Department of Employment, Education, Training and Youth Affairs

Engineering Training Opportunities into the Future

An Examination of the Recent Workplace Reforms and Their Impact on Future Training Opportunities in the Water, Electricity and Road Sectors

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Foreword

Until recently Australians have taken infrastructure for granted. It was expected that clean drinking water, sufficient electricity and safe roads would be available. However, recent developments in Sydney Water and in New Zealand's electricity sector have provided a useful reminder of the extent to which the whole society is dependent upon essential services and infrastructure.

Reliable and safe infrastructure requires a skilled and competent workforce to design, build and maintain it. In the past, the training for engineering work was carried out in the public sector. We are currently going through a fundamental change in this arrangement, one which is unique to Australian infrastructure. Never before has the private sector had to take the major responsibility for the provision of training engineering graduates in these sectors. We must meet this challenge in such a way as to minimise any negative effects and, in so doing, provide new opportunities for Australian industry and universities.

The Institution of Engineers, Australia (IEAust) worked with the Higher Education Division of the Department of Education, Employment, Training and Youth Affairs (DEETYA) to provide a preliminary report on the impact of recent changes in the road, water, and electricity sectors on engineering graduate training opportunities.

The future options in this report were drawn from a variety of sources, including:

- a one-day workshop with representatives from the water, electricity and road sectors, universities and the private sector;
- the results of two surveys of young engineers and consulting engineers; and
- follow up discussions with various representatives.

This particular study confined its definition of training to the experience and industry formation required to turn a young engineering graduate into an engineer with three years industry experience.

Contents

Graphs

Acknowledgments

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Acronyms

ACCC	Australian Competition and Consumer Council
ACRE	Australian CRC for Renewable Energy
APESMA	Association for Professional Engineers, Scientists and Managers, Australia
ARC	Australian Research Council
AWWA	Australian Water and Wastewater Association
CRC	Cooperative Research Centres
CPD	Continuing Professional Development
DEETYA	Department of Employment, Education, Training and Youth Affairs
EA	Energy Australia
EEA	Engineering Education Australia
GHD	Gutteridge Haskins & Davey Pty Ltd
IEAust	Institution of Engineers, Australia
ITABS	Industry Training Advisory Bodies
MBA	Masters of Business Administration
NUITAB	National Utilities ITAB
SME	Small to Medium Sized Enterprises
TAFE	Technical and Further Education
UTS	University of Technology, Sydney

Executive Summary

Any study on the future of training opportunities for technology and engineering must be set within the context of the developments occurring in the workplace. As well as the structural changes such as privatisation, contracting out and corporatisation there is the broader issue of the increasing importance of the global knowledge economy.

In a highly competitive world market, the future economic and social development of Australia will depend critically upon the availability of increasing numbers of graduates with the attitudes, skills and knowledge needed to enable them to provide competent engineering services, or to bring a genuine technical understanding to their work in other professional roles.

The study found that as a result of public policy reforms, such as competition policy and privatisation, the road, electricity and water sectors are changing rapidly. It is only possible, therefore, to provide a snapshot of the changes that are occurring. Each of the sectors are at different stages in their reform agendas, and individual States and Territories are tackling reform in different ways. Victoria has chosen to privatise its electricity supply systems; South Australia has contracted out the operation of major elements of its water and sewerage system to an international consortium; Queensland and Western Australia have corporatised those elements of government sectors providing services directly to the community. New initiatives are being announced regularly and some of these statements will be out of date by the time this report is published.

However, it is possible from the information collected to provide a broader perspective of the overall trends and policy implications for engineering in these sectors.

For engineers who were in the past trained, by and large, in the public utilities and government instrumentalities, the changes are substantial. As these organisations have been downsized, privatised and increasingly moved to contracting out technical works, the provision of training has shifted to the private sector. How ready the private sector will be to provide the required training resources is still to be determined.

The engineering workforce has moved from the public sector into the private sector in an unprecedented way. The Institution of Engineers’ membership reflects this pattern. In the past, up to 70 per cent of its members worked in the public sector. Current statistics show that just 27 per cent of members now work in the public sector.

This study does not provide in depth skills forecasting information. Recent DEETYA figures (1998) indicate that, except for the mining industry, there is no current shortfall in engineers. However, this study does provide some evidence that the implications of the structural changes, which result in fewer training opportunities will not be felt for 5 to 10 years.

The signals sent to the emerging private sector training market are of paramount importance. Graduate engineers, industry, private training companies and universities all need guidance in assessing the best way to work together to ensure Australia has an adequate supply of skilled technologists and engineers in the future.

Currently there is a shift from government funding of education and training, to funding by the individual who wishes to maximise the private benefit of further qualifications. Individuals cannot be expected to also define their own training needs without a support system from universities, professional associations and the companies that employ them. In addition, universities, private training providers and industry all require clear messages from government on the importance it places on training as a fundamental element in economic growth and as a significant aspect of industry and education policy.

This new environment will require the development of new partnerships between universities, industry, private sector providers, the TAFE sector, the professions, graduates and all levels of government.

The TAFE sector has had a long history in working closely with industry: this is the nature of trades' training. Universities have always had a role in educating professionals, but have not always worked closely with industry in their teaching programs. In recent years universities have become more responsive to changing economic and employment needs, and have formed partnerships with industry in a number of key discipline areas. In becoming more focused on industry outcomes, universities will require new ways of operating. In doing this, it is vital that the essence of university education is not lost. Educating for critical thinking skills should not simply be replaced with training for specific activities.

There are great opportunities for universities to be major players in forming these new partnerships. The days are past where governments will fully fund education and training. Equally, we cannot expect the private sector to take on the full burden of these roles. Yet education and training are essential for Australia's future. This report is a contribution to the debate on how to go about forging these new alliances, and in redefining the roles and contribution of the various stakeholders in the alliances.

1

Background

This study is premised on the fact that the reform of the public sector and the new role of the private sector, in providing services that in the past were delivered by government, will bring about fundamental changes to future training opportunities for engineers.

In continuing the trends to privatisation, contracting out and downsizing of government services, the assumption appears to be that the private sector will meet the needs of future employment and training opportunities. In particular, small to medium sized enterprises are seen as the generators of jobs in the future.

On-the-job training is vital for the development of skills and, therefore, future job opportunities. Marketable skills will become an increasingly essential requirement for employment opportunities as technology is removing the need for unskilled work in many sectors.

Whilst there is still debate amongst economists about the linkages between advances in knowledge and long-run growth, there is also an increasing recognition that national resources of skill and knowledge are the most important assets in a modern economy.

In the past the public sector has provided a rich training ground for graduates, many of whom later moved into the private sector, particularly in the technology sectors. The Institution of Engineers, Australia's own membership figures highlight the massive switch that has occurred from the public to the private sector. In the past, up to 70 per cent of its 66,000 members were employed in the public sector and around 30 per cent in the private. Today these figures are all but reversed with 26 per cent in the public sector and 74 per cent in the private sector.

Training is, by and large, a long-term solution to meet the changing skills needs of industry. If training opportunities are not being provided to an appropriate extent, then more detailed forward planning should be carried out to anticipate skills shortages. Whilst this study did not undertake forecasting of skills shortages in these sectors, an IEAust study of the rail sector, which is about to be released, found that rail companies predict a shortfall in skilled engineers within five to ten years. The survey of 1100 professional engineers and engineering technologists and 210 organisations found that 56 per cent of rail organisations believe there will be a shortage of engineers within the next five to ten years. Sixteen per cent of railway engineers intend to retire in the next five years. At the same time, the public sector has reduced their recruitment of new graduates significantly which, until recently accounted for 30 per cent of the rail sector's uptake of graduates. (Appendix 4)

It will be increasingly important to document what proportion of those employers, who find it difficult to recruit appropriately skilled staff, resort to training as a solution, since this would be one of the most important tests of industry's commitment to training reform.

A report of the Small Business Research Program within the Department of Industry, Science and Tourism (1997) found that the larger the firm the more it spent on training. Only one in ten micro firms (less than 5 persons) and one in three firms employing 5–9 persons undertake some formal training. In contrast about 80 per cent of enterprises employing more than 100 persons undertake some formal training of employees.

These results are perhaps not surprising, given that small to medium sized enterprises (SMEs) have difficulty in taking qualified workers off-line to provide training.

This, of course, is not true of all SMEs but overall the barriers to training for SMEs are considerable. An evaluation of the Training Guarantee Levy, which existed from 1990 to 1994, found that in circumstances where there was no prospect of an employer seeing tangible short-term gains in profitability from an increased training effort, or where the short-term costs greatly exceeded the minimum expenditure requirement, firms were reluctant to provide training opportunities for their employees (DEETYA 1996).

A discussion paper released by the WA Chamber of Minerals and Energy (1996) included research results from a survey of its members. The survey, with a response rate of 60 per cent, found that only 16 per cent of respondents had employed new graduates in the past year, preferring instead to employ young professionals with at least 2–3 years' experience.

It is assumed that the trend to contracting out will also continue to provide employment opportunities. By and large it will. However, a report on the mining industry from the Western Australian Department of Training (1996) found that, with the use of contractors, many companies are no longer taking on apprentices. Whilst industry assumed that the training component will be picked up by the contractors, from the contractors' point of view the high competition and short-term nature of mining contracts (one to two years) made it difficult to take on long-term trainees (four-year apprenticeship indentures). It was estimated that skilled contractors now comprise approximately one-third of the mining workforce.

Australian industry is currently benefiting from 'ready made' consultants who were senior officers in public sector organisations and utilities. Given the shift from public to private sector that have already been noted, it is not clear where the technically qualified and experienced consultants will come from in the future. A report released by the National Utilities Industry Training Advisory Board (NUITAB) concluded that:

> *The evidence would suggest that a skills shortage will emerge in the near future if strategies are not identified and implemented to fill the training gap caused by the contracting out of services and the closing down of many in-house facilities.*

The changes that have occurred in recent times and are still occurring are bringing fundamental changes to the nature of the workforce. It is important that the efficiency gains of these changes are not offset by poorly monitored implementation strategies in the provision of training.

The private sector has forcefully argued that it should be given the opportunity to undertake work that in the past has been undertaken by governments. Having now been given opportunities to take on the commercial advantages, it is vital that there is a recognition that this also involves responsibilities. Training opportunities are an integral part of that responsibility. Equally, there will always be a role for government in addressing market failures; ensuring adequate levels of training may well fall into that category.

2

International Experience

The experience of other countries can be useful in reflecting on developments within our own. In Germany at the beginning of the 1970s, it was decided to diversify higher education schemes and to train new generations of technological engineers. The duration of the studies is three and a half years, including training periods in industry. This educational scheme has proved successful; two-thirds of the graduate German engineers graduate from fach-hochschulen.

The French tradition is completely different, but can be observed also in Mediterranean, Latin-American and African countries. According to the French culture, the engineer is primarily someone who can supply a global answer to social or human needs. The entrance exams to grand ecoles are considered in France as the most important event in the life of an engineer. During the five to six years at university, students take part in many projects developed by industry.

The Irish Government is doing two things in relation to young engineer development. First there is a program which encourages, if not requires, all university students in engineering to undertake a semester of studies in another European country. Second, the Government has in place funding arrangements to provide industry training programs for engineering graduates to increase their skill levels to corporate membership for the Institution of Engineers in Ireland.

The Government also has specific programs for providing resources to assist companies prepared to undertake properly structured graduate training programs in a range of occupations where there is high demand for labour. This is one of the key incentives that government offers to companies to establish themselves in Ireland.

There is a similar program in Hong Kong, funded by government to provide incentives for industry to engage in this post-university development of their graduates.

3

The Government's Perspective

The Government believes that science and technology are some of the underpinning forces for economic recovery (DIST 1996). It is aware of the concerns in the science and technology sector over the last several years, as a result of the impact of policy decisions. In response to this the Government will continue to monitor the outcomes of recent policy changes on the national innovation system, the connection to research and development, and the role of science and technology research.

The Department of Employment, Education, Training and Youth Affairs (DEETYA) shares the concerns expressed about training by IEAust. It acknowledges that there has been a reduction in both graduate training places and apprenticeships and that this apparently coincides with the contracting out of public service works. The duration of contracts, for instance, is less than the normal apprenticeship period and what was concentrated employment is now distributed. Employment in the professions is more in an open market environment. The generalised success of the modern apprenticeship scheme is unfortunately not fully transferable to the engineering sector; however, there is some increasing flexibility in the development of training packages.

In the past, organisations were typified as large structures with uniform solutions, centralist approaches, secure employment, hierarchical arrangements, cost plus pricing, slow in response times, with many industrial issues around demarcation and other disputes. Now there is much fiercer competition amongst providers, changes in the structure of ownership and organisation of firms and a focus on technological innovation, product substitution and greater customer expectations for service quality and standards. The impact of deregulation and various other changes has been to create new organisations which have got few core parts and gradually bring in their labour 'just in time' from a variety of providers.

This means that individuals can now be employees of a number of organisations simultaneously. This represents the consultant model of employment, where the engineer owns a small business and contracts to a variety of employers.

It is statistically clear that the States have cut back on their funding for education and training. At the Commonwealth level, the intent of government policy is not to make further cuts into higher education but to see if it can maintain the current effort. Increasingly this will require the university sector to diversify its sources of income, as their prospects for growth and development are increasingly in non-government hands.

Education and training providers will need to increase the availability and improve the responsiveness of their services to meet the varying and rapidly changing needs and circumstances of individuals. In 1996 there were over one million enrolments in non-award and other programs, mostly short courses in the vocational education and training sector. There were only about 13,000 in equivalent courses in the universities, albeit that the statistics for university non-formal programs are understated in existing collections. Deakin University alone has some 17,000 enrolments and they are not included in these statistics.

Nevertheless, on the most optimistic estimate short cycle enrolments in the university sector would be no more than 30,000. This means that the ratio of enrolments in short cycle programs and non-award programs in the vocational education sector, in comparison to the higher education sector is a ratio of 33 to 1.

There is now a global market opening up in relation to upgrading and broadening professional skills. There is vigorous activity underway by several global education and training providers, including online providers. This will emerge as a major area for commercial expansion for post-secondary education and training. Government policy here is about encouraging diverse private sector solutions.

Universities need to respond to the opportunities offered by the electronic medium, otherwise they may well find themselves displaced by others in the training market who recognise the potential. The challenge for providers is to develop convenient, affordable and appropriate quality offerings tailored to individual needs. The challenge for professional bodies is to assure standards without stifling diversity or inhibiting competition.

There is a related challenge: to continue to reform the initial professional qualification as a foundation for lifelong learning. This could be achieved by broadening curriculum content, diversifying methods of learning and revising modes of assessment.

A recent publication of the OECD (1997) on education policy analysis refers to education providers having to develop new partnerships with employers in the wake of the reduction of dependency on government. The report comments:

> *An important requirement of these new partnerships is to move beyond the view of graduates as people with homogeneous attributes and knowledge, and beyond a single narrow conception of what a first degree or diploma should certify.*

This does not mean abandoning standards or quality control; rather, within and among the diverse range of learning options, each study program needs to have well defined standards, content and qualifications. The characteristics of programs should be made transparent to employers and others and students should be able to move more flexibly among them.

The challenge on the providers’ side is to be more flexible and coherent in terms of the foundations for lifelong learning. They must be able to provide the post-initial professional development through a greater diversity of offerings. In order to maintain professional credentials there will be a continuing requirement for individuals to invest in their own human capital on an ongoing basis.

Early estimates of 1998 university enrolments indicate that total enrolments in engineering are up some 7 per cent on 1996, with undergraduate engineering enrolments up 5.5 per cent.

At the postgraduate end as well there has been an increase in post graduate fee paying courses. Over the period 1997–2000 the universities are planning to grow in the field of engineering processing and surveying by 7 per cent, in computing and computing sciences by 7 per cent and natural sciences by 3 per cent. The share of the ARC large grants flowing to engineering has risen from 17.9 per cent in 1991 to 22.6 per cent in 1997.

That data can now be compared across time from 1982 through to 1986, and it is evident that the rate of engineering employment is volatile. The peak period for employment outcomes for engineering seems to have been 1989 and the trough 1992. In 1989 for instance chemical engineering employment outcomes were 96.8 per cent, civil was 97 per cent, electrical 96.2 per cent, mechanical 94 per cent, mining 94 per cent, surveying 96 per cent. Those high 90s figures by the year 1992 had plummeted down to the low 70s or high 60s. They have now come back to the mid-to-high 80s. Chemical engineering is now 82 per cent, civil engineering 90 per cent, electrical engineering 88 per cent, mechanical engineering 83 per cent, and mining engineering 98 per cent. So there has been some restoration in terms of employment outcomes. The overall view is that we do not have a quantitative problem in terms of engineering. It’s not that there is insufficient supply, or oversupply, nor insufficient funding, nor that the price signals that the government have set are stifling demand. To the contrary, all the indicators are showing improvements in terms of engineering education.

The issue is one of appropriateness and quality. The appropriateness and the availability of the courses to meet the needs and circumstances of individuals at different points in their lifetimes and the need for the providers to be more responsive to their users is in question. This is strongly echoed in the vocational education and training sector but much less so in the higher education sector where we still have a provider-driven supply.

As the commercial demand increases for postgraduate engineering education, the universities will be forced to be more responsive to the demand side and we should start to see further developments in innovation and curriculum design development and in flexible modes of delivery.

4

Recent Developments in the Electricity, Road and Water Sectors

4.1 Electricity Sector

Over the last eight to ten years there has been major upheaval in the electricity industry. Within the electricity supply industry there has been a number of reforms through national and state agendas with significant implications for individuals, administrative structures and the future directions of organisations. The introduction of the National Electricity Management Council and the National Electricity code administrator, the Australian Competition and Consumer Council and the competition agenda has seen quite marked changes. Coupled with privatisation, it seems to be inevitable that engineers will need greater flexibility and broader range of skills to continue to remain relevant and useful to organisations.

In an era of restructuring in the electrical industry, staffing reductions within existing organisations have meant that previous endeavours to upgrade and retain skills, which were focused on training and cadetships, have now been eroded quite considerably.

In 1980 the Electricity Commission of New South Wales had over 12,000 employees. At the present time the sector has been broken up into generators and transmission groups which have forced organisations to rationalise. Only Pacific Power has an initial training group, while other parts of those organisations are moving away from the cadetship scheme and more towards scholarship schemes.

Organisations have moved towards scholarship schemes that save money, yet still have prospective graduates working in the organisation. With a cadetship, students are contracted to the company to work during their summer breaks and, on completion of their studies, to work full-time for the company for the length of their degree. With a scholarship, students work for the company during summer break but, on completion of studies, are not necessarily offered full-time employment.

Electricity firms are now headhunting the best of the university graduates. Whereas rotational schemes and mentoring may have been part of the sector in the past, firms have now shifted responsibility for career development to the individual, who is expected to select various courses on an individual basis, with approval at executive level.

What seems to be missing in these electricity sector reforms is the opportunity for younger engineers to gain appropriate skills, particularly those learnt through large construction and maintenance programs. However, this is not the experience in New Zealand, where many younger engineers have development plans approved by executives. One of the contributory problems in Australia is that the National Electricity market is not yet fully in place and it is not really evident when these current reforms will end. Change seems to be part of the culture and the engineers' ability to manage that change is vital.

In the future there will need to be some particular framework to develop young engineers. If it is to be left to the young engineer to plan their own career and develop their own courses, assistance should be provided. At a time when human resource departments are being cut back, the support systems for young graduates are decreasing. Graduates need to have a vision outside the organisation, outside the framework of their engineering degree, on the broader aspect of business skills and communication skills, as well as broader life skills.

One way of addressing this issue could be through the reintroduction of the Teaching Company Scheme (TCS). The TCS is currently making a resurgence, and is the subject of a major international conference to be held at Oxford University in July 1998. The scheme comes from the United Kingdom and involves a graduate working in a company for two years, under the supervision of an academic. In the UK, since 1975 some 2,000 companies have established commercial partnerships with universities. Each TCS program is part-financed by a government grant made to the academic partner institution, and in turn is complemented by funds from the partner company. This scheme provides opportunities for partnerships between universities, industry and government, and its application should be reviewed in the current environment.

Mentoring opportunities have diminished as many experienced engineers have moved out of the large utilities and have set up as consultants. In many cases this has resulted in those organisations having few senior engineers to mentor and assist young graduates to develop expertise in technical work.

Distance education may be one possible alternative, as there are many courses being run over the Internet, thus making flexible education more of an reality. The electronic classroom should be able to bring lifelong learning opportunities to the individual, tailoring education to their own lifestyle so that learning becomes part of life and career development.

Case Study: ENERGYAUSTRALIA (EA)

There have been major changes in the electricity industry in recent times. EnergyAustralia has undergone major restructuring. For example in the early 1980s the then Sydney County Council amalgamated with McKellar, St. George and Brisbane Water County Councils and employed just under 10,000 people. More recently, Sydney Electricity and Orion Energy merged to form EnergyAustralia and now has just under 3000 employees.

EnergyAustralia maintains a core of key strategic engineering expertise within the organisation; it also regularly augments its resources by joint venture and sub-contract for its growing external engineering business.

In terms of graduates, the number of new graduates offered employment in 1990 was 2, and four in 1994. In 1998 they have employed 6 graduates and are due to take on another 10 before the end of the year. EnergyAustralia conducts an extensive graduate engineering development program. Graduates are placed on a rotation scheme where they go to different sections in EnergyAustralia for 6 months to gain exposure to various facets of the business and develop skills and experience in a variety of sections. To a certain extent the graduate is able to choose their placements and because EnergyAustralia is able to offer a huge range of activities in electrical engineering there are many opportunities for the graduate to essentially carve out the career path of their choice.

EnergyAustralia is currently planning to have a pool of around twenty graduates who will rotate on the graduate engineering development program. In addition to that pool there will be three other graduates who essentially fill in for resource requirements, particularly in the event that EnergyAustralia wins a major contract, or to replace staff on annual leave or sick leave.

EnergyAustralia does not simply look for academic results in graduate selection, although that is one of the key areas that will facilitate an interview. The company also looks for attributes such as interpersonal skills, communication, innovation, creativity, and leadership—essentially, people who can get on with other people as they will be working in a team environment. Overall this amounts to a well-balanced person as opposed to a graduate whose major attribute is very high academic results.

In terms of mentoring, there is a fairly well defined program. When a graduate first starts with EnergyAustralia they are given one full week of training—that is essentially safety training and an induction day into Energy Australia. Each mid-year they have a full training week that consists of non-technical training in areas such as negotiation or presentation skills.

EnergyAustralia also encourages all of its graduates to do additional courses such as an MBA. The company will meet the full costs of the MBA provided the graduate passes the subject/s.
EnergyAustralia has only one cadet remaining who will be graduating in June 1998. EnergyAustralia has moved from cadetships to scholarships and participates

in a number of scholarship schemes. In addition to their own EnergyAustralia scholars, they also sponsor every university in its franchise area—that is, The University of Sydney, The University of New South Wales, University of Technology, Sydney and also the University of Newcastle. In addition to the scholarships, EnergyAustralia also takes on industrial students over the three-month period during the universities' summer break. In 1998 EnergyAustralia took on approximately 21 students, including its own scholars.

Phil McKee, Senior Consultant — Engineering Development, EnergyAustralia

4.2 Road Sector

AustRoads is a central group comprising representatives from local government, the road authorities and New Zealand. As in other sectors, road authorities throughout Australia are all undergoing reform at slightly different rates.

In VicRoads staff numbers have fallen from 5,700 in 1990 to 2,433 in 1998 and they are still falling. Professional staff numbers, constituted mainly of engineers, have been reduced to 440, where once they were 750.

In terms of downsizing the story is different in different states. Some road authorities have downsized considerably and will be moving to downsize even further. That is quite significant, particularly in Western Australia, which may lose between 500 and 1000 employees in the next few months as they move to a purchaser-provider model.

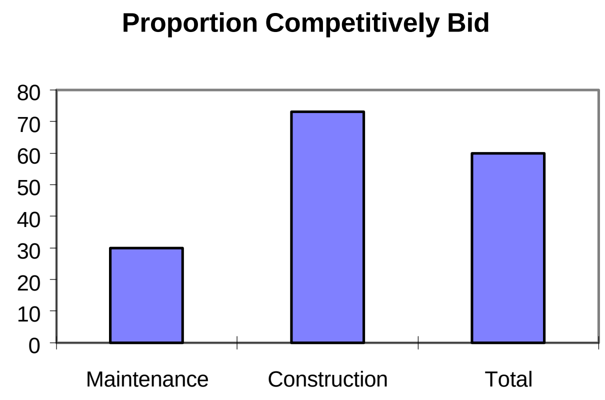
Many of the services which were previously performed in-house and provided engineers with an exposure to a wide variety of different experiences, are now being contracted out to the private sector. As an example, much of the design work is now contracted out, leaving limited opportunities for young engineers to develop these skills. A major question being raised by these changes is: how best can road authorities become informed purchasers? This is particularly pertinent as, at the moment, graduates are learning all aspects of purchasing, while at the same time being given only limited exposure to the experience of road building.

Most of the road organisations have now recognised that some technological expertise needs to be maintained within organisations. However, these units have been required to work in a commercially competitive way. These units manage their own budgets and bid for work both within and outside the organisation. If they fail to win the work they are likely to go out of business. This mode of operation represents a huge change in the culture of road authorities and in the skills required of those professionals in these organisations.

Engineers are now required to learn new disciplines and skills in the workforce as the organisations they work for, adopt the purchaser-provider model. Training opportunities will need to reflect this change and provide opportunities to learn those skills. Another issue arising out of these changes is that of developing appropriate partnerships. At the moment there seems to be a limited partnership between the consulting industries and the road authorities. This relationship needs to develop so that all professionals can develop a greater understanding of the role of a skilled purchaser and skilled provider.

In the road industry the general evolution in road networks over the last 10 years in Australia shows that 60 per cent of the roadwork is now being offered for competitive bid. It is also of interest to note that there is no difference between the amount of work that is bid on national highways, which are the Federally funded projects required to be contracted out, and what is going on at the local, arterial network.

Graph 1 Proportion of Work Competitively Bid in 1996–97: National View



In the future the contracting industry will take taking over more and more of road rehabilitation, road maintenance and construction. Maintenance contracts have increased significantly since 1990 and the private sector is winning most of this work. In some States of course the authorities bid for the works themselves, but generally the private sector is winning more bids than the public sector.

AustRoads has recognised the problem of professional skills development as a very serious issue. In the roads sector State Governments and Federal Governments are focusing on identifying their core businesses, on the basis that other services can be undertaken by outside consultants. In terms of the role of the road authorities there has been seen an increased amount of contracting out, with a very high tendency toward improved contract management and quality insurance contracts.

Previously in road authorities, as in the water industry and the electricity industry, the large organisations brought graduates in at the bottom, provided them with training and they became great recruits for the industry, the consulting industry and other building industries. They can't do that any more. In other words the authorities were 'training grounds' for graduates. Now industry must take a role in this as public utilities become smaller.

As already identified in other sectors, the types of skills now required by the road authorities are quite different, and include such things as contract and project management and the formulation of policy, strategy and standards. Managing the consulting process will continue to become a vital skill for engineers.

AustRoads has found that throughout the various road authorities many experienced engineers in the 50–60 age group have left to become consultants and therefore, in the future, there will be less skills and expertise available for mentoring programs.

Graduate engineer recruitment across the road authorities is not very high, although road authorities have been taking on some graduates. They do this in the recognition that they need to train and encourage younger members into the sector to ensure its ongoing viability. Nevertheless, AustRoads is anticipating that there will be a perceived shortage of professionals in the future, particularly in specialised areas.

When road authorities employ engineering graduates they do not just look for the pure engineer. They are now employing those dual degree civil engineers who have a broader range of discipline skills.

Engineers in the road authorities are mostly put on graduate rotation schemes, where they are given exposure to a wide range of skills in engineering and non-engineering ares. These programs are about to be accredited by the Institution of Engineers, Australia.

4.3 Water Sector

Australia is one of the driest continents in the world. Of the total national annual water consumption in Australia, the largest proportion (over 70 per cent) is used in irrigation for agricultural purposes. Groundwater is a critical resource in much of inland Australia, where it is often the primary source of water for small communities.

The major responsibility for water resources resides with State Governments and each State has taken a different approach to reform. In the Australian Capital Territory (ACT), water supply is the responsibility of Actew Corporation which is owned by the ACT Government. Stormwater services are provided by the ACT Department of Urban Services.

In New South Wales the two major areas are served by Sydney Water Corporation and the Hunter Water Corporation. Outside the major city areas, water supply and sewerage responsibility is shared. The Broken Hill Water Board and the Cobar Water Board provides water services to a wide country area and the Department of Public Works and Services gives technical assistance to local councils which provide water services to some urban areas.

South Australia’s water authority is the South Australian Water Corporation. In 1996 the operation and maintenance of metropolitan water supply and sewerage services were contracted out to United Water, an international consortium, with a view to developing an export industry in South Australia to provide water infrastructure to the rapidly developing Asian nations. In addition ten water treatment plants for country areas have been contracted to Riverland Water as build-own-operate schemes.

In the Northern Territory the Power and Water Authority provides utility services to major centres, communities and outstations across the Northern Territory. The Water Resources Division, previously with the Authority, has now been amalgamated with the Department of Lands, Planning and Environment.

Overall responsibility for water management in Queensland is provided by the Departmental of Natural Resources through its Water Resources unit. In Brisbane, Brisbane Water, a business unit of Brisbane City Council, treats the water supply to surrounding local authorities.

In Tasmania the Department of Primary Industries and Fisheries is the major authority for water. Bulk water for the Hobart area is provided by the Hobart Water Authority.

Water services in Victoria are the responsibility of a number of autonomous companies. In the Melbourne metropolitan area there are five separate corporate businesses, Melbourne Water, City West Water, South-East Water, Yarra Valley Water and Melbourne Parks and Waterways. Urban water and wastewater services to other cities and towns are now provided by 15 independent regional water authorities, while four autonomous regional authorities provide rural water services.

In Western Australia, the Water Corporation provides the full range of water-related services throughout the State. The Office of Water Services is the independent regulator of the water services industry in the State. Twenty-two small local authorities run their own sewerage schemes, under licences from the Office of Water Services (AWWA 1998).

In the water industry, the traditional mode of postgraduate training, involved graduates being taken on by one of the major water authorities, or by local government, and assisted to become productive employees by trained, experienced workers. After three to five years, having gained useable skills, graduates sought employment either within the public utility or in the private sector. That system has now all but collapsed, and few in the water industry hire new graduates readily. Environmental science graduates and environmental engineering graduates are finding it difficult to get into the workforce because many employers prefer an experienced graduate.
This situation was also confirmed in the IEAust's report *Engineering the Transition to Competitive Utilities*. In public hearings, Dr John Langford of the Australian Water Association stated,

> *A lot of people are coming to me and asking, where our skill base is coming from? I am worried about the generation of our skill base from here on. Because in my view, we've stopped training in the water industry and unless we start doing*

something about it reasonably soon, we've got a big problem. But nobody wants to listen to problems you're going to have in five or ten years time.

5

Universities

University engineering schools are extremely conscious of the far-reaching structural changes in the utilities and in the business environment generally, and are working in various ways to respond to them.

5.1 Professional Formation

Traditionally, university engineering schools have provided a theoretical education in engineering science. Typically, the first two or three years after graduation are spent in professional formation-acquiring practice skills, and understanding the relationship between the intellectual training acquired at university and the realities of its application. Progressive employers would structure this period as a kind of graduate apprenticeship or, in some cases, as a cadetship undertaken concurrently with the degree course.

Former electricity utilities, now commercialised or privatised, have a fundamental problem: in a climate of intense competition based on day-to-day customer pricing, how to make long-term provision for the replacement of major plant and infrastructure with massive capital costs and lifetimes of the order of 40 years. Exactly the same question applies to human resources, which also have high initial costs and long lifetimes. Just as many entities are now trading on established plant, so as a country we may be trading on established human capital with a finite use-by date and inadequate replacement strategies.

Today there are few cadetships where employers sponsor students through a degree course and subsequent professional formation. Some large employers still provide structured professional formation programs; but many companies hire and fire on a project basis and, for many graduates, soundly-based developmental experience is almost a matter of chance. To fill the vacuum left by the major public-sector engineering utilities, and restore some kind of integrity to professional formation on a national scale, new mechanisms and incentives have to be found and new responsibilities recognised.

The Institution of Engineers has developed a professional-formation framework and has established the National Professional Engineers Register, for which graduates can qualify by attaining carefully-defined and assessed practice competencies on top of their educational qualification. However, registration is only essential for certain categories of professional engineering practice. It is not formally required for employment in most private-sector enterprises, and adoption of the associated competency standards by such enterprises is voluntary.

Many universities are now keen to facilitate the professional formation of students and graduates, but can only do so in active partnership with industry and in a climate of recognition by industry of a responsibility to provide the necessary environment. The recent review of engineering education (1996) sponsored by the Institution of Engineers, Australia, the Academy of Technological Sciences and Engineering, and the Australian Council of Engineering Deans, laid great emphasis on the need for stronger educational partnerships between industry and universities. There is almost certainly a role for at least some universities to play a part in managing postgraduate professional formation, particularly for graduates employed by SMEs which might not have all the necessary resources in-house.

The training needs of SMEs—often seen as a growth sector—need particular support, both because of their slender operating margins and difficulty of committing resources to training, and because they often cannot provide the breadth of experience necessary for generic skill development. Networked training arrangements are one answer, supported by industry associations. These are relatively well understood at trade and paraprofessional levels, supported by the TAFE sector and by Industry Training Advisory Boards; they need to be better developed at professional-engineer level, in partnership with universities. However, experience indicates (in Australia and elsewhere) that such partnerships are extremely difficult to sustain on a commercial basis alone, and benefit very greatly from even a modest level of government incentive such as the former Training Guarantee Levy.

One significant contribution to professional formation is cooperative education, in which students are required to gain substantial approved industrial experience as part of their undergraduate program. Only one Australian engineering faculty (University of Technology, Sydney) now maintains this requirement for all its students; some others, such as The University of New South Wales and RMIT University, have strong cooperative programs but for relatively small numbers of students. It is understood that at Swinburne University of Technology, the other institution with a long-standing cooperative tradition, cooperative is now optional. Cooperative schools have extensive experience of partnership with industry.

Each year, APESMA, in conjunction with the Institution of Engineers, conducts a graduate employment survey. An interesting finding in the last survey was that in 1991-1993, when there was very high graduate unemployment, there was a noticeable exception among graduates from the cooperative universities, which were able to maintain their employment level significantly above those of other universities. Companies and enterprises clearly saw the cooperative experience as a valuable commodity.

5.2 Professional Extension and Development

With today's fast-moving developments in both technologies and business methods, it is well recognised that a first degree is no longer an end-product, but a licence to begin navigating through a world of evolving professional challenges and opportunities. More than ever, this points up the need for sound professional formation. It also points to the need for periodic development and extension programs throughout a professional career.

The short-course market is growing rapidly and is certainly not the province of universities alone. There is a view that, if universities do not lift their game in this area, they will be sidelined by private providers, many of them international and many operating substantially through the Internet. It seems clear that Government wishes to see universities building new revenue-earning businesses alongside traditional undergraduate and postgraduate award courses. At the same time, many universities feel themselves to be under acute financial pressure and find that much of the income generated from this kind of entrepreneurial activity now goes into subsidising undergraduate programs, for which the price is fixed by government and is declining steadily. Some universities or faculties are talking of getting out of undergraduate education because it simply doesn't pay. Others are setting up private divisions or offshore operations, or relying on international fee-paying students, to subsidise government-funded programs and to develop levels of quality that government funding will not support.

Case Study: Melbourne University Private

Detailed business plans are currently being prepared for Melbourne University Private and its constituent schools. Melbourne University Private's programs will be designed essentially for an emerging domestic and international market which demands high quality education and training to meet the professional upgrading and re-skilling of early to mid-career technical and managerial clients already in employment.

Melbourne University Private has been established in response to the changing nature of higher education. It believes that there is an opportunity to develop programs that are client-orientated, strategically focused in high-demand ares, that will provide commercial returns.

Both the Melbourne School of Energy and the Environment and the Melbourne School of Communications, Multimedia and Information Technology will be established on a commercial basis, and the overall, management and direction will operate as for a normal business partnership.

The School of Energy and the Environment will offer education, training, research and consultancy programs designed for specific client groups concerned with matters related to energy production and/or environmental management. Many engineering schools are engaging in quite enterprising ways with the issues of continuing professional development. Graduate-level courses can clearly contribute but again, the days of set-piece coursework Masters degrees (liberally supported by the former public-sector engineering utilities) are largely gone. The current demand is for shorter offerings, often project-specific and required on a just-in-time basis. The market is highly competitive, based on price and convenience and to some extent on quality. Employers are reluctant to provide time-release and often stipulate that attendance must be in candidates' own time and at their own cost, sometimes contributing 50 per cent.

Face-to-face program delivery and on-campus attendance are no longer the norm. Most universities now offer CPD modules in distance and/or block-release modes, often in association with APESMA or Engineering Education Australia, the professional-development arm of the Institution of Engineers. Modules can often be credited towards formal awards. Cross-crediting arrangements between universities, networked program opportunities, and recognition of prior learning are competitive elements. These represent substantial changes over the past five years.

Many universities are still wary of programs offered entirely in distance mode, and attach considerable value to an element of face-to-face interaction. Other universities and private providers see Internet communication as equally effective. It will take some time for these alternatives to find their place in the market. A recent entrant to the scene is Work-Based Learning, which seeks to base organisational and staff development on facilitated, tripartite learning contracts. Particularly in areas of new technology, traditional boundaries between undergraduate and postgraduate content, and between universities and the TAFE sector, are becoming increasingly transparent.

Continuing professional development in the future is likely to draw on flexible mixes of all these elements. The most successful providers will be those adept at making connections and building partnerships that clearly add value.

At the same time, there is an insidious risk of dominance by short-term, project-focused bottom-line thinking, ignoring the generic skills essential to enterprise and national capability. Like initial professional formation, these cannot be built on a base of short-term competition. They require collaboration of the kind referred to in other countries as pre-competitive, facilitated by government as an agent of the national interest.

Case Study: UTS–Thomson Software Engineering Program

The strategic importance of software engineering is internationally recognised. Following a prediction made several years ago, well over 50 per cent of the cost of all manufactured goods is now in software; and infrastructure services are not far behind. Despite this, most of the enterprises involved still do not have a mature, repeatable process for software development, or the capability to assess major software projects. Enterprises with this capability will have increasing competitive advantage; and a growing history of software failures attests the converse.

The UTS-Thomson Software Engineering Program comprises an articulated set of modules available as short courses, or leading to Graduate Certificate or Masters degree. It is designed to educate effective real-time software engineers for companies needing to develop real-time systems in industrial control, on-board automobile electronics, air and vehicle traffic control and navigation, telecommunications and radio communication networks, and defence systems, and provides intensive practical training using international-standard methodologies and software development tools in an industrial context. The program is a university-industry joint venture between the University of Technology, Sydney, Thomson-CSF and Thomson Marconi Sonar, developed from a heavy investment by Campus Thomson in Paris over several years.

In France, the program is highly successful and has placed some hundreds of effective software engineers in industry during its ten years of operation. In Australia, after several revisions to slim down the requirements and minimise the time demands for candidates and employers, it is still struggling to reach viable numbers. Why should this be so? One difference may be that in France the Government pays the salaries of participants for the duration of the course.

5.3 Cooperative Research Centres

The Cooperative Research Centres Program (CRC) was established to strengthen collaborative research links between industry, educational institutions and relevant government agencies. There are now 67 CRCs across Australia, covering six industry sectors. The Federal Government contributes some $145 million a year to the program, and the CRC industry partners support the investment through direct funding and/or in-kind support.

Because of the interaction with industry partners, CRCs provide research-training programs and produce research graduates who are more attuned to industry research-and-development needs. At present there are some 1900 graduate students engaged on CRC research projects.

This is an example of a government-supported university–industry partnership which would have been highly unlikely to survive on a purely commercial basis. Ways need to be found to promote the same kind of synergy in other aspects of national infrastructure and capability development.

Case Study: ACRE

As an example the Australian Cooperative Research Centre on Renewable Energy (ACRE) was established in 1996 and has an ongoing industry sponsored renewable energy training program. It is currently developing a training facility at Curtin University of Technology as part of the Cooperative Research Centre Education Program and now offers a number of short courses on a range of topics.

Their 1998 program includes courses on:

- Grid Connected PV Inverters—The Technology and Regulations
- Developing an Effective Policy for Energy Conservation
- Introduction to Renewable Energy
- Remote Area Power Supplies for Home Systems and Small Remote Communities
- Recommended Practices for Batteries in Stand Alone Systems
- Solar Water Pumping
- Tropical Building Energy Management

6

Private Engineering Training Providers

Engineering Education of Australia Pty Ltd (EEA) is a wholly owned subsidiary company of the Institution of Engineers, Australia, which brokers education and training courses from universities, TAFE institutes and private providers. It also develops new courses, if seed development funding can be sourced. In its broker role, EEA contracts to subject matter experts from universities, the TAFE sector, the private provider sector, and from industry.

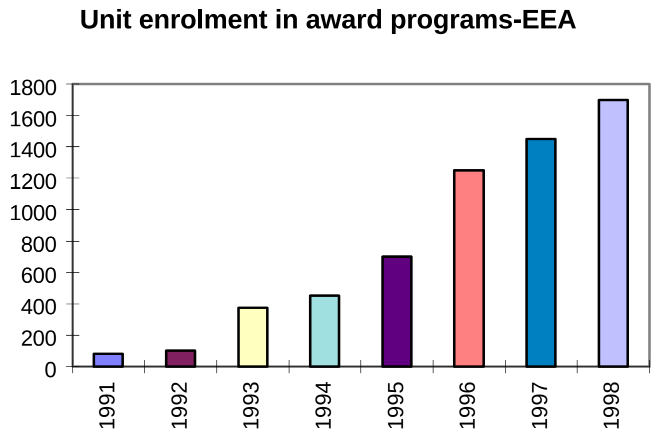
It is of concern to private providers that the level of funding going into education and training is diminishing. EEA would not exist if it was not for funding from such organisations as the Victorian Education Foundation, the New South Wales Education and Training Foundation, UNESCO, the Institution and Department of Employment, Education, Training and Youth Affairs. Seed development funding allows EEA to train just over 2000 customers a year and this figure is growing dramatically.

The subjects in demand, and those capable of adding value to organisations, are those where funding assistance has been in place. As an example, EEA developed a series of eight distance education units in road and pavement technology with AustRoads and the Australian Asphalt Pavement Association and the Australasian Pavement Studies and Research Centre. The course has proved successful in filling a gap in the market. EEA also provides a series of five distance education units in project management, which attract hundreds of enrolments each year.

In the same vein, EEA also offers a distance education unit on power systems protection, in conjunction with the Electricity Supply Association of Australia. That program is not as large as project management or pavement technology, but, between those enrolling full-time and those purchasing the notes, it currently provides training for twenty employees in the electricity sector.

Engineering Education Australia figures indicate that the growth in courses for engineering related activities is growing quite substantially.

Graph 2 Unit Enrolment in Award Programs—EEA



The review of the Training Guarantee Levy (DEETYA1996) commented that one consequence of changing patterns of access to training has been a shift in the burden of responsibility for training from employers to individuals. It stated that the proportion of employed respondents who had undertaken some training or study at their own expense almost doubled over the past four years.

However, EEA figures indicate that 70–80 per cent of those undertaking their courses have them paid for by the employer. This would indicate that, whilst the percentage of those paying for courses may have increased, at least in engineering courses that figure is still relatively low. This trend was also confirmed by the survey of young engineers, which found that 67 per cent of graduates had study assistance from employers (Appendix 5).

An area that some universities are now moving to, in conjunction with private providers, is that of offering corporate degrees and corporate masters. There is enormous scope for MBA or a Master of Engineering to be customised to a particular company, including company specific training and education. Industry experience is vital for professionals. For example, to become a Chartered Registered Engineer, the Institution is facilitating collaborative assessment processes between universities and industry for graduate development programs with industry. Industry experience is a requirement to meet the competencies expected of those who want to become a Chartered Registered Engineer after three or four years of work experience.

Another product that EEA runs in conjunction with Deakin University is a Bachelor of Technology. There are two or three hundred people a year enrolled in this course to upgrade an initial TAFE qualification or an Associate Diploma to upgrade to a Bachelor of Technology. They are then referred to as engineering technologists.

Graduates of this program can increase their salary prospects, their career progression and can reach a professional level. A major policy issue in Australia, is the lack of advanced standing, or credit and articulation from TAFE to higher education.

EEA is seeking, through the programs it offers, to address the broader range of skills required of engineers. EEA has had feedback from employers saying that engineers are not good communicators or managers. One of the objectives of programs offered by EEA is to develop business skills. In the near future EEA will be offering an online engineering Continuing Professional Development (CPD), which will be user friendly and comprehensive.

APESMA, in conjunction with Deakin University, also offers technology management courses. APESMA's 1998 survey showed that about 25 per cent of the IEAust membership falls into the category of self-employed or contract engineers. Management studies will be vital in keeping these companies afloat. The courses are designed to aid in the transition from university to the commercial world. The courses incorporate leadership skills, commercial awareness, change management, cost control, and sales and marketing. Units are provided by distance education which allows graduates to work at their own pace.

7

Professional Associations

The Institution of Engineers, Australia (IEAust), as the major professional engineering association, accepts its responsibility for ensuring the future of the profession and has produced graduate development programs to achieve this.

IEAust works with companies to assist young graduates to develop skills for their individual benefit. It then provides feedback to the companies on the students progress, the diversification of their skills and the capacity to fit into a full professional environment.

IEAust has found that small to medium sized enterprises tend to place the student into a highly specialised area. Having mastered those particular skills it became constraining for the individual in that they obtain only narrow skills exposure. Companies have now realised that this is not a long-term solution, in that they create a workforce which is not useable as a basis for expansion.

For an SME to employ an engineering graduate represents an investment of $50,000, including on costs. No SME will invest $50,000 unless there is a contribution to bottom line and that's the dilemma. The survey undertaken as part of this study confirmed that cost was indeed a major barrier to training (see Appendix 2). If it is not possible to employ additional expertise, the next best option is to deliver training and development directly to the shop floor.

A course has now been developed which delivers directly to the employer, a program which allows an employee with trade experience to graduate to at least an Engineering Technologist level (i.e. three-year trained). From the company's point of view it was found that this program contributed to bottom line by returning to the company the investment in the course. The course is entitled Bachelor of Applied Science in Manufacturing Operations (Industry Stream) and is run by RMIT University. It is delivered through the Internet, so that students can access it at any time, and can download reading material, conferencing systems for sharing ideas, NetMeeting for tutorials and Cu-SeeMe facilities for collaborative projects.

The Institution has now introduced a new accreditation process and one of the fundamental elements of that process is a requirement for exposure to professional practice as an integrated part of the course (see Appendix 1). This exposure has to be integrated and commenced on day one of the course. This has the potential of growing a bridge between industry and education presenters that is going to be win, win, win.

It is a win for the student because they will gain industry experience; it is a win for the university because they may receive some cash flow from the industry, and it is a win for industry because they will have a resource to do small and worthwhile projects. Schemes such as these cut the cost of training to small business and provide the graduate with a diversity of skills that small business requires.

8

Consulting Firms

In the past, public authorities have provided training for a large percentage of engineers who did not then spend their whole career with that particular public authority. They therefore provided training to a much higher proportion of the engineering workforce than they themselves employed. Government authorities did this because they perceived a continuing need to develop engineers for their own purposes. There was also an informal government acceptance that it was providing training for the whole of the engineering workforce which had positive spillover effects to the whole sector.

Nowadays you find the larger private sector organisations that rely on engineers are developing their own training programs in just the same way as those government agencies did in the 1940s and 1950s. Major contractors like Leightons and Baulderstone Hornibrook are still trying to reorganise or re-invent themselves, but they still have to settle down to the point of recognising their own training requirements. The expected working life of an engineer is about 35 years and training and recruitment programs need to reflect this. Some of the larger consulting companies are taking proactive measures to identify and meet their own emerging needs.

Case Study: Theiss Contractors Pty Ltd
Learning Summit May 1998

The Summit bought together representatives from universities, the TAFE sector, other large consulting firms, group training private providers and the ITABs. The Summit was put on as a result of a concern by senior management at the rate at which Theiss was developing its employees was not keeping pace with globalisation and the company’s own evolution.

The Summit outcomes were:

- an increased awareness of training needs at all levels of the organisation, to meet the training challenge and the skill re-investment demands of the future;
- an increased awareness of innovations in training and learning methodologies;
- a commitment by management to provide training and learning opportunities for employees;
- a commitment by business unit managers to provide suitably equipped training facilities at each workplace; and
- a commitment by each business unit to develop a model project of excellence in development and learning programs within the financial year 1997–98.

As a buyer of consulting services, it will be important that governments recognise companies which invest in training, alongside the bid, possibly at a lower price, from a firm that doesn’t offer this particular capability.

The large and successful private sector organisations, many of which have absorbed within them the best or most readily commercialised parts of public sector organisations, to some extent have become the grounds on which the young engineers of the future are trained.

There is a caution in this, however: if you simply expect the large consulting firms to take over from the government instrumentalities, you may simply replace one opaque system, owned notionally by the public, with another opaque system owned by a combination of private and public shareholders. Better ways need to be found of making an investment in the public good within an environment in which the delivery of that investment is something which is competitively tendered by the private sector. The real essence of the investment in these engineers is not to secure the long-term well being of the large consulting firms, which are well able to look after themselves; the aim is to secure the capacity of existing SMEs to develop effectively in an environment in which they must have access to a pool of skilled labour, as they often cannot afford the time to go out and develop their own.

One of the biggest driving forces for training is the requirement to get the experience and competencies necessary to be a chartered engineer in Australia. If employers are not developing the competencies required for recognised chartered status then there is an important role for the professional organisation to work with industry and governments to offset any short fall.

Consulting engineers tend to focus on current contracts, and the requirements to win the next round. There is a hesitancy in employing people with a long-term expectation, until they are sure that they are going to win the next round of contracts. There is a feeling generally in the consulting industry that change is taking place and given another couple of years or so, when that settles down, they will then be willing to take on and train new graduates.

Case Study: Large Consulting Firm Gutteridge Haskins and Davey (GHD)

In August last year, GHD acquired Works Australia which was a Commonwealth business unit and part of the Department of Administrative Services. GHD now has a total staff of about 1120 equivalent full-time positions.

GHD is divided into four separate regions and each one is, to some degree, operated independently. There’s an ACT/New South Wales region, Queensland/Northern Territory region and Victoria/South Australia/Tasmania region and Western Australia region. Each one of those regions has a regional manager who is responsible for all the offices within those states.

The size of the offices that we have vary from about 25 up to 250. Darwin is our smallest office while the Perth office employs about 250 people. As a result the opportunities for training and the need for training varies quite considerably from office to office.

The majority of employees are permanent and as a result of that there is obviously a need for on-going training. That is something that GHD does take reasonably seriously. We have 11 per cent contract staff and some of those are contractors who come in when there is a high workload. GHD also has casual staff and that’s again generally in response to workload where there might be enough work for say two days a week.

Employees who came from Works Australia (formerly part of the Department of Administrative Services) all came into GHD as permanent staff. There were some who were looking for casual employment and they were taken on a casual basis. But the majority of Works Australia staff were all offered permanent positions. In terms of training opportunities, given the fact that we are a consulting practice, obviously our prime objective is to service a client, with a focus on commercial outcomes.

The training opportunities that arise are really dependent upon the projects we have with any one office and probably there are greater training opportunities in the larger offices because they are the offices that tend to get the larger projects. Therefore there is an ability to be able to put more junior staff onto a major project under the management of a senior engineer to provide on-the-job training.

Engineering is an area where there are changes and you do need to keep up to date. GHD has a policy of trying to take on up to 12 graduates per year, subject to having the required workload. GHD has been successful in the last couple of years, with 3 to 4 graduates taken on within each region.

In addition, GHD has a number of scholarships which they offer to third year engineering students. There are about 3 or 4 issued each year. The scholarship is about $7,500 and it’s designed to assist students through their final year of university. In allocating them we choose those we feel are able to make a contribution to the business once they graduate.

In terms of training overall there have been a number of changes that we’ve seen within the industry over the last probably four or five years, and it’s probably arisen out of the demise of departments such as the Department of Housing and Construction. A few years back it had a workforce of 10,000–12,000 people and that department was really one of the areas where a lot of training took place. With the demise of the Department of Housing and Construction those who were in that organisation have all filtered through to various organisations including many of the consulting engineering practices.

The same applies to the Department of Defence. With the downsizing of the Department of Defence there are a lot of Defence staff that have been trained as Army engineers moving into consulting engineering practices. One of the realities is the level of training that is afforded within Defence and previously within the Department of Housing and Construction simply can’t be afforded by private consultants, the impact of this will not be felt for another 10 to 15 years once those people have retired.

For graduates working with GHD we offer informal training up until such time as they’ve gained some experience. At that stage GHD explores the possibility of any relevant courses that they might want to do. Postgraduate study is encouraged by GHD. The arrangement is that GHD will cover the cost of the course subject to the graduate passing the course. Employees cover the costs up front, and when they pass GHD will reimburse the cost of the study.

Within our staff appraisal system there is also an opportunity to look at training requirements. Annually staff do a self appraisal and as part of that they identify any needs areas in which they feel extra training is required; this is then reviewed by their manager.

GHD also provides on-the-job training via an expert mentoring system. GHD has a large number of senior professionals in its main offices who are experts in their respective fields. Opportunities are provided for the staff in smaller offices to carry out work under close supervision from an expert in one of the main offices; that way the staff in the smaller local offices have a chance to develop their skills.

Michael Brouwer—Manager, Canberra Office, Gutteridge Haskins and Davey

9

Small to Medium Sized Enterprises (SMEs)

In the past few years SMEs have been forced to cut staff to the bare minimum because of the current market. A survey undertaken as part of this study found concerns by consulting companies in the provision of training. The survey of 180 consulting engineering firms (26 per cent response rate) found that the barriers to providing training are: overall costs 53 per cent; time required of supervisor 38 per cent; non-productive time of graduate 32 per cent; and 20 per cent of small firms cited regional isolation as a barrier. It was interesting to note that the majority of these factors were as much a barrier to large firms as they were to SMEs. Full survey results are listed in Appendix 2.

These figures coincide with work done by the Australian Centre for Industrial Relations Research and Training, Sydney University. Figures in relation to hours of training per employee show that across all industries the time spent dropped from 5.55 to 4.91 hours between 1993 and 1996; and the percentage of employers providing training dropped from 22.62 per cent to 17.77 per cent, between 1993 and 1996. The Centre's Director concluded that:

> *Over the past five years there has been a dramatic reduction in the amount of structured training provided by employers ... If organisations continue to demand skilled workers that are available to work at any time …then new arrangements need to be put in place that will deliver productivity benefits and flexibility. This may only be achieved if the present focus on the enterprise is reassessed and industry and economy wide initiates that can enhance the development of skills are pursued. (Callus 1998)*

In discussions during the workshop it was concluded that a group training scheme would assist SMEs in providing an environment in which employees are trained with a minimal overhead cost. Then SMEs could participate in a cost-effective way, over a four-year period where engineering graduates could move between companies gaining practical training experience.

In essence group training schemes means that companies pay a subscription and become part of the network. In rapidly growing industry clusters there is an awareness for a skilled workforce in the future, and yet often SMEs can't afford to train in the short term.

Case Study: Hunternet Group Training Scheme

The HunterNet Group Training Scheme was established in 1996 and has 29 member companies ranging in size from 10–150 employees who collectively employ more than 1400 people. The companies have a combined turnover in excess of $170 million.

HunterNet is a registered cooperative under the NSW Co-operative Act, and members hold one share and are entitled to one vote. HunterNet members have recently established their own training scheme because the companies identified a shortage of skilled labour and saw there were insufficient resources in small companies to provide training and a variety of work.

The concept behind the scheme was to use the strength of the network to provide specialist skills and experience to the apprentices, to encourage the TAFE sector to look at the program content and delivery and to then create a company to administer and coordinate the training of the apprentices.

The companies have all signed onto a code of ethics to guard against unethical practices by individual companies. In particular, there is an agreement by firms not to make unsolicited offers of employment to any trainee not of the parent company. Trust is a vital component in group training schemes and the fact that industry has taking the initiative in establishing the scheme greatly assists in developing that trust. Government has provided the essential administrative support to develop the network.

Hunternet Group Training Scheme: Code of Ethics

This Code of Ethics reflects the spirit of mutual understanding, co-operation and respect of member companies working in unison to provide a creative training environment for apprentices and trainees.

Conduct of shareholders

As a parent or foster company:

1. Provide a safe and healthy environment for all employees
2. Maintain a creative environment for apprentices and trainees in which training competency and outcomes are maintained and achieved.
3. Liaise closely with the training manager on all issues and concerns regarding the apprentices’ and trainees’ welfare and training.
4. Avoid production pressures impacting on the integrity of the training program.
5. Not make unsolicited offers of employment to any apprentice or trainee of which the member is not the parent company.
6. Ensure clear communication between fellow shareholders on all issues regarding the achievement of company objectives or impacting on fellow shareholders.
7. Provide adequate resources to implement the training program.

8. Maintain a professional approach to all business matters so as to enhance the reputation and standing of the HunterNet Group Training Company.
9. Ensure all financial commitments and obligations are met on time.

From a presentation entitled A networking solution to skills shortage by Harvey Knox—Manager, HunterNet Cooperative Ltd June 1998

Whether schemes such as these will be sufficient to compensate for what could be called the involuntary surplus, created by the downsizing of the public sector bodies, is yet to be determined, bearing in mind that lead times are at least three or four years before you see a benefit from training investment.

In the survey of consulting firms it was found that 75 per cent of large consulting firms (over 50 employees) offer job rotation schemes to new graduates, whereas only 50 per cent of the smaller firms surveyed provide this benefit. Similarly, 75 per cent of large firms offer short courses to new recruits compared to around 69 per cent of smaller firms (Appendix 2).

This was also confirmed in the survey of young engineers, who reported that the firms they were working for offered cadetships (19 per cent), and job rotation schemes (29 per cent). They did report that short courses offered were 71 per cent, and in-house training (86 per cent). However, there was no break down according to firm size (Appendix 5).

It will be vital in establishing partnerships between universities and industry that appropriate communication mechanisms are in place so that industry requirements can be clearly defined.

The opportunity to establish a cooperative professional resource to SMEs is one of Australian industry’s big gaps at the moment. Information data bases should be made available to the community and industry to inform them of their options. These could provide responses to such questions as what courses are being run;, what assistance is available to employees; how do SMEs train technologists to be professional engineers; if they come on as graduates what do SMEs need to do to ensure their development; and what courses are available on the Internet?

Collectively a supportive environment for both the graduates and the industry needs to be structured to provide the framework for a good training package that’s not overly bureaucratic, comprehensible and works without too many on-costs. This will assist in ensuring that Australia will have qualified, trained personnel to meet the challenges of the development of our country in the future.

10

Industry Training Advisory Bodies

The National Utilities Industry Training Advisory Body (NUITAB) has responsibility for electricity supply, which includes electricity generation, transmission and distribution, the water industry and the electro-technology industry. The NUITAB is funded by the Australian National Training Authority which in turn is funded through Department of Employment, Education, Training and Youth Affairs, thereby providing a formal link back to the Department.

ITABs work in the vocational education and training system, which comprises about 80 per cent TAFE representation, but also includes private sector training providers. The major project the NUITAB has been developing over the last several years is the training package. The package is an extension of the competency standards that the Industry Training Advisory Bodies have been working on since 1990–91 and incorporates packaging units of competency to form a qualification. The agreed national training framework, of which training packages are an element, was endorsed by the Ministerial Council in November 1996. The Council comprises the ministers for vocational education and training in all the State Governments and includes the Federal Government.

The NUITAB supports the group training idea as it believes that it has the potential to assist SMEs, which may not be able to take on new graduates for three or four years. The graduate or the trainee is employed by the group training company and is rotated through a number of employers. The New South Wales utilities which developed out of the old Pacific Power or Electricity Commission have discontinued the rotational experience of their graduates, because they are concentrating more on what they define as their core business.

The NUITAB believes that the most large employers will be able to deliver in training will be about 5 per cent or 10 per cent of what the old public sector departments used to deliver in the way of employment and training and the rest of it may well be fragmented.

There needs to be an opportunity to cross-link with the sort of experience that the TAFE sector can offer, so that graduates can step sideways into trade training areas to develop the sort of competencies that experienced engineers need.

Twenty-one per cent of engineers are currently studying for a formal postgraduate qualification in a technology area or in management. It is 14 per cent in management and 7 per cent in the technology area. The proportion focusing on technology has gone up slightly in the last ten years, but the largest increase has occurred in management. That again has gone up from 2 per cent in the early 1980s to 14.1 per cent in 1998.

The proportion of engineers working as contractors and the proportion of engineers who are acquiring management skills will mean a significant change in the culture of the engineering profession and the way in which engineering is practised in Australia.

Increasingly engineers will see themselves as small business people and the emphasis will be on gaining a required blend of technical skills and small business skills. The Karpin Committee, which examined leadership and management skills, found that the professional development of managers in particular was something that was shifting very quickly from a responsibility initially imposed on the enterprise to one that was becoming a shared responsibility.

11

Conclusion

The Institution of Engineers originally undertook this study because of its concern with aspects of the development of training of engineering graduates. But it continued its interest because it believes that the problem is in fact much wider than that of the early professional formation of graduate engineers.

Recent figures from the report, *High Road or Low Road?* (ABF1997) indicate that Australian employment growth has generally been faster in industries which have spent less time training their employees, while employment loss has taken place in the more training-intensive industries. They conclude that the Australian economy is broadly characterised by faster employment growth in:

- lower skilled broad occupational groups;
- lower wage industries;
- industries with a lower measured propensity to innovate;
- industries with a lower commitment to training.

Australia is a small economy and governments in this country and other countries of similar size have always recognised the need to ensure that market failures are not allowed to obscure the fundamental benefits of allowing a free market to operate wherever it is reasonable.

While it is true that individuals, industry and the profession will have to take an increasing responsibility for their own development and for the development of the profession over the next few years, it is also true that there are steps that governments must be taking if they wish to provide a framework in which desirable growth can occur. It is vital that government be willing to contribute to what is an absolutely essential investment for our future. How we go about sharing that responsibility is the main challenge.

The smaller, medium sized industries (SMEs) as well as large consulting firms, indicated in the survey that overall costs and the time required of supervisors are the main barriers to them providing training. This, along with other studies, cited in the papers indicate that the provision of training opportunities cannot be left solely to the private sector.

Universities, government, private education providers and the profession itself all have a role to play in assisting in the provision of engineering training. The HunterNet Group Training Scheme and the Teaching Company Scheme would appear to offer good examples of how to create these partnerships. The HunterNet scheme will next year introduce a group training scheme for professional engineers. The success of the Hunter Valley scheme came from a realisation within industry that there was value in working together.

It may be that their particular geographical space assisted in the initial establishment of that network. Representatives from the workshop all agreed that a group training scheme at the professional level should be trialled. Identification of the factors which assist industry to establish their own schemes would assist in fast tracking this process.

The Institution has in recent times issued two publications which are designed specifically to assist graduates to manage their training needs. *The Career Planner and Logbook for Professional Engineers* is produced in conjunction with Engineering Education Australia and provides clear guidance on options for career planning. The other publication, *Graduate Development and Continuous Assessment*, is more targeted for enterprises to work with graduates in establishing professional engineering training pathways. To date it has been the larger companies which have taken advantage of the graduate development program. From the positive feedback IEAust has received, it would also have substantial benefits for the smaller companies.

More clearly understanding the linkages between investments in training and economic benefits is becoming increasingly significant. It is vital that Australia as a major player in the global technology market, guards against undervaluing our substantial intellectual resources. This will in part require balancing the investment in tangibles, such as capital equipment, with investments in intangibles, such as research and development and training. There has been much work already done on the knowledge economy and in the workshop discussions it was agreed that it is important that Government should continue to find better ways of measuring what types of investment in training provide the best returns.

Graduates and companies will continue to need assistance in developing their training programs. SMEs have indicated that taking resources off their main business is not something they do readily. Assisting them in this process will deliver better outcomes. Just as the Department of Science, Tourism and Industry have developed programs through AusIndustry to assist industry in developing their research and development programs, the Department of Employment, Education, Training and Youth Affairs could work to provide information to address training requirement.

Training our engineering graduates will ensure that Australia remains on track to grow the necessary high technology firms, to ensure they remain both domestically and internationally competitive.

12

Issues and Options for the Future

- IEAust, appropriate peak bodies (e.g. ESAA, AWWA, AustRoads) and all levels of government work together to define the necessary conditions to establish group training schemes for graduate engineering training in the water, electricity and road sectors. This could draw on experience of the scheme currently underway in the Hunter Valley, entitled Hunternet Group Training Scheme.
- IEAust could identify pathways for those who wish to take advanced diplomas which have a strong on-the-job component and which, in turn, provide opportunities for articulation for non-university graduates to complete degrees and move into the professional workforce.
- The Department of Employment, Education, Training and Youth Affairs could commission case studies of Australian companies which have taken the initiative and worked with private providers and universities to design courses which can be taken as part of work practice, e.g. the software engineering masters course of Campus Thomson and University of Technology, Sydney.
- There is a need for greater provision of temporary placements for students in industry, with attention to the fact that placements of semester or greater length can provide better value to both students and industry than vacation placements. The Department of Employment, Education, Training and Youth Affairs, Department of Industry, Science and Technology , IEAust and the ACED could investigate the relevance to Australia of any revised Teaching Company Scheme, currently the subject of an international conference in the United Kingdom. The scheme involves a graduate working in a company for two years, under the supervision of an academic.
- There will continue to be a requirement for universities to work with their students and with industry to identify options for training opportunities. This is already occurring to some extent in the form of industry partnerships with universities, but will need to be strengthened.
- Governments could continue to provide seed funding, on a case by case basis to private providers, particularly in those cases where new courses address emerging problems, and are therefore not as readily subject to early commercial return. In these circumstances the private sector partner should continue to provide 50 per cent or more of the costs of developing the course.
- Given the importance of correcting the imbalance between investment in intangibles, and investment in tangibles, the Department of Employment, Education, Training and Youth Affairs and the Department of Industry, Science and Technology could undertake a study to further the OECD work on the development of more direct economic measures of lifelong learning skills and the role of learning in the workplace.

- The Institution is continuing to work with industry to assist in defining graduate development needs. The Graduate Development Program has already been used very successfully within large corporations. The Institution believes that the program would also greatly assist small to medium sized enterprises in developing training programs for engineers. The Department of Employment, Education, Training and Youth Affairs and the IEAust could work together to draw up a program that would effectively deliver the Graduate Development Program to the SME sector.
- The Department of Employment, Education, Training and Youth Affairs and IEAust could work together to link existing data bases on products which exist in universities, private training providers, the IEAust and on the Internet, which would assist SMEs in developing their training programs.

Appendix 1

Manual for the Accreditation of Professional Engineering Courses

November 1997

Institution of Engineers, Australia

Introduction

In response to the recommendations of the Review of Engineering Education and to the changes that have occurred and continue to occur in higher education in Australia, the Institution of Engineers, Australia, in consultation with key stakeholders, has developed a new system for the accreditation of professional engineering courses.

The new accreditation system aims to focus more explicitly than in the past on the need to ensure that Graduates from professional engineering courses are adequately equipped to begin engineering practice and to prepare themselves, through appropriate practical experience and continuing professional development, to carry out the duties and responsibilities of independent Professional Engineers.

Under the new system, Universities seeking accreditation of the professional engineering courses which they deliver will be required to demonstrate that they have in place a quality management system. The Institution is aware that the quality systems in place will differ from University to University but they should follow the principles embodied in international standards such as ISO9000 and should encompass the following elements:

- the quality management system should cover course content, curriculum development and specification of student assessment. It should include provision for regular review of course and subject objectives and content and for monitoring Graduate attributes and performance against the course objectives and performance standards;
- the quality management system should apply to all engineering courses offered within a University;
- an appropriate records management system should be in place to ensure that at any time an audit of the quality management system can confirm the integrity of the system;
- a significant number of practising Professional Engineers (both from industry and academia) should be involved in quality management system reviews;

- a significant number of practising Professional Engineers should be involved in the development or review of course objectives and content and in reviews of the quality of the Graduates, as reflected in their attributes and performance.

The new system will be introduced from the beginning of 1998. To provide Universities with an opportunity to optimise their existing quality management systems to meet the requirements of the new accreditation system, preliminary discussions will be held during the first Semester in 1998 with Universities whose courses are scheduled for routine review in 1998. During these discussions, advice will be given on the information and documentation that will be required to be submitted prior to a visit by an Accreditation Panel in the second Semester 1998.

Policy on Accreditation of Professional Engineering Courses

1. Preamble

University education provides the learning base upon which competence for a professional engineering career is built. It is important that the education provides the Graduate with the generic attributes listed in Section 2 below.

It is equally important that the education process be accredited by The Institution of Engineers, Australia (IEAust) to give confidence to the students, the Universities and the profession that the education will indeed provide a Graduate with the required attributes. Through the process of accreditation of the University education, as the representative of the profession, the IEAust will:

- ensure that Graduates from an accredited course are adequately prepared to enter and to continue the practice of engineering;
- promote best practice;
- promote the standing of accredited courses to members and potential members of the engineering profession in Australia.

2. Generic Attributes of a Graduate

Graduates from an accredited course should have the following attributes:

- ability to apply knowledge of basic science and engineering fundamentals;
- ability to communicate effectively, not only with engineers but also with the community at large;
- in depth technical competence in at least one engineering discipline;
- ability to undertake problem identification, formulation and solution;
- ability to utilise a systems approach to design and operational performance;
- ability to function effectively as an individual and in multi disciplinary and multicultural teams with the capacity to be a leader or manager as well as an effective team member;

- understanding of the social, cultural, global, environmental and business responsibilities (including an understanding of entrepreneurship and the process of innovation) of the Professional Engineer, and the need for and principles of sustainable development;
- understanding of and a commitment to professional and ethical responsibilities and
- a capacity to undertake lifelong learning.

3. Principal Elements of IEAust Accreditation Process

There are three principal elements in the IEAust accreditation system which are seen as essential in determining whether the attributes of the Graduate engineer are being achieved. These are:

- the teaching and learning environment;
- the academic course being offered;
- exposure to professional engineering practice.

4. The Teaching and Learning Environment

The following must be in place within the teaching and learning environment:

- an identifiable structure responsible for engineering education within the University;
- a strategic statement by the University on engineering education;
- an effective advisory mechanism involving industry participation;
- capabilities in terms of staffing and resources to ensure that the stated objectives can be met.

5. The Academic Course Being Offered

The minimum requirement for the academic course is a four-year full-time course or equivalent. The following elements of the academic course are seen as critical to ensuring that the Graduates acquire the generic attributes listed in Section 2.

5.1 Course Philosophy and Objectives

There must be a clear statement of the mission and the objective for each course along with the broad characteristics expected of a Graduate.

5.2 Course Structure and Content

The course structure and content must be such that the Graduates acquire the generic attributes listed in Section 2 and achieve the course objectives. Typically a four-year professional engineering course will have the following elements:

- mathematics, science, engineering principles, skills and tools (computing, experimentation) **appropriate to** the discipline of study. This element should not be less than 40 per cent of the total course content;
- engineering design and projects. This element should be about 20 per cent of total course content;
- an Engineering Discipline specialisation. This element should be about 20 per cent of total course content;
- integrated exposure to professional engineering practice (including management and professional ethics). This element should be 10 per cent of total course content;
- more of any of the above elements or other elective studies. This could be in the vicinity of 10 per cent of total course content.

5.3 Course Standard

The University must employ some method of external benchmarking to ensure that the course material and standards reflect relevant best practice.

6. Exposure to Professional Engineering Practice

The students must be exposed to professional engineering practice **integrated throughout** their course to enable them to develop an engineering approach and ethos, and to gain an appreciation of engineering professional ethics. The purpose of this is to facilitate their entry into the profession and to better prepare them to be able to develop the attributes listed in Section 2. This exposure **must include**:

- use of staff with industry experience;
- practical experience in an engineering environment outside the teaching establishment;
- mandatory exposure to lectures on professional ethics and conduct.

Exposure to professional engineering practice may also be obtained through a combination of the following:

- use of guest lecturers;
- use of industry visits and inspections;
- an industry based final year project;
- regular use of a logbook in which experiences are recorded.

7. The Accreditation Process

The IEAust accreditation process will increasingly focus on outcomes as the Universities develop internal systems which ensure that the Graduate is adequately prepared to enter the engineering profession. It will enable Universities to play a more significant role in the accreditation process.

The concept involves quality assurance systems and processes being in place which will ensure that the Graduate is adequately prepared to enter the practice of engineering. As Universities conduct internal accreditation processes which cover much common ground with the professional accreditation undertaken by the IEAust, there is scope for improved efficiency by minimising duplication in the two accreditation processes.

The IEAust will visit at five-year intervals to ensure that the education that is being delivered provides the Graduates with the attributes listed in Section 2. During the visit emphasis will be placed on verification of the standards reached by the students through detailed inspection of the applicable quality output measures. Verification that the quality systems are in place will increasingly be carried out by Desktop Assessment.

Objectives and Measures to be used in the Accreditation of Professional Engineering Courses

1. Introduction

The following information outlines the objectives and measures to be used by the Institution of Engineers, Australia (IEAust) in the accreditation of professional engineering courses.

2. Generic Attributes of a Graduate

Graduates from an accredited course should have the following attributes:

- ability to apply knowledge of basic science and engineering fundamentals;
- ability to communicate effectively, not only with engineers but also with the community at large;
- in depth technical competence in at least one engineering discipline;
- ability to undertake problem identification, formulation and solution;
- ability to utilise a systems approach to design and operational performance;
- ability to function effectively as an individual and in multi disciplinary and multicultural teams with the capacity to be a leader or manager as well as an effective team member;
- understanding of the social, cultural, global, environmental and business responsibilities (including an understanding of entrepreneurship and the process of innovation) of the Professional Engineer, and the need for and principles of sustainable development; of sustainable development;
- understanding of and a commitment to professional and ethical responsibilities and
- a capacity to undertake lifelong learning.

Accreditation Objective

The accreditation process will focus on there being in place a strategy and process which will ensure that the Graduates from a professional engineering course have the above attributes.

Accreditation Measure

A statement **(approximately 2 pages)** must be submitted describing the educational strategies and philosophies which are in place and which demonstrate that the generic attributes will be developed in the student.

3. Principal Elements in the IEAust Accreditation System

3.1 The Teaching and Learning Environment

The University should ensure that a structure is in place for managing the delivery of professional engineering education within the University.

Accreditation Objective

The accreditation objective is that the Teaching and Learning Environment will be structured so as to deliver an education in which the Graduate will have been exposed to the following aspects of the engineering profession:

- staff having a professional approach;
- equipment representative of modern practice;
- computing technology and information retrieval systems relevant to modern practice.

Accreditation Measure

It is expected that the following elements will be in place within the Teaching and Learning Environment. If not, details must be provided of how the Teaching and Learning Environment is structured so as to achieve the stated objectives.

3.1.1 An identifiable structure responsible for engineering education within the University with responsibility for:

- management and control of the delivery, design and content of **all** engineering courses;
- management and control of resources relating to the delivery of **all** engineering courses;

- the appointment of staff with competencies that encompass:
  - teaching skills;
  - discipline skills;
  - research skills;
  - English language competence
  - (both written and oral);
  - industry experience.

3.1.2 A strategic statement on engineering within the University with the following elements forming part of the accreditation measurement process:

- a plan for course development and maintenance;
- a resourcing plan for engineering within the University;
- a ‘long range’ forecast for engineering within the University;
- evidence that the claimed strategic objectives are linked to Australia’s overall economic and industry policies.

3.1.3 Demonstration that the stated objectives can be met as evidenced by the following:

- resources such as to ensure that the stated objectives can be met;
- sufficient staff with engineering competence, in both knowledge and experience, to be able to adequately teach the topics from an engineering viewpoint and as evidenced by registration on the National Professional Engineers Register (NPER)[1];
- staff numbers to meet teaching loads, for providing advice and guidance to students, to allow for professional development and for interaction with practitioners and employers of Graduates.

3.1.4 An advisory mechanism involving industry participation for course development and maintenance

For the maintenance of standards and for the future development of the undergraduate engineering courses, it is expected that an advisory mechanism is in place which involves industry participation.

4. The Academic Course

The minimum requirement for accreditation of the academic course is a four-year full-time course or equivalent.

Accreditation Objective

The accreditation objective is to ensure that the elements generally considered as essential in an engineering course are included within the structure at an appropriate standard.

4.1 Course Philosophy and Objectives

Associated with **each** course there must be a clear statement of the mission and the objective of the course with the broad characteristics expected of a Graduate.

Accreditation Objective

The accreditation objective is to ensure that there is a clear statement of the specific streams of specialisation in a discipline area and to ensure that the focus is such as to so characterise a graduate from that course.

Accreditation Measure

A statement must be provided which defines the attributes of a graduate within each stream of specialisation.

4.2 Course Content and Structure

The course structure and content must be such that the graduates acquire the generic attributes listed in Section 2. It is expected that the course will have the following elements:

- mathematics, science, engineering principles, skills and tools (viz. Computing and experimentation) **appropriate to the discipline of study**. This element should not be less than 40 per cent of the total course content;
- engineering design and projects. This element should be about 20 per cent of total course content;
- an Engineering Discipline specialisation. This element should be about 20 per cent of total course content;
- integrated exposure to professional engineering practice (including management and professional ethics. This element should be 10 per cent of total course content;
- the remaining 10 per cent of the course can encompass the above elements or other electives.

Accreditation Measure

The course structure and content must be consistent with a professional level course. Any substantial deviation from the representative allocations above must be demonstrated to be consistent with the course objective so as to produce a Graduate with the generic attributes listed in Section 2.

4.3 Course Standard

The University must employ some method of external benchmarking to ensure that the course material and standards reflect international practice levels. (Refer also to Section 3.1.4).

Accreditation Objective

The accreditation objective is to ensure that each of the elements of the course is taught and assessed at internationally recognised levels for professional engineering.

Accreditation Measure

During the visit the standard of the course will be assessed by scrutiny of the quality output measures which are applied to ensure that the generic attributes of the graduate are being met. This will involve scrutiny of examination papers/scripts, project and design reports and other applicable output measures as are applied.

5. Exposure to Professional Practice

The students must be exposed to professional engineering practice to enable them to develop an engineering approach and ethos and gain an appreciation of engineering professional ethics. The exposure must be **integrated throughout the course**.

Exposure to professional practice **must include** the following elements:

- teaching by staff with industry experience;
- practical experience in an engineering environment outside the teaching establishment;
- lectures on professional ethics and conduct integrated into the course.

If the exposure cannot be obtained by the above specified methods, evidence must be provided that equivalent exposure is included in the course.

The following are additional elements that may be considered in meeting this requirement:

- use of guest lecturers;
- use of industry visits and inspections;
- an industry based final year project;
- regular use of a logbook by the students in which professional engineering experiences are recorded.

Accreditation Objective

By exposing students to professional engineering practice throughout the course, it is intended that the student will acquire an understanding of what will be experienced in entering the profession of engineering and of the needs and expectations of the profession.

Accreditation Measure

It is expected that the mandatory exposure itemised in Section 5 will be integrated into the course structure. The cumulative amount of structured exposure throughout the course is expected to be equivalent to 12 weeks of experience in industry. The accreditation process will focus on practices/strategies being in place for ensuring that students are exposed to professional engineering practice prior to graduation and on the measures that are used to assess the results.

Documentation to be Submitted by the University to the Institution Of Engineers, Australia for the Accreditation of Professional Engineering Courses

General Information

- Name of University seeking accreditation.
- Title of courses(s) for which accreditation is being sought.
- Current accreditation status.
- Level of accreditation sought.
- Date of previous accreditation assessment.
- Date of introduction of the course(s) being assessed.
- Contacts within the University for accreditation purposes.
    - Name, title and contact details:
    - Phone:
    - Fax:
    - Email address:
- Name, title and contact details of officer responsible for the preparation of the accreditation documentation:
    - Phone:
    - Fax:
    - Email address:
- Name of the Teaching Unit responsible for the course(s).

- Name of the University conferring the qualification or award.
- Name and nomenclature of award on testamur.

In addition to the general information listed above, the following additional information is to be added to this template. The documentation should be provided in **one** Volume in a spiral binder.

1. Introduction

Give brief details of the organisational structure responsible for the delivery of engineering education within the University, including both the academic and administrative components. This may be represented diagrammatically with an organisation chart being attached. The names and titles of the principal office holders from Vice-Chancellor to Head of Department level should be identified.

2. Generic Attributes of a Graduate

Provide a statement in narrative form **(approximately 2 pages)** describing the quality management system that is in place which demonstrates that the Graduate will have achieved the generic attributes listed under Section 2 of the *Policy on Accreditation of Professional Engineering Courses*.

3. The Teaching and Learning Environment

Under the following headings, outline the Plan for establishing an appropriate Teaching and Learning Environment to deliver professional engineering courses. If details about the following elements are not able to be provided then details should be provided showing how the Teaching and Learning Environment is structured so as to achieve the stated objectives.

3.1 An identifiable structure responsible for engineering education within the University with responsibility for:

- management and control of the delivery, design and content of **all** engineering courses;
- management and control of resources relating to the delivery of **all** engineering courses;
- the appointment of staff with competencies that encompass:
  - teaching skills;
  - discipline skills;
  - research skills;
  - English Language Competence (both written and oral);
  - industry experience.

3.2 A strategic statement on engineering *within the University with the following elements forming part of the accreditation measurement process:*

- a plan for the development, monitoring and maintenance of professional engineering courses such that they are at a contemporary level and that the generic attributes of the Graduate are met;
- a resourcing plan for engineering within the University;
- a 'long range' forecast for engineering within the University;
- evidence that the claimed strategic objectives are linked to Australia's overall economic and industry policies.

3.3 A statement on the capabilities in terms of staffing and resources as defined in the resourcing plan to ensure that the stated objectives can be met.

This should be provided in terms of the following:

- **adequacy of the facilities** to deliver engineering undergraduate courses e.g. laboratories, computing facilities, information retrieval systems;
- **adequacy of the funding** to deliver engineering undergraduate courses;
- **adequacy of the current staff** in terms of numbers, competencies and registration on the National Professional Engineers Register (NPER)[2].

3.4 A description of the mechanism used for industry participation in the development and maintenance of courses.

4. The Academic Course

Provide a statement which confirms that the course is of four years duration or equivalent.

4.1 Course Philosophy And Objectives

Provide a statement on the specific streams of specialisation which are being offered within the course and of the attributes that a Graduate from the course will have both in terms of the generic attributes listed in Section 2 of the *Policy on Accreditation of Professional Engineering Courses* and in terms of the stream of specialisation.

4.2 Course Content and Structure

4.2.1 *For* ***each subject*** *in the course, provide the following details (maximum of one page per subject) :*

- Subject objective
- Subject description
- Contact hours
- Credit value
- Assessment methods

4.2.2 *Demonstrate that the course contains the elements listed in* ***Section 5.2***

4.2.3 ***Course Structure and Content*** *of the Policy on Accreditation of Professional Engineering Courses.*

This should be done by a mapping in matrix or tabular form of **each subject** in the course against the typical content of a four-year professional engineering course as prescribed in Section 5.2 of the *Policy on Accreditation of Professional Engineering Courses*.

The representative allocations should show conformance with the percentage allocations set down for each element. Any substantial deviation from the representative allocations must be justified as being consistent with the course objectives and with producing a graduate who has the *generic* attributes defined in Section 2 of the *Policy on Accreditation of Professional Engineering Courses.*

4.3 Course Standard

Provide a statement on **each** of the following:

- the measures that are in place to provide the Graduate with the defined generic attributes.

Examples of measures are:

- Examinations
- Projects, in particular final year projects
- Employability of Graduates
- Presentations
    - on how the processes used within the University ensure that there is a continual improvement in the standard of the Graduate.
    - on the methods used for external benchmarking that the course material and standards reflect international practice levels.

5. Exposure To Professional Practice

Provide statements on the practices/strategies that are in place which ensure that students are exposed to professional engineering practice prior to graduation and on the measures used to assess the results.

Appendix 2

Employer Provision of Training Opportunities for Graduates: Survey of Consulting Firms

This report summarises the responses from a survey of 180 engineering consulting firms (with a 27 per cent response rate) to a *one* page fax survey of training opportunities for graduates in their firms.

The 47 firms employed a total staff of 1846, 770 of whom were engineers (42 per cent).

The firms varied in total staff size from 3 to 274. Mean staff size was 40 but the median staff size was 20. Engineers on staff showed a mean of 16 and a median of 8.

For comparative analysis the firms were categorised as small (total staff 20 or less), medium (21–50) and large (>50). The number of firms in each category was 25, 14 and 8 respectively.

The firms had taken on a total of 217 graduate engineers over the last six years (an average of 0.77 graduates/firm/year). The average number of graduates taken on each year (36) represented 4.7 per cent of the engineers on staff.

A table showing the uptake across categories of firms is shown below.

Table A2.1 Response Rate Across Categories of Firms

	Small Firms	Medium Firms	Large Firms	Total Firms
Number of Respondees	25	14	8	47
Total Employees	317	466	1063	1846
Average Employees/Firm	13	33	133	39
Total Engineers	136	196	437	769
Average Engineer/Firm	5.4	14	55	16
Graduate Uptake (6 years)	48	57	112	217
Average Graduates/Firm/Annum	0.32	0.68	2.33	0.77
Average Graduate/Engineers/Annum	5.9	4.9	4.3	4.7

Table A2.2 shows the percentage of firms which offer different training mechanisms for new engineering employees.

Table A2.2 Percentage Firms Offering Training Mechanisms for New Engineering Employees

Types of Training	Percentage of Firms Offer This Type Small Firms	Medium Firms	Large Firms	Total Firms
Short courses	60	57	75	62
Job Rotation	52	50	75	55
Secondments	4	7	25	9
Cadetships	0	0	12	2
Traineeships	8	7	12	9
Scholarships	4	0	25	6
In-house Work	16	29	0	17
Post Graduate Support	4	0	0	2
External Seminars	4	4	12	6

It should be noted that the last three types were not offered as a standard option in the survey but were provided by some respondees under the option ‘other?’. This would explain why some small and medium firms stated ‘in-house work’ as a form of training, whereas larger firms did not record it in that manner. In the former case, it was offered by some firms as their only type of training.

The table below shows the firms views on ‘what are the barriers to you providing training opportunities?’

Table A3.3 Employers’ Response to Barriers to Provision of Training Opportunities

Barriers	Percentage of Firms Who Consider This Issue a Barrier Small Firms	Medium Firms	Large Firms	Total Firms
Time required of Supervisor#	36	36	50	38
Non-productive time of Graduate#	28	50	12	32
Overall Costs#	48	64	50	53
Regional Isolation	20	0	0	11
Graduates leaving after training	8	7	0	11
Low fees#	16	21	12	17
Quality of Graduates	4	7	12	?
High wages for Graduates#	4	0	0	6
Lack of Work#	4	0	0	2

#Note: Overall costs were mentioned in many respects, including in relation to size of firm, quantum of work and the need to receive more from fees. Hence many of these factors are related. Of the 40 respondees who provided answers to this question —5(11 per cent) did not—38 (95 per cent) considered one or more of these factors were a barrier to graduate employment/training.

The table below illustrates responses to the question ‘what incentives could be provided for firms to take on new graduates?’.

Table A2.4 Employers’ Response to Provision of Incentives to Employ New Graduates

Incentives	Percentage of Firms Who Support This Incentive			
	Small Firms	Medium Firms	Large Firms	Total Firms
Contributions to HECS#	4	0	0	2
Funding Assistance#	28	7	25	21
Training Courses (externally provided)	12	0	25	11
Scholarship Assistance/Wage Subsidy#	20	43	12	26
Lower Salaries for Graduates#	16	0	0	9
Tax Incentives#	0	21	12	9
More Work for the Firm#	4	21	12	11
Higher Fees for the Firm#	12	14	12	13
Time (uncosted)#	0	14	12	6
Bonds to Retain Graduates	4	0	0	2

#Note: The question was open to respondents. Hence there is a variety of responses many of which relate to either a reduction in cost, taxation incentives or increased income—all of which relate to cost implication. Of the 40 respondees who offered views on incentives—7 (15 per cent) did not—all but one (i.e. 98 per cent) suggested one or more of these ‘cost’ initiatives.

Respondees were asked about their links with Universities. Twenty (43 per cent) stated that they have close links with a university. The proportion in each category were:

- Small 24%
- Medium 43%
- Large 100%

The table below shows the nature of the close links (percentages are the percentage of all firms in the category including those which don’t have close links).

Table A2.5 Percentage of Firms with Links to Universities

Links with a University	Percentage of Firms Which Link as Shown			
	Small Firms	Medium Firms	Large Firms	Total Firms
General Liaison/Discussion	16	29	37	23
Assistance with Finding New Graduates from University	4	0	12	4
Consulting Services to Firm	0	0	12	2
Lecturing by Employees	0	14	12	6
Firm Assistance to Research Funds or Personnel on Faculty Boards	4	29	75	23
Firm Assistance to Students	4	7	12	6

Appendix 3

AustRoad Report to the Workshop

May 1998

Most State Road Authorities and Department of Transport and Works, Northern Territory have provided 1996–97 data to update earlier data collected under the National Transport Planning Framework.

It now provides an up-to-date picture of the amount and type of competition delivery of roadworks on the Nation's State and National road network. Importantly it provides clear information on trend through the 1990's. Unfortunately there is no new local government data at this stage.

The presentations in this report show:

1. Overall 60 per cent of roadwork on State and National roads is being offered for competitive bid.
2. There is not a distinct difference between the amount of work that is competitively bid on the National Highway compared with other roads overall.
3. The proportion of maintenance work on roads that is competitively bid is much less than for non-maintenance roadwork.
4. The proportion of roadwork offered for competitive bidding has increased dramatically since 1990–91 and significantly since 1994–95. The amount of work competitively bid in 1996–97 was double that in 1990–91.
5. The private sector is winning the majority of roadwork on State and National roads and virtually all the work that is offered to competitive bid.

Background

A number of past studies have highlighted the need for competition reform in the supply of roadworks to government as a means of gaining greater value from the roadworks dollar.

In November 1995, Australian Transport Ministers agreed to a proposal to examine the issues in more detail and that this work form part of the cooperative policy development process known as the National Transport Policy Framework.

A draft NTPF report dated March 1997 was presented to the 27th meeting of SCOT in April 1997. It used the results of a survey of roadworks expenditure by Commonwealth, State, Territory and Local Governments to examine the extent and nature of competition in the supply of roadworks to government. It considered the extent to which different types of roadworks suppliers—and private sector suppliers in particular—had the opportunity to compete for government roadworks contracts, the extent to which they were successful in winning these contracts, the constraints on the competition process, and the reforms that had been or were being adopted to improve competition in the supply of roadworks to government. The report did not consider other important roadworks issues such as how much should be spent on roadworks or question the allocation of roadworks expenditure between alternative projects.

In considering the report, SCOT noted concern from members on the lack of currency of data used in the preparation of the report, particularly with respect to key tables. SCOT agreed that the report should not be published as an NTPF paper, nor forwarded to ATC Ministers, in its current form. SCOT also agreed that Austroads be asked to update, where possible, the data contained in key tables, with a view to presenting a preliminary report to the November 1997 ATC meeting.

SCOT further agreed that a brief explanatory paper should also be prepared to accompany the Austroads report, emphasising the significant changes that have occurred in this area in recent years.

This report provides both the updated data presentations and the ‘explanatory paper’ I sought by SCOT.

Context

The construction and maintenance of roads in Australia in the first 60 years of this decade was undertaken almost entirely by public sector organisations. These organisations were accountable to their respective governments for the deployment of road funds and management of the road network. They generally owned significant road plant and employed direct labour to undertake the road work. There was little competitive bidding for the work except where it was beyond the resources of the authority. Some of the inputs to construction such as sealing aggregate were sometimes provided under a contract which was competitively bid, but even this was not universal. These authorities exercised a high degree of control over the quality of the road work.

Since this period there has been a steady increase in the amount of work competitively bid. This has occurred at all levels. At the inputs level, roadwork materials have increasingly been supplied under contract after a competitive bidding process. At project level, whole road projects have been delivered following competitive bidding. More recently contracts for maintenance of areas of road networks for a given period, mostly 35 years, have been competitively bid.

These changes have been accompanied by organisational changes. In particular the need to have a client or principal to a contract has caused clear organisational separation of this role from service delivery functions in road and traffic authorities. Service delivery functions have adopted commercial operating principles. In some cases they have remained in the client organisation. In other cases they have remained in government ownership but have been made a separate corporation (e.g. Civil Construction Corporation in Tasmania). In other cases ownership has moved to the private sector by management buy out, sale or simply closure.

The draft NTPF report commented on the competitive neutrality of works bid under these various organisational arrangements. This report does not comment further on that matter.

The report's focus is on the amount of work that has been offered for competitive bidding and the trend of this over time. It draws on the previous data collected and presented by the NTPF project team and updates that data to show a recent time trend. The data presentation herein shows a clear national trend to increase the proportion of work that is competitively bid. In some places and for some types of work (notably construction ad National Highway work) where the competitive market has quickly established, all work is competitively bid and there will therefore be no further trend to increase. In other places (notably outlying areas) for other types of work (notably maintenance) much less work has been competitively bid and the pace of development of competitive market conditions may be slow and extend for some time into the future. The data in this report reflects a much lower level of competitively bid work in maintenance.

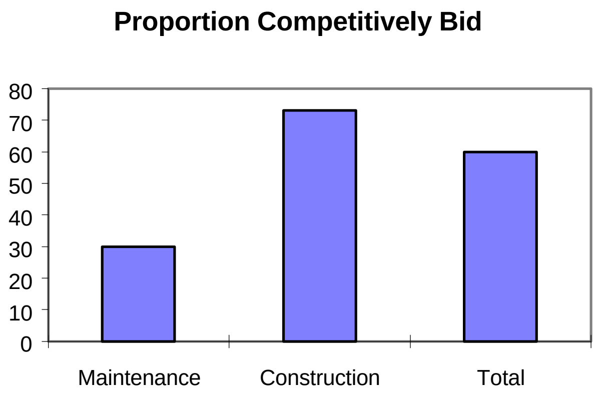
Finally the report also presents information on which parties undertook roadwork whether or not it was competitively bid as well as the same information for only that work which was competitively bid.

Updated Presentations

The following presentations are based on data captured for the 1996–97 year. No data was collected for local government because of the logistical issue of collecting it in the timeframe between SCOT meetings. The Australian Local Government Association (ALGA) have however expressed interest in collecting the data to measure trends over time and are approaching a wide sample of Councils to participate in such a study. ALGA have reported that this is unlikely to be commenced before the end of 1997.

The key definitions are provided with each presentation below and a fuller set of definitions is provided in the appendix. In some cases these definitions have been altered from those used in the NTPF report to improve the quality of the data. Where a road and traffic authority has expressed reservations about their data capture or has sought to add explanatory comment, that has been included under Qualifications.

Graph A3.1 Proportion of Work Competitively Bid in 1996–97: National View

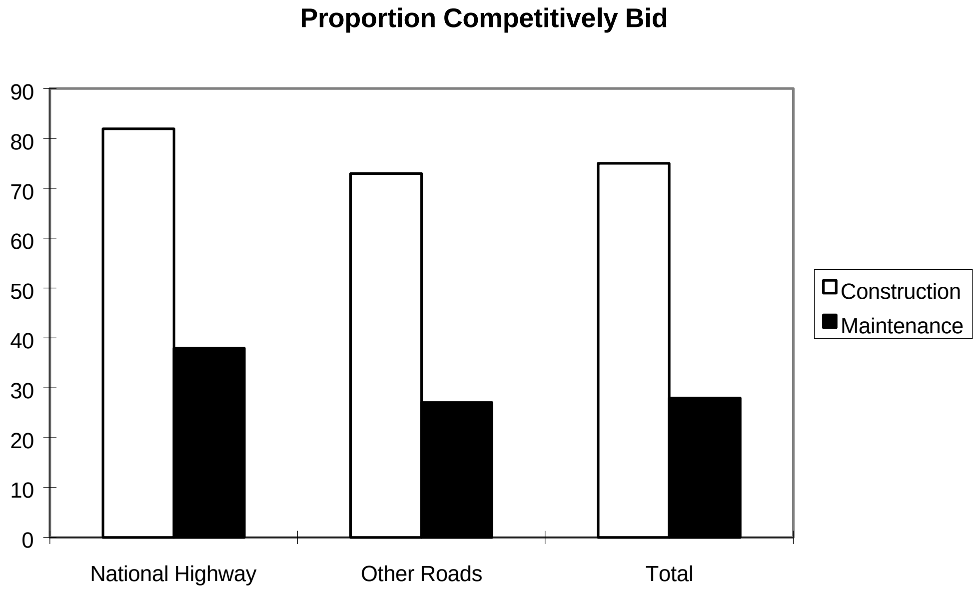


The presentation shows that overall 60 per cent of work was competitively bid. A smaller proportion of maintenance work was competitively bid than other work.

Definitions

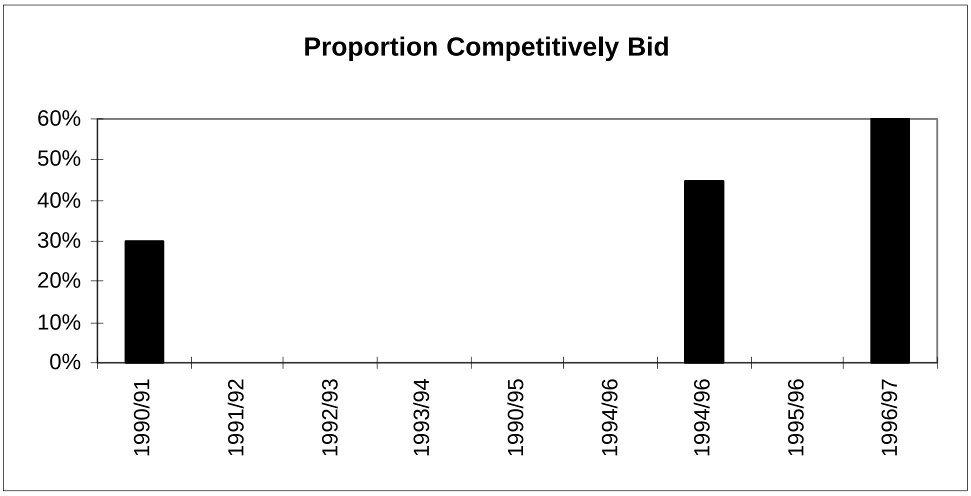
- Competitively Bid: where two or more trading entities are free to bid for the work.
- Maintenance: routine maintenance only (pot hole repairs, minor patching, edge repairs, shoulder grading, etc.)
- Construction: all roadwork that is not maintenance under the above definition.

Graph A3.4 Proportion Competitively Bid



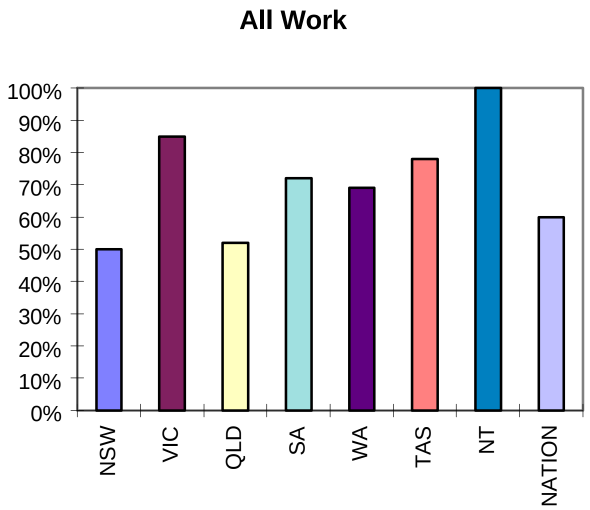
The presentation shows that there is not a distinct difference between the amount of work that is competitively bid on the National Highway compared with other roads overall.

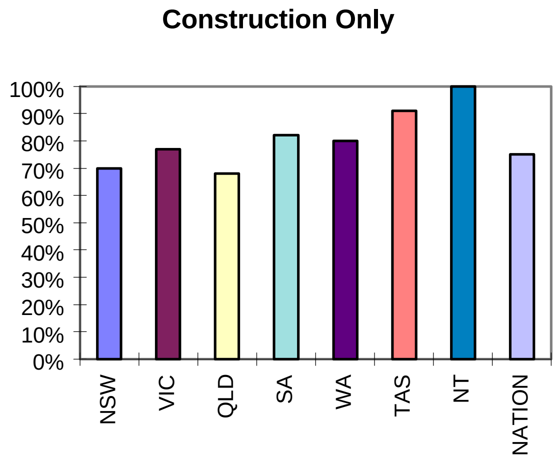
Graph A3.5 Trend in Competitive Bidding: National View

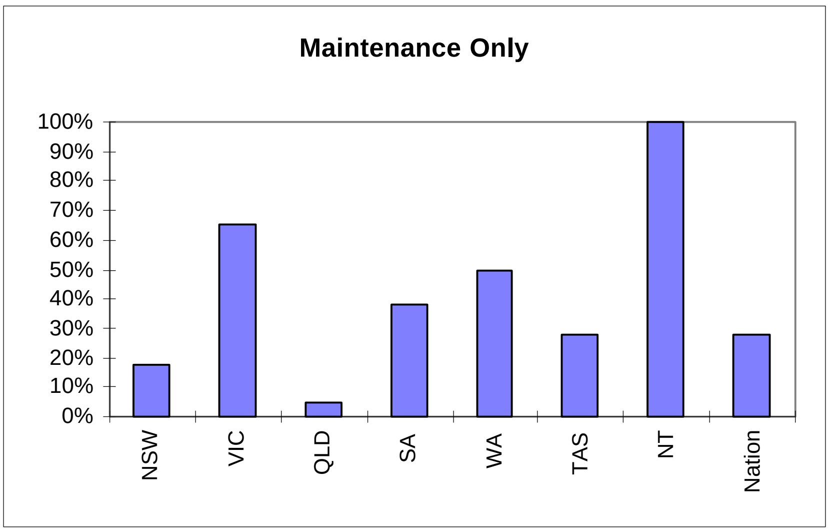


This presentation indicates that there has been a dramatic trend since 1990–91 to increase the amount of work that is competitively bid. In the last six years the amount of competitively bid has more than doubled.

Graph A3.4 Proportion of Work Competitively Bid in 1996–97: By State







Definitions

Private Sector Supplier: a trading entity that is majority owned by private sector interests.

Separate Public Sector Supplier: a trading entity that is majority Government owned whether at the local or State level. Examples are local Councils supplying works on State Government funded projects or corporatised Government workforces in separate Department or Business enterprise to the client Department.

Same Organisation Supplier: trading entity that operates under commercial principles and responds to an organisationally separate client but both are within the same organisation, responding to the same CEO and Minister.

Qualifications of the Data by State

New South Wales

The methodology adopted for this study does not take account of the degree of competition and commercial approach applied in New South Wales through the New South Wales Government's Service Competition Policy whereby all services are compared to private sector performance and bidding only applied where "the cost of the work over the contract term would exceed $250,000, subject to the other appropriate considerations, such as risks and other constraints; and where current cost levels are estimated as higher than 10 per cent of viable, alternative service providers."

The concentration on output and outcome level competition does not capture movements to more competition at the input level. A full assessment of competitive bidding should include consideration of the following two categories or work:

1. Projects in which State Agencies project manage work and some or all inputs are competitively bid.
2. Cases where agencies benchmark construction and maintenance costs but do not introduce competitive bidding because cost levels are not deemed to warrant competitive bidding, in line with the NSW Government Policy referred to above.

The RTA's report to Federal Department of Transport and Regional Development for National Highway Maintenance Performance Agreement, in which input level competition is included, indicated that in 1995–96. 53 per cent of National Maintenance was undertaken by competitive bidding.

Victoria

Nil

Queensland

Nil

South Australia

- The South Australian data is indicative only. The existing financial system does not yet provide information in the categories required. A significant amount of interpretation of available financial data has been required. The accuracy of the information is expected to increase in future years if this is a regular reporting requirement.
- During 1996–97 all routine maintenance on the sealed road network in South Australia moved to competitively bidding. The figures in this report do not yet show a full year effect for this.
- Maintenance responsibilities for the unsealed network in the far north of South Australia, with the exception of some small private contractors, is undertaken by Departmental resources and is not subject to competitive bidding. this is not expected to change in the near future. This represented some 20 per cent of maintenance and 1 per cent of construction expenditure in 1996–97.

Western Australia

Nil

Tasmania

All maintenance is being competitively bid under contracts being tendered in 1997–98.

Expressions of interest are also being called for transfer of technical services to the private sector in 1997–98. These two effects will see all work competitively bid by the end of 1997–98.

Northern Territory

Nil

References

Commonwealth Department of Transport and Regional Development *Competition in the Supply of Roadworks to Government* June 1997

Definitions

Key Definitions in the Information Framework

Term	**Definition**
Roadwork	Construction, long term and short term maintenance, upgrading of roads, bridges, tunnels, road furniture, traffic control devices and roadsides. Any activity required to deliver these works such as design, tender documentation, tender assessment and contract administration is also included.
Competitively Bid	Where two or more trading entities are free to bid for work, if they so choose, to a common client in a competitive way, any resulting contract is said to have been competitively bid.
Private Sector Supplier	A trading entity that is majority owned by private sector interests.
Separate Public	A trading entity that is majority Government owned whether at the local, state or Sector Supplier federal level. The entity may respond to the same Minister as the client organisation but not the same Board of Management or Chief Executive Officer to be in this category.
Same Organisation	A trading entity that operates under commercial principles and responds to a Supplier separate client on a purely contractual basis but has accountability to the same Chief Executive as the client responds to.

Other Definitions

Term	**Definition**
Client	The part of a Road and Traffic authority that *has* responsibility for procuring *roadworks.*
Commercial principles	Use of *a* pricing *and* costing system by a business unit to ensure that all costs of operating the unit *are* robustly brought to account. Revenue is the result of having a *client* pay for work done and profit or loss is used as a key performance measure
Construction	All roadwork that is not *maintenance.* Construction includes the *services* necessary to deliver *the* works and corporate overhead.

Contract	A formal binding agreement for delivery of defined works made between a *client* and a *supplier* for works specified at an outputs or higher level (ref clause 5.2.1). By definition the two parties to a contract must be organisationally separate at some level.
Contracting out	Where a *contract is* let by a *client* to a *trading entity* that is not accountable to the client's Chief Executive officer, Board or Minister.
Direct Control	Where work is performed under a line and staff system within an organisation and there is no separate *client with* whom a *contract for* delivery *is* formed.
In-house	The Department, Authority or entity that provides the *client* function is defined as the ‘house’. Where the *supplier* for any given works sits in the same ‘house’ (reports to the same Chief Executive, Board or Minister) it is termed as in-house delivery.
Local government	The third tier of government in Australia. Includes Councils and Shires. In many areas of Australia local government employs workforces capable of undertaking roadworks for a State Government *client.*
Maintenance	Routine maintenance, including pot hole repairs/ minor patching less than 500 sq m, crack sealing, edge repairs, shoulder grading, resheeting of unsealed roads and shoulders including the cost of services and corporate overhead. Not included is reseals, asphalt overlays, rehabilitation ‘cyclic’ maintenance, signs and lines and widening. Caveat: New South Wales data however does include reseals and rehabilitation as the accounting systems collect data in that way and programming the large data volume involved was too expensive.
Preferred Supplier	A *supplier* which has some strategic or preferred status with the *client.* Normally this would involve the *supplier* getting some work from the *client* without having to competitively *bid* that work.
Private Sector	The sector of the national economy that is not Government owned or operated.
Provider	An entity that delivers work or services to a client under a contract.

Public Sector	The sector of the national economy that is Government owned and operated.
Services	Engineering and related services such as design, tender assessment and contract administration required to procure roadworks by contract.
Supplier	An entity that delivers work to a client under a contract.
Tender	Submission by a potential *supplier* to a *client* with a view to being awarded work. Tenders may or may not be *competitive* although common usage is to regard tenders as part of a competitive process.
Trading Entity	A company, Government Department, local Council or shire or a business unit in one of these that undertakes work as a supplier to one or more clients.

Levels at which competition can occur:

Term	**Definition**
Input	*Inputs* include the supply of materials, hire of plant and supply of works or services by sub contract to a main contractor.
Output	*Outputs* the work delivered under a conventional contract that leads to an identifiable road work such as construction of a new road or rehabilitation of a length of existing pavement. This involves contracting at a higher level in the supply chain than inputs.
Outcome	Contracting at the *outcomes* level is higher in the supply chain again. This is where the client specifies the outcomes wanted and the Contractor has extensive scope to design and package the work needed to achieve that outcome. Design/construct contracts and long term performance based maintenance contracts are in this category.

Appendix 4

Engineering Skills Analysis of the Rail Sector

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Summary

There is considerable evidence to indicate that the shortage of experienced rail engineers many companies are now facing will increase over the next 10 years. This assessment is based on the assumption that the rail sector either remains at its current size or expands, and that wage rates remain static. As many rail commentators consider that the rail sector is starting to undergo a renaissance, the shortage may be larger than currently expected. Such a shortage may affect completion dates and the profitability of future rail projects.

Despite the shortage being recognised by rail sector organisations, very few are taking substantial action to address it. This is surprising as organisations can undertake several actions which are effective in both reducing specialist staff turnover and attracting experienced rail engineering staff. However, these actions do not address the underlying reasons for shortages. The only way to ensure the availability of a pool of skilled engineers is to develop a long-term industry-wide strategy which involves the majority of stake-holders. However, given the current market instability, developing such a strategy is probably overly ambitious in the next few years.

1 Introduction

This paper examines the skills market for professional engineers and engineering technologists in the Australian rail sector. The purpose of the paper is to identify if there will be a shortage and suggest ways to overcome any identified problems.

The principal reason for undertaking the study was concern about a potential skills shortage. This concern was raised by the Institution of Engineers, Australia (IEAust) National Committee on Railway Engineering and was reinforced by a meeting on industry training needs organised by the Australasian Railway Association on 10 March 1998.

The study's steering committee comprised:

- Chris Venn-Brown, IEAust National Committee on Railway Engineering
- John Kirk, Australasian Railway Association
- Malcolm Menadue, Institution of Railway Signal Engineers
- Athol Yates, IEAust Policy Unit

Contributions were also made by the Federal Department of Transport & Regional Development; Department of Employment, Education, Training and Youth Affairs; Rail Track Association; Permanent Way Institute NSW; and Australian Railway Industry Corporation.

1.1 Definitions

A ***professional railway engineer*** is a person who has graduated from a university engineering faculty and has one or more railway engineer specialities.

A ***railway engineering technologist*** is a person who has graduated with an engineering diploma or Bachelor of Technology and has one or more railway engineer specialities.

A ***graduate railway engineer*** is a professional engineer who has gained their degree within the last five years.

The ***railway engineer specialities*** are power supply for electric traction; rolling stock; signalling and communications; terminals; track and structures; train control and operations; workshops; and business liaison and management. These are defined in detail in the IEAust *Railway Engineering Competency Profiles*.

The ***rail sector*** is made up of the following broad groups: track owners; operators; rolling stock manufacture and maintenance organisations; track construction & maintenance organisations; signals and communications manufacture and maintenance organisations; general product and service suppliers; research (technical and non-technical) organisations; education and training organisations; regulators; policy development organisations; industry, professional and employee associations; customers (freight and passengers); and other organisations (rail media, user groups).

To aid the statistical analysis of the rail sector, it was divided into three ***rail sector categories***:

- ***rail transport***, which includes organisations involved in the movement of rail traffic, such as the public transport agencies and private rail operators;
- ***rail equipment manufacturing***, which includes both equipment manufacturers and suppliers whose main business is in the rail industry; and
- ***rail support services***, which includes organisations and parts of organisation which provide services to the rail industry as well as other industries.

These organisations include civil consulting firms, electrical contractors and rail policy units within government.

A ***skills shortage*** exists when employers have difficulty filling, or are unable to fill, vacancies in a specialisation at reasonable levels of pay, conditions and locations. Shortages are typically for specialised and experienced workers, and can co-exist with relatively high unemployment. Shortages may be numerically small, or in specific geographic areas.

1.2 Study Process

The study process had four main steps: problem definition, data collection, data analysis and validation of the analysis with selected industry representatives. Only the most important step, data collection, is discussed below due to space limitation.

Data was collected via three means:

- Census data from the Australian Bureau of Statistics.
- A 4-page survey for individual rail professionals was sent to 1,300 current and former railway engineers. The mailing list consisted of members of the Institution of Railway Signal Engineers, members of the Institution of Engineers who had expressed an interest in railway engineering, and employees of railway industry organisations. A total of 479 completed surveys were returned. Of the 479, 57 were from former rail engineers now working in other sectors and 37 were from retired rail engineers. Therefore the response rate was 38 per cent of the current population of rail engineers.
- An 11-page survey for rail organisations was sent out to 220 organisations in the rail sector. A total of 55 completed surveys were received which represents 26 per cent of the population.

2 Rail Sector Engineering Employment

2.1 Calculating the Number of the Professional Railway Engineers

Three methods were used to calculate the number of railway engineers. All provided substantially different results as the calculations depend on the definition of an engineer and on which organisations are included in the three rail sector categories of rail transport, rail equipment manufacturing and rail support services. However as the employment trends are the most significant element in this study and these are not dependent on the absolute number of engineers in the rail sector, the calculated number of engineers should be treated only as an indicative figure.

The first method used to calculate the number of engineers was the 1991 and 1996 Census figures which provides figures on the rail transport and rail equipment manufacturing components. Using survey data provided by individual engineers, the third component can be calculated by comparing it with ABS information for the other two sectors.

The second method used survey data provided by the rail organisations and individual engineers. It involved calculating the percentage of engineers within each component of the rail sector who participated in the study.

The third method used survey data provided by individual engineers and rail organisations. It involved calculating the survey response rate of engineers in individual companies and then applying that factor to all engineers who participated in the survey.

Table A4.1 provides a summary of the number of professional engineers in the rail sector based on the three methods. Due to different definitions of engineers and inaccuracies in survey data, this figure should be treated as indicative only.

Table 4.1 Number of Professional Engineers in the Rail Sector Analysed by Three Methods

Rail Sector Component	Method 1	Method 2	Method 3	Indicative Number of Engineers
Rail equipment manufacturing	336	758	435	500
Rail transport	130	243	211	200
Rail sector services	115	546	188	300
Indicative number of professional engineers in the rail sector				1000

2.2 Calculating the Number of the Railway Technologists

To calculate the number of railway engineering technologists, 1996 Census statistics were used. Table A4.2 presents the results.

Table A4.2 Number of Engineering Technologists in the Rail Sector

Formal Qualification	Rail Transport	Rail Manufacture
Number with a diploma	108	69
Number with a degree	309	125
Percentage of diploma with degree holders	35	55
Average percentage of first 2 categories		45

Assuming that there are 1000 professional engineers in the rail sector, then the number of engineering technologists is 450.

2.3 Adjusting the Number of Engineers and Technologists Based on Self-Assessment

If individuals' descriptions of themselves as engineers and technologists are used with no reference to their formal qualification, then the number of these two groups increase substantially. Table 3 summarises the number of professional engineers and engineering technologists as identified by qualifications and by self-assessment. The proportion is based on data from the Census and surveys.

Table A4.3 Indicative Number of Professional Engineers and Engineering Technologists Based on Qualifications and on Self-Assessment

Engineer Class	Based on Qualifications	Based on Self-Assessment
Professional engineers	1000	1270
Engineering technologists	450	684

3 Profile of Rail Engineers and Technologists

This section provides a profile of rail engineers and technologists derived from the survey of individuals and organisations.

3.1 Professional Engineers

Age: The mean age of all engineering staff who responded to the survey was 41.6 years. The mean age of public sector engineers is 0.4 years older than private sector engineers. Notably the mean age of self-employed consultants (of which 45 were identified) was 49.5 years, which is 7.9 years older than the mean age for all engineers. Based on the 1991 and 1996 Censuses, the mean age is increasing by 0.9 years per year.

Table A4.4 Mean Age for Professional Engineers Based on the Individual Survey

Professional Engineer Sub-Groups	Mean Age
Self-employed consultants	49.5
Private sector	41.9
Public sector	41.4
All engineers	41.6

Sector of employment: Most engineers work in the private sector (54 per cent). About 43 per cent of engineers work in the public sector (including corporatised bodies).

Work responsibilities: Table A4.5 reveals that the most common main work responsibilities of rail engineers are engineering management, project management and product and system design. A number of respondents nominated additional responsibilities including customer support, training, safety management and compliance, maintenance and business development.

Table A4.5 Main Work Responsibilities for Engineering Staff

Main Work Responsibilities? N=418	%
Engineering management	33
Project management	28
Product & system design	22
Studies & investigations	19
Installation & maintenance	13
Contract administration	11
Planning	9
Research & development	7
Non-engineering management	5
Manufacture & production	4
Operations	3
Marketing & sales	2
Other	12

Engineering specialisations: Table A4.6 lists rail specialisations and the percentage of engineers who claim to work in that area. The two main rail specialisations as identified by both individual engineers and organisations are signalling and communications, and track and structures. Several respondents also identified safety as their main specialisation.

Table A4.6 Engineering Specialisations as Identified by Individual Engineers and Organisations

Specialisation	Specialists in that Area (via the Survey of Individuals) N=418 (%)	Specialists in that Area (via the Survey of Organisations) N=40 (%)
Signalling & communications	30	27
Track & structures	30	15
Rolling stock	25	16
Planning & economics	6	9
Power supply for electric traction	5	2
Train control & operations	5	7
Workshops	4	2
Terminals	1	1
Other	8	18

Consultants: The survey reveals that about 48 of the respondents are self-employed consultants. This translates to 11 per cent of the workforce.

3.2 Graduates

Graduate engineers entering the rail sector can be divided into two groups: cadet engineers and direct-from-university graduates. Cadet engineers are usually taken on when they are at university and work at the organisation during their vacation periods. Based on the survey results, about 50 per cent of graduate engineers entering the rail sector were employed through cadetships. Between 1994 and 1997, 66 per cent of cadetships were provided by the private sector.

Why organisations do not employ more graduates: Table A4.7 shows that the main reason why organisations do not employ more graduates is because of insufficient work. The second most common reason given was because the training period for graduates is too long. One organisation wrote that the problem was that consultancies require only experienced staff and cannot take on staff who are still learning.

Table A4.7 Reasons Why Organisations do not Employ More Graduates

Reasons for Not Employing More Newly Qualified Engineering Staff N=37	%
Not sufficient work	68
Training period of the newly qualified staff is too long	34
Do not have the staff to supervise the newly qualified staff	22
Other	19

Ways to encourage organisations to employ more graduates: Table A4.8 shows that the major impediment to employing more graduates is market instability followed by the inability to employ graduates on short term contracts via mechanisms such as Group Training Schemes. Other impediments included that it is difficult to attract suitable graduates, and graduates are not interested in part-time work.

Table A4.8 Ways to Encourage Organisations to Employ More Graduates

Ways to Encourage the Organisation to Employ More Newly Qualified Engineering Staff? N=31	%
Greater market stability	61
Ability to employ graduates on short-term contracts	26
Improved university education	22
Wage subsidy	16
Other	1

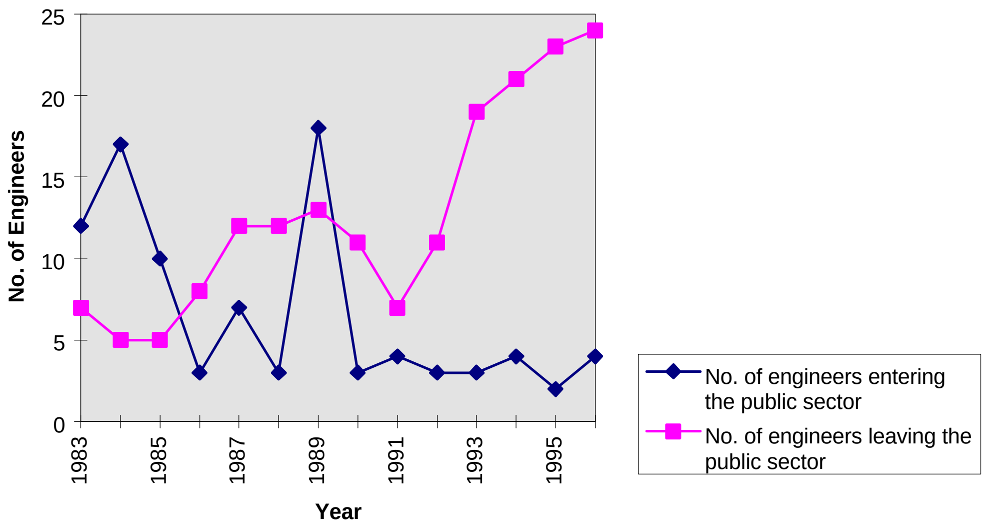
4 Changes in Industry Composition

The Australian rail sector has been undergoing considerable change since the mid 1980s. The two major trends are public sector downsizing and private sector growth, and decreasing graduate employment.

4.1 Public Sector Downsizing and Private Sector Growth

In 1997, about 43 per cent of railway engineers were employed by the private sector. The numbers employed in the public sector are decreasing rapidly, as illustrated by the survey results in Graph A4.1. As the number of survey respondents was just under half of the indicative number of engineers in the rail sector, the real figures are at least double those in the graph. About 64 per cent of engineers that leave the public sector are re-employed by the private sector.

Graph 4.1 Railway Engineers Entering and Leaving the Public Sector



4.2 Decreasing Graduate Employment

According to the survey results for individual engineers, the number of new graduate engineers being employed is decreasing. Survey data from organisations confirmed that the increase in graduate employment is flat. Based on the 15 organisations which provided data for the 5 years, the total growth in the number of graduates employed is 1 in 1998 and 12 by 2005. Note that 7 organisations stated that they were unable to predict their employment position in 1998. This means that 32 per cent of organisations were even unsure of the number of graduates they will employ this year. The number of organisations unable to predict their graduate employment numbers grew to 50 per cent in 2003.

5 Employment Mobility

5.1 Length of Employment for Engineers

According to the individual survey, 52 per cent of engineers have not changed employers in the last decade. Of the 48 per cent who have changed employers, about 53 per cent of these have only changed employers once in the last decade. This indicates that many railway engineers are long-term employees. This is supported by the statistic that 62 per cent of engineers state that they have worked with their previous employers for more than 10 years, with many working for over 20 years. The weighted average of the length of service for engineers who have changed employers one or more times in the last 10 years is 4.1 years.

5.2 Reason for Changing Employers

The survey results indicate that the main reasons for changing employers are new challenges (39 per cent), followed by company restructure (27 per cent), combined reasons (23 per cent), promotion (5 per cent), higher salary (5 per cent) and better conditions (3 per cent).

5.3 Experienced Engineers Moving into the Rail Sector from Other Sectors

Of the survey respondents, 37 per cent worked in another sector before moving into the rail industry. The engineers who worked in other sectors mostly came from the construction, civil and structural engineering sector.

Training upon joining the rail sector: About 16 per cent of engineers who moved into the rail sector, from another sector undertook formal retraining. About 75 per cent (i.e. 15 respondents) of these engineers completed an in-house training course which took on average 12 months to complete while another 16 per cent (ie 4 respondents) undertook a degree or diploma. Below is a list of some of the training undertaken:

Training	**Duration**
Classroom Training in Signalling	12 months
Basic Signalling Training Course	6 months
Cadet Engineership	60 months
Electrical Engineering Degree	48 months
In company training in railway signalling	48 months
Completed MBA with focus on privatisation of railways	24 months
BSc Power Engineering degree	12 months
Short course	6 months

6 Employment Intentions of Engineers

Table A4.9 shows that 12 per cent of rail engineers expect or plan to leave the rail sector within 5 years. An additional 50 per cent expect to leave the rail sector between 5 and 10 years. Graduates have similar intentions. It is interesting to note that several engineers and graduates wrote they would stay in the rail sector their whole working life. This reinforces the anecdotal evidence that the sector is more than just a job for some engineers.

Table A4.9 Engineers' Expectations in the Industry

Planned or Expected Length of Stay in the Rail Industry	% of All Engineers N=365	% of All Graduates N=34
Less than 5 years	12	9
Between 5 and10 years	50	44
Not sure	37	47

The main reasons for people expecting to leave the rail sector are to seek new challenges (27 per cent), retirement (25 per cent) and being forced to leave due to company restructure (44 per cent). The survey reveals that 63 per cent of engineers intend to continue practising engineering in the medium term while only 14 per cent intend to move into non-engineering management.

The major reason engineers would move into non-engineering management is new challenges. However graduates are more likely to identify promotion as a more important reason than other engineers.

7. Organisations' Views on Skill Shortages

Table A4.10 shows that 34 per cent of rail organisations are currently experiencing a skills shortage. About 50 per cent of organisations consider that shortages will occur over the next 10 years while about 20 per cent do not believe this.

	Is your organisation currently experiencing difficulty in recruiting professional engineering staff? N=44	Do you think there will be a shortage within 5 years? N=41 (%)	Do you think there will be a shortage between 5 and 10 years? N=42 (%)
Yes	34	47	52
No	66	22	14
Unsure	-	27	33

Table A4.10 Organisations' Views on Skill Shortages

7.1 Engineering Specialisations where Shortages Will Occur

Table A4.11 indicates that the three most likely specialisations which will experience a skills shortage are signalling and communications, rolling stock, and track and structures. Survey respondents wrote in the 'other' box a number of additional areas where shortages were predicted to occur and these included data handling, recording and on-board electronics, noise and vibration, overhead line design, and rail logistics.

Table A4.11 Organisations' Views on the Specialisation in Which Shortages Will Occur

Area	% of Organisations Expecting a Shortage in this Area N=28
Signalling & communications	50
Rolling stock	43
Track & structures	32
Business liaison & management	21
Train control & operations	14
Workshops	11
Planning & economics	11
Power supply for electric traction	10
Terminals	5
Other	19

7.2 Engineering Specialisations Required for New Projects

Organisations which were planning major projects over the next 10 years were asked what engineering specialisations would be required. The largest specialisations required are rolling stock, signals and communications, and track and structures. As these specialisations are the same ones as identified in Section 8.1, it provides internal consistency in the answers provided by the organisations.

7.3 Staff Turnover

About 33 per cent of rail organisations stated that they were not concerned with staff turnover. This is despite the fact that some organisations are experiencing a shortage of engineers, and many are predicting a future shortage.

For those organisations which are taking measures to reduce staff turnover, the range of measures included:

- attempting to reconcile engineering career paths with the management career paths especially with respect to remuneration;
- reviewing staff performance targets and training needs;
- stability in management;
- offering overseas training and challenging careers;

- improving career progression, work environment and conditions;
- enhancing career development opportunities and introducing an employee share scheme; and
- hastening the rail reform process to reach relative stability.

7.4 Obtaining Engineering Staff for Large Projects

The survey indicates that 77 per cent of organisations expect to get the number of engineers they require from the existing pool of Australian rail engineers. The second most nominated source was from overseas (62 per cent).

For organisations undertaking large projects (N=13), 85 per cent had not developed plans to guarantee the availability of the required number of professional engineers.

8 Sponsored Foreign Engineers

Within the last 5 years, 23 per cent of organisations (N=43) sponsored foreign engineers to work in Australia on working visas or relocate here under the skilled migration category. About 70 per cent of the ten organisations which sponsored foreign engineers did so to overcome a skills shortage. About 60 per cent of the sponsored foreign engineers spoke English as their native language. About 29 per cent of organisations (N=42) are currently considering sponsoring foreign engineers to work in Australia on working visas or relocate here under the skilled migration category. Of these 12 organisations, 67 per cent of them are doing this to overcome a skills shortage.

9 Evidence which Indicates Future Shortages Will Occur

From the above information, evidence to indicate that there will be future shortages of experienced rail engineers in Australia includes:

- 50 per cent of organisations consider that shortages will occur over the next 10 years;
- 67 per cent of organisations considering sponsoring foreign engineers to work in Australia are doing so to overcome a skills shortage;
- the workforce is ageing at the rate of nearly 1 per cent a year;
- the number of graduates entering the rail sector is declining;
- as many rail consultancies are limited in their ability to take on staff who are still learning, these organisations (which are becoming more common in the rail sector) are unable to generate new skilled rail engineers; and
- market instability is resulting in rail organisations taking a conservative position on staff hiring and training, resulting in reduced numbers of new entrants to the rail sector.

10 Conclusion

This paper highlights the most significant findings of the rail engineering skills study. A copy of the complete report can be downloaded from http://www.ieaust.org.au/government/home.htm.

The study identified that a shortage is occurring and will continue into the foreseeable future. It also identified the reasons for the problem and suggested solutions. While individual rail organisations can undertake effective actions to address short-term shortages, the only effective long-term solution is for a rail sector-wide approach. So it is now up to the rail organisations to collectively decide that it is a problem affecting them all and call upon all stake-holders to develop an effective strategy.

Appendix 5

Survey of IEAust Young Engineers Committees

A survey of the Institution's representatives on the Young Engineers Committees was undertaken to gain an understanding of their perspective. The survey sought comment on the experience of young engineers in gaining industry experience whilst at university.

The survey was confined to the members of the Institution's Young Engineers Committees. Each Division has such a committee and have a membership of 7–15. The survey was sent to 65 members in all and had a response rate of one-third.

Of the respondees, 15 (71 per cent) had undertaken work experience beyond the course requirements. Seven of these had undertaken substantially additional work experience, either as a result of a decision to delay the academic component (e.g. 'a year off' or 'overseas'), part-time 'traineeship' or through a scholarship condition of full-time work through each vacation.

The average additional experience of the 15 positive respondees was 22 weeks. The average additional experience over the 21 respondees was 16 weeks.

The following comments arose from the 15 who had undertaken additional work experience:

- 86 per cent obtained the work experience position by approaching the firm directly;
- 50 per cent stated the university provided support for them in seeking work experience;
- 14 per cent had approached IEAust for assistance through the Vacation Employment Handbook;
- 92 per cent considered that the work experience was useful in providing additional skills for competency in the work place; and
- 73 per cent considered that the work experience was useful in providing an insight into how the tertiary education would be utilised in the workplace.

In their current employment, the following forms of training are provided:

- Cadetships (19 per cent)
- Short courses (71 per cent)
- Secondments (24 per cent)
- Traineeships (14 per cent)
- Postgraduate qualifications (33 per cent)

- In-house training (86 per cent)
- Scholarships (5 per cent)
- Study assistance (67 per cent)
- Job rotation schemes (29 per cent)
- Mentoring (52 per cent).

Appendix 6

Workshop Attendees

- Barry Grear, Institution of Engineers, Australia (Workshop Chairman)
- Tracey Brimler, Vocational Education and Training Division, DEETYA
- Michael Brouwer, Gutteridge, Haskings, & Davey Pty Ltd
- Chris Davis, Australian Water and Waste Water Association
- David Gain, Vocational Education and Training Division, DEETYA
- Mike Gallagher, Higher Education Division, DEETYA
- Sue Harris, Vic Roads
- Frank Martinelli, Engineering Education Australia
- Phil McKee, Energy Australia
- David McCann Higher Education Division, DEETYA
- Peter Nicholson, Higher Education Division, DEETYA
- Paul O'Brien, National Utilities and Electro-Technology Industry Training Advisory Body Limited
- Professor Peter Parr, University of Technology Sydney
- Lynne Reeder, Institution of Engineers
- Bruce Sinclair, Sinclair Mertz Knight
- John Vines, Association of Professional Engineers, Scientists, and Managers Australia
- Averil Walters, Higher Education Division, DEETYA
- Peter Walker, Institution of Engineers, Australia
- Dr John Webster, Institution of Engineers, Australia
- Athol Yates, Institution of Engineers, Australia
- Frank Zammit, Electricity Supply Association of Australia

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