senior managers of mining technologies firms as part of an Australian Research Council (ARC) Large grant.[11] The semi-structured interviews investigated the role of mining technology firms in the service economy and covered some aspects of the knowledge intensive service activities undertaken by firms. The interviews took each respondent through each major purchase/supply service mixing, matching and integrating process in relation to product innovation and the processes involved.

Step 2. In-depth case studies.

In-depth case studies of 6 selected firms and 2 organisations were conducted in 2004-2005 covering KISA undertaken by firms – internal/external – over the course of the decision to acquire and integrate KISA of different kinds and from different sources of expertise. The aim of this step was to understand the nature of KISA and the complex web of factors affecting the co-production of knowledge within the firm.

The selection of the 6 firms participating in the case studies was based on several parameters which are identified as:

- Market focus
- Size
- Ownership
- Annual Turnover
- Phase of Company Life Cycle
- Innovation/Industry awards received
- State location
- Mining companies referrals

During the course of the case study other firms or organisations were referred and included in the analysis.

In-depth interviews were conducted using the following themes for the guided discussion:

- Background of the firm
  - Customers
  - Most recent innovation
  - Network KISA
- Importance and use of KISA
  - KISA within the firm
- Access and interaction with external providers
  - External inputs to KISA
  - Public inputs to KISA
- Integration of external and internal inputs to KISA
  - Integration of expertise
  - Knowledge management and KISA
  - KISA and innovation capabilities
- Challenges to the innovation process
- Business Models and competitiveness

There are certain limitations to the analysis presented in this report. The number of case studies is small so it is not possible to draw conclusions about innovation across the MTS sector as a whole. Nevertheless the analysis of the firms participating in the study contributes to an understanding of the role of KISA in innovation of the Australian MTS and mining firms.

2. Overview of The MTS Sector in Australia[12]

In April 2004 the Mining Technology Services Action Agenda (MTSAA) Implementation Group reached a consensus on the definition of the sector as follows:

> 'The MTS sector comprises companies, institutions, associations and other organisations which receive a substantial portion of their revenue, directly or indirectly, from mining companies for the provision of goods and services based on specialised technology, intellectual property or knowledge. Such organisations identify themselves principally with the mineral industry. 'Goods and services' include, but are not confined to, equipment, software, consulting and engineering services, and R&D. 'Mining' includes exploration, mining (extraction), quarrying and coal and mineral processing (including smelting and refining of metals and minerals)'[13].

Previously, ABARE conducted a survey in 2002 of technology based businesses that service the mining industry. The products of these businesses could be based on information and communications technologies (ICT), or products that incorporate other scientific, technical or engineering based technologies, as well as services that provide expertise within these technology areas.

ABARE's 2002 definition of the MTS sector differs from that used by Austmine Ltd (an export association supporting companies in the Australian mining services sector). It is important to appreciate these differences because both ABARE and Austmine provided estimates of the economic contribution of the MTS sector, and its potential for growth. The Austmine definition is more broadly based because its membership includes heavy plant and equipment as well as other mining services outside the mining technology services sector, e.g., catering services. Heavy machinery and equipment is excluded from the ABARE surveys (ABARE 2002, 2004), because its activities are already covered in the Heavy Engineering and Infrastructure Action Agenda (currently being implemented). According to Austmine, the MTS sector is recognised as one of the best in the world, with a significant international customer base.*

2.1 The Economic Contribution of the MTS Sector[14]

Bearing these definitional issues in mind, ABARE estimates that the MTS sector makes a significant contribution to Australia's economic growth in its own right, contributing $3,120 million to Australia's gross domestic product in 2000-01 and expected to increase by 13 percent per year to AUD$1.9 billion in 2005-06. [15]

In addition to its strong domestic focus, the sector is expanding export opportunities in the global minerals marketplace. The ABARE survey estimates that gross export sales revenue contribute AUD 1110 million in 2003-04 and this revenue is forecasted to increase to AUD 1240 million in 2004-05[16]. ABARE and Austmine predict strong annual export growth rates to 2005-06, of at least 25 percent, with Austmine members potentially contributing up to AUD 6 billion in export earnings by 2010[17].

The ABARE 2004 MTS survey shows that there is a minimum of 331 companies in Australia.

They range from small companies to the largest mining firms employing whole divisions. The majority of the firms (52.7%) are however SME's employing 10 people or less; 25.2 percent employed between 10 and 50 people, and 22 percent employed over 50 people. The sector is estimated to have 16,800 fulltime equivalents employees down from 17,300 employees in 2000-01.

The most important occupations in the sector are high knowledge occupations such as engineers (62.1%), geologists and other earth scientists (49.1%) and computer scientist specialists (46.0%). Managers and administrators was considered important or very important by 42.6 percent of the firms, down from 58.3 percent in the 2001 survey. The possibility of a skill shortage over the next five to ten years was considered important by 66.8 percent of the surveyed companies in 2001.

Skilled professionals, particularly those with science, engineering and technology qualifications are considered very important factors to increase the sector's competitive edge. There is also a need to ensure that people already in the Australian mining industry are aware of the MTS sector and the skills and experience required by MTS employers, and that information about relevant training programs and opportunities is accessible. [18]

MTS firms export mainly to East and South East Asia regions; the biggest market is Indonesia (AUD 382 million) which accounts for 12.3 percent of Australia's export market. In order of export market share North America, East and South East Asia and Central and South America are the biggest regions for MTS firms. It is also important for the MTS sector to maintain current export markets while developing new markets and opportunities[19].

2.2 Research and Development (R&D)

According to a recent report prepared by ABARE on R&D in exploration and mining,[20] industry investment in R&D focused on applied and experimental development. Total expenditure on R&D in the sector was AUD $456 million in 2000-2001. Government expenditure on R&D was AUD $147 million in the same period, with a focus on basic and applied research (see table below).

Table 1: Mining Sector R&D expenditure

R&D	Industry expenditure (AUD $456 m.)	Government expenditure (AUD $147 m.)
Basic	5%	40%
Applied	23%	48%
Experimental	72%	13%

Source: Adapted from Hogan (2004).

R&D relevant to mineral exploration is mainly undertaken within individual companies, industry–government partnerships and public organisations. The main organisations are:

- CSIRO; mainly multidisciplinary research and technology development activities relevant to the Australian geological environment;
- Geoscience Australia; provides state/territory geological surveys and basic geoscience information;
- Universities; focus on basic research into geological processes and Australia's geology;
- The cooperative research centres (CRCs); bring together private and public organisations to solve particular problems;
- AMIRA International; a private organisation that engages in collaborative research by minerals companies in consort with public institutions.[21]

The ABARE 2002 study indicates that 41 percent of respondents did not invest in (R&D). This result is typical of the many small companies that comprise the MTS sector. Up to 59 percent of companies did invest in R&D and their total expenditure in 2000-01 was AUD 382 million, or 12 percent of gross sales revenue (see Table 2). The 2004 survey shows that 36.8 percent of respondents did not invest in R&D and the majority of firms (23.8%) invested between AUD 1 and AUD 100,000.

Table 2: Company R&D expenditure

Company Size	AUD $ Expenditure - million	Percentage of sales revenue
Small (1-10 employees)	53	16
Medium (11-50)	175	43
Large (+50)	153	6

Source: Tedesco et. al (2002)

ABARE estimated in 2002 that 15.7 percent of Australian MTS companies funded external R&D projects relevant to their MTS operations in Australia. R&D tax concessions and access to finance appear to be the most important issues for Australian MTS companies, with 85.6 percent and 82.7 percent respectively of all MTS respondents indicating that R&D was fairly to very important. Low rates of commercialization, low retention of intellectual property, access to public research organisations and availability of staff with specialist skills are also important issues for MTS companies. Current estimates for R&D expenditure are AUD 339 million; 7 percent of gross sales revenue (ABARE 2004 Survey)[22].

R&D strategies were noted by 58.5 percent of the companies surveyed in 2001 as an important factor for competitive advantage in contrast to other factors of higher importance such as management skills, intellectual capital, reliability as a supplier and quality of MTS goods and services (see table 3).

Table 3: Sources of Competitive Advantage

Sources of Competitive Advantage	% Companies
Quality of MTS goods and services	96.3
Reliability as a MTS Supplier	93.5
Intellectual Capital	90.8
Access to, and familiarity with, Australian Markets	84.4
Management Skills	84.3
Access to, and familiarity with, Overseas Markets	68.6
Promotion and Marketing Strategies	66.0
Use of ICT	65.9
Research & Development Strategies	58.5
Training/Education Opportunities	52.0
Access to Finance	44.7
Other	3.7

Source: Tedesco et. al (2002) p.43

In particular, R&D has been associated with the success of software applications to mining. According to the Department of Industry, Tourism and Resources (DITR)[23] 60 percent of the world's mining operations are now utilising software developed by Australian companies, indicating that Australian MTS companies are at the leading edge of technological innovation in the MTS sector. The sector contributed AUD $1.9 billion in high technology exports in mining services in 1999-2000.[24]

Many of the MTS companies in Australia are aware of the benefits of collaborating with other organisations for R&D purposes. Up to 83.8 percent of these organisations consider collaboration with exploration and mining companies important, 11.5 percent more than in 2001.[25] Table 4 shows the importance of organisations for collaborative MTS R&D.

Table 4: Importance of Collaborative MTS R&D

Organisations for collaborative R&D	Level of importance
Customers	3.5
CSIRO	3.0
Universities	2.8
Other MTS companies	2.4
CRCs	2.4
Other GFRO's	2.2
Other	1.1

Source: Tedesco et. al (2002) p.39

Note: GFRO's are Government Funded Research Organisations (GFRO's) as well as a number of non-Government funded or partly Government funded organisations. Examples of R&D organisations in Australia are for example CSIRO, universities and CRC's.

The 2004 ABARE survey identified as the more important forms of collaboration used for competitive advantage; strategic alliances (70.1%), promotion and marketing strategies for domestic market (61.7%), professional development (68.9%) and exchange of industry information (66.9%).

2.3 Service Innovation in Mining Technology Firms

In 2003, AEGIS conducted a study of service innovation in the mining technology sector of Australia.[26] A sample of 25 companies were interviewed in November 2003. This section presents an analysis of this survey in relation to service innovation.

The boundaries of the mining technology industry are difficult to determine as most companies offer services[27] and products that are used in industries other than mining. *The survey focused on firms that supply and manufacture mining machinery and equipment.* These firms also provided services related to maintenance and training of the machinery and equipment supplied. Using Kompass[28] data to inform the contours of those companies that supply mining machinery and equipment, a population sample of 277 companies was defined for the study.[29,30] Using the latest version of Kompass (version 2003/3) these companies distributed on a state-by-state basis as shown in Table 5. Of these 277 companies, approximately 59 percent of companies export part of their products. The geographical distribution of companies concentrates in NSW, Victoria and Queensland.

Table 5: Location of Mining Technology Companies

State	No of firms
New South Wales	115
Victoria	64
Queensland	45
Western Australia	30
South Australia	16
Tasmania	4
Northern Territory	3
Total	277

Source: Kompass database 2003/3

From this sample of 277 (table 5) companies, 25 firms were interviewed. A large number of the companies were single and privately owned businesses (32%) or a subsidiary of a multinational corporation (36%). Most of the companies consider themselves either competitive in the global market (40%) or competitive at the national level (40%). Turnover or sales for over half the local companies in the survey are less than AUD 25 million. Up to 48 percent of all the companies have 50 or less employees, and only 12 percent have more than 250 employees.

2.3.1 Knowledge Intensive Services (KIS) and Activities

Mining Technology firms offer a range of services bundled in the manufacturing and supply of machinery and often have divisions in the firm that offer similar services than the

companies included in the MTS sector by ABARE. The following table shows categories and some examples of the diversity of activities that can be performed by Mining Technology Companies and MTS companies.

Table 6: Mining Technology KIS

KIS	Examples of Activities
Exploration and other Mining Consulting	Total exploration management
	Mineral exploration consulting
	Prospect exploration
	Supply of registered mine surveyors for contract and staff relief situations
	Coordination of exploration and drilling data
Design and Engineering Consulting (product support)	Electronic drill guidance system for surface and underground drilling applications
	Leach enhancement technology
	Other application of technology
Civil Construction services	Construction management
	Construction surveys of existing plant and machinery
	Surveys of the layout of critical machinery
	Alignment surveys for conveyors
Scientific research services	Increasing recovery rates of valuable metals and decreasing levels of impurities
	Decreasing the environmental impact of base metal production
	Improving the performance of thickeners for the mineral processing industry
	Cleaner technology for uranium mining and milling
	Management of sulfidic wastes
	Flotation research
Technical services	Geotechnical modeling for stress analysis, seismicity, pillar closure and back-fill exposures
	Geochemical and metallurgical laboratory analysis of samples from ore deposits
	Engineering design of an underground conveying and distribution system
	Analysis of GIS data, aerial photography, GPS computations and mapping accuracy
	Design of measurement and data collection processes for survey design
	System design including application, tests, trials and training
IT Consulting & Computer services	Data processing and analysis software for geochemical and environmental applications
	Desktop GIS and mapping computer software
	Computer system that integrates all phases of mine operation
	Software package that monitors the quality and quantity of materials as they move through the minerals supply chain process
	System designed for the acquisition of field data using remote telemetry
	Laboratory information management system
	Multimedia based induction and training programs for the mining industry
Occupational Health and Safety (OH&S) consulting and Training *	
Legal and Accounting consulting *	
Business Management & Marketing consulting *	
Transport and Logistics*	

Source: Adapted from Tedesco, et al (2002) p. 15. * Note: These services are not covered by the ABARE surveys

2.3.2 Supply & Purchase of KIS

At the level of *services supplied* to customers, the AEGIS survey of mining technology firms found a higher frequency of the following KIS:

- Design and engineering consulting (such as consulting related to manufacturing capabilities or new equipment design services);
- IT Consulting Computer Services (software testing, computer systems & data communication);
- OH&S consulting and training.

Of these services, OH&S consultancy and training, and consulting engineering for product support and technical assistance have increased by 10 percent or more of turnover from 1998 to 2003. The main services added to the range since 1998 are software testing, computer system and data communication.

There were a number of factors that were significant for competitiveness in relation to the supply of expertise. Companies that were able to link a product-service package reported an increased demand for services. Companies report an increase in their competitiveness when they offered services that:

- Differentiated the company from other companies;
- Were linked with products sold;
- Aided the company diversification;
- Take into account environmental regulations as the mining industry moved to a more safety conscious environment; and
- Accommodated changes in OH&S guidelines.[31]

Over 80 percent of respondents combined their products and services into packages and they focused on increasing the number and range of these packages. For example a company mentioned that their KISA take the form of underground audit and problem solving that could be supplied with their underground coal mining product supply. Other companies mentioned that they would be increasing the amalgamation of service maintenance packaging and marketing so that every piece of equipment had a KISA maintenance package attached to it. These findings are congruent with an earlier AEGIS study on the linking of product-service packages in manufacturing companies as well as 'services' companies.[32] This study also revealed that a very large proportion of manufacturers in New South Wales (NSW), across a variety of firm sizes and production sectors, had moved to competitive strategies that involve selling 'solutions', products and services together in different ways and at different places in the production-sales cycle. These services are so closely linked to the products produced by the firms that we concluded what the firms were selling were 'product-service packages' rather than either goods or services.

The main KIS *purchased* were in the following areas:

- Research & Development (R&D);
- Information Technologyy (IT) Consulting & Computer Services;
- Legal and accounting consulting;
- Management consulting (strategic and analytical planning); and
- Design & Engineering Consultancy.

Among the KIS purchased by the mining technology companies interviewed, R&D and software & computer services have the highest frequency. These KIS include Run 3D modelling packages such as AutoCAD, unigraphics and finite elemental analysis (FEA). Another KIS frequently purchased are legal and accounting, and strategic planning services. The purchase of IT and computer services, strategic planning services and analytical services has increased by 10 percent or more of turnover since 1998. Such KIS are considered central to the operations of the companies.

Changes in the KIS purchased have had a significant effect on competitiveness of the firm. Significantly the firms in the survey reported the following KISA impacts:

- Broaden their range and skills;
- Allow to concentrate on their product/service while hiring people with specialist skills that the company did not have;
- Become more efficient by saving time and /or reducing costs;
- Manage changes in volume while minimising excess capacity;
- Take advantage of reduced costs as a result of deregulation;
- Improve customer services; and
- Monitor the suppliers and purchases in real time. [33]

Specifically companies mention IT consulting (engineering software and IT services) as having a significant impact on company competitiveness because software has enabled virtual product typing and design of a product in three dimensions on the computer. Finite elemental analysis can also be done in 3D to allow testing simulations for time and cost development. Other services purchased such as strategic planning services have the capacity to make the most impact on the bottom line of the company.

Companies also have a focus on improving internal efficiencies through the use of technical support, product development advice, IT services and ISO accreditation services. Only two KISA were mentioned as future needs. These were virtual prototyping through collaboration with various university-based labs and electronic engineering.

Private provision of KIS was more widely accessed (50%) than any public provider source alone (Universities/TAFE 41%). Although 76 percent of respondents used a public agency (public or university libraries, universities or TAFE, universities or TAFE laboratories, State/ agencies departments, Federal agencies/ departments, CSIRO, or some other public agency) during the period of 2000-2003 to provide expertise, hybrid organisations[34] such as the Cooperative Research Centres (CRCs) were accessed only by 4 percent (see Table 7).

Table 7: Public/private sources of KIS

Public/Private Providers	% of firms
Private sector service suppliers (eg IP lawyers, business management consultants etc)	50%
Universities or TAFE	41%
CSIRO	33%
State agencies/departments	21%
Federal agencies/departments	21%
Public or university libraries	17%
Other public agencies	5%
CRCs	4%

Source: AEGIS Mining Technology survey 2003

Of the companies surveyed, 34 percent indicated that their use of these sources had increased; 56 percent said it had remained the same and 10 percent said it had decreased. For example, one company mentioned the increase in the use of electronic libraries for general research on market areas. Other companies mentioned the increase in using specialised expertise provided by local universities or export and market assessments provided by state agencies and departments.

The use of services provided by the CSIRO and the CRC has decreased in several cases because of conflicts with Intellectual Property (IP) ownership or lack of application of knowledge to the company. In contrast, sourcing from private sector service providers has increased in the form of IP and technical consultants and patent lawyers to protect IP and advise on registration of products. Other service activities that have increased are engineering and IT consulting as companies do not have these skills in-house. Business and strategic advice are also sourced externally to

re-structure some of the internal operations and confirm new service and marketing focus to have good systems in place.

2.3.3 The Network Dimension

The quality of knowledge intensive service activities (KISA) undertaken by firms depends on the quality of sources and professionals participating in the activity. The manner that companies access sources of knowledge and the partners utilised for a particular activity give an indication of the usefulness of the partnership. Clients and customers appear to be the most important sources of information and as KISA partners. Network KISA seems to be very important for MT companies. Table 8 illustrates that the sales force or other front-end staff, customers and clients, competitors and suppliers and the Internet are very important sources of information, knowledge and skills for the organisation. These sources depend on the web of organisations and specialised employees that constitute the operating network of the company.

Table 8: Importance of sources of information, knowledge and skills

Sources of Knowledge (N=25)	Not important				Extremely important
	1	2	3	4	5
Sales force (or other front-end staff within the company)	-	-	4%	24%	72%
Competitors	4%	12%	28%	40%	16%
Clients, customers	-	-	-	24%	76%
Suppliers	-	12%	24%	40%	24%
Universities, TAFE, other higher- and further-education organisations	28%	40%	16%	12%	4%
Research institutes (eg CSIRO divisions), CRCs	20%	44%	24%	8%	4%
Consultants	17%	17%	33%	33%	-
Fairs, exhibitions, journals, professional conferences, meetings and associations	8%	16%	52%	24%	-
Owner company	12%	27%	14%	23%	23%
Public patent documents	28%	48%	8%	4%	12%
Data based information networks (eg. Internet)	8%	12%	24%	40%	16%

Source: AEGIS Mining Technology survey 2003

Although R&D is fairly important for firms in the sector the firms participating in the survey did not rate research institutions as important as sources of knowledge and information. The case studies in the next chapter provide further insights on this issue.

There has generally been an increasing importance in all the sources of information (with the exception of fairs, exhibitions, journals, professional conferences, meetings and associations) since the year 2000. For example, 65 percent of respondents mentioned that the Internet has increased in importance. The internet is not only important as a source of information but also due to The use of e-transactions and B2B strategies to reach international markets by using software to convert data into formats that support multiple communications protocols (NIEF, 2003).

The highest reported change relates to the increasing role of clients and customers as sources of firm innovation while the role of universities, research institutes, consultants and public patents remain largely unchanged. What

is apparent is that many companies do not have dedicated R&D New Product Development (NPD) employees working within a dedicated R&D/NPD department. However there may be engineers within the company that co-ordinate their research with public sector innovation services such as CSIRO or research institutes, or subcontract out their R&D or have their R&D departments located offshore. Companies thus rely on more informal sources of information from different parts of their network.

Table 9 illustrates that the majority of collaboration activities occurs across the network of the firm: customers (96%), suppliers (92%) and other firms in the same industrial group (44%). Approximately one third of the firms surveyed collaborate with universities and colleges or public/private non-profit research institutes. The majority of firms (70%) do not collaborate with industry associations on innovation activities.

Table 9: Collaboration partners

Collaboration Partners	% (N=25)
Customers	96
Suppliers of equipment, material, components or data programs	92
Consultancy firms	50
Other firms within the same industrial group	44
Universities and colleges	39
Public or private non-profit research institutes	33
Industry associations	30
Competitors	4

Source: AEGIS Mining Technology survey 2003

Generally, collaboration increased in the past three years across all categories with the exception of collaboration with competitors. The partnership with customers and suppliers had the highest increase in the past three years. The main type of collaboration structure was informal arrangements only. Stressing the importance of non-commercial KISA in innovation processes.

2.3.4 Rationale for the use of KIS

Outsourcing as a business strategy may bring organisations many new opportunities to build capabilities. For example, with the utilization of outsourcing businesses can achieve lower costs, higher service levels and customer satisfaction. Secondly, firms can focus on core competencies such as the personnel skills, training and growth in its core competencies. External sourcing provides opportunities to introduce and infuse new concepts, ideas and best practices from outside the organisation and from other industries into products, services and processes. Businesses need to continuously align with the business strategy and with internal and external resource markets. Decisions on the level and place to outsource depend on the resource markets, and will define the competencies to be developed and remain internally. However the need for in-house competencies must be continually reviewed in light of continuously evolving resource markets.

Out of the 25 companies interviewed, 40 percent of firms indicated sourcing innovation services from external sources while another 48 percent indicated that they sourced innovation services in-house (see Table 10). Businesses acquired external expertise in areas that were lacking within the firms. One manager interviewed mentioned sourcing specialist areas such as sales training in capital equipment or business plan training. Other firms indicated the internal implementation of services was cost prohibitive due to small and infrequent demand. Two firms mentioned that services were related to the one-off requirement of gaining knowledge enhancing internal capabilities.

Table 10: Sourcing innovation related expertise

	Percent of Firms (n=25)
Innovation services sourced externally	40
Innovation services provided internally	48

Source: Source: AEGIS Mining Technology survey 2003

48 percent of the firms indicated that the innovation services were mainly conducted within the firm, these were small companies with cost issues the main factor for such decisions. For instance one manager expressed that the business was undercapitalised and could not afford additional ongoing expenditure while current expenditure was driven by cash flow considerations. Other firms indicated that there was no requirement to outsource as they had the necessary resources and could implement the services in-house. Three of the firms indicated that some of the services, such as R&D were provided by their parent companies or Head Office overseas. Another reason for providing in-house forms of innovation was a result of the difficulties encountered in managing the innovation process. One manager explained that a lot of innovation happens on site or in the laboratory to solve customer problems considering it is best to work one-on-one to solve individual problems.

There were also management issues that needed to be addressed when outsourcing. For instance, managers needed to coordinate people from different sources, with different backgrounds, skills and talents to achieve objectives. Furthermore managers may also bring in knowledge from different sources, organising and structuring it, and ensuring that is it appropriately shared and ultimately protected.

Out of the 25 firms interviewed, 64 percent of firms indicated that they try to develop long-term relationships with their external sources of expertise. The building of relationships, based on trust, enabled firms to share knowledge and information as well as facilitating future dealings. Managers interviewed explained that they try to develop longer-term relationships to understand the business and people and therefore aim to provide better services by utilizing the knowledge. The other 36 percent of firms interviewed did not try to develop such relationships or intend to use them for more than one project. These firms either carried out the services internally or did not perceive such services as necessary. One firm conducted everything in-house due to the unique nature of the end product. Businesses tend to build up and retain knowledge internally without reliance on anyone else because they are the most knowledgeable about the end product. Firms also considered the process of improvement as slow and continual. One of the companies interviewed has been in operation for 125 years and has developed a database of all projects that is continually utilised. Operating in a niche market, and other areas of expertise means that generally other firms have less knowledge than their firm. Another issue includes the hesitation to share information owing to the need of firms to protect the intellectual property of business.

2.3.5 KIS and Firm Capabilities

The companies were interviewed on the capabilities they considered should be developed in-house in the future, in order to facilitate new product development and new market development of other innovation projects. The responses from the managers varied and are depicted in Table 11.

Table 11: Capabilities firms wish to possess for future

Capabilities	Percent of firms (n=25)
Marketing/enter new markets	36
Organisational change	28
Developing new products	28
Having skilled personnel	20
Collaboration and alliances	12
Growth and expansion	4
R&D	4
Having manufacturing ability	4

Source: AEGIS Mining Technology survey 2003

Marketing skills were the most frequently (36%) mentioned capabilities that companies desired to obtain. Such requirements were characteristic of the mining industry as many firms interviewed were small and privately

run, and do not have sufficient resources for marketing their products. As a result, many organisations wish to develop marketing skills in-house or enter new markets. One manager stated that the company has the products and services which can be readily used in other industry sectors beside the mining industry. Businesses need to enter new markets with existing products and another manager affirmed the need to package products and skills to be more acceptable in the market.

The second most important capability that organisations want to develop is the *ability to change* indicated by 28 percent of firms. Reasons for organisational change proving to be more effective in improving margins include its ability to facilitate greater communication between departments, better management of products and business innovation.

Twenty percent of firms indicated developing new products was an important capability for the future because of market competitiveness and the pressure applied to firms. New product development is a global issue and therefore reliant on overseas trends. New product development may determine what firms manufacture and the manner firms should manufacture these products. Similarly, another 20 percent of firms indicated that they wanted the firm to possess competent skills and knowledge, mainly as an attribute of the employees working in the organisation. Firms considered important for staff to have the right skills, knowledge and aptitude for innovation. Furthermore, it was also considered important to recruit the right people in the organisation. One manager highlighted the fact that due to the nature of the mining industry, contracts were becoming more dominant. Thus it was becoming a necessity to employ a person with the right skills responsible for overseeing contracts.

Organisational changes were the most frequent reasons that have resulted in significant impacts upon the organisation's operations. For example, one company mentioned the installation of a real-time computer system to speed up customer order processing and all aspects of administration and accounting. This improved output and financial reporting for the company. Another company mentioned how streamlining the IT improved the level of automation and analytical services. Activities related to IT were reported as having significant impact on organisational change and company operations. The same company mentioned staff training as another activity to improve the knowledge-base to provide higher level consulting services. Other internal KISA are oriented to changing the organizational structure in the form of adopting flatter management structures and teams based models. Increasing OH&S KISA is also expected to generate organisational changes. Up to 82 percent of the respondents indicated that process changes were expected to have a significant impact on the operation of the business in 2003/4. An example of KISA in process change latest methods is the use of a specialised technology (polymer) that is expected to lower costs, increase output from existing equipment and improve product quality.

Activities leading to change in 80 percent of the companies are largely formal processes. An example of one of these activities is internal R&D that plays a central role in change for 68 percent of the companies. Another KISA mentioned as having a central role in 'change' is *marketing* related activities. 12 percent of firms indicated having strategic relations and contacts as an important capability. Firms require these relations and capabilities as they need to network with service providers, suppliers and customers in the mining industry. Some managers affirmed the need to establish alliances of some form of collaboration. One manager interviewed indicated requiring the capability to source new products from around the world and to develop new business opportunities through forming strategic alliances. These actions were undertaken in order that competitors not were ahead of them.

Other capabilities firms regarded as resulting in organizational change were growth and expansion of the business and entering international markets, having the resources for research and development, as well as the capability to manufacture products themselves. The majority of firms, 84 percent, indicated that they build capability through c*ollaboration with major clients and multinational corporations (MNCs)*. Of these firms 43 percent of them indicated having formal agreements with their major clients or MNCs. The managers mentioned using licensing agreements, memorandum of understanding and formal contracts. Another 38 percent of firms with collaborations indicated adopting an informal approach. This was through a mutual understanding based on trust and conventional relationships. For instance, one manager indicated the long-term relationship with major clients due to the established relationships. These include obtaining good feedback on what needs changing or development on the products.

The majority of firms use some form of collaboration and up to 16 percent of the firms indicated using both formal and informal collaborations. This is illustrated in Table 12.

Table 12: Building capability through collaboration

Type of collaboration	percent of firms (n=25)
Formal collaboration	36
Informal collaboration	32
Both formal and informal collaboration	16
No collaboration	16

Source: AEGIS Mining Technology survey 2003

2.3.6 Managing the Integration of KIS

When companies utilise innovation–related services from various sources, they require an adequate and appropriate management for the whole process. Organisations are faced with the challenge of how to mix expertise from different sources. During the interviews, managers gave varied responses of how this was managed in their organisations. The most frequently used method was that the o*wner of the company or an assigned project manager* handle the knowledge integration in-house (See Table 13).

Table 13: Managing innovation-related expertise

Parties	Percent of firms (n=25)
Managers	28
Project managers	28
Task force	20
Combination	8
External consultant	4
Not applicable	12

Source: AEGIS Mining Technology survey 2003

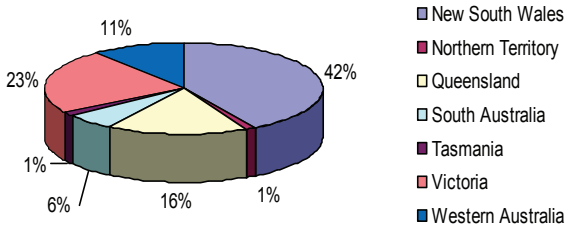
Twenty-eight percent of firms indicated that managing innovation related expertise was handled by the management themselves within the firm. For some small firms, the Managing Director or owner of the firm managed the whole process. For other firms, they indicated that the group of managers or the parent organisation managed these activities. Another twenty-eight percent of firms indicated they utilise a project manager to handle this process. For example one firm mentioned that everything was managed internally by a project manager who is a full-time employee of the business. His role was to coordinate teams and ensure that what is being developed is in the interest of the business and not in the interest of the sub-contractor. Another firm adopted a project basis. A project manager was assigned for a specific job and the team might involve one or two project managers from Australia and the remainder from the UK and America.

The third highest response was using a *project task force* or a team. Twenty percent of firms interviewed indicated using this method. One company mentioned they used this approach because product teams have a narrow range focus. Particular teams had specialised areas. The teams source ideas externally and as a result, are able to develop internally. Eight percent of firms indicated a combination of methods used. It was mentioned that the size and significance of a project or service would determine whether to use an external consultant, assign a project manager or set up a task force. One manager interviewed indicated that it was more of an ad hoc situation and some processes were not structured. Only one firm employed an external consultant to handle the innovation-related expertise.

2.4 Clustering Capabilities of the Sector

The geography of mining in Australia has changed over the years from a strong activity that developed towns such as Broken Hill or Mount Isa around mining operations to the new wave of mining settlements in nearby coastal cities.[35] These changes reflect lifestyle permutations and acceptance of a commuting culture that results in a shift of mining impacts from the remote mining sites to coastal centres. Another factor affecting this shift is the growing demand for services in the industry. As mining operations become more sophisticated, the outsourcing of services to specialised companies increases. Most of these companies are Knowledge Intensive Business Services (KIBS) which are predominantly found in business centres and inner city locations. New South Wales, Victoria and Queensland have the highest number of these KIBS specialised in mining technology (see Figure 2).

Figure 2: Location of MT Firms by State (2003)

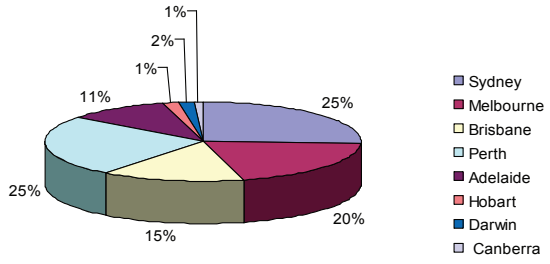


Source: Kompass database 2003/3

Specialised MTS KIBS in Australia are found predominately in the CBD areas of Sydney, Perth and Melbourne. The two cities with the majority of mining technology services head offices are Sydney and Perth (O'Connor & Kershaw, 1999:6). In 1993, 646 companies and 918 branch offices were involved in the provision of 87 different services to the Mining Industry Sector.[36]

The 1999 study by O'Connor & Kershaw indicated that MTS companies[37] cluster in metropolitan areas (80% of head offices and 77% of regional offices) supporting the important role that financial centres, corporate networks and access to facilities have in choice of settlement for mining related knowledge workers. Although many branch offices are located in non-metropolitan areas, metropolitan sites still more important than non-metropolitan locations even when the geographical distance would suggest the opposite such as in Western Australia.[38] The research by O'Connor and Kershaw indicates that the MTS sector has specific geographical features of clustering in the cities of Sydney and Perth, stressing the importance of network connections to corporate headquarters and other KIBS often associated with financial centres, especially in the case of Sydney. Figure 3 below shows the clustering of MTS offices in Australian Cities.

Figure 3: MTS Offices in Australian Cities



Source: O'Connor & Kershaw, 1999

Perth constitutes another centre of significance with a large number of head offices for various companies. For example, the Eastern Perth region has a high concentration of companies servicing the mining industry. The region has 950 engineering based companies, and 200 of these companies are involved in mining technology services, vehicle manufacturing and other activities closely linked to these.[39] In the late 1960s and 1970s the eastern Perth region had a major growth in exploration and mining activity, and led to the establishment of many foreign equipment suppliers. It also led to the start up and growth of local suppliers of materials, equipment and engineering and geological expertise.[40]

Even though the concentration of firms is high in eastern and central Perth, and in areas of Queensland and New South Wales (NSW), high concentration may not necessarily result in high performing 'collaborative clusters'. Despite high concentration of firms in the mining industry over the last few years, collaboration is rather rare (MGB, 2004). Analyses carried out in Perth by the MGB Group suggest that MTS-related firms have organised themselves into supply chains, and many of these alliances are longstanding. Perth in particular has an excellent position in regards to the Asian markets because of the short flying distance to South East Asia. The air link between Sydney and Perth also facilitates the good perspectives for future developments of the MTS in these two locations.

2.5 Policy Framework and Major Challenges of the Sector

There are no policies and programs specifically supporting the MTS sector or the supply or promotion of KISA in the MTS Sector in Australia. However, the current MTS Action Agenda provides the development environment for the sector. More generic policies and innovation related programs that might be relevant for the support of KISA in the MTS sector are also outlined in this section.

The MTS sector is well linked to Australia's National Research Priorities, which were announced by the Australian Prime Minister in December 2002. The sector is aligned with at least two priorities: Environmentally Sustainable Australia and Frontier Technologies for Building and Transforming Australian Industries (DITR, 2003).[41]

Part of the Commonwealth Government's strategy to develop Australia over the next decade is the Action Agendas. The Action Agenda is a cooperative dialogue between industry, Government and State Agencies, with the common aim of promoting sustainable economic growth. The Mining Technology Service Action Agenda was announced on the 6th of June, 2001.[42]

The Mining Technology Services Action Agenda (MTSAA) provides the opportunity to develop strategies for long-term development and growth of the industry. The Action Agenda identifies the steps needed to develop and improve the sector's competitive advantage. It aims to provide an identification, definition and classification of the industry.

The Action Agenda focuses on five areas:

- Response to the globalisation change;
- Technology and research and development coordination;
- Improving industry market share and competitiveness;
- Education and training; and
- Promotion and marketing.[43]

The vision for the Mining Technology Service Action Agenda is:

- to build on the current technology base and reputation of the Australian MTS industry sector to maintain Australia's position as a world leader in the supply of mining expertise and technology;
- to achieve a level of export performance where the sector is the second largest contributor to Australia's mining exports with sales expected to equal to or exceeding AUD 6 billion by 2010.[44]

There are five critical elements in the Action Agenda process[45]:

1. *Future opportunities and growth.* Exploration of where the sector should be positioned globally in five to ten years and application of this foresight to determine trends in products, markets, technologies, innovation, best practice, knowledge, linkages and industry structures.
2. *Strategic analysis of competitive position*. Provides a stocktake of the industry's current structure, products, markets, technology, energy utilisation and performance, and strategically assesses current capacities to secure or hold a globally competitive position.
3. *Capturing growth*. Analyses the changes that will be required to capture future opportunities and growth for the industry. It matches the trends identified in element 1 with the strategic analysis of element 2.
4. *Action priorities and responsibilities*. Sets out measurable outcomes and prioritises specific actions by both industry and government to achieve those outcomes.
5. *Timetable and progress reporting/ evaluation.* Each action agenda must establish a timetable for achieving the priority action items identified in element 4. This will involve regular assessment of progress toward achieving the stated outcomes. Wherever possible, success or failure by both government and industry in achieving agreed outcomes from action agenda responsibilities should be measurable'.

The successful development and implementation of the Action Agenda is due to leadership and participation by industry. The MTS industry was represented in the strategic development phase of the action agenda process by the Strategic Leaders Group (SLG). It is also represented through input of all industry members via workshops and consultations. An industry driven Implementation Group was established in December 2003 for the implementation phase of the action agenda process. Recommendations and actions are outlined in the report at www.industry.gov.au/mtsaa.

The **key challenges** identified by the Action Agenda for the sector are:

1. Unifying the MTS sector;
2. Innovation through technology;
3. Attracting investment;
4. Embracing e-business for growth;
5. Supply of skilled professionals;
6. Intellectual property; and
7. Implementation (by a group of representatives of the MTS sector selected by the Minister for Industry, Tourism and Resources, the Hon. Ian Macfarlane MP). [46]

Although no specific programs target MTS, there exist generic programs, which might be of assistance to the MTS sector. Some of these programs are:

- The R&D Start Program and the R&D Tax Concession Program. Generic programs providing financial support to the development of R&D.
- Cooperative research Centre Program[47]. There are nine CRC's in the mining and energy sector; AJ Parker CRC for Hydrometallurgy (Murdoch,WA); CRC for Clean Power from Lignite (Mulgrave); CRC for Coal in Sustainable Development (Queensland); CRC for Landscape Environments and Mineral Exploration (Kensington, WA); CRC for Predictive Mineral Discover (Melbourne); CRC for Sustainable Resource Processing (Kensington, WA); CRC for Greenhouse Gas Technologies (Canberra); CRC for Mining (Brisbane).
- The COMET program supports the commercialisation of innovative activities in any sector. The program may support KISA as it aims to assist individuals and small businesses overcome barriers to getting new products and services to market by providing assistance and advice in areas such as raising capital, management skills, and market research'.
- The Industry Cooperative Innovative Program (ICIP) aims to encourage business-to-business cooperation on innovation projects that enhance productivity, growth and international competitiveness in Australian industries.

Facing the MTS sector is the challenge of financing and in particular access to venture capital, which will allow the sector to develop and commercialise technology as highlighted by the Minister of Science, Engneering and Innovation Council (PMSEIC, 2001): 'Raising the financial community's awareness of the work of the MTS sector and emphasising its highly technical nature is essential to improving the ability of the MTS sector to attract finance'.

Major issues affecting the Australian MTS sector were reported in the ABARE 2002 study and considered for the MTS Action Agenda process. Some specific examples of the comments received include:

- Smaller companies have superior technology to overseas competitors, but are unable to access these markets;
- The aging workforce in the MTS sector will mean that there will be fewer people left working in it in less than 10–15 years, with a resultant massive negative effect on the Australian economy;
- Short-term growth of major companies carries more weight in financial markets than longer-term focused research and development;
- More aggressive representation of Australian capabilities via Australian trade representation in a wider circle of countries;
- Better collaboration between the states and individual companies comprising the sector for improved global penetration and prominence;
- Internet standards for transfer of technical data;
- Maintaining our international reputation for being proactive and highly Skilled;
- Lack of domestic interest in funding development activities with high capital cost/risk from conception through to commercialisation.[49]

The survey conducted by AEGIS among Mining Technology firms shows the main barriers to respondent's innovation process were the organisational management resources required, lack of skilled personnel, the high innovation costs and the great economic risk that is associated with the innovation process. Lack of technological and market information and competitors were minor barriers to the

innovation process. One of the companies referred to the short-term profit business driver as a critical risk for the innovation process:

> 'The drive towards short term profit over longer term development that is rife today within business is particularly unhealthy. It is driven by the remuneration packages that many executives and senior management are paid that are based on short term performance. As such the drive to ever increasing short term profits is eroding the capability of business to devote human resources and funds to R&D. In the case of our business there are simply too few people to have any spare personnel for R&D other than a token attempt from time to time. Outsourcing is not the answer as the so called experts and consultants do not understand individual businesses nor is it affordable to allow them time to understand. R&D needs to come from within as driven by a commitment to R&D for the longer term benefit of the business. This commitment must come from those who control the purse strings which increasingly (and unfortunately) is more likely to be an accountant or a lawyer than it is a true business entrepreneur.' (AEGIS interview data, 2003)

2.6 Summary

A recent definition of the Mining Technology Services (MTS) sector by the MTS Action Agenda includes companies, institutions, associations and other organisations which receive a substantial portion of their revenue, directly or indirectly, from mining companies for the provision of goods and services based on specialised technology, intellectual property or knowledge. Such organisations identify themselves principally with the mineral industry. 'Goods and services' include, but are not confined to, equipment, software, consulting and engineering services, and R&D. 'Mining' includes exploration, mining (extraction), quarrying and coal and mineral processing (including smelting and refining of metals and minerals).

The Australian Bureau of Statistics does not collect data on the MTS sector. The Australian Bureau of Agriculture and Resource Economics – ABARE estimates that the MTS sector makes a significant contribution to Australia's economic growth in its own right, contributing $3,120 million to Australia's gross domestic product in 2000-01 and expected to increase by 13 percent per year to AUD1.9 billion in 2005-06. The ABARE 2004 MTS survey shows that there is a minimum of 331 companies in Australia. They range from small companies to the largest mining firms employing whole divisions. The majority of the firms (52.7%) are however SME's employing 10 people or less; 25.2 percent employed between 10 and 50 people, and 22 percent employed over 50 people. The sector is estimated to have 16,800 fulltime equivalents employees down from 17,300 employees in 2000-01.

Current estimates for R&D expenditure are AUD 339 million; 7 percent of gross sales revenue (ABARE 2004 Survey). In particular, R&D has been associated with the success of software applications to mining. According to the Department of Industry, Tourism and Resources (DITR) 60 percent of the world's mining operations are now utilising software developed by Australian companies, indicating that Australian MTS companies are at the leading edge of technological innovation in the MTS sector. The sector contributed AUD 1.9 billion in high technology exports in mining services in 1999-2000.

A survey conducted by AEGIS among 25 mining technology firms shows that over 80 percent of respondents combined their products and services into packages and they focused on increasing the number and range of these packages. In relation to the services purchased, companies mention *IT consulting* (engineering software and IT services) as having a significant impact on company competitiveness because

software has enabled virtual product typing and design of a product in three dimensions on the computer. Finite elemental analysis can also be done in 3D to allow testing simulations improving time and cost development. Other services purchased such as *strategic planning services* have the capacity to make the most impact on the bottom line of the company. Out of the 25 companies interviewed, 40 percent of firms indicated sourcing innovation services from external sources while another 48 percent indicated that they sourced innovation services in-house. Private provision of KIS was more widely accessed (50%) than any public provider source alone (Universities/TAFE 41%).

The firms noted the 'ability to change' as the most important capability for innovation. Activities leading to change in 80 percent of the companies are largely formal processes. An example of one of these activities is internal R&D that plays a central role in change for 68 percent of the companies. Another KISA mentioned as having a central role in 'change' is *marketing* related activities. The majority of firms, 84 percent, indicated that they build capability through *collaboration with major clients and multinational corporations (MNCs).*

The survey shows the main barriers to respondent's innovation process were the *organisational management* resources required, *lack of skilled personnel*, the high innovation costs and the great *economic risk* that is associated with the innovation process.

Mining technology service firms are predominantly found in business centres and inner city locations. New South Wales, Victoria and Queensland have the highest number of mining technology companies. The sector has specific geographical features of clustering in the cities of Sydney and Perth, stressing the importance of network connections to corporate headquarters and other KIBS often associated with financial centres, especially in the case of Sydney.

In Australia there are no policies and programs specifically supporting the MTS sector or the supply or promotion of KISA in the MTS Sector. However, the current MTS Action Agenda provides the development environment for the sector. The Action Agenda is a cooperative dialogue between industry, Government and State Agencies, with the common aim of promoting sustainable economic growth in the sector. The Mining Technology Service Action Agenda was announced on the 6th of June, 2001. The Action Agenda focuses on five areas:

- Response to the globalisation change;
- Technology and research and development coordination;
- Improving industry market share and competitiveness;
- Education and training; and
- Promotion and marketing.

3. Case Studies: KISA stories**

Six case studies were selected; 4 cases were Mining Technology Companies and 2 were mining companies. The selected MTS companies provided services to the selected mining companies, which allowed for a better analysis of the relationships between the mining company and the service provider and the activities they perform. The profile of the case studies is presented in the table below.

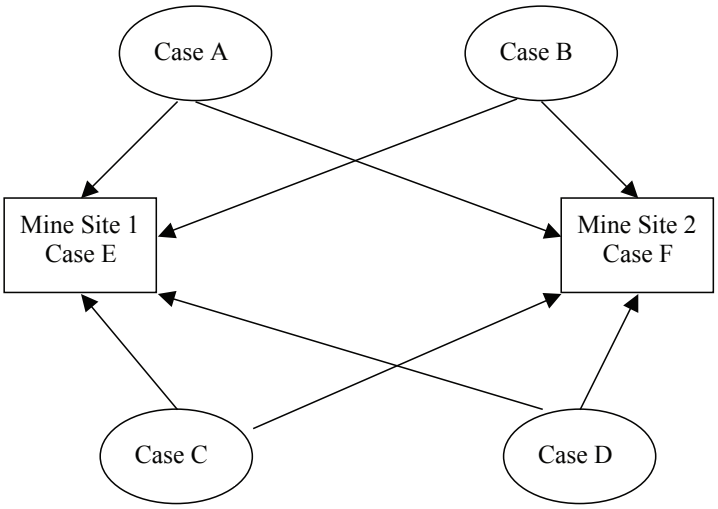
Table 14: Profile of Case Studies

Cases	Owners.	State	Life-cycle	No Emp	Main product/ service	Market Focus	Recent Innovation	Type of Innovation
MTS companies								
A	Private Australia	Queensland	Profession. managmt.	5	R&D, technical & training	National	Incremental	Service (training)
B	Public listed Foreign	Queensland	Expansion	1000	Engineering & construction project management	National Internat.	Incremental	Processes (project management)
C	Private Australia	NSW	Expansion	25	Geoscience software	National	Radical	Product (GIS software)
D	Private Australia	Queensland	Expansion	90	Consulting software training	National Internat.	Incremental	Product (forecasting program)
Mining companies								
E	Public listed Foreign	Queensland	Expansion	2500	Cooper, lead & Zinc	Internat.	Radical	Product, process & organisational
F	Public Listed Australia	South Australia	Expansion	5000	Cooper, Uranium, silver & gold	Internat.	Radical	Process

The location of mining sites in Australia was considered a significant factor affecting KISA in MTS as per the remoteness associated with many prosperous mining sites. Two remote locations were chosen for the analysis and discussions were held with City Councils and Chambers of Commerce in relation to the contribution of mining and MTS companies to the town[1] development. Figure 4 shows the provision of services of the case studies. The MTS companies did not have collaboration links with each other nor the two mining companies but the mining sites provided the context where all the four MTS companies provided services. The relationships depicted in Figure 4 refer to the provision of services from MTS companies to mining companies. The case studies analysis focuses on the knowledge intensive service activities performed by the companies.

Mining sites in Australia are often located in remote locations that are very rich in minerals which allows for a long-term exploitation and the formation of permanent settlements. Hundreds

Figure 4: Case study companies' service provision relationships



of contractors can be associated to the mine site having a significant impact in other services business operating in town. In this respect mining sites are knowledge intensive hubs and innovation intensive environments. The analysis of the case studies has taken into account the activities performed by mining companies and the impact on community development and city planning strategies of this highly knowledge intensive environment.

This chapter first presents the innovation capacity of the case study companies and their use of KISA, the interaction with providers of expertise, the mix & match process, the network KISA, challenges to the innovation process & participation in government programs.

3.1 Innovation Activity and the use of KISA

The two mining companies analysed were undertaking radical innovations while tree out of four MTS companies reported incremental innovations. Examples of *incremental innovations* are as follows:

One of the MTS companies (MTS-a) was collaborating with a multimedia company to develop an electronic training delivery/ assessment system which will allow the end-user to customise the program to suit their needs from a core training program and add-ons. The intention is to make the selection process such that the product the user sees is seamless. The partner company is located in an innovation centre where the MTS company has recently relocated and the association aims to lead to innovation in the ways the company deliver technical and training documentation to mining companies - eg the use of Palm Pilots, Interactive on-line programs, etc. The company sees their relocation to the Innovation Centre (within an university campus) as a structural change for their personnel and an advantage to be relocated next to other companies that have a major focus on innovation.

Another MTS company (MTS-d) focuses their incremental innovations in upgrading their forecasting software to do new things. The software helps mining companies forecast the future and it is continually released and re-realised with upgraded features and functions. Although the forecasting software is predominantly for mining, recently the company has found that some of the forecast can be used in electricity generation and other mechanical intensive industries such as power generation, manufacturing etc. which allows the company to apply their innovation to other sectors. This company is also undergoing complete change in their back-office systems buying new technology to become quicker and better and using external software consultants for the implementation. In terms of organisational changes the company is also providing more structures to support staff (90 people) with, for example, a dedicated training manager. The purpose for this training is to allow internal knowledge transfer and new staff training, and to support and keep current the company's new professional development. Training is an important activity of the business as the company runs external training courses for the industry, and there is an increasing need to keep the material current and to have the latest delivery mechanisms for training, such as web-based. For this company these mechanisms where not only about innovation but about success dependent on the people they have; getting them, keeping them and getting the right people for the right job. The systems above are needed for training them quickly and to support them in their work for customers.

Examples of *radical innovations* are as follows:

MTS-b is a leading innovator and major supplier of specialist software, data and services to petroleum and mineral exploration industries in Australia and other parts of Asia and South America. Some of its innovations which the company terms as 'flagships' are a leading GIS software for geologists all over the world. It is a tool to effectively compile, visualise, analyse and map spatial geoscience data. Another one is software which connects geophysical data, modelling, satellite imagery, geochemistry and geological mapping in a single interactive interpretation environment.

One mining company refers to their method of copper 'smelting technology' as leaders in the world. It is a radical technology introduced in early 1990s based on work developed and patented with CSIRO. This company in particular is very oriented to technological innovations and they have a group working on R&D technology and in marketing the technology to other countries such as China. The group looks for technological solutions all over the world and them they work on the implementation in their mining sites. The firm also market the technology externally for other companies. Another radical innovation is a 'concentrator for copper' – a technology developed through work with the University of Newcastle in the 1990s. The technology was developed by a previous mining company and it is now exploited by the current mining company on site who has the rights to use it and sell it. This is an example of how innovation intensive mining sites are and how that intensity has been captured by the new mining company operating on the site. Different business models do not seems to have much impact in the way the technology is adopted and developed; the previous company had a business model centred in Australia and the new one has a business model that is international and it's based in using and improving technology that is available. One of the managers of the firm reputs that the differences between both companies seems to be at the level of the organizational model, with the new company developing guidelines for all operations with clear goals and objectives and giving local managers the power to make decisions. As a result the organisation produce better results than with the previous operator which has a more centralised decision making model.

Another mining company refers to their new Security Management System as a radical innovation. Another innovation considered radical refers to the training of 100 percent of their workforce in leadership analysis, people management and teamwork.

The case study companies were asked to specify the importance of the Knowledge Intensive Service Activities they use. The list of KISA was derived from Table 6 which includes some of the generic KISA used by other industries and specialised KISA for the mining sector. The table below shows the importance of KISA for MTS and mining companies.

Table 15: Use & Importance of KISA

KISA	MTS			Mining Companies		
	High	Med	Low	High	Med	Low
1. Exploration & other mining consulting	■			■		
2. Design & Engineering consulting	■	■		■		
3. Civil Construction consulting		■		■	■	
4. Industry Development advice		■	■		■	■
5. Technical consulting services relevant to industry (systems development, customisation and integration)	■			■	■	
6. Marketing services	■					■
7. Research & Development services	■			■	■	
8. IP-related (legal & accounting) services	■			■	■	
9. Management consultancy related to organisational aspects of product development (eg team creation)		■	■		■	■
10. Industry-related training services	■				■	■
11. Employment agency supply of specific personnel		■		■	■	
12. Strategic & business plan development advice/ service		■		■	■	
13. Occupational Health & Safety (OH&S) consulting & training	■			■		
14. It related (licenses)	■	■				

Source: AEGIS KISA MTS Case studies data (2005)

KISA of high or medium importance for both MTS and Mining Companies are:

1- Exploration and other mining consulting;
2- Design & Engineering consulting;
5- Technical consulting services relevant to industry;
7- Research & Development services;
8- IP-related services; and
13-Occupational Health & Safety (OH&S).

KISA of high importance for MTS but low importance for mining companies are:

6- Marketing services; and
10- Industry related training services.

For example, one of the MTS firms gives high importance to R&D, marketing and IP related activities; and medium importance to IT and engineering consultancy and services in generating KISA. The firm created a specialised R&D centre where IT professionals and professionals with mining engineering and geological sciences background are working.

As a firm involved in the specialised activity of geosciences and mining exploration much of the inputs to KISA are sourced internally from its R&D centre. While software professionals are mainly involved in developing customised products and processes and designs; professionals in geosciences provide expertise in geophysical interpretation, exploration data integration, imaging, mapping, survey planning and quality control. The firm has developed expertise in developing specialised database services for various clients on closed networks on the Internet. This firm had given high importance to recruitment of professionals with specialised skills to combine and work in interdisciplinary framework. The ability and skills of professionals with geological and mining background who can combine their professional skills with software and IT related activities are the main factors in the criteria for personnel recruitment.

In relation to KISA critical for the product life cycle, IP related activities, marketing, exploration and other mining and technical consulting are common to different stages of the product life-cycle. The following ones were noted per each phase.

None of the case study companies could differentiate KISA among the three product-life cycle to any great extent.

Table 16: KISA and product life cycle

Creation Phase	Maturing Phase	Standardisation phase
R&D Design engineering consulting Civil construction services Strategic & business plan Management consulting	Industry related training Employment agency	R&D Management Consulting Industry related training Strategic & business plan OH&S

Source: AEGIS KISA MTS Case studies data (2005)

3.2 Interaction with Providers of Expertise for KISA

Services or expert contributions to KISA are largely sourced in-house or by KIBS or by a combination of both with exception of industry development advice which is mainly sourced from industry associations. Only one mining company would source expertise from universities. Networks were not important as a source of services for KISA as KISA contributions were mainly sourced under formal contracts.

Companies varied in the way they *interact with external providers* of services for KISA.

MTS-a would base outsourcing in cost related decisions. If it is cost-effective and cheaper to do it internally they will keep it inside. If it is cheaper to outsource that is what the company will do; the best example is with software developers. The firm prefers to outsource that because it cannot afford to develop those services internally and be competitive. For this company sourcing external providers of expertise is part of their strategic goals. In terms of evaluation of the services provided, the company has internal processes that allocate responsibilities and they use Key Performance Indicators (KPIs) to put it through management processes and them follow the failures and measure the services through a matrix. The company review these processes regularly to make sure they remain competitive. Professionals have an impact on the way they innovate in services. The knowledge is available but the demand is big and the number of jobs are also numerous and there is a lot of competition to get the best people. Although the company has enough

people for the current demand this is one of the risk issues for the future even if Australia is very self-sufficient in terms of knowledge development.

Another MTS company rarely needs to source external services other than for research purposes. This firm have worked on site with external sources but these have been *collaborative exercises* rather than the firm seeking outside advice. For example partnerships occur by interacting with other firms in the Innovation Centre where they are located, word of mouth or by attending specialised seminars. The firm usually seeks outside advice for some technical aspects associated with their work. The firm will source these from within the Innovation Centre where they are located. For example, IT capability is outsourced because there is not enough expertise in-house. By outsourcing expertise there are some risks, such as a potential loss of control and a potential for customers to be headhunted. There are also the difficulties and cost of making commercial arrangements with other companies and the potential waste of funds.

One of the mining companies has *economic reasons for retaining the core knowledge in-house* without the overheads expenses. The firm outsources areas that are needed about 20 percent of the time as specialists cannot be affordable all the time. The firm believes it is an advantage to have wider expertise available and they have confidentiality agreements in place regarding some of their technology so the risks are minimised. The company tries to hold core competences in the organisation and it is part of their company's philosophy to get things done by a combination of acquisition plus development. If things are not too complicated they might be able to do it in-house in the future. The firm tries to use the knowledge accumulated by people over the years. Evaluation is up to the individual project manager. The firm looks at the objectives and how it fits into the overall company goals. As public research organisations such as CSIRO are changing, now they have to go and ask industry for partnerships so the firm has some research with Universities and CSIRO.

Another mining company refers to the variety of provision of services in the mine site. They require technical expertise specially in engineering consulting and also on human management on professional development. They also need specific staff for maintenance. In total the firm might have 1000 different contractors and above 300 different ones on site every day. The firm's largest contractors are in the areas of engineering consulting, training provision & professional development and maintenance. A tender document is usually used first to source the provider. Then there is an interaction with the service provider through a project manager responsible for making the interactions, getting the right people on site, and giving the right information. Unfortunately not all levels of expertise are available and sometimes is not possible to attract the best people because the remoteness of the mine sites. People stay for 2-3 years only; Some stay for a maximum of 15 years. Part of the contract has KPIs and it is the responsibility of project manager to follow them up. Some expertise such as Metallurgical is very difficult to get because it is very technical so there are not enough experts in this field, neither in-house nor externally. It is difficult to get qualified people so the firm offers to qualify people in-house instead, sponsoring university training, apprentices and people from overseas.

For the majority of the case study companies sourcing external expertise was a cost-related decision balancing sourcing the expertise needed externally but retaining core knowledge in-house. For mining companies the issue seems also to be linked to the difficulties of finding skilled personnel and also to the fact that mining sites are knowledge intensive hubs with different complex technologies that require specific ad tailored expertise.

3.3 Mix and Match Process and Firm Capabilities for Innovation

MTS-a refers to the mix & match of internal-external expertise as a *process occurring in a daily bases.* This process is drove by *Project Managers* for certain projects but the firm is always on the lookout for new inputs and would use them as and when they were suitable and if they were available. Part of the modus operandi of the firm is to develop and maintain long-term relationships with both clients and suppliers/contractors so they became a source of expertise that the firm needs to absorb. The firm does not have a dedicated staff member to deal with all external providers, as their number is not significant. For this company, internal expertise was difficult to replace. When people leave the company or when their contract is completed, they will often take significant amounts of knowledge and skills with them. However, they also leave a certain amount of knowledge and skills behind them. In some cases the firm has lost people who have left significant 'holes' in their knowledge and skills base.

As informal transfer of knowledge is expected and on-going the firm captures the technical knowledge obtained over the years by written it up in manual format and, thus, it is readily available for all personnel at a later time. All archives are freely available to all current employees. Despite the importance of the knowledge generated by the firm, they do not go to any special lengths to protect what they have already garnered from industry. Instead, the firm's business model is based in their ability to produce new material as and when required. The firm is developing a new on-line delivery systems, and in this case it will be protected from piracy.

In relation to the most important innovation capability of this firm it is the R & D of specific technical or training documentation. They also deal significantly with IP - both in what they deliver and in the way it is delivered. Due to the nature of what the firm does as a part of the day-to-day work the firm needs to develop in-house skills in marketing their own product and in marketing training as a whole. Their services and products are very difficult to market without a very large budget and they deal with multi-nationals from a relatively weak position. One of the managers noted: 'We are a tiny operation compared to the majority of our customers'.

MTS-b refers to both internal and external expertise as important for accumulating knowledge. The firm put special emphasis in operating as an '*open book*' in the different parts of the company and with the communication flows. For example, conversations with clients are a source of knowledge that is recorded before to formalise a job. The knowledge is recorded in a central system and shared throughout the company. Platforms that the firm uses for integrating and transfer knowledge are task forces, committees (especially for safety meetings every month), and weekly staff meetings. Formal and informal communications are balanced for learning and the firm has 2 managers that keep OHS knowledge for the group.

This firm use to first work in an informal bases and them progress to a more formal setting involving more people from the company. Informal outings are quite normal with prospective clients. Because the business is so diverse they learn from different parts of the company that have different processes that led to different solutions and ways to resolve problems. The firm have 2 managers looking after knowledge management. People come from different backgrounds and their experiences differ a lot, as one of the managers noted:

> 'People form our company and the client have a combined knowledge that it's not always common ground.

> We learn from the clients as they maintain the equipment and they want to improve their processes. Sometimes we feel we cannot achieve a common ground, it doesn't happen always. A contract leads to another one and small improvements and designs are made from the interactions. The knowledge also works on the other side; we learn from them while they learn from us. The way the knowledge transfer works is that new ways to do things are implemented for new clients with solutions we have seen in other mining site for other clients'.

In-house capabilities of the firm are in the area of civic construction, Design & Innovation, from which they won a National Award in 2002. New capabilities for the firm are in the area of technology uptake which is generally performed by getting new capabilities with the new people incorporating to the company.

MTS-c technological capabilities in developing products and processes and catering to a variety of specialised services is mainly dependent on the expertise and skills of its professionals who *work in interdisciplinary teams* consisting of software, engineering and geoscience backgrounds. As a firm, which is also sustained through in-house R&D centre, this company has given considerable importance to training which combines professional, technical and marketing skills as the professionals themselves undertake the marketing processes. As the Manager of the firm observed, these are called *'hybrid' teams* working on projects which are of interdisciplinary nature and mostly interacting with research institutions and government departments in geosciences, mining and exploration. Within these teams the firm has identified certain key professionals whom it terms as 'Product Champions' who co-ordinate projects and regulate interaction with various clients and customers. These key persons are referred to as 'cheap innovator', 'thinker', and 'creator' who are instrumental for absorbing information and knowledge flows and interaction processes for generating what we term as KISA. It was quite explicit in the discussions maintained with the firm that such key personnel and their expertise cannot be easily obtained externally on contractual basis. These key personnel ie 'Product Champions', are endowed with 'tacit knowledge' and 'competencies' which are person embodied and are generally developed through processes of 'learning by interaction' or 'learning by doing' over a period of time.

MTS-d mix and match expertise through project managers. They will continually report to project groups with their experiences. *Internal rotations and moves and changes of projects* assure integration and transfer of knowledge. There are also internal processes such as 'learning lunches' where someone stand up and present what they have done through some type of innovation or new way to resolve problems. There is also a *'knowledge coordinator'* responsible for keeping a 'dynamic library' of possible solutions so people do not need to reinvent the wheel. People will submit a synopsis of the solution; them other employees can look at it and if they find a better solution through a project they will modify the synopsis for the next person. Another mechanism is to have other individuals appointed to the project to act as peer-reviewers for assuring a minimum standard of quality, assuring employees follow the right procedures for documenting the project etc. This firm has created new ways to manage knowledge that were not there five years ago, as one manager reports:

> 'The reasons for the company to put these mechanisms in place was that they needed to become more efficient in the job; customers wanted quicker jobs and cheaper jobs, there was a frustration internally that we always were reinventing the wheel, so there was a combined requirement that evolved. We also wanted to capitalise in what people have done and not repeat the same mistakes twice'.

Over the last five years the firm had significant growth in performance as a company due to a number of facts; one is the number of structures for knowledge management the firm has put it in place. Through these structures, critical IP is developed internally while support processes are outsourced. The capabilities for innovation in this firm come very much from the relationship with the clients. There is a constant evolutionary process with customers: 'we listen to them, think about what they want, and we can either do it now or go away, work on it and them come back'. The most important capability relates to business and management skills. New capabilities needed are in marketing skill, which is also core to the revenue.

One of the mining companies indicates that their management of knowledge is specific to the problem; basic knowledge can be integrated but variations of knowledge might be difficult to implement. The company will have natural incremental improvements processes by internal services but specific problems need external solutions that sometimes are radical. The company will them use task forces and working groups. The firm has informal group discussions about new technologies in the group. The diffusion of knowledge is by letting people know what is happening and who is playing an important part on it but the core of the information is embedded in the group that is managing a particular project. Public relations people inform staff about issues from projects. For example, the firm will have written procedures about the operations covering safety and hygiene as the firm have many procedures for safety reasons at the plant level. The firm also has technical papers presented to specialised professional bodies and mining groups. Newsletters or email is not generally used to disseminate information, neither magazines. The website is also not really used in the same way that universities do. One manager reports:

> 'Economic factors might force us to do things in a different way. Innovation need the external provision, we need to learn from the effective use of technology that might be around from many years. We have less risk when we take the advice from an external provider'.

Another mining company has established 1 to 2 seminars per month where technical staff would meet and listen to an expert. The firm has a *formal quality documents system* to capture information. Also there are spin-offs from one implemented product to a service. Sometimes the company that provides the software also provides the training so the firm integrates that capability. Sometimes the provider suggests new training or other activity that involves implementation. Depending on projects the firm will have external experts delivering, and not all examples are successful:

> 'We had an external company to provide the housing for workers but they didn't understood the culture here and they wanted to profit from the housing and that was a failure. We do this now in-house as we understand better the culture in a remote location'.

To disseminate and integrate knowledge this firm has some formal platforms such as Project management, Seminars, Procedures (manuals), and ongoing services specific to projects. The firm has project managers with 10 years experience that learn in the process and are responsible for implementation and transfer of knowledge. The best capability of the firm refers to their technology: mine design, metallurgy, plant equipment, and processes. The fir has a '10-day growth cooper cycle' that is totally managed in-house and that constitutes an innovation that other mines are looking at; it might become a service offered to others in the future. Capabilities for the future are related to maintenance, which will be better in-house because the on-cost. This is a huge service that has always been provided externally. Attracting

staff is the biggest challenge for having this service done in-house.

MTS companies don't see themselves as 'users' of services but as providers. The interesting feature here is the activities they develop for the mining company (customers), the way they interact, how they are able to improve in their solution base and how they are able to implement innovation with each job. In doing this, these companies could present similar behaviour than software or tourism companies but they differ in that the customer itself is an enourmous and very dynamic provider of knowledge as mining companies today held a constellation of services at the mining site. Knowledge interactions are so frequent that the mining site can be considered as a laboratory of continuous learning for the companies working on the site.

The mix and match of internal and external expertise is usually done by project managers, product champions, and knowledge coordinators or by using formal platforms such as seminars and manuals. MTS companies seen to have more innovative solutions when it comes to knowledge management than mining companies despite the fact that mining companies are managing a significant number of contractors every day. MTS companies are highly dependent on the integration of knowledge they learn from each contract, as the application of new solutions is frequently based on their previous experiences. In this way, MTS companies act as transformers of the mining industry by transporting innovations from one mining site to the next and by providing enhanced solutions based in previous solutions that worked well for other clients. The dependence of mining companies on MTS companies is high when it comes to think for better solutions to particular problems. Mining companies relay on MTS firms to provide these solutions or to help them to find the most suitable. MTS companies are them able to implement that solution elsewhere within their confidentiality agreement with the mining company. As a result the whole mining industry, from site to site, benefits and it is transformed through the enhanced technological knowledge.

3.4 Network KISA

Other firms in the network space, customers, competitors and universities are all partners of high importance both for MTS companies and for mining companies. Mining companies also considered of high importance their relationships with regional and community organisations while for the MTS companies this was only of medium importance. In general, MTS firms acknowledge the importance of working in cooperation, not isolation. Table 17 shows the importance of partners for the case study companies and their type of relationship.

Table 17: KISA Partners

PARTNERS	Formal (contracted)	Informal (non-contracted)	High Importance	Medium Importance	Low Importance
1. Other firms within the same industrial group (Network)		■	■		
2. Competitors		■	■		
3. Customers	■		■		
4. Consultancy Firms (KIBS)	■			■	
5. Government Departments	■			■	■
6. Universities and Colleges (RTOs)	■	■	■	■	
7. Industry Associations		■		■	
8. Regional/Community Organisations		■	■	■	

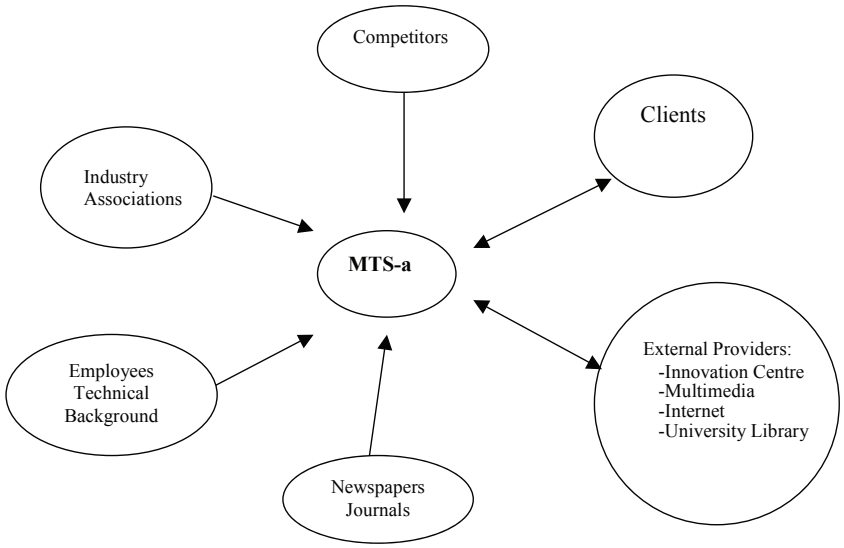
Source: AEGIS KISA MTS Case studies data (2005)

Most MTS firms will tend to have long-term relationship with customers. They do this by offering a variety of products and services and by updating them. For one of the MTS firms innovation is an ongoing evolutionary circle:

> 'We are given a job as we have something they want straight away. Then they [clients] might say it would be nice if you could do this or that, and then we work on it and bring it back to them. That is the long-term relationship. For example, our software product is developed based on their feedback. We have developed software for 25 years. Our focus of that development comes from the feedback from the industry. So we take part in their innovation process that way. We can do something straight away but them the client asks for other things and as we have a long-term relationship we adapt the software. The customers direct us and we provide solutions'.

Another MTS is part of the South Queensland Mine Training Network which is facilitated by the QMITAB but their interaction has not been as positive as they thought. The firm is also part of the Sunshine Coast Exporters Network (SCEN). Again, this relationship has failed to deliver the positive outcomes expected. The firm is now part of the University of the Sunshine Coast community through the Innovation Centre. As this is a recent move it is difficult to ascertain if this will yield positive results for the company. At the moment the firm is cooperating with other firms in the innovation centre and that is bringing innovation to their services. Some of the advantages of being in a university campus are the possibility to select interns or cadet writers from university graduates; the use of university facilities such as the library and using these associations to improve and make innovations in their products. The network space of this firm and the elements influencing their growth and development is depicted in Figure 5.

Figure 5: MTS-a network space



Source: AEGIS KISA MTS Case studies data (2005)

MTS-C specialised in software for mining companies engages in mainly formal contracted collaboration with private sector KIBS, government departments, universities, customers and other firms within the same industrial group or network; and gives high importance to universities and public research institutions and firms in the network group. The firm is interacting with research institutions (geology and mining related) such as CSIRO, universities and government departments. The firm partners with CSIRO and private firms and some professional associations (Australian Society of Exploration Geophysics; society of Exploration Geophysics; and Petroleum Exploration society of Australia) in exploration geophysics. The firm interacts with external business enterprises but had given medium importance to such collaboration. These are the main external clients and customers whose demands and interaction processes have led to developing products and services. *Thus external clients and customers are important inputs for KISA generation internally by this firm and as such there is very little KISA that is obtained externally by the firm.*

Another MTS firm will refer to their close network with MNCs as well as their relationship with particular professionals or CEOs that they will know and follow across cities or continents. This is a very important component of the success of their business and in fact of the success of building a career for their own professionals. It is important also for building future business. Their relationship with universities is diminishing, they are not well resourced and lack of availability makes them a low priority for their company. One of the managers of this firm states:

> 'If they [universities] were busy and dynamic sure we will be collaborating more with them. They are just not around. This is disappointed. For instance, we collaborate with the CRC. We work in conjunction with them but they are not working for us to give us any product'.

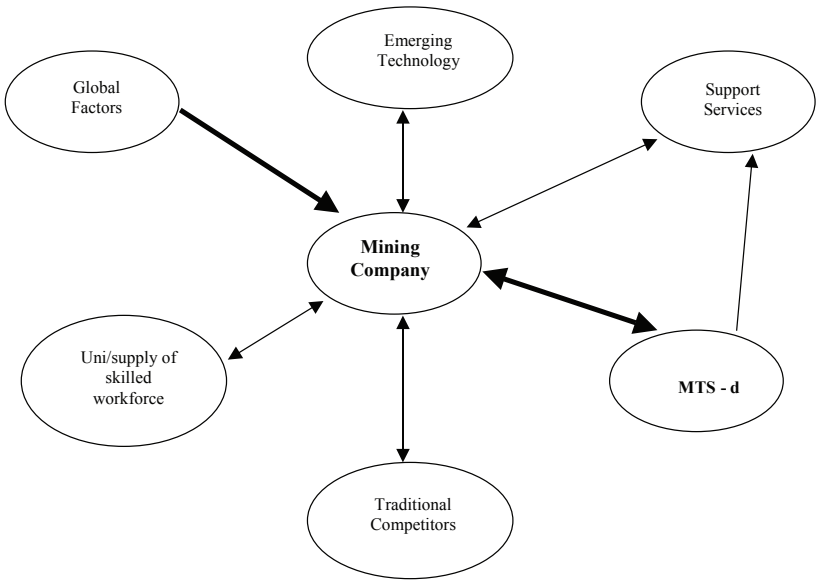
The firm will base the success they have to the fact that they offer the right mix of people with operational experience and some technology to support their service. In addition these professionals leave behind processes that the customers can them go and use by

themselves. Part of their success is that they 'leave behind sustainable processes' as one manager recalls.

Case study MTS-d sees their position in the network space of the mining company as central to their provision of expertise and in a triadic relationship with other support services to the mining site. The firm also notes other forces impacting the network space of the mining firm such as global factors, emerging technologies, supply of skilled workforce and traditional competitors in the industry. Figure 6 shows the location of the MTS case D in the network space. This company explains the figure as follows:

'Global factors are a big driver in where the mining company moves and where we move. We need to keep an eye in our *competitors*. As companies are very kin in changing *technologies* such as computer software and the way they manage their business we also need to change and advance with them. *Support services* are very important as they work for them and us and they have an influence in our business. If they change the way to do business so we have to'.

Figure 6: MTS-d Network space



Source: AEGIS KISA MTS Case studies data (2005)

One of the mining companies refers to the mining industry as very open in terms of competitors, and the need to know what they are doing. Government departments are regarded as regulators; the ones that 'set the environment for the mining firms to operate'. There is some degree of informal relationships with them as well as with industry associations or industry bodies such as the Mineral Council of Australia. Customers are very important and the relationship is more formal.

Another mining company has set up a department of 'public affaires' for collaboration with the community specifically regarding environmental issues and indigenous issues. The relation with universities is more informal and refers to geology activities, environment and site visits.

Customers are the most important relationship for the MTS companies. Even if they develop relationships with support services and

external providers, the most important KISA is generated internally.

3.5 Challenges to the Innovation Process & IP Protection

All case studies report 'skills shortage' as the biggest challenge for the industry. In particular it was noted that Universities are not producing enough technical graduates such as engineers and geologists. One case reports skills shortage has been a problem for years, and it is almost to late now to fix that. By the time graduates start getting through again (5-6 years away) it will be too late; the problem needs to be fixed now. The problem is not unique to Australia as one of the managers interviewed noted:

> 'In North America, in 1999 they had 13 mining schools, now they have 2. The problem in South Africa is the same. South America is not so bad. India and China area a source of technical professionals but in the western world mining professionals are not produced in the quantity they are needed. People leave the industry, go to do something else, or retire, and there are not enough employees'.

Another company noted that the challenge for the industry is to attract people to work in the mining industry. To balance this problem the company work hard at being an 'employer of choice':

> 'We are a global company to support the industry. People likes to work for us, nice offices, we pay well, interesting career, we are in the city. We need to formulate responses to the shortage of people in the market. Attracting any employee to go and work in the mines is difficult; so we have to offer the best environment and opportunities we can'.

Other barriers to the innovation process are the great economic risk, high innovation costs and lack of market information (see Table 18). Among these other, high innovation costs and economic risks are the two most important factors which stand out in so far as the product development is concerned.

Table 18: Barriers to the Innovation Process

INNOVATION BARRIERS	Yes
Great economic risk	
High innovation costs	
Lack of appropriate financing possibilities	
Organisational management resources	
Lack of skilled personnel	
Lack of technological information	
Lack of market information	

Source: AEGIS KISA MTS Case studies data (2005)

Another MTS company refers to the need to be able to look to the future and make a quality call about what industry will need and will be happy to pay for as the biggest challenge to maintain competitiveness. The costs and risks of innovation are very high and could seriously damage the current operations of the firm so the challenge is to move from opportunistic business to entrepreneurial business. For this company (specialised in training and education products and services) electronic delivery is still in its infancy and has not yet been exploited fully. There is still room for innovators to introduce new products that can monopolise the market.

Other important challenge noted by one of the MTS companies is the training in the specialised area of geological and geophysical sciences relating to software and retaining the trained personnel. As the company is developing software at the cutting edge and it is developing for global markets, lost of key personnel is a serious threat for business development.

The case study companies note as challenges in accessing knowledge the requirements to

enter cross-licensing agreements to get a license from other firms and, sometimes, the refusals to transfer know-how by other firms. For example, given that software programs are highly open to infringement and copying, one firm gives high importance to 'copyrights' and 'license agreements' to protect their IPR. The methods used by these companies to protect their Intellectual Property (IP) is indicated in Table 19.

Table 19: Methods of IP Protection

METHODS	Never	Sometimes	Systematically	Do not know
Formal Methods				
1. Registration of design				
2. Trademarks				
3. Copyright				
4. Patents				
Informal Methods				
6. Secrecy				
7. Complexity of design				
8. Speed to market				

Source: AEGIS KISA MTS Case studies data (2005)

Barriers to the innovation process refer to skills shortage and retention of people. Other barriers are the great economic risk, high innovation costs and lack of market information.

3.6 Government Programs

The case study companies were not participating of government programs in any great extend. One of them recalls that they have not done anything that would qualify them for government assistance for innovation. They have considered applying for export grants but have not met the criteria as yet for such assistance. There are also other barriers for applying for government programs:

> 'Furthermore, all government grant systems seem to be too heavily wrapped in red tape to be of real value unless they are particularly large grants. Government programs info is relatively easy to access - the red tape surrounding applications is a significant barrier'.

Another company will refer to safety information from government departments and training advice as their only contact. Legal reasons are behind extending consultations with government departments.

Another MTS firm places considerable importance on government programmes and schemes in the field of ICT but much of the firms interaction and partnering is with CSIRO divisions dealing with mineral and geophysical exploration to commercialise geophysical and geological interpretation software developed under AMIR A (Mineral industry association scheme) sponsorship. This firm also works with NSW Department of Mineral Resources.

Another MTS firm refers to export development grants, Queensland state grants, R&D grant funding, and R&D tax concession as the programs they have applied for. Another MTS does not applied very often to government programs because there is a cost involved. The firm allocates a consultant to go through the paperwork, someone expert in submitting applications if they have a program in mind. For example they looked at COMET but didn't thought they would qualify so they didn't applied in the end. Another MTS mentions that government assistance could go into facilitate visa applications when they need to go to work to other countries as there is a lot of red tape for movement of personnel. For example the firm cannot send Australians to America to do a job there.

One of the mining companies participates in R&D programs, which provides 25 percent tax deductibility for the whole. Again the bureaucracy is mentioned as a barrier:

> 'Not easy, not always clear [application procedures], and there is a very short focus (3 years). The bureaucracy and changing of rules make it difficult [to apply]. We have used some training programs but, in general, we see the role of government as more in taxation'.

Another mining company sees the mining industry as very diverse but specific and some of the government programs are too generic.

> 'It should be programs more specific to defined areas of expertise. We look at programs that are specific to the different areas of expertise (such as education) also for attracting people to work in mining. We don't have enough people trained for the mining industry'.

The companies mentioned 'bureaucracy' and 'red tape' as responsible for the lack of applications to government programs. As the mining industry is heavily regulated all companies were aware of the regulatory framework and considered relationship with government agencies important to keep abreast with changes to the legal framework.

3.7 Summary

Six case studies were selected following criteria of location, service focus, size and referrals by industry: 4 cases were Mining Technology Companies and 2 were mining companies. The selected MTS companies provided services to the selected mining companies which allowed for a better analysis of the relationships between the mining company and the service provider and the activities they perform.

The firms' activities relate to two mining sites. Mining sites in Australia are often located in remote locations that are very rich in minerals, which allows for a long-term exploitation and the formation of permanent settlements. Hundreds of contractors can be associated with the mine site having a significant impact on other services business operating in town. In this respect mining sites are knowledge intensive hubs and innovation intensive ecosystems. The analysis of the case studies has taken into account the complexity of the activities performed in this environment.

The two mining companies analysed were undertaking radical innovations while three out of four MTS companies reported incremental innovations.

KISA of high or medium importance for both MTS and Mining Companies are:

- Exploration and other mining consulting;
- Design & Engineering consulting;
- Technical consulting services relevant to industry;
- Research & Development services;
- IP-related services; and
- Occupational Health & Safety (OH&S).

KISA of high importance for MTS but low importance for mining companies are:

- Marketing services; and
- Industry related training services.

Services or expert contributions to KISA are largely sourced in-house or externally by KIBS or by a combination of both with exception of industry development advice which is mainly sourced from industry associations. Only one mining company would source expertise from universities. Networks were not very important as a formal source of services for KISA as KISA contributions were mainly sourced under formal contracts. However, other firms in the network space, customers, competitors and universities are all collaborating partners of high importance both for MTS companies and for mining companies. Mining companies also considered of high importance their relationships with regional and community organisations while for the MTS companies this was only of medium importance. In general, MTS firms acknowledge the importance of working in cooperation, not isolation. Even if they develop relationships with support services and external providers, the most important KISA is generated internally. The most important relationship for innovation purposes is with customers.

For the majority of the case study companies sourcing external expertise was a cost-related decision, balancing sourcing the expertise needed externally but retaining core knowledge in-house. For mining companies the issue seems also to be linked to the difficulties of finding skilled personnel and also to the fact that mining sites are knowledge intensive hubs with different complex technologies that require specific and tailored expertise.

MTS companies don't see themselves as 'users' of services but as providers. The interesting feature here is the activities they develop for the mining company (customers), the way they interact, how they are able to improve in their solution base and how they are able to implement innovation with each job, is simular to behavior observed in other industries, namely software and tourism companies, but they differ in that the customer itself is a dynamic provider of knowledge as mining companies today hold a constellation of services at the mining site on a daily bases. Knowledge interactions are so

frequent that the mining site can be considered as a laboratory of continuous learning for the companies working on the site.

The mix and match of internal and external expertise is usually done by project managers, product champions, and knowledge coordinators or by using formal platforms such as seminars and manuals. MTS companies seem to have more innovative solutions when it comes to knowledge management than mining companies despite the fact that mining companies are managing a significant number of contractors every day. MTS companies are highly dependent on the integration of knowledge they learn from each contract, as the application of new solutions is frequently based on their previous experiences. In this way, MTS companies act as transformers of the mining industry by transporting innovations from one mining site to the next one and by providing enhanced solutions based on previous solutions that worked well for other clients. The dependence of mining companies on MTS companies is high when they are seeking better solutions to particular problems. Mining companies rely on MTS firms to provide these solutions or to help them find the most suitable option. MTS companies are then able to implement that solution elsewhere within their confidentiality agreement with the mining company. As a result the whole mining industry, from site to site, benefits and is transformed through the enhanced technological knowledge.

The case study companies note as challenges in accessing knowledge the requirements to enter cross-licensing agreements to get a license from other firms and, sometimes, the refusals to transfer know-how by other firms.

The case study companies were not participating in government programs to any great extent. The firms mentioned ‘bureaucracy’ and ‘red tape’ as responsible for the lack of applications to government programs. As the mining industry is heavily regulated all companies were aware of the regulatory framework and considered relationships with government agencies important to keep abreast with changes to the legal framework.

4. Conclusions

4.1 KISA in the Innovation Process of MTS Firms

The study sought to achieve a better understanding of the nature of innovation processes through the analysis of the of knowledge-intensive service activities (KISA). The main conclusions are as follows:

One of the important points arising from this study relates to the meaning of KISA. An earlier survey of mining technology firms and the case studies suggest that there are information flows and knowledge flows between different actors in the network space of the firm. KISA is generated within the firm or through interaction processes with customers and external providers in the network space. Results from this study and previous KISA studies of the software and tourism industries (Martinez-Fernandez et al, 2005 a,b) suggest that we need to distinguish between inputs/providers of inputs to KISA and KISA itself.

In the knowledge economies KISA can be considered as an important dimension of innovation in firms contributing to their market dynamics and success. KISA has both tacit and codified dimensions and for its manifestation, generation and effectiveness to have an impact it is mediated through professionals and their skills. The latter is an important feature of organisational and institutional innovation.

The MTS sector is considered highly innovative in the Australian economy. Although the Australian Bureau of Statistics (ABS) does not collect data for the MTS sector, the latest survey of the sector by ABARE estimates a minimum of 331 MTS companies in Australia (chapter 2). The majority of the firms are SMEs employing 10 people or less with a total of 16,800 full time equivalent employees in 2003-04. Gross sales revenue in the MTS sector in 2004-05 is forecasted to be approximately AUD 4,430 million. MTS is a critical component of Australia's largest export earner, the mining industry. The mining sector is estimated to contribute AUD 1.9 billion in high-technology exports in mining services, in particular to the East and South East Asian region but also to Central and South America, North America, Africa and Europe. The export revenue for 2004-05 is forecasted to be AUD 1,240 million.

The case study analysis (chapter 3) suggests that KISA performed by MTS have an important role to play in the transformation of the mining industry in Australia. First of all, *mining companies heavily rely on the expertise and operational capacity of MTS firms operating in mining sites*. Knowledge Intensive Service Activities are at the core of the business of mining technology services companies. KISA of high importance for both MTS and Mining Companies are:

- Exploration and other mining consulting;
- Design & Engineering consulting;
- Technical consulting services relevant to industry;
- Research & Development services;
- IP-related services; and
- Occupational Health & Safety (OH&S).

Services or expert contributions to KISA are largely sourced in-house or by KIBS or by a combination of both with exception of industry development advice which is mainly sourced from industry associations. The process underpinning KISA that is supplied and KISA that is purchased is different and seems to be linked to company competitiveness. Supply of KISA is increasingly happening in the form of 'packages' linking products and services such as maintenance, marketing or management services. Purchase of services is oriented to

strengthening the core capabilities of the firm. These include KISA related to IT Consulting and Computer services, Management Consulting and acquisition of new skills or specialist skilled personnel. The purchase of services has a direct relationship with the capabilities firms wish to have in the future. These KISA are not static but subject to changes in the market and to the release of new knowledge as it emerges from R&D efforts and business practices elsewhere.

Secondly, *mining sites constitute hubs of knowledge intensity* where internal and external experts prepare innovative solutions tailored to specific problems. The process of KISA development by MTS firms is not dependent exclusively on formal contractual arrangements but on flexible interchanges and interactions across the network of companies in the 'innovation milieu' of the firm. Within this space, those in closer relationship to the 'product' constitute the main 'actors' with regard to source knowledge. These are the sales force front-end staff, customers and clients. KISA collaboration has specially increased among customers and suppliers of the firm. Integration of the different KISA within the company is usually handled by the management team or by a dedicated project manager, it is not a fixed strategy but determined on a project-by-project basis. The mix and match of internal and external expertise is usually done by project managers, product champions, and knowledge coordinators or by using formal platforms such as seminars and manuals. MTS companies seem to have more innovative solutions when it comes to knowledge management than mining companies despite the fact that mining companies are managing a significant number of contractors every day. MTS companies are highly dependent on the integration of knowledge they learn from each contract, as the application of new solutions is frequently based on their previous experiences. In this way, MTS companies act as transformers of the mining industry by transporting innovations from one mining site to the next one and by providing enhanced solutions based in previous solutions that worked well for other clients. The dependence of mining companies on MTS companies is high when the are seeking better solutions to particular problems. Mining companies rely on MTS firms to provide these solutions or to help them find the most suitable option. MTS companies are then able to implement that solution elsewhere within their confidentiality agreement with the mining company. As a result the whole mining industry, from site to site, benefits and is transformed through the enhanced technological knowledge.

Thirdly, *the number of MTS companies working in a particular site at any one moment constitutes a complex network of KISA* that is not usually evaluated nor does it form part of central management systems. The six case studies analysed in this study relate to two mining sites. Mining sites in Australia are often located in remote locations that are very rich in minerals which allows for a long-term exploitation and the formation of permanent settlements. Hundreds of contractors can be associated with the mine site having a significant impact both on the mining company where they operate and in other services business operating in town. In this respect mining sites are innovation intensive ecosystems that often lack the attention to the management of KISA as a value added to the organisational structure.

Closely related to the above is the fact that MTS companies don't see themselves as 'users' of services but as providers. The interesting feature here is the activities they develop for the mining company (customers), the way they interact, how they are able to improve in their solution base and how they are able to implement innovation with each job is simular to behavior observed in other industries, namely software and tourism companies,but they differ in that the customer itself (the mining company) is a dynamic provider of knowledge. Knowledge interactions are so frequent that the mining site can be considered as a laboratory of continuous learning for the companies working on the site.

One of the main conclusions from this study is that KISA performed by MTS firms strongly impact innovation and competitiveness of mining firms. The frequency and diversity of these KISA are influencing the rapid transformation of the mining industry in the knowledge economy into a 'knowledge based techno-economic network' (KBTEN).

Despite mining sites been often found in remote locations, Mining technology service firms are predominantly found in business centres and inner city locations. New South Wales, Victoria and Queensland have the highest number of mining technology companies. The sector has specific geographical features of clustering in the cities of Sydney and Perth, stressing the importance of network connections to corporate headquarters and other KIBS often associated with financial centres, especially in the case of Sydney. The study suggests the importance of internationalization of actors as vital for the innovation process of these companies. At the same time, and due to the remoteness of mining sites, people transport infrastructure and logistics plays a major role in the sustained growth of the industry.

4.2 Emerging Policy Themes

The findings suggest the following areas of policy discussion:

- There is a need for governments to promote the awareness of the role of KISA in innovation. Specifically, it is important to focus attention on the different functions of internal and external knowledge intensive services for KISA and their relationships to firm competitiveness. For instances, sourcing external expertise to keep abreast with international technological innovations and solutions that internal experts might not have been exposed too. Thus, future capabilities might depend on increasing external contributions to KISA;

- Particularly in the mining industry the importance of knowledge management is growing in importance for the sustainability of the industry and government departments should attract attention to the fact that MTS firms have advanced knowledge management systems and practices that can be shared within the mining site environment;

- Significantly the findings of the study suggest that there is a need to see the MTS sector as part of a Knowledge Based Techno-Economic Network (KBTEN) together with mining companies. This network presents clustering features in mining sites and in financial business centres. Thus, policies and programs oriented to build and develop this network across mining sites and financial business centres would enhance innovation capability of both MTS and mining companies;

- There is a need for different government levels in Australia to increase the quality of transport infrastructure and urban logistics for the remote mining areas as an important part of the MTS sector development. An important feature of the sector is based in moving people to remote locations that lack the sophistication for network connections and development that developed urban areas have;

- Finally, the MTS Action Agenda could consider promoting or recommending initiatives to enhance KISA that is tailored to both MTS and mining firms as they are part of the same innovation ecosystem and their interactions are indeed of an intense nature.

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Endnotes

[1] This paper reports on the Mining Technology Services case study part of the ARC Linkage grant on 'Driving Innovation: Mixing, Matching and Transforming Knowledge-Intensive Services into Innovation'. The Australian Expert Group in Industry Studies (AEGIS) of the University of Western Sydney in partnership with the Department of Industry, Tourism and Resources and the Department of Communications Information and the Arts are the recipients of the grant. The study also informs the KISA OECD study. The overview of the sector is largely based on the ABARE surveys 2002 & 2005, other relevant ABARE and DITR reports and the cluster 2004 report by the MGB group. Information on the survey of mining technology firms is drawn from the AEGIS ARC Large grant on 'Investigation of the Changing Role of RTOs and KIBS in Fostering Innovation' (Marceau, Hyland and Martinez-Fernandez).

[2] New MTS Definition, MTSAA implementation committee, May 2004.

[3] Available data on MTS significance is based on the definition used in the ABARE reports (Tedesco et al, 2002, 2005)

[4] Tedesco, et. al (2002)

[5] An earlier version of this report was submitted to DITR Resources Division on May 2004 and presented to the OECD KISA Focus Group in June 2004. We thank Ms Tess MacDonald and the MTSAA Implementation Committee for their comments and suggestions.

[6] ABS (2003) Australian National Accounts: National Income, Expenditure and Product (5206.0).

[7] ABS (2003) Year Book Australia (1301.0), 2003

[8] ABS (2003) Year Book Australia (1301.0), 2003

[9] MTSAA implementation committee, 7th May 2004, email correspondence

[10] www.oecd.org/sti/innovation (follow the link to Sectoral Case Studies on Innovation).

[11] A000106313 'Investigation of the Changing Role of Research and Technology Organisations and Knowledge Intensive Business in Fostering Innovation'. (Marceau & Highland)

[12] Thanks to Professor Venny V.Krishna and Dr Claudine Soosay for their comments and contribution to this section.

[13] MTSAA implementation committee, 7th May 2004, email correspondence

[14] Even though the MTS sector has been defined, the sector has no formal classification for statistical purposes. The Australian Bureau of Statistics does not recognise, or publish data corresponding to the MTS sector. Many of the activities within the MTS sector also occur in other traditional industries.

[15] Tedesco, et. al (2002)

[16] ABARE surveys 2002, 2004.

[17] Macfarlane 2003

[18] Tedesco, et. al (2002) p.4.

[19] DITR, 2002

[20] Hogan (2004)

[21] Hogan (2004)

[22] Tedesco & Curtotti 2005.

[23] DITR, 2003

[24] PMSEIC, 2001. The data obtained from the PMSEIC may have included firms which are not in the definition of MTS by ABARE and Austmine.

[25] Tedesco et. al (2002), 2005

[26] The study was funded by an ARC large grant [A0000106313]titled 'Investigation of the Changing Role of RTOs and KIBS in Fostering Innovation'.

[27] In defining the mining technology services, ABARE (2002) classifies mining technology services as being businesses that are based on information and communication technologies (ICT) or products that utilise scientific, technical or engineering based technologies or services that accompany the use of this technology. Austmine, an export association supporting companies in the MTS export sector, uses a more broader definition of MTS sector that includes heavy plant and equipment as well as other catering services to the mining industry.

[28] Kompass is a self-reported business directory of companies.

[29] These classifications from Kompas 2003/3 include product codes 2772147 or 2936230 or 3059249 or 3261030 or 3261114 or 3315051 or 3395040 or 3405047 or 3450120 or 3558135 or 3580111 or 3750040 or 3873125 or 3886106 or 3921047 or 3987047 or 4012016 or 4034120 or 4054024 or 4509025 or 4562017 or 4578020 or 6650116 or 4501000-4501099 or 4501100-4501199 or 4507000-4507099 or 4509000-4509099 or 3294002 or 3294010 or 8325001.

[30] This may not be a complete list of mining technology companies, as some companies may not list themselves in the Kompass dataset.

[31] Australian Research and Technology Organisations and Knowledge Intensive Business Services in the Service Economy: Keys to an innovation based Knowledge Economy (2004) Data report on the Mining Technology Industries, AEGIS Working Paper.

[32] AEGIS, 2002

[33] AEGIS (2002) p. 35.

[34] Includes public and private organisations

[35] O'Connor & Kershaw, 1999.

[36] O'Connor & Kershaw, 1999.

[37] The data obtained from O'Connor and Kershaw may have included firms which are not in the definition of MTS by ABARE and Austmine.

[38] O'Connor & Kershaw, 1999.

[39] MGB Group, 2004:8

[40] Ibid: 8

[41] Australia's National Research Priorities aim to give strategic guidance and assistance with priority setting to both industries and policymakers who are considering investment decisions.

[42] DITR, 2002

[43] Ibid.

[44] Extracted from Tedesco, et. al (2002) p. 10.

[45] Tedesco, et. al (2002) p. 9

[46] Tedesco & Curtotti 2005

[47] Cooperative research centres bring together researchers from universities, the public sector and private industry. CRCs cover long-term, collaborative research and development efforts that contribute to national objectives (PMSEIC, 2001)

protect confidentiality of our sources.

[48] Ibid, p. 4.

[49] Extracted from Tedesco, et. al (2002) p. 44

[50] OH&S Consulting and Training; Legal and Accounting and Consulting; and Management Consulting are not covered by the MTS definition in the ABARE (2002) report

* Australian Journal of Mining 'Towards $6 bn in MTS exports'. AJM September/October 2005:30

** Name of companies, location of mining sites and full summaries of each case study are not presented in order to keep their confidentiality

[i] Towns are not named in order to keep the confidentiality of the companies

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