DEVELOPING STRATEGIC ASSET MANAGEMENT LEADERS THROUGH POSTGRADUATE EDUCATION

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The modern engineering asset manager is required to develop, operate and maintain engineering assets economically and in a socially responsible and sustainable manner. Key issues confronting the asset manager of today include taking a strategic life cycle approach to asset management, meeting user requirements and minimising risks. To achieve this, it is necessary to understand asset life cycle issues including economic analysis and sustainability, be aware of social impacts, understand technological risks and work at the cutting edge of technology. While undergraduate engineering programs can meet this need to some extent, postgraduate education is often the best approach for learning the principles of strategic life cycle asset management. This paper discusses one such example of postgraduate engineering education, the Master of Technology Management, offered by the Faculty of Engineering and Surveying at the University of Southern Queensland. Topics discussed include the rationale for this type of study program, how it addresses the needs of life cycle asset management including risk and innovation management, its approach to learning, and its role in developing strategic technological leaders. The future role of programs of this type in developing leading asset management professionals is also discussed.

Key Words: Asset management, Technology Management, Postgraduate, Education

1 INTRODUCTION

The engineering asset manager of today faces many challenges. The types of assets managed may vary from infrastructure assets like major physical installations and distribution networks, to fixed and mobile plant and equipment such as manufacturing installations and transportation equipment, through to communication networks.

Asset management in such an environment is a complex task that requires application of a combination of engineering, strategic management and financial skills. In the modern world, it is also just as important to achieve social and environmental goals as it is to reach the more traditional technical and economic goals. The modern engineering asset manager is therefore required to develop, operate and maintain engineering assets economically and in a socially responsible and sustainable manner over the life cycle of the asset and throughout decommissioning and disposal.

While undergraduate engineering study programs include engineering management courses, their ability to develop the skills for effective asset management are limited, as undergraduate programs are principally aimed at meeting formal academic training to meet the requirements of professional organisations. Engineering management training in such programs is therefore of necessity at a fairly basic level. Postgraduate programs, aimed at providing sound engineering management training in asset management and related concepts like sustainable development, technological innovation and risk management, can achieve the goal of offering the additional academic development needs by today's integrated strategic asset managers.

It has been in this environment that programs such as the Master of Technology Management (MTM) program at the University of Southern Queensland (USQ) have been developed. As well as taking graduate engineering and technology management education beyond that at undergraduate level, programs of this type aim to develop the skills needed to compete and be successful in the complex world of technology, engineering and entrepreneurship in which the advanced engineering and technology manager will work.

This program was developed out of the recognition that a large number of engineers and other practicing professionals aspire to managerial positions in a technology or engineering environment. It was also recognised that qualified managers of technology play a crucial role in technologically advanced as well as developing societies. Thus it was reasonable to expect that many of these professionals would want to achieve postgraduate qualification in a coursework-based management-focused program [1].

This paper discusses the way in which the programs like the Master of Technology Management can assist to develop strategic asset managers through an integrated program that teaches not only asset management but also explores related topics like technological management and its impact, sustainable development, management of technological risk and other key technology management areas. Initially, the paper discusses the context and issues in strategic asset management. It then explores the options for strategic asset management education, discusses the MTM program and the approaches it uses for teaching, evaluates what it has achieved so far and explores the challenges of the future.

2 CONTEXT OF STRATEGIC ASSET MANAGEMENT

In developing a study package suitable for strategic asset management in an engineering environment, it has been firstly necessary to establish the context for the asset management process. This has consisted of developing an understanding of the types of assets being covered by the program and what the term "asset management" means in the engineering asset management environment; and from this developing the concept of the asset life cycle and the goals that need to be met by the asset manager. This was followed by an evaluation of the challenges faced by asset managers in the delivery of their responsibilities.

While an asset may be broadly defined in a financial sense to mean any item of economic value owned by an individual or corporation, it was decided that in an engineering sense an "asset" would normally mean installations, plant, equipment, knowledge, resources and related items that that support the community, commerce and industry.

Like "asset", the term "asset management" can be also defined in several ways. A common definition of asset management used in highway engineering is "A systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach to making the decisions necessary to achieve the public's expectations" [2]. While not all engineering assets will have the public as asset owner or user, this definition can form the basis of a more general description of many engineering assets by substituting the words "expectations of asset owners and users" for the words "public's expectations."

The life cycle asset management process breaks into the four main streams of identification of the need for the asset; provision of the asset (including its ongoing maintenance and rehabilitation to suit continuing needs); operation of the asset; and disposal of the asset [3]. In performing these tasks, the asset manager is required to not only use sound engineering principles, but also sound business practice and an economic rationale. Modern asset managers also need to take account of social and environmental issues. The strategic asset management leader also needs to look to the future, and therefore as well as applying sound budgeting and engineering management practices is required to consider the long term as well as the short term.

Engineering assets typically serve a number of communities of interest (or stakeholders), and are usually closely liked with the environment of which they are part. For example, physical infrastructure assets are founded on the natural environment and support the economic environment and social environment; and serve the communities of interest of the owner and/or manager, user and the community external to the asset (see Figure 1). A road, for example, is constructed on a natural foundation and is part of the wider environment; supports the economic environment represented by the transportation industry; and serves the road owner, vehicle drivers and other users (such as cyclists and pedestrians), and the community external to the road (such as residents or owners of the properties passed by the road and the wider community whose products they transport). A similar discussion can be developed for other fixed (in location) assets like power stations, water supply and sewerage facilities, and distribution systems. This thinking can be extended to other assets, such as mobile plant and equipment.

The communities of interest to assets each have different requirements of the asset manager, who therefore has to meet a number of goals to meet these requirements. Thus, users expect the asset to have the ability to provide an adequate level of service at the required level of demand; and meet a required level functional serviceability (i.e., condition). Owners and managers require the asset to deliver the optimum service life consistent with the requirements of stakeholders; deliver maximum benefit over the life cycle consistent with other requirements; and operate at minimum life cycle cost, again consistent with other requirements.

Stakeholders external to the asset can be divided into the two sub-groups listed above – the local external community and the wider community. The local external community, which will have relatively close geographical proximity to the asset, will require that the asset satisfies external requirements of interest to that community (for example, environmental and political requirements) to a level acceptable to the community outside the users, owners and managers. Finally, the wider community, which often funds the asset (for example, taxpayers funding a community asset, financiers funding an industrial asset), will require the asset to deliver a whole of life performance (the integral of functional serviceability) acceptable to its stakeholders [4].

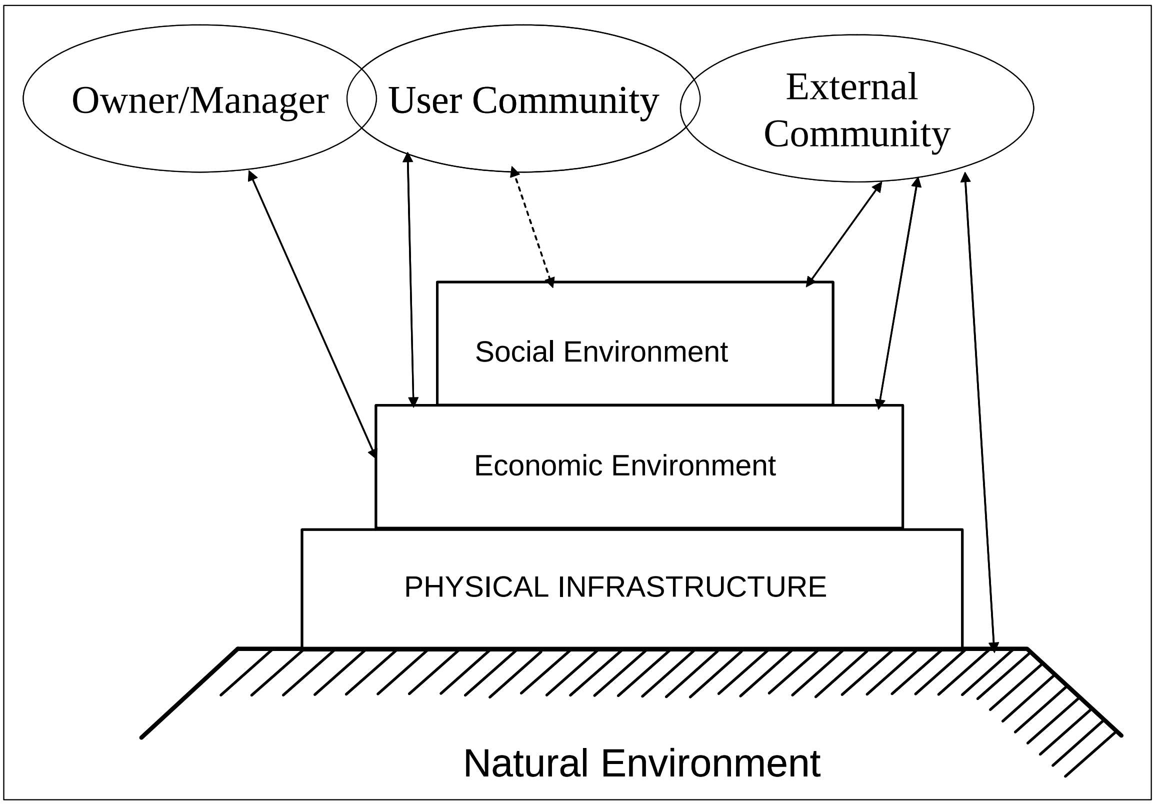

Figure 1: Physical Infrastructure Communities.

Source: Grigg, Neil S. (1988), Infrastructure Engineering and Management, John Wiley and Sons, N.Y., USA.

3 CHALLENGES IN STRATEGIC ASSET MANAGEMENT

While asset managers are required to meet (and optimise) the requirements of key stakeholders, they are also required to meet other requirements. One of these – sustainability - follows from the need to meet social and environmental requirements of the wider community. It is at the core of sound strategic asset management principles that ensure that assets not only meet the requirements of today's society but also the requirements of society into the future. This needs to be considered in practical terms. Johnson [5} sees sustainability is as an ideal state of long-term social, economic and ecological stability, a target towards which we strive, rather than one we expect to reach. In this scenario, sustainable development would consist of striving towards sustainability, while still pursuing production goals and overall economic growth

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Sustainability has been identified as a desirable quality in engineering leadership competencies [6]. It has also been recognised as an important issue for research organisations, such as the Cooperative Research Centre for Construction Innovation, which has developed a report on sustainable subdivisions [7] and has placed considerable effort into the development of a life cycle assessment tools to evaluate eco-efficiency of buildings from CAD drawings [8]. The social and environmental responsibilities of engineers have also been adopted by Engineers Australia, which in its Code of Ethics has stated that its members 'shall, where relevant, take reasonable steps to inform themselves, their clients and employers, of the social, environmental, economic and other possible consequences which may arise from their actions.' [9]

A common outcome of the discussion on sustainability is that to achieve a sustainable future, any development and management project we undertake needs to carefully consider the needs of future generations, the ability of natural resources to continue to meet the needs of those generations, and what we can do to manage those natural resources to enure that this occurs. This argument can be extended to include all aspects of human endeavour. Thus, when we consider a sustainable future, we should be considering, in additional to environmental sustainability, concepts like social sustainability, economic sustainability, technological sustainability and sustainability in other fields of human endeavour and nature. Examples of this approach include a sustainable and cohesive society, the maintenance of historical artefacts, the ability to economically support the world's population and management of technological knowledge.

Clearly, the asset manager has a significant role in ensuring that assets are planned, designed, developed, operated, maintained, rehabilitated, retired and disposed of in a socially and environmentally responsible manner. Thus, there is a responsibility to investigate and resolve social issues and conduct environmental impact assessments over the whole asset life cycle. An example of this is in the use of some modern asset management materials. Fibre composites, for example, are now becoming used as a strong lightweight construction material, and are also used in applications like bridge asset management to replace timber, which is in quite short supply. While they clearly have benefits from this aspect of sustainability, there is also potential concern with their disposal when the structure of which they are part has come to the end of its useful life. Will such materials be disposed of easily? Should consideration be given to making them biodegradable at the end of their useful life? What other issues will arise? Such considerations require careful thought by the strategic asset manager.

A second key issue for asset managers is risk management. Risk is defined by the Australian/New Zealand Standard for Risk Management as a 'systematic process to understand the nature of and to deduce the level of risk' and risk management as 'the culture, processes and structures that are directed towards realizing potential opportunities whilst managing adverse effects' [10]. Risk so defined can lead to be both positive and negative outcomes.

The process of risk management as defined in the standard consists of seven main components: communicate and consult, establish the context, identify risks, analyse risks, evaluate risks, treat risks, and monitor and review [11]. It is important to recognise the importance of communication and consultation in this process.

An example of the role of risk management in asset management is the abolition by the High Court of Australia of the 'highway rule', which protected road authorities from action being brought against them due to failure to maintain a road, as part of the common law of Australia. This ruling is further explained in the cases of Brodie v Singleton Shire Council and Ghantous v Hawkesbury City Council [12]. It has led impetus to the management of risk in civil engineering asset management and of the development of good asset and maintenance management systems.

In some cases there have been specialised adaptations of risk management principles for a particular requirement. Thus, the risk management process described in the International Infrastructure Management Manual assesses critical failure in terms of a business risk exposure model that combines the costs of the consequences of failure of the asset (for example, repair cost, loss of income, loss of life, injury) and the probability of failure. The approach used in this manual has a strategic focus – 'should do' work that has to be completed within the next five years, 'could do' work that could possibly be deferred for another five years, and 'defer' work that could be deferred for a further five years. It also discusses strategies for risk management, such as risk reduction through capital or maintenance expenditure, emergency response plans, acceptance of some risk and carrying the consequential loss, and insurance against the consequential loss [13].

Other challenges for the strategic asset manager include the importance of seeking and adopting innovative practices in the asset management process, balancing short-term and long-term asset management requirements, quality management; systems management; project management; and management of resources. In particular, the asset manager is required to maximise life cycle economic return on the asset while optimising stakeholder goals, achieve social and environmental requirements, and to effectively plan and manage the asset management process to best achieve these results.

4 DEVELOPING STRATEGIC ASSET MANAGERS

The above discussion has outlined a number of the challenges faced by the strategic asset manager, including the need to optimise the achievement of a number of often conflicting goals, meet the requirements of various communities, address sustainability and other social and environmental issues, manage risk, be innovative, and plan and mange the asset management process for the benefits of key stakeholders.

While experience as an asset manager is relevant in developing these skills, it is important that the effective asset manager be given a solid theoretical grounding in them. From the point of view of the manager of engineering assets, this may be undertaken through specialised study. In particular, the strategic asset manager needs to focus on the larger picture as well as operational issues such as asset condition monitoring and maintenance.

Many engineering undergraduate courses now include courses (or subjects) that address engineering management and the responsibility of the engineer in society, and so partially meet the requirements of the education of the asset manager. This may commence with a compulsory first level course addressing communication issues, followed by courses later in the curriculum that deal with concepts like the engineer and society, and engineering management.

The University of Southern Queensland (USQ), for example, offers the course Principles of Professional Engineering and Surveying, typically taken during the first year of the engineering curriculum, which teaches engineering investigation and report writing. This lays the foundation for further studies in the responsibility of engineers in society and the principles and practice of engineering management.

This is followed by the course Technology and Society, typically taken in the second or third year of the engineer's studies, which builds on this foundation and deals with topics such as the history of technology, sustainability, environmental impact assessment, politics, economics, models of society, social impacts of engineering, a brief introduction to law and some key management issues such as management systems. As this course is offered in the second or third year of the engineering study program, all Bachelor of Engineering Technology (three year) and Bachelor of Engineering (four year) graduates (as well as a significant proportion of those exiting after two years with an Associate Degree) are exposed to key concepts like sustainability, globalisation, economics, and the need for the engineering graduate to relate to society and be innovative in addressing wider societal issues.

A third course, Engineering Management, builds on the principles of Technology and Society to teach management principles and practice for engineers and further develop the engineering student's appreciation of the social environment within which they will practice, and in particular those aspects of the law and ethics pertaining to the engineering profession. An optional fourth level course, Engineering Management Science, which provides the engineer a number of mathematical management tools, completes the undergraduate engineering management curriculum.

These courses, and similar courses at other educational institutions, provide the engineering undergraduate with a foundation in socially and environmentally responsible engineering principles and methods. This can however only be partially achieved in engineering undergraduate curriculum courses, as the large number of courses required to be studied by the undergraduate engineering student and the need to focus in undergraduate study on technical competence mean that there are limitations with developing the skills of effective and efficient asset management during the education of undergraduate engineers. For example, in the University of Southern Queensland engineering curriculum, the courses described above are only about 12.5 per cent of undergraduate study. Their impact is therefore lessened by the other 87.5 per cent of courses required to be studied by the engineering undergraduate.

Further dilution of the education of undergraduate engineers in the strategic management of assets occurs because the types of courses discussed above (with the exception of Engineering Management Science) are primarily verbally based rather than mathematically based, and therefore a number of students (particularly international students whose first language is not English) can find these courses difficult to understand, and hence may not achieve as well in some of them as they would in technically based courses. Students can also perceive that such courses are not really relevant to their future careers as engineering. For example, over the four offers to Semester 1 2005, the Technology and Society course had a drop-out rate of about 15 to 20 per cent, an overall pass rate of about 65 per cent, and only about 10 per cent of students achieving high grades (distinction or high distinction). These figures are worse for international students, to whom English is at best often only a second language.

The other main issue with undergraduate courses are that although they address issues such as social and environmental responsibility, economics, legal issues and management principles and practices, they of necessity cover these areas at very high level and do not really train engineers in the skills required to strategically manage assets. In addition, there tends to not be a very high emphasis on specific training in asset management and maintenance, and in key skill areas like risk management and innovation management.

Undergraduate education therefore achieves a basic understanding of the principles of sustainability and engineering management in graduate engineers, but falls short of providing the real focus on specific skills in particular specialisations such as asset management. Because of this limitation, the best opportunity of providing engineers with the skills of effective and efficient life cycle strategic asset management is through dedicated postgraduate engineering education.

It is therefore contended that postgraduate courses that focus on real tools for practising engineers provide the best approach for developing the required theoretical and practical concepts they require. Such courses must be directly applicable to practising professionals, and must been seen as a real asset to the corporations and institutions employing them. The

University of Southern Queensland has consequently developed a number of postgraduate programs that meet these requirements. Several of these have courses suitable for asset managers, while one has a set of related courses that meet the requirements for asset managers outlined in the previous section.

5 POSTGRADUATE ENGINEERING PROGRAMS AT UNIVERSITY OF SOUTHERN QUEENSLAND

Postgraduate engineering education is offered within the University of Southern Queensland by the Faculty of Engineering and Surveying, sometimes in conjunction with other Faculties such as Business and Science. The programs offered include the Master of Engineering Technology, Master of Engineering Practice, Master of Technology Management (MTM), Master of Professional Engineering and Master of Engineering. There are also Engineering Doctorate and Doctor of Philosophy programs available.

In the Master of Engineering Technology, engineers and technologists develop increased technological skills through studying eight courses (equivalent to a year of full-time study) and undertaking a dissertation project equivalent in value to four courses (one semester of full-time study or equivalent), or alternatively studying an engineering management path of equal workload.

Students in the Master of Engineering Practice study a portfolio based program aimed at providing opportunity for experienced technologists to gain recognition equivalent to a four year professional engineering program.

The Master of Technology Management is a quite recent development. It is a coursework program that is aimed at combining technological and managerial skills for practising technologists and engineers. A related program is the related Master of Professional Engineering, which is a partial coursework and partial professional portfolio (and/or research) based program that utilises Master of Technology Management and other courses to develop a higher level of engineering specialisation.

A number of the courses offered in the Mater of Technology Management are also available in the Engineering Doctorate and in other University courses such as the Master of Project Management offered by the Faculty of Business. The management path of the Master of Engineering Technology program consists of a selected number of these courses.

6 OUTLINE OF THE POSTGRADUATE ASSET MANAGEMENT COURSES OFFERED AT USQ

The purpose of the Master of Technology Management is to produce graduates "that are equipped with essential management knowledge and an appreciation of the latest technologies much broader than the initial specialisation", in order to equip them to manage complex technological or engineering businesses [14].

This program is completed by part-time external delivery mode, over a minimum of six semesters. It consists of twelve courses, four of which are core Master of Business Administration (MBA) courses and eight of which are specialised technology management courses, four of which are considered core to the program. The first specialised technology management courses were undertaken by students in 2004.

The engineering courses in this program are shown in Figure 2.

Core Courses (all to be completed)
Technological Impact and its Management
Towards Sustainable Development
Management of Technological Risk
Asset Management in an Engineering Environment

Other courses (4 to be completed)
Engineering & Surveying Research Methodology
Assessment of Future Specialist Technology
Management of Environmental Technology
Technology Management Practice
Whole of Life Facilities Management
Technological Innovation and Development

Figure 2: Engineering courses in the USQ Master of Technology Management

As previously stated, this program was developed out of the recognition that a large number of engineers and other qualified people aspire to managerial positions in a technology or engineering environment. It was also recognised that qualified managers of technology play a crucial role in technologically advanced as well as developing societies. This latter characteristic, which emphasises the crucial role of the technological manager in society, illustrates the importance of such a program in key technological functions like strategic asset management.

It is primarily aimed at attracting engineers and technologists who wish to develop management skills but want these to be in the field of technology management. They would come from both Australia and overseas, and would be likely to be ambitious and motivated, and see additional qualifications as a means of career enhancement.

In the next section, the key courses related to strategic asset management are described in more depth.

7 KEY ASSET MANAGEMENT RELATED COURSES IN THE MASTER OF TECHNOLOGY MANAGEMENT

The Master of Technology Management program contains a range of integrated courses that address the requirements of the strategic asset manager. Those currently offered are the specialised Asset Management in an Engineering Environment course, Technological Impact and its Management, Management of Technological Risk, Technology Management Practice, Technological Innovation and Development, Future of Specialist Technology and Engineering and Surveying Research Methodology. A course in sustainable development is expected to be developed in 2007.

To show how a program of this type can assist to meet the requirements of strategic management as discussed above, the courses of Asset Management in an Engineering Environment; Technological Impact and its Management; Management of Technological Risk; Technological Innovation and Development; and Technology Management Practice are discussed below in more depth. This is followed by an overall summary of how the program addresses the development of strategic asset management leaders.

7.1 Asset Management in an Engineering Environment

Asset Management in an Engineering Environment is aimed at developing the skills of asset managers in making strategic and operational decisions in the development and maintenance of engineering assets. It recognises that that in the modern world one of the highest expenditure for any government is the cost of developing and maintaining infrastructure.

This course is designed to enhance the ability of managers in making better economical and financial decisions for the construction and maintenance of engineering infrastructure assets. Such decisions, if properly made, will mean better use of resources in obtaining optimum performance and longevity of engineering assets. This course addresses this requirement by taking a strategic view of asset management; discussing the principles of the asset management process and asset management economics; and applying the principles to the asset management process.

Specifically, this course discusses the asset management context as discussed in section 2 of this paper and establishes the need for the asset manager to optimise the requirements of the main stakeholder groups – owner/manager, user (where the user is not the owner), local external community and wider community. Building on this foundation, it then discusses the strategic asset management framework including the asset life cycle and its issues, performance requirements and deterioration. Following a module on asset management economics, the course then applies the principles in asset operations, renewal and maintenance; integrated asset management including investment decisions for both individual assets and asset network; and asset management systems. It concludes with a discussion of future issues in asset management, such as developments in asset management systems, data collection, sustainability and globalisation and management practices.

The course aims to develop a multi-skilled strategic asset manager who is conscious of sustainability and globalisation issues and able to interact with a range of people from many facets of society [15}. A further course, Whole of Life Facilities Management, focusing on the tactical and operational process of asset operation and maintenance, is in the process of development.

7.2 Technological Impact and its Management

Technological Impact and its Management is based on the understanding that that the world of today is one in which there is dynamic change in the creation and development of technology. Therefore, it is necessary for managers of technology to understand the impact of technological development and the ways in which it can affect the society in which we live and the controls necessary to achieve a positive impact on mankind.

This course reviews current technological development, evaluates its impact on the world on we live in, examines the relationship between modern society and technological development, and discusses the role of technological development on wealth creation and business. It also assesses the overall social need to manage such development as well as technology creation, transfer and exploitation. While it does not specifically focus on asset management, it introduces the asset manager to the principles of strategically and innovatively managing technological development in a world that demands increasing social and environmental responsibility in the technological management process.

7.3 Management of Technological Risk

As previously discussed, risk management is a priority area for the strategic asset manager. It is particularly important for the asset management leader who needs to consider a range of risks when managing both single assets and asset networks. This course concentrates on the management of technological risk with respect to both taking advantage of opportunities and minimising the effect of negative impacts. There is a financial incentive, as well as community and corporate responsibility, to achieve the best results from an asset management point of view and to improve reliability. Increasingly, there are statutory requirements to address reliability and safety issues explicitly. In addition, there may be opportunities to manage risks to the benefit of the organisation. Consequently, strategic asset managers need to be aware of the tools and techniques used for the identification, assessment and treatment of technological risks.

In the first part of the Management of Technological Risk course, risk management is discussed in the context of the Australian/New Zealand Standard for Risk Management AS/NZS 4360:2004. In the second part of the course, learners apply risk management principles to technological and engineering projects and processes, and discuss the future of risk management, which is an important tool in evaluating the likely benefits and costs of alternative approaches in developing a sustainable future. Of particular interest to asset managers are sections on risk management in project management; health safety and environmental risks and their management; and a detailed discussion on risk management in asset management, which is based on the principles similar to those of the International Infrastructure Management Manual described in section 3 above.

7.4 Technological Innovation and Development

Technological Innovation and Development builds on Technological Impact and Its Management, and is designed to enable learners to understand the commercial research and development process; appraise the factors which impact on innovation and its development from a managerial point of view; understand and apply the organisational, social and environmental factors which impact on product and process innovation; appreciate and manage the relevant risks; and understand key issues such as intellectual property management and commercialisation. It begins with understanding the concept of innovation and the management of research and development processes, and discusses key issues such as technical risk, intellectual property management, commercial risk and social impact, and the technology transfer process.

From a strategic asset management point of view, this course develops the skills in the asset manager of not only being creative in the asset management process, but also to seek and adopt advances in technology to optimise the life cycle planning, development and ongoing operation and maintenance of the assets for which the manager is responsible.

7.5 Technology Management Practice

Technology Management Practice covers a range of engineering management topics. In particular, it covers the principles of management, project and works management; engineering economics, probability and statistics, law (as related to engineering), contracts and project delivery, accounting and personnel. It complements specialised business management courses taken as part of the Master of Technology Management through teaching specialised engineering aspects of the management process. For example, the project and works management section takes the learner through the basic principles of good project management; then introduces the principles of planning, estimating and scheduling; and discusses procurement, quality management, plant and equipment management, and office management. The contracts module deals with tendering and contract management, and will in future deal with modern forms of project delivery such as public private partnerships and relationship contracting.

This course provides the tools to enable all engineers, including asset managers, effectively manage the engineering function.

7.6 Summary

While this program does not specifically target one particular discipline of the management of technology, it has specific courses designed for the strategic asset manager and a number of complementary courses that use a similar theme of combining technological, economic, social and environmental issues in a strategic framework aimed at developing the technology leader. From the specific asset management viewpoint, it aims to provide courses assist that manager to better implement whole of life strategic asset management, manage in a sustainable manner, manage technological risks, be innovative and apply engineering management principles to the asset management function.

8 DEVELOPMENT OF THE PROGRAM

8.1 Considerations in Development

Programs like the Master of Technology Management are designed to meet the needs of both potential learners and industry. It is expected that most learners will already be practising professionals, located in both Australia and overseas, many of whom will be working in organisations that are dynamically changing and will have different levels of technological maturity. While most students will be engineers and technologists, some (including some asset managers) may have other basic professions. Hence the courses in this program have been written with a view to their understanding by a range of professionals.

Learners in such a study program are likely to have differing needs, and come from a range of organisations. These organisations, and the people in them, will have differing understandings of the concepts in this program, and will also have differing geographic and cultural backgrounds. As an example, engineering asset management is likely to be quite different for a person in a developed country whose main concern is to ensure that an expected standard of service from a particular asset (such as a four lane asphalt surfaced road) is met, and a person in a less developed country, whose main concern might be justifying the construction of a road to a reasonable standard for its expected traffic and community needs. Course material therefore needs to meet both sets of requirements.

Similarly, requirements and expectations may differ across geographical and political regions. Therefore, course development has needed to consider both Australian and overseas practice. For example, Management of Technological Risk is primarily based on the Australian/New Zealand Standard for Risk Management. However, the course developer has had to appreciate that there are also other equally valid risk management methodologies which need to be considered. For example, see Chapman and Ward [16].

Finally, learners are likely to have different levels of access to the courses. In Australia urban centres, for example, most learners will have access to fast Internet access, and therefore they are likely to both expect and be provided with interactive on-line teaching materials. People in remote areas of Australia may well have minimal Internet access, and those in remote parts of the world could have little or no access to the Internet. Assessment (such as assignments) from students in some more remote regions of the world may need to allow for good hand-written assignments as well as the normal typed assignment expected of a person who has ready access to computers, and may need to allow for slower postage from some locations. Therefore, delivery of the course delivery needs to cater for all of these needs and expectations. This is particularly important for asset managers, many of whom will be managing assets in a range of geographical locations, with differing levels of equipment, expertise and access to labour and equipment.

Therefore, when developing the courses in the program, it has been important to be aware of the differing academic and professional backgrounds of learners, their needs and expectations and those of their employers, and the best way in which they can receive course materials and interact with lecturers.

8.2 Challenges in Developing the Courses

Because of the range of student interests and backgrounds undertaking programs like the Master of Technology Management, it has been necessary to develop courses so that they provide sufficient material in the course material to give basic information, while maintaining a strong focus on a balanced management approach. This needs to be balanced by providing sufficient challenge for people who want to learn a topic in depth. There is also a need to meet the requirements of people with differing levels of mathematical background. For example, people who have a bachelor level degree in engineering technology are likely to have less training in formal mathematics than people with a four year engineering degree. Asset managers can come from both groups, and also from people with business and other backgrounds with a lower level of mathematical skill than fully qualified engineers. Therefore, the level of mathematics in the courses in this program been kept to a minimum, subject to ensuring that necessary standards are maintained.

This requirement has been met by guiding learners through the necessary basic process while giving them access to learn the necessary basic quantitative skills (such as the use of statistics). At the same time, the needs of advanced learners have to be considered. Therefore, the courses have been designed to cover the necessary background material at outline level only, and then move fairly quickly to applications. Those learners who need to know the theory in more detail have been directed to appropriate books and websites..

This type of approach has also been used in other aspects of this course, such as the writing of English expression.

Developing courses to meet the needs of diverse learners is best illustrated by the example of developing Asset Management in an Engineering Environment, which is relevant to the needs of the asset manager. Thus, it was necessary to decide the asset management context (as discussed in section 2 of this paper), assess what material should be included in the course, identify the likely profile of potential learners, and decide how course material should be delivered and assessed.

A particular challenge was to decide on the way in which the course should be organised and presented to meet course objectives and to challenge learners. Thus, while the thrust of the course is on the strategic aspects of managing engineering and technological assets, operational aspects of asset management have also been addressed, both to enure that they are fully considered and to lay the platform for a future facilities and maintenance management course that is expected to cover tactical and operational management and maintenance of assets in more detail. In addition, material relating to sustainable development, whole of life focus, risk management, innovation and technological management has been included, at least to an extent that it links to other courses in the program.

A modular design has been employed, both for ease of study and to allow selected modules to be offered as future short courses suitable for possible industry training purposes. Therefore, the first modules that students study deal with theoretical issues, while later modules in the course focus on application of these principles. Current and emerging issues like sustainability, risk management and optimising multiple asset management goals are addressed throughout the course. The course uses guided research – reflection, research into key issues (supplemented by a series of questions to prompt the research process), development of opinions and problem solving. Use is made of on-line research to supplement written material. As with most courses in this program, a textbook is used to supplement study resources prepared by university staff.

To assist learners with mastering the amount of material in the course, it has a number of activities that are classified into differing ranges of importance. The first level is essential tasks, which provide basic knowledge of the course material. Tasks classified as "important" are designed to provide further understanding. They include reading and understanding explanatory course or text material, or undertaking a reading or exercise that aids understanding of the principles being explained. Learners may also optionally further research course material ("background tasks") or undertake in-depth research to understand it in more depth ("other tasks"). Material in essential and important tasks is examinable and is accordingly structured to enable learners with minimal mathematical background to succeed in the course

9 IMPLEMENTATION OF THE STUDY COURSES

The Master of Technology Management program is in its third year of offer. The first courses, offered in Semester 1 of 2004, were Asset Management in an Engineering Environment and Technological Impact and its Management. These were followed in the second semester of 2004 by Management of Technological Risk. A further three courses were added in 2005. Students enrolling for these courses are from diverse academic backgrounds that include engineering, engineering technology, business administration, technology management and project management.

All course material is provided in written paper form. While there can be some variation, this usually consists of an introductory book, a study book, and a book of readings. The introductory book contains information about the course, the study book contains the course material, and the book of readings a number of readings to aid understanding.

Written learning material has been enhanced with on-line discussion using the WebCT on-line teaching tool. This allows online discussion, notices, and posting of supplementary course material on the web for those with web access (the majority of students). As systems and communications continue to improve, online learning facilities are being enhanced with discussions, quizzes and other interaction with students.

There have been many studies in the literature that support on-line teaching and learning. For example, Macdonald [17] reported on the use of online interactivity in assignment development and feedback in Britain's Open University; Deeks [16] discussed the use of web-based assignments for structural analysis; and Ferris [19] used web-based teaching for management engineering management. However, it is also desirable to be able to meet the requirements of learners in remote locations, and therefore it is expected that there will be a paper based system of study materials for some time.

Because the courses have been offered for a short time only and many have limited enrolment at this early stage, it is too early for statistically valid student feedback. However, comments received have been positive, and the program appears to be meeting student requirements.

10 THE CHALLENGES AHEAD

Educating strategic asset manager leaders requires a combination of understanding technological and economic asset management, the management of sustainability, risk management and innovation management within an overall technological or engineering management framework. Programs like the Master of Technology Management have been developed in an attempt to meet this requirement by endeavouring to combine business and engineering skills into an integrated package aimed at the innovative management of today’s and tomorrow’s technology assets and organisations in a changing world with changing demands.

Because of its need to be a dynamic program delivered by distance education to motivated professionals, this program has needed a tight focus, suitability for learners with a range of backgrounds and experience, and development within a tight timeframe. As the requirements of stakeholders change, new materials and methods emerge, better systems are developed, and more is understood about asset management, it is important to develop innovative asset management leaders who are strategic thinkers. This requires continuous updating and upgrading of the courses in this program and the program itself.

A significant component of the course adaptation process will be in meeting the needs of world wide approaches and demands in asset management. This will require better understanding and appreciation of international requirements, and of the diverse expectations of many communities across the world, each with differing social, environmental and economic values and needs. Incorporation of this information into the course delivery process is expected to improve the relevance of course material to learners in local communities and at the same time improve understanding of global issues by all learners. Recent feedback from this process is being incorporated in modification to this program and incorporation of some of its courses in other postgraduate engineering programs offered by the University.

One of the key challenges ahead within the whole engineering profession will be the extent to which a traditional engineering undergraduate program, with its strong emphasis on technical training, will be able to produce the graduate who can effectively manage engineering and technological assets. Courses like the Master of Technology Management can help to fulfil this need by offering a diverse postgraduate technology management education that considers current and emerging issues in strategic asset management, with a view to developing leaders in this field who have a combination of business and technological expertise, as well as a solid grounding in current and emerging issues such as sustainable development and risk management..

A future challenge is likely to be the development of industry based programs as well as the individual programs that are primarily currently offered for course work master degrees. In this way, courses like Asset Management in an Engineering Environment are likely to develop to meet a range of specific industry and community based educational and training needs. This will mean that not only should individuals attain the skills necessary for strategic asset and other management, but also that these skills are expected to be transferred to industry and the wider community.

11 CONCLUSION

While there are limitations in the management education of strategic asset management leaders at the undergraduate level because of the need for students at this level to focus strongly on technical issues rather than the broader issues associated with strategic lifecycle asset management, postgraduate education provides the opportunity to develop the broader skills necessary. Through combining business and technological education, and targeting a range of modern asset management requirements such as sustainability, risk management and innovation, postgraduate engineering management programs like the Master of Technology Management have the potential to develop and empower strategic asset managers in the execution of their duties.

Such programs are considered important in the process of educating current and future strategic asset managers in the sustainable management of engineering assets in a diverse, ever changing and increasingly global environment.

While there are a number of challenges to be overcome, education programs of his type aim to provide the opportunity for such managers obtain a level of postgraduate technological management education that enables them to posses the skills required for them to be leaders both now and in the future.

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