related coordinate system (Groot, 1991: 380). This appropriately describes all those elements in LIS, GIS, facilities management (FM) and SIS which, while representing a specific layer of information, ultimately aim at providing geo-referenced spatial information. Rather than use the word 'information', geomatics (refer to 2.2.1 and Williams, 1996: 30) is proffered as uniquely representing the full processes and structure of the currently fragmented surveying, mapping and spatial information industry entities.

During the early development stages of the SIS, surveying was perceived to comprise four fields, viz. legal, position and measurement, LIS and land information management (Williamson, 1981: 299), and that all members of the surveying and mapping industry should participate in SIS (Usher, 1985: 302). This perception continued to be expressed by describing the many skills in the surveying and mapping industry as really constituting the SIS industry (Davies, 1991: 4 and Worth, 1992b: 5). This SIS industry, comprising a combination of LIS (surveying domain) and GIS (cartographic domain) highlighted the merging portions of the surveying and cartography disciplines (Trinder, 1990: 2). This was similarly acknowledged by Williamson and Hunter (1990: 22) when they described surveying and LIS/GIS strengths as complementary. There are those that have viewed pragmatically the change occurring in all the spatial information related disciplines and concluded that GIS comprises all the aspects of surveying, cartography and photogrammetry (Leis, 1992: 472 and V svalingam, 1992: 52), providing the multidisciplinary nature of SIS. It is this multidisciplinary involvement that has the SIS industry fragmented in small, specialised and local operations (Baker & McLaughlin, 1991: 3). This perception of the dominant discipline area, and hence thrust of spatial information and its' development, must have a profound affect on current and future curriculum (refer to 2.4.10). Similarly, if GIS data measurement is to be taken from being done on an informal on-demand basis, by the various sub-cultures of the geomatics' industry, to being performed on a formal basis as part of a 'national' total information system (Epstein, 1992, presentation), then this will also direct curriculum development towards a geomatics' approach. As geomatics is ... *used to build a SIS; is a means vs. a result* (Bedard *et al.*, 1988), and its power is in managing related data layers or sets, then geomatics is SIS management (Baker & McLaughlin, 1991: 4). More accurately, geomatics is the industry and everything to do with spatial information is the activity of that industry. Hence, the foundation of the philosophy for curriculum development in the perceived spatial information industry is the concept of geomatics (refer to 2.2.1).

The surveying and mapping industry must define its role in GIS (Davies, 1991: 5 and Gerber, 1990: 47) and establish the industry's dominance, or witness its dispersion with subsequent loss of traditional expertise (refer to 1.2). The dominance should be related to base data establishment, integrity and amalgamation expertise. GIS users will control the technology and applications. Already GIS, remote sensing and cartography education and training are being lost to a variety of other professional courses (Chapman, 1992: 281 and Dahlberg & Jensen, 1985: 173). While there are numerous users of GIS, many do not require accurately geo-referenced data, e.g. social sciences (AKCLIS, 1992: 16; de Meyere, 1989: 14 and Douglas & Eccelston, 1992: 82). It must be remembered that GIS is a universal vehicle for integrating a whole range of other applications, e.g. modelling and data visualisation (Baker & McLaughlin, 1991: 10), of which many of the users are not concerned with the positional accuracy to which geomaticans work to. The loss of expertise in quality management in the surveying and mapping industry (refer to 2.2.1(i) and (ii)) in data capture, manipulation, integration, portrayal methodologies and integrity assurance can only diminish its global usefulness, by reducing grouped data integrity to the least reliable component, and integration capabilities of the SIS and the importance of the geomatics' industry itself. Jordan and Star (1992: 853) note that the 'generalist' users have little time or patience with the intricacies of data exchange and that data are coming from widely divergent methods of measurements. Hence, data accuracy and quality assurance are major considerations in the spatial information industry. Also, supplying spatial information methodologies has changed along with user expectation, computer handling technology and communications technology. This has resulted in the move (by marketplace economics) to a generic products approach, able to be converted into any thematic output, from an application specific products approach (Baker & McLaughlin, 1991: 7). This has been exemplified by the greater concentration of technology into the information arena, emphasising the thrust to become information rich rather than data rich and information poor (Baker & McLaughlin, 1991: 2). The information richness, coupled with integrity, quality and speed of delivery, is increasingly important in decision making, i.e. use to management. This has been achieved through improving organisation, its availability and the analysis and reference support to decision making (Baker & McLaughlin, 1991: 2). Information is fundamental to a business and provides for the delivery of business goals (Douglas & Eccelston, 1992: 82). Generally, GIS can be considered as functioning in two roles, that of administration (cadastral data, etc., and book keeping operations) and modelling (for forecasting and presenting information). The major contemporary concern of the geomatican is not the multiple uses of the data that do not require a high order of positional accuracy, but in maintaining a data integrity commensurate with the greatest accuracy requirement so that it is suitable for all practical and legal purposes. As never before, the geomatics' sub-cultures need to unite into a single geomatics' profession as the only way of achieving the high level of understanding, co-ordination and co-operation required for their dominance in spatial information base data integrity and maintenance.

GIS, remote sensing and GPS, or space and automated cartography technologies, are the foundation blocks of spatial information (AKCLIS, 1992: 16 and Task Force, 1991: 4). With full digital processes for maps and graphics indistinguishable from manual means (Anderson, 1992: 116), cartography should naturally envelope GIS (Gerber, 1990: 47). SIS is the confluence of cartography and remote sensing (Dahlberg & Jensen, 1985: 173) reflecting in the move from maps into thematic data bases (de Meyere, 1989: 12). Surveying and geography at the University of Newcastle-Upon-Tyne amalgamated to create an Information bachelor's degree, as it became evident that there was increasing convergence of the subject matter in geodesy, remote sensing, photogrammetry, land and engineering surveying, cartography and management information systems (Fairbairn & Openshaw, 1991: 79). However, the development of new techniques and methodologies has not occurred without causing problems. The doubling in the number of subjects, including remote sensing, GIS and GPS, in courses from 1965 to 1985 (Foster & Williamson, 1985: 431) suggests that there has generally been a tacking on of new technologies, rather than the integration or replacement of old or obsolete methodologies and techniques. Although such a situation is 'politically' expedient and far less resource demanding than fully integrating it via an 'industry needs based' curriculum development process, it is technically and professionally less affective and unsustainable.

In Canada, the acronym SIMA (Spatial Information Mapping and Analysis) was offered to define a new emerging profession (ACSM, 1993: 14). Spatial information was perceived as offering an unifying theme encouraging a transition from data collection to proactive involvement in a data environment (ACSM, 1993: 14). There should be a top-to-bottom approach, with data collection considered as only a means to an end: a general ... *move from technical specialist roles to participants in the solution of societal problems* (ACSM, 1993: 7). As a consequence *The educational emphasis must shift from dependence on state-of-the-art instrumentation and equipment specific training to the appropriate application and analysis of the use of these ever changing technologies* (ACSM, 1993: 8), and hence the need to develop more skills and flexibility (Lodwick & Wright, 1993: 294).

There are problems in the SIS industry as the sections of hardware, software, new users and applications are rapidly changing or expanding, demanding new standards for data transfer, measurement methods, accuracy and quality assurance (Jordan & Star, 1992: 863; Kennie, 1994: 81 and 90 and McGrath & Harding, 1985: 346). Also, networking is becoming ubiquitous everywhere with a high degree of interconnectedness and interoperability in both professional situations and general users (Openshaw, 1992: 104). The need for data quantity, quality and delivery speed, coupled to the increasing abilities in automated data capture, means that there is a need to amalgamate all digital and analogue (sound, picture etc.) data with all multimedia facets. While there is still confusion in differentiating between LIS and GIS, as both have a narrow perspective (Johnston, 1991: 2), in reality *GIS technologies is only a small part of a much broader picture* within the information technology industry (Openshaw, 1992: 107). Therefore, the integrity (accuracy and validity of classification) of the spatial base data is of paramount importance to ensure the correlation, integration and integrity of other related data forms to the base data and to one another. This integrity can be best achieved by geomatics' professionals with the professional attributes similar to those described in 2.2.1(i) and (ii). The building of these attributes must, initially, be part of the curriculum, before being reinforced by the professions' activities.

In an acknowledgement to changes that are occurring, the Queensland Land Information Council was established to refocus the surveying and mapping role to a surveying, mapping and information system perspective (refer to 2.3.3). Functioning as a single authority, it operates with an overarching strategy encompassing technical and human resources, for developing procedures to ensure the co-ordination of land information management (Department of Lands, Queensland, 1992: Appendix A), and provides the mechanisms to permit community access to land information (Eden & Barker, 1992: 272). Such developments for a coordinated single purpose industry approach are required to ensure homogeneous accuracy [through standards, consistencies and truth in labelling] and positional accuracy of data (Hirst & Masters, 1992: 436). These developments are a manifestation of acknowledging the needs of clients and acquiescing to societal pressures for accountability, public access to public information, and contemporary administrative and technical efficiencies.

The traditional surveying and mapping discipline's professionals cannot expect to just move into the SIS arena without appropriate education (Trinder, 1990: 2). However, they should be the SIS professionals as they have those necessary skills to ensure: accurate data acquisition, manipulation and storage; data exchange expertise, correlation, integration and integrity; a high level of analytical and interpretation skills; correct presentation methodology and techniques; and are accustomed to producing information for multiple-user clients. Baker and McLaughlin (1991: 4) describe this expertise as meta information, which is non-spatial information which does not relate to the real world situation but to information that reflects the real world, e.g. how to access information, validity, accuracy and its location, etc. The users of SIS are varied and expanding in numbers and backgrounds (AKCLIS, 1992: 16; Jordan & Star, 1992: 863 and Rhind *et al.*, 1991: 1), for example, a Regional Transport Authority (Douglas and Eccelston, 1992: 82), town and city councils, real estate agents, social and applied scientists, etc. Hence, there exists an enormous potential for errors, through a lack of adequate and suitable education and training, by 'non-experts' using the systems (Hunter & Beard, 1992: 113). Much of the demand for training in all disciplines has been with post bachelor graduands (ACSM, 1993: 4; ACSQ, 1991: 4 and de Meyere, 1989: 12). While there is still a lack of educated SIS personnel (Leis, 1992: 476), and a need to focus SIS usage development, these were the concerns that initially led to the establishment of AKCLIS. This organisation was to foster formal education and training and assist, support or compliment educational and training programmes (AKCLIS, 1992: 6) ... *to enable higher education to respond to the need for high level training and applied research in areas which are important to national development and to the community in general* (AKCLIS, 1992: 2). However, the role of AKCLIS would appear to be reaching redundancy [and would certainly do so in a geomatics' structure, becoming simply a natural function of that structure] with increased SIS in undergraduate curricula, increasing open access curriculum developments, and changing continuing professional development organisation.

Within the SIS industry there is a need for the professional to both build and manage the structure and the paraprofessional to gather and apply spatial information (de Meyere, 1989: 12; Groot, 1991: 367; Ormeling, 1988: 530 and Task Force, 1991: 33). This has been reflected in the TAFE sectors' radical redesign developments of its paraprofessional cartography course - cartography has given way to GIS (Chapman, 1992: 280) - to reflect a SIS emphasis (Skitch, 1991: 7), acknowledging that professional education is occurring at the university level (Skitch, 1991: 8). However, the lack of available trained people, and because of the need for hands-on knowledge of the particular system, has also meant that much of the training has been carried out on-the-job (ACSQ, 1993: 4 and Blinn *et al.*, 1992: 60). Davies (refer to 2.2.3) supports this concept of the division between education and training that enables universities to focus mainly on education issues. The validity for this dichotomy between education and training is further supported when it is considered that 26% (McLaughlin *et al.*, 1991: 9) - from 21% in 1985 (Usher, 1985: 297) - of persons working within the Canadian surveying and mapping industry hold a bachelor's degree, the remainder with lesser or no formal qualifications. Similar situations are evident in Australia, where 71% of the membership of the Australian Institution of Cartographers commenced work with a technical qualification, still an acceptable qualification and flourishing (Worth, 1992b: 4), although 46% now have a degree [the majority of these have, however, been gained in a different discipline in which institutional membership is also held (refer to 2.3.3), e.g. surveying] (Murphy, 1992: 37). This trend is likely to continue as approximately 50% of new students in the University New South Wales undergraduate course articulate from the TAFE sector (Trinder, 1993: 288 and presentation); 86% of undergraduates doing courses in the USA have prior surveying and mapping experience; and few are coming directly from school (ACSM, 1993: 4). The numbers seeking or requiring a degree, and the articulation trends, substantially question the impact on the division between education and training, the specific needs of both, and where or when they should occur.

The Australian and New Zealand Land Information Council (ANZLIC) defines land-related information (relating to the atmosphere, surface, sub-surface and aquatic regions) as ... *encompassing information about natural resources, the environment, land ownership, land use, transport, communications, mapping, demography and socioeconomic factors where such land information can be related to geographic position* (ALIC, 1988 as quoted in Eden & Baker, 1992: 270). While his definition prescribes the need for a broad knowledge base, the conclusions Davies drew from contemporary curricula objectives do not reflect such a thrust and, apparently, the industry does ... *not envisage the opportunities that are likely to develop for it* (Davies, 1991: 4). Hence, changes in curriculum philosophy are perceived as necessary for the advancement, or even survival, of the industry. The incorporated syllabus changes deemed necessary include an increase, or inclusion, of mathematics, social sciences, land studies, communications, law, environmental studies and humanities; to the exclusion or reduction of the traditional areas of geodesy, hydrography and engineering (ACSM, 1993: 5; ACSQ, 1991: 3; Bedard *et al.*, 1988: 109; de Meyere, 1989: 14; Gracie, 1985: 374; Ormeling, 1993: 116 and Ormeling, 1988: 529). Part of this curriculum change includes educating students in the art of being responsive to niche markets (Groot, 1991: 367), data use to solve problems (ACSM, 1993: 11) and developing a particular attitude, motivation and behaviour focus (Blinn *et al.*, 1992: 59). These and other developments appear to still require implementation, further development or application changes, as there was no clear evidence from a survey of Australian academic institutions ... *to indicate the degree to which existing courses are satisfying the identified needs of the urban and regional information industry* (Granger, 1992: 8).

GIS in Canada was generally taught under the umbrella of a variety of courses which were offered mainly at technician or technologist training levels (Dahlberg & Jensen, 1985: 183 and Gracie, 1989: 269) or are 'added on' short courses without any real integration (Gracie, 1989: 262). Now, the GIS technology is now incorporated into the various geomatics and applications Departments. In Australia, spatial information education has been incorporated in, and is common to both, surveying and cartography courses (Lodwick & Wright, 1993: 300), but most of the concentration is still in the post-graduate studies arena (Williamson & Hunter, 1990: 23 and Worth, 1992b: 6). The majority of spatial information training is university conducted non-award short courses (55%) with a duration of less than five days, although the average of all the courses is five days duration (Granger, 1992: 7): they are also conducted on an *ad hoc* basis, targeting specific programmes or equipment (Blinn *et al.*, 1992: 60). The apparent need is for increased SIS education, industry based training arrangements, and open access to educational opportunities, especially for continuing professional development needs. In an attempt to provide the training and educational needs in Australia and overseas, a consortium with educational institutions was established: the Australian Institute of Spatial Information Sciences and Technology (AISIST). The organisation mostly aimed to develop competency based practically orientated course modules suitable for use in industry and academia, as in-house training was not successful and because of continuing professional development needs (refer to 2.4.4). Despite all these innovations, there are still overseas and Australian [1995 USQ market research] concerns expressed about the efficiency of GIS courses to cater adequately for the needs of society (Gerber *et al.*, 1992:18). As spatial information in Australia is a growth area and an integral part of geomatics' practice, rapid and innovative curriculum changes are required to overcome the current shortcomings and to provide efficient and consistent accessible education for past and future graduates. The University of Southern Queensland has endeavoured to specifically address this challenge through full-time and distance education delivery of its Bachelor of Technology (GIS) and Graduate Diploma of Geomatics (GIS) courses. Given the diversity of spatial information users and the current fragmented nature of the spatial information professional practices (refer to 2.2.1), and without a coordinated single approach to industrial practices, the geomatics' industry will forfeit control of base geographic data accuracy and integrity in the spatial information structure. Also, the opportunity to develop a geomatics' industry supporting coherent, viable and comprehensive geomatics' curricula could be lost.

2.4.6 Resources.

Now, and in the future, education and training will be a costly but necessary investment for those firms that want to prosper (Task Force, 1991: 8). This is the summary of the feelings of the Canadian industry's questioning of the educational sectors ability to deliver, in an environment of high level of scientific and technical processes, the quality and quantity of learning employees need (Task Force, 1991: 2). Physical resources in educational establishments are generally considered not current, or obsolete (Carter & Moynihan, 1988: 290 and Ruger, 1995: 202). Financial resources are considered severe (Task Force, 1991: 57) or inadequate and constantly decreasing in value due to the increased needs to purchase and update technology; to facilitate changes in government policy (Anson, 1991: 70; Williams, 1988: 553 and Balle, 1994: 181); or from academic institutions allocating funds based on business and not education principles (McLaughlin *et al.*, 1991: 5). In Australia, from 1975 to 1992, overall student numbers have increased by 42% with a corresponding 37% decrease (as a portion of the GDP) in Commonwealth Grants (Trinder, 1993: 284). This is likely to continue to meet student need in their pursuit of procuring employment, despite various successive governments pursuing 'user pays' policies and encouraging institutions to be partially self funding.

The surveying and cartography students appeared to be declining in quality and number, but this reduction has been the migration of students from the traditional surveying and cartography courses into SIS courses (ACSQ, 1991: 2; Bretreger, 1991: 292 and Task Force, 1991: 32). The lack of an adequate spatial information industry human resources strategy, a major concern of a Canadian study (McLaughlin *et al.*, 1991: 5), has precipitated numerous Australian and overseas short courses in SIS and major reviews of curriculum to provide for perceived shortages within, or as an adjunct to, traditional surveying and cartography courses (refer to 2.4.5). In 1996, student numbers have generally been maintained, and although some institutions experiencing increases, others are expressing concerns about future viable student intakes.

Resource restrictions establish a resistance to curriculum changes and locks academic institutions into established and conventional discipline areas (Dahlberg & Jensen, 1985: 179; Groot 1991: 372; McIlroy, 1989: 337 and Ruger, 1995: 197). This resistance not only crystallises because the additional manpower or commitments to the development [including processes such as the costs of 'selling' the new curriculum and obtaining accreditation] may not be supported, but consequential staff development, course developments and equipment resource needs may also not be made available by the academic institution. This level of support is also not available through an industry wide linkage. Other personal rewards are rarely offered to offset the penalties and overcome this inertia. Within the existing constructs, the institutions are unable to maintain a level of current technology and provide current and relevant practical training (Greenfeld, 1991: 39; Pollard & Robinson, 1985: 365 and Williams, 1988: 552): new developments increase this burden. An increased student demand for value for money has amplified the existing physical and teaching related problems associated with limited resources (Hoogsteden & Williamson, 1991: 309). One particular continuing problem is that less resources has meant increased workloads, with the existing curricula, hence a subsequent decrease in contact hours and the increase in the requirements for student self study (Trinder, 1993: 286). While the process of continuous curriculum development will consume more of the available resources, the resultant curriculum must ultimately minimise the affect that limited resources have on providing appropriate and valued education. Also, developing full or partial open access programmes, the distance education strategy in particular, or other industry co-operative arrangements, could significantly reduce contact time and physical resources.

Courses commenced through an agreement between an academic institution, the profession and industry to meet specific needs, have attracted a high level of vendor, government and industry support, alleviating some resources problems (Allaburton, 1990: 52). Where possible, many institutions now rely on attracting external non-government funding through direct support, joint ventures, consultancies, full fee paying students and other linkage arrangements, such as benefits from cross fertilisation activities (Anson, 1991: 70; Cassettari, 1991: 74; Hoogsteden & Williamson, 1991: 305; and Trinder, 1993: 287). The Australian government funding arrangements in 1995/1996) have increased the need to gain non-government funding to support these education programs. Leasing arrangements or cooperative ventures between all stakeholders has been suggested as a means of maximising the available resources (Groot, 1991: 379 and Williamson, 1988: 554). This includes better use of resources within institutions where it is seen as a priority to reduce ... *the insularity that exists within most academic institutions* to ensure a full use of available subjects and facilities within that institution (Granger, 1992: 8). The open access (refer 2.4 9(c)) to subjects within another educational institution, equivalent subjects having been considered an uneconomical proposition by the 'original institution', is also an important resource utilisation efficiency that could be developed. Attempts at better resource utilisation have been made, such as the hiring out of equipment by academic institutions during non-teaching periods (Hoogsteden & Williamson, 1991: 317). Other localised efforts, with varying levels of success, include academia and industry combining to develop non-profit GIS educational packages for general usage (Rogerson, 1990: 60) and an attempt at sharing resources between institutions (Bretreger, 1991: 294).

While resource linkages are a major concern of academic institutions, the most desirable long-term curriculum development can only occur if all linkage arrangements (refer to 2.2.3) can be developed and maintained amongst the academic, government, industry and professional organisations sectors. Institution barriers to, or difficulties with, resource sharing arrangements with other institutions would require some institutional attitude or infrastructure changes (refer to 2.4.9(b)): the changes could be more easily negotiated and accepted if they were seen to come from, and be supported by, a single geomatics' industry authority (refer to 2.3.1, 2.3.2 and 2.4.8 and 2.4.9(c). While resource constraints will ultimately determine the delivery and visible form of the curriculum, the fundamental construct of a curriculum should be developed within 'reasonable and logical' limits, largely ignoring resources, on real fundamental needs identified by the 'collective' stakeholders. Remaining physical resource problems can then be solved through arrangements involving the principles within open learning and the separation of education and training philosophies.

2.4.7 Surveys, studies and reports.

Surveys on human resource requirements are generally in response to a need to solve a current dilemma. These surveys are often introspective and elicit answers that only pertain to specific current practice problems, within a largely 'cottage industry' (in Australia) network, generally focussed from understandings of only the present or past. Privately written responses can also be easily influenced by what is thought to be wanted, rather than the reality, or by short-term rather than long-term needs, and may vary significantly depending on an individuals life experiences. These life experiences include previous education and training experiences; professional and personal work environment; membership to professional associations; and the attitude to questionnaires and the implied threats of its questions. Membership profile surveys also portray what currently exists and reflect on what has occurred (Murphy, 1992: 35-37 and Usher, 1985: 297), making comparisons and drawing conclusions against perceived practice needs or the inadequacies of meeting current needs (ACSM, 1993: 2 and Granger, 1992: 3). Respondents to a questionnaire generally provide statistical and 'results' data by identifying with specific predetermined and limiting questions, based on a reasonable perception of the outcome, as demonstrated from the surveys conducted by McLaughlin *et al.* (1991: 13); Williamson (1981 :296) and Williamson and Morrison (1978: 94-114). Data analysis is then carried out on this pre-categorised criteria. The written feedback segment of such surveys will mostly elicit an elaboration of answers to some of the specific set of questions asked, and not related to pertinent issues for which there were no questions, but may be a result of, or an influence on, the question (Williamson & Morrison, 1978 : 115). For example, Williamson and Morrison ascertained those topics that should be included or excluded in their undergraduate surveying curriculum evaluation survey, neglecting issues such as course duration; a distance education option; credit transfer and advance standing needs; practice and knowledge redundancy rate due to technological influences; communication difficulties with other profession and clients; difficulties with participating in continuing professional development; or difficulties encountered on moving interstate or overseas: all aspects that influence curriculum development. Such studies should be aimed at 'illuminating' how the industry perceives itself and how the individuals understand, think and learn about specific phenomena and concepts within their industry (Marton, 1988a: 53-57); not just providing statistical proof as an outcome of past practices. Such findings would have direct educational relevance and help shape the curriculum so that future human resources can be fully managed (Marton, 1984a: 44). No such survey has been done on the conceivable future needs of the geomatics' industry, or in trying to ascertain an understanding of the whole industry structure, so that necessary change, even those contrary to current practices, can occur to challenge real human resource needs.

Despite the range of specific issue surveys (e.g. Toms, 1990) and reviews (e.g. Lyons, 1984), concerning the nature of surveying and mapping education that have been completed in Australia in the last decade, there has not been any comprehensive attempt to develop a pre-service course that addresses the societal and technological challenges of professional education for the 1990s and beyond (Davies, 1991: 3; Lagerlow, 1988; Toms & Perel, 1990: 2; Williams, 1988: 554 and Little, 1993: 5). Nor has there been any recent investigation on how such courses can be delivered most efficiently to meet the challenges faced by industry, professional organisations and academia, while still satisfying professional requirements; equity; access: and social justice to the variety of prospective students (Dawkins, 1988: 15; Davies, 1991: 5 and Hannigan, 1992b: 425). Realisation of these types of problems are also being expressed by other Australian professional organisations (Institution of Engineers, 1990: 5). Some individual journal articles express views on changes needed for the geomatics industry and curriculum and speculate on future practices: these may not necessarily reflect the real needs of the whole industry. The difficulty is in not knowing what expertise is required for the future, and being able to establish the right changes to satisfy current concern and for servicing the future needs.

It is acknowledged that the current professional practices and structures and land regulations in New Zealand and Australian are similar, but differ to those in North America. However, a greater emphasis on geomatics has been evident in the North American geomatics industry environment, due mainly to the wealth of available information and the greater development of a specific geomatics philosophy.

Recent Canadian and American reviews into the activities of the surveying and mapping industry and their human resource requirements (ACSM, 1993; Groot, 1991; McLaughlin *et al.*, 1991 and Task Force, 1991) suggest that a fully integrated multidisciplinary curriculum, not separate surveying and cartography courses, is the method of satisfying contemporary and future demands for the surveying and mapping industry to achieve a cohesive whole (McLaughlin *et al.*, 1991: 15 and Groot, 1991: 367). The New Zealand Survey Industry Review Commission (1991: 30-31) also concluded there was a need for broad-based courses. While some curriculum development data gathering surveys have revealed the need for full time GIS courses in their own right (Cassettari, 1991: 77), other researchers are endeavouring to ascertain the nature of the discipline so that curriculum better addresses the needs of the profession and society (Gerber *et al.*, 1992: 19). ACSM (1993: 13) perceives that the outline of a new educational curriculum should be in a more open form containing scientific, societal, legal and economic debate to encompass:

(i) a broad general education to provide a basic understanding of world, its cultures and institutions;

(ii) a comprehensive education in the technology of spatial data gathering and management; and

(iii) application of learnt knowledge towards a solution of identified problems.

This is a geomatics (refer to 2.2) and cooperative philosophical approach for the spatial information industry which would require professional and paraprofessional levels within the discipline.

Surveys across the geomatics industry spectrum have persistently revealed a professional and paraprofessional educational need for increased social sciences and humanities studies (specifically, personal skills in written and verbal communications, management and leadership, mathematics, computer science and general sciences) and a lessening emphasis on 'measuring science' (ACSM, 1993: 7; Bedard *et al.*, 1988: 109; Leahy & Williamson, 1991: 3 and McLaughlin *et al.*, 1991: 13). An earlier survey of staff and graduates of a university provided conclusions emphasising the need for an increase in studies of law, surveying and computations, and a decrease in social science and humanities subjects. Other suggested reductions were in photogrammetry, geodesy and astronomy: these would largely be moved to post graduate studies topics (Williamson, 1981: 294 and Williamson & Morrison, 1978: 115). This highlights the recent changed emphases towards professional education and training within the broader societal context, although still focussing on current localised issues.

The effects of the outcomes of these surveys are demonstrated in the increased occurrence of SIS and applications orientation changes to courses. This was revealed in an Australian comparative study of fifty-seven institutions (Granger, 1992: 2) and two consecutive surveys in Britain (Anderson, 1991c: 157). These surveys also revealed that, despite changes, students were not being exposed to many technological changes (Anderson, 1991c: 157) and that there was a large increase in subject areas, a doubling over twenty years (refer to 2.4.5), rather that a philosophical approach of integration or replacement. These outcomes indicate physical and human resource problems; a lack of understanding of the 'broader' industry and its integrative nature; and a lack of cooperative linkages to ensure technological consequences 'fit-in' in the profession.

The results from a more recent survey, used in curriculum development at the University of Melbourne, saw a decrease in emphasis on the measurement science and the formation of a three strand structure while maintaining an industry-needed balance between surveying science and land management (Leahy & Williamson, 1991: 3 and 10). An even more integrated approach was revealed by a Delphi survey in Canada, which predicted the winding down of the traditional surveying and cartography courses and a merging into a single curriculum (Groot, 1991: 370): in June 1992 the University of Calgary (following the lead of Laval University) changed the name of its Department of Surveying Engineering to the Department of Geomatics Engineering to reflect industrial trends. Similarly, during an Australian industrial needs survey and curriculum development process, which included significant professional, academic and professional organisations involvement, evidence of the merging of the surveying and cartography disciplines was uncovered (Cameron & Williams,1989: 828). This knowledge resulted in a significant emphasis attributed to commonality of subjects for these disciplines; a broader education base by including greater emphasis on business management, marketing, land development and environmental development; a balanced mix of theory, applied technology, and practical application; and all while retaining enhanced specialist streams of surveying and cartography and the previous course skills levels (Cameron & Williams, 1989: 829). These changes, while enhancing the teaching environment viability and providing for 'todays' structure, provide a broader common base from which a geomatics' programme could be readily developed.

In addition to the technical practices needs of industry, the break-up of human resource needs also impact on curriculum development. Investigations carried out by Coleman and McLaughlin (1988: 20), McLaughlin *et al.* (1991: 8), Task Force (1991: 13 and 33) and Usher (1985: 297) elucidate the general discipline, professional and paraprofessional employment trends in the geomatics' arena, *viz.* there are insufficient trained personnel in SIS and it will remain so for some time (refer to 2.4.6). They also found that paraprofessionals are increasingly performing in what was previously considered professionals work while professionals are becoming managers, increasing the ratio of paraprofessionals to professionals (refer to 2.2.2 and 2.4.1 and 2.4.2). Also evident was the lack of a total industry human resource strategy (refer to 2.4.10). It is also estimated that the land surveying personnel percentage will continue to diminish despite an industry employment increase over the next decade (McLaughlin *et al.*, 1991: 11).

A comparative study of the Australian and New Zealand spatial information industries (refer to 2.2.2) revealed that the surveyed professionals were concerned by the threat of encroaching disciplines, unsure of their discipline boundaries, conservative, introspective and slow to adapt and adopt change. Other elements elucidated by similar general or human resource surveys indicate needs for amalgamation or merging of discipline area and associated professional organisations; continuing education opportunities; enhanced linkages (refer to 2.2.3); and concerns with the ability of universities to deliver and help these processes (McLaughlin *et al.*, 1991: 17). The slow reaction to the needs of industry and society by universities surfaced in numerous investigations, e.g. McLaughlin *et al.* (1991: 15) and Granger (1992: 8). In his analysis of course offerings, Granger concluded that there is a priority to reduce the insularity within most academic institutions to ensure a flexibility, full use and a variety of available subjects within that institution, i.e. a better use of available resources (refer to 2.4.4 and 2.4.6). Traditional insularity between the various discipline departments tend to mitigate against a well 'rounded' course. Granger also considers there will be no change until there is an acceptance that ... *competency in spatial issues is as important to life and vocational skills as is literacy and numeracy* (Granger, 1992: 8). He also noted that a broad-based professional organisation representing all the spatial information industry is needed, and not a major emphasis on surveying and cartography (refer to 2.3.3).

Analysed data from a survey of any profession, or of any situation within that profession, provides valuable information of the situation at that time or an insight into past occurrences. The above discussed investigations have been quantitative in nature, 'testing' or exploring current situations to draw conclusions and predict needs. To address long term needs, particularly for the industry as a whole, there is a need to use a probing and reporting instrument that endeavours to isolate unbiased (or subconscious) holistic perceptions of real future needs, eliminating as many of the 'predicting-the-required-answer' influences as possible. This technique should be able to produce different categories of conceptions (refer to chapter 3) of the primary needs of the industry which can be used in curriculum development to prepare students better for their professional environment. The way in which people conceptualise within the geomatics' context is critical, firstly, in the educational praxis elements of relevance and efficiency and quality in geomatics education and training. Secondly, it is important in developing those professional attributes of abstraction of meaning and understanding, cognition levels beyond the paraprofessional requirements of acquiring and applying facts and being skilful. Such an assessment of the geomatics' industry has not been performed and is needed to develop curricula that possess relevance and sustainability, but able to be easily and smoothly developed to accommodate change.

2.4.8 Competency based education.

Incorporating competency based education in schools will affect both TAFE and university curricula, present ideological conflicts, and have considerable resource and organisational consequences (Johnson, 1993: 10). Competence is considered to comprise a myriad of personal attributes, eg. knowledge, abilities, skills, attitudes and performance related to a role or task (Johnson, 1993: 6). Hence, competency principles place an emphasis on the outcomes (perform in a given context and transfer knowledge and skills to a new task and situation) and not the process (Johnson, 1993: 5). *A competency is defined as a combination of attributes, such as knowledge, abilities, skills and aptitudes, underlying specified aspects of successful professional performance* (Higher Education Division, 1992: 22). The Key Competencies (fundamental work environment skills) form a part of a Unit of Competency (the dominant or highest Performance Level) which are identified and include: collection, analysing and organising information; communication; planning and organising; team work; mathematics application; problem solving and using technology (NTB, 1992: 6). So, in theory, competency standards and evaluation procedures are applicable to all levels of training and education, from mundane tactile tasks to professional attitudes. Initially, this was an industrial led response to changing industrial and economic needs [especially in international competitiveness (Walker, 1993: 16)], and mainly developed for the sub-professional vocational education and training arenas, (e.g. Wilson, 1994: 53). It is then apparent that the highest level of a set of competencies in a unique skill (comprising application, performance and attitude) would be required to differentiate a professional from others competencies in non-unique skills and forms of functioning at a lower application and attitude competence level.

Within the structure of most professional courses there is already attention to competence standards, although mostly focussed at all levels of tactile skills and at training, where Hannigan (1993a: 4) believes it should be, but is rarely seen as applying to professionalism education. Most universities have visiting professional accreditation panels who, after making assessment on the standards of tactile professional competencies from syllabi content, recognise (or accredit) the course to permit membership to a professional organisation and some relevant statutory body registration endorsement (Hannigan, 1993a: 5; Johnson, 1993: 3; Whitehead, 1992: 7; Edwards, 1995: 9 and 2.3.2). However, curriculum development, course structures and teaching methods in universities remain the responsibilities of the academics, whose independence must be maintained, including the role of commenting on, criticising and examining society without impediments from society (Johnson, 1993: 4). This must continue irrespective of accreditation processes or whether or not competency standards are used (Johnson, 1993: 15). Hence, these institutions have the responsibility of not only fitting the graduate to the profession, but ensuring the attainment of the broader educational outcomes of clear thinking; a high level of conceptual skills; a breadth of understanding; the capacity for innovative thinking; the ability to make good judgments, and are articulate and principled (Anderson,1991b: 13 and Johnson, 1993: 3), *viz.* nurturing graduates for both their profession and society to a level of professional competence (Anderson,1991a: 310). Professionals should be seeking levels of 'high competence' or excellence, not just being competent (i.e. adequate) as they generally describe themselves (Brennan, 1993:12). This is essential and entails continuing professional education (refer to 2.4.4), not only for maintaining knowledge competence, but for 'societal' competence. It is also necessary because many practitioners have often not been able to solve the problems of clients or society, i.e. may understand the most recent professional advances but be at a loss to comprehend the client (Anderson 1991b: 12 and Brennan, 1993: 3). This situation is a manifestation of the near exclusive priority placed on technical competence, both within the geomatics' industry and educational institutions, rather than the 'professional attitudes' competencies and a wider discipline knowledge base. The construct of the geomatics' professional concept 'consequential curriculum' changes will address these problems.

The formalisation of competency-based training was introduced with the establishment of the National Training Board (NTB) in January 1990 and the introduction of The Australian Standards Framework (ASF) in 1991 (Johnson, 1993: 7 and Walker, 1993: 16). NTB operates within an agreement (where vocation is perceived in a technical rather than a professional sense):

> *to provide and accredit vocational education and training nationwide within the framework of the national competency standards ...,* with a role ... *to assist industry to develop and then endorse national competency standards for occupations and classifications in industry or enterprise awards or agreements.* It also believes competency standards . .*will be the benchmark for curriculum development, assessment, training delivery, accreditation, and individual certification in Australian vocational education and training.*
>
> (NTB, 1991: 1)

However, pertinent government ministers have been asked ... *to work with the view to developing national competency standards for all registered occupations and professions by the end of 1992* and told that ...*the professions and higher education providers involved will need to discuss and establish the relationship between standards and professional education* (Johnson, 1993: 9). Despite such commissions, as of 1993 [little has changed to 1996] the coverage of professions by competency standards has not occurred as most of the effort has so far gone into vocational areas: this is due to resistance by the professions, attitudes of the universities and limited resources of the relevant government authorities (Johnson, 1993: 10). The problem is that the thrust has been in determining competency standards based on a method of observing a performance of a particular behaviour, i.e. separable, specifiable, observable and measurable competencies: an atomistic approach which can not separate the constituents and the structure, things emphasised in the integrated approach (Walker, 1993: 18). However, competencies are complex and are constituted by personal attributes such as knowledge, attitudes and values, all which have cohesion and structure. Competencies never appear unaccompanied in practice and the set may vary from time to time, place to place and practitioner to practitioner. The assemblage of elements depends on judgments of a practitioner pursuing a goal and responding to feedback (Walker, 1993: 17): a professional is expected to perform in any, and varied, combination of these attitudes. However, it is nonsense to say that knowledge, values and attitudes are too difficult to include in competency standards (Walker, 1993: 19). Hence, the basis for professional competency standards should be one of the development of an integrated and holistic approach, one which requires insight; intelligence; understanding; cannot be done routinely; and includes consideration of group processes and professional cultures. The 'professional competence' is then an amalgamation and simultaneous employment of any combination of the highest level of the competencies in an application unique to that discipline. This is what geomatics curriculum development should address.

From the beginning of 1994 the Australian National Training Authority (refer to 2.4.4) became effective (Johnson, 1993: 11), influencing curriculum through competency based and open learning initiatives. Another body, the National Office of Overseas Skills Recognition (NOOSR), while focusing on overseas qualification recognition, is charged, by DEET [now DEETYA], with developing National Competency Standards for the professions (Walker, 1993: 16 and Whitehead, 1992: 8). This body is continuing to provide advice and assistance to professions where the workforce exceeds 2000 and to self-accrediting higher education institutions, the latter being the predominant deliverers of the education and training (Johnson, 1993: 12). There are currently nineteen professions under the aegis of NOOSR (Gonczi, 1993: 2): any increase will be voluntary as NOOSR has undertaken not to force competency standards where they are not practical or are unwanted (Persson, 1993: 8). In reality, professions will be involved in this and similar government 'policies' to maintain any influence on government policy and the long term security of the profession. However, government policies on industrial relations, contract awarding, trade practices and deregulation will continue to 'force' the geomatics profession into further documenting or developing competency standards.

The full impact of adherence to an increase in mandatory and specified competency standards is not totally clear, but some professions have found value in developing competency standards. The National Training Board (1992: 16) states that Key Competencies provide information on job standards requirements and for work integration and participation. If competencies are universally recognised and given credit, then: training flexibility; equity; organisation; integration (workplace and on-the-job); occupational mobility; and efficiency, can all be enhanced to increase their usefulness in the realisation of the micro-economic reform process (NTB, 1991: 2 and Persson, 1993: 5). The Institute of Engineers Australia, have gone quite some distance in developing professional competency standards [which they maintain must remain the property of the profession] and are ensuring they assist with qualification recognition and articulation (Johnson, 1993: 14 and Whitehead, 1992: 8). They have, however, determined competency standards and conducted assessment on individual paraprofessionals for many years (Whitehead, 1992: 7). Others, such as the Royal Australian Institute of Architects, the Australian Veterinary Association, the Pharmaceutical Society of Australia and the Australian Physiotherapy Association, have developed standards and are developing assessment procedures. Accountants in Australia and New Zealand are in the process of developing standards (Johnson, 1993: 15 and Higher Education Division, 1992: 22) while the Institution of Surveyors, Australia, obtained a grant in 1995 to be able to accommodate specified competency standards for registered surveyors set out in the proposed Land Professions Bill (NBEET, 1992: i). However, it is likely that the geomatics profession may only need to more clearly document and monitor competency standards within curricula to satisfy social pressures for accountability, quality assurance and the defined role and need for a professional as well as a paraprofessional. It appears likely that competency standards documentation will have to be addressed to address government agenda and to regulate levels of practice within the geomatics' industry.

The professions have set out their collective view, *viz*. that professions are different, that professions should decide their own competency standards and retain responsibility and control of them: The Institution of Surveyors has accepted this responsibility (Thorne, 1995: 17 and ISA, 1996). The National Training Board (1991: 1) supports this decision through stating that, if an industry is to own its own competency standards, then it must also develop them. Any introduction of these standards should not reduce professional practice, nor should they be used by a statutory or regulatory purpose or any binding determination, unless agreed upon by interested parties (Johnson, 1993: 15). These stipulations are derived from the belief that a totally uniform curriculum derived from professional autonomy and competency standards would destroy the diversity between schools, diminishing competition that encourages innovation in methods and ideas (Johnson, 1993: 5). *There are many who believe that flexibility, multi-skilling and the capacity to think innovatively are important at all levels, especially in the competitive and changing situation, and that a system directed primarily to specific outcomes may not give sufficient attention to these characteristics* (Johnson, 1993: 11). Competency is a fusion of behavioural objectives [which must be taught so that they are transparent, observable and measurable - but not necessary in small bits] and accountability, i.e. outcome and product orientated. As learning is a cognitive development, competency standards may provide an undue emphases on outcome, diminishing the major skill of a university graduate: the management of knowledge. Generally, it is considered that the competency based process underplays knowledge and undervalues creation of new knowledge, reemphasising the highly trained technician situation all to prevalent in the contemporary geomatics' industry. Professionals should be process and applications orientated: they should seek excellence rather than competence and there should be ... *no constraint of breadth of thinking or innovation in thinking, so essential to the advancement of excellence in professional performance, and we should seek nothing less than excellence* (Johnson, 1993: 16).

Other positive aspects of a move to Competency Standards, in addition to universally accepted levels of competence, are that they will largely resolve current restrictions on national mobility in the workforce and facilitate articulation (Heywood *et al.*, 1993: 8 and Clarke, 1995: 1). They could also provide the launching pad to provide the suggested new industry incentives, which include coordinated end-on-education, registration of education standards, a clear career progression and an understanding of it by students, and professional recognition for progression (ISA & ACSQ, 1992: 50). The professions that have been involved consider competency standards are highly desirable to (Gonczi, 1993: 3):

- i) assist the profession to monitor, more effectively than currently, the quality of members' service;
- ii) help the community to choose between professionals and judge the quality of service received;
- iii) provide clearer goals for education and training than currently exist;
- iv) potentially provide more coherent and integrated courses for professional preparation;
- v) encourage thought for the relevance and needs for on-job and off-job education and training;
- vi) encourage thought for the role of universities and the profession in initial professional education;
- vii) clarify learner expectations;
- viii) improve the currently rather weak assessment procedures for professional qualifications; and
- xi) help determine the status of non Australians seeking professional recognition.

Hence, the competency based approaches to assessment could be significant in higher education by concentrating on a greater variety of performances, including an emphasis of application and synthesis of knowledge and the other attributes associated with professional judgment (competency based on intentionality). The consequences are that ... *this leads ultimately to a greater integration of the theoretical and practical which is at the heart of successful professional practice* (Gonczi, 1993: 6). If the educational trend is to increase the fundamental knowledge level and provide a broader professional content to set university education competency standards, decreasing the time for the practical training content (refer to 2.2.3), then curriculum development will need to include industry wide linkages (refer to 2.2.3) to enable this to occur; be relevant to the geomatics, profession, and training competency standards; and to gain acceptance throughout the industry.

Generally, the endeavour has been to reveal and classify competencies, tabulating and reducing them to rules, laws and formulas or, in the case of professional manager competencies, reducing them to a complete list of personal characteristics. Another approach has been to attempt to capture the competence phenomena - the individuals repertoire of skills compared with the qualities of the task (Sandberg, 1991: 2). These approaches consider competence as an entity in itself, asking what knowledge and skills form the competence in question (Sandberg, 1991: 3). In contrast is the intentionality-based approach: ... *intentionality implies both direction towards the task ... and the intended meaning of that task* (Sandberg, 1991: 13). As we are always intentionally related to the world and the world is always intentionally related to us, competence as intentional achievement is that which accomplishes the task (Sandberg, 1991: 3). This competence is identified by discovering an individuals' conception of the phenomena, where each conception, in a cognitive sense, expresses the meaning-bearing (intentional) relation between the structure of thought and content of the thought (about phenomena) (also refer to Chapter 3). Hence, human competence is not a quantity of something or only consists of a number of different skills and knowledge. but exists as a dynamic inseparable individual 'thing' and the task phenomenon. Each intentional experience is constituted by a number of subsidiary intentional experiences (co-exist within the act of conceiving the work content): their flow appears in the work content and the competence at accomplishing that work becomes visible:

> *An individual's conception of the work expresses the intentional dimension of competence in terms of how the meaning of the work is delimited and distinguished in the act of conceiving. The conceptions precede and work as a base for all our subsequent knowing and doing. That is because knowing something presupposes a meaning that is delimited, distinguished or organised. The same applies to our doing; skill in mastering a particular work content presupposes that the content is delimited, distinguished and organised. If we have not made a phenomena intelligible, then we are not able either to know anything about it or to skilfully master it.*
>
> (Sandberg, 1991: 4)

Any use, by governments, of competency standards to force professional regulation (outside of professional self regulation based on government Acts and accepted professionalism parameters) appears to reverse centuries of intellectual evolution which has provided today's separation between the professions and trades: a separation that de-regulation or industrial lethargy could help extinguish. What is hard to define and measure are intellectual skills of problem solving, professional judgment and attitudes. In some ways the competency standards appear to be a utopian project designed to link education, training and industry awards in a simplistic and compartmentalised way, providing no intellectual incentives. If so, this would ultimately obviate the necessity for course accreditation by providing a competencies check list, for any institution or organisation, to assess an individual for a registration certificate that entitles the holder to perform tasks as a professional in that sphere. The geomatics' industry will need to be vigorous to defend the intellectual standards aspects of the discipline and be vigilant with curriculum development to ensure competency standards are applicable and do not detract from professional abilities education.

One dialectic with competency standards may be between government centralist control (government intervention) and individual professional enterprise (professional autonomy). While government policy is encouraging de-regulation, e.g. in the 'cadastral surveying' profession, or preventing registration overtures, e.g. engineering surveyors, it is also endeavouring to regulate other sectors of the market place [where there appears to be benefits from less government costs and increased control in taxing]. Efforts by the Government to de-regulate professional sectors the geomatics' industry, while demanding formalised uniform (and possibly compartmentalised) national competency standards in geomatics education, involve a contradiction of policies. The hidden agenda would appear to be the centralisation of the geomatics industry, within an overarching body, effectively controlled by government regulations in those areas considered politically advantageous: the de-regulation of those sectors that are costly or inconsequential to government, ie. they offer no direct resource benefits or legal liability, will then become the responsibility of the industry. However, in seeking regulation, the engineering surveyors are endeavouring only to gain recognition for their competencies and equivalence of their performance to that of the recognised professional surveyor, highlighting the nexus between professional and paraprofessional overlapping hands-on practices. De-regulation, or regulation, of all stakeholders within geomatics would require redefinition of competencies and levels of competence, in consultation with all stakeholders, with corresponding recognition in curriculum development, if the distinction between paraprofessional and professional role is to remain. A second dialectic *...between the quest for excellence* (discussed earlier) *and the need to increase basic competence* (Willis, 1993: 110) to perform a task, would respectively represent in the geomatics' industry the 'internal' division requirements between the professional and paraprofessional levels.

While the introduction or consolidation of an outcomes-based approach to competency standards will have minimal affect in the skills training aspect in the geomatics' arena [many skills competency standards already exist], if the issue is enforced in university education [through legislative means or societal pressures], then there will be ramifications for curriculum evaluation, development and presentation. Curriculum development will be affected by implementation of, and adherence requirements to, competency standards at different educational and training levels and in industry. This will occur from either validating and formalising their existence, from their introduction, or in defending the non-introduction. By adopting the intentionality-based approach to competency, individuals would be able to respond in a more illuminated way to the expressed importance placed on knowledge, self learning and application within each contextualised work environment. Assessment of competency should then occur in these, or simulated, situations.

2.4.9. Open learning.

Open learning ... *attempts to give the student as much choice as possible to determine what one would like to study; to determine how much one wants to study, considering one's purpose in studying; to determine where and how one wants to study - on campus or at home, full-time or part-time, using various media, at one's own pace; to determine the level one wants to achieve and the ways in which and the times at which those assessments will be made.* (Report of the House of Representatives Standing Committee on Employment, Education and Training: An Apple for the Teacher? Choice and Technology in Learning, 1989: 7 as quoted by Lundin *et al.*, 1991: 9). Also implied is the removal of other participation barriers such as entry restrictions [simply have fewer prerequisites]; articulation barriers between educational levels; being able to negotiate and form their own study programme from the variety of providers; and have continuous access to academic and administrative support structures (Johnson, 1990: 4; Scriven, 1991: 300; TAFE.TEQ, 1992: 10-13 and 46 and Tight, 1989: 3)

To achieve an open learning environment there must be access to these facilities. The access concept, that part of the philosophy of open learning in which most has been achieved, is termed open access and described as: ... *the application of the whole range of delivery methods for education and training. This is achieved, ideally, through providing infrastructures which extend opportunities to participate in all forms of teaching and learning from on-campus, face-to-face, through to the use of advanced telecommunications and information technologies formerly associated with distance education* (Lundin *et al.*, 1991: 1). Open access is then the mechanistics of the open learning philosophy, such that when an open learning environment is established and functioning, open access and open learning are synonymous.

(a) Background to open learning for geomatics education.

The challenge offered by the Commonwealth White and Green papers on higher education was to maximise the links amongst employers, institutions of higher education and professional organisations. Such arrangements are largely undeveloped and were perceived to be beneficial for education, training and the nation as a whole. The planned 'modernising' and more effective use of educational and community resources was to occur through a broader curriculum, common first years, student access and equity improvements and established articulation and credit transfer arrangements (Dawkins, 1988: 5-13, 19-20, 87 and 96). It was also proposed that bridging courses and other training programmes be established to enhance and facilitate credit transferring (Dawkins, 1988: 35-37, 42 and 64). This document placed an enhanced stress on educational quality and efficiency and opportunities for flexibility through diversity. Current attention to open access and equity problems at all levels of education, and the efforts to establish an Australian Open University and the open learning television broadcast programme, to meet perceived unmet demands and community needs, underlined Dawkins's educational philosophy (Johnson, 1991: 5 and TAFE.TEQ, 1992: 22-24). The openness and relevance of curricula that permits a diversity of subjects to be accessible to students, and the subsequent needs for credit transferability and subject accountability, is a challenge for curriculum managers (Griffin, 1983: 66-85). Open access education can then be considered morally, socially and politically desirable and an individual's access should not be restricted by financial `strings', social background or location. However, this philosophy must be placed in context as there has to be efficacy in equity and access, as there is no purpose in offering the wrong education or education to the wrong person. Government policies on reduced funding and user-pays principles continue into 1996, increasing availability and access difficulties and necessitate changes to curricula and university operations.

Strong messages for change are still occurring: in terms of industry needs they are those of flexibility, relevance and de-emphasising institutional rigidities (NBEET, 1992: 21) and *... should ensure that educational processes and offerings be related to work requirements. This was echoed by employer groups; the implication being that a cross-sectoral or programme approach should be adopted* (NBEET, 1992: 19). Others include the need to extend training to remote localities for all retraining needs (NBEET, 1992: 20), especially in view of the increased student age mix created increasingly by those entering into life long learning strategies (Johnson, 1990: 7 and refer to 2.4.4). These pressures for access and equity are increasing with the expanding and more diverse market of students (particularly the mature aged) and the acknowledgement of the need for formal adult training and retraining (Dawkins, 1988: 15, Gough, 1980: 52 and Scriven, 1991: 299), especially with a convergence between general and vocational training (Dawkins, 1988: 68). Current communication technologies (refer to 2.4.9(b)) could readily provide the facilities for more off-campus programmes and an increased use of programmed learning techniques to accommodate these needs. Other learning opportunities can also occur with the rescheduling of classes to times more convenient to the student: this could include extending the teaching hours during the day and into Saturdays and Sundays, and offering courses in the traditionally regarded non-teaching periods.

The demand for open leaning is demonstrated by there being increasing numbers of urban dwellers, in addition to the normal clients, availing themselves of distance education opportunities (Campion & Kelly,1988: 174). Students in the University of Southern Queensland distance education programme [over 70% of the student population in 1996] include major city dwellers, where alternative full-time courses are available, in addition to overseas and rural based students. While elements of open learning have existed in Australia for decades (Johnson, 1990: 5), a coordinated and enhancement of these elements is needed to extend its economic and functional viability. Cooperation and linkages between institutions in course development and sharing, use of technology, and accepted credit for subjects in each others courses, is required to facilitate the effectiveness of open learning (Johnson, 1990: 17). Hence, open learning is viewed as system-based, not institutional-based, able to use and offer student access to all programmes in existing institutions and, in doing so, have established and accepted credit transferring arrangements (Johnson, 1990: 5).

(b) Access in open learning.

Distance education is an integral part or platform of the open learning environment, and is essential in achieving that environment (Johnson, 1990: 4 and 21). However, because it is generally regarded as the fore-runner to the open access concept and its current prevalence, the term distance education features prominently in discussions on open access opportunity. Initially, distance education aimed to provide access (you can study but you are on your own) and later, equality (students were inundated with material replicating the attendance environment, including some compulsory attendance) (Gough, 1980: 50). While distance education centres still function as providers of distance education, it is now those experienced centres that are moving towards the wider open learning philosophy (Johnson, 1990: 17; Scriven, 1991: 299 and McDougall & Dowling, 1996: 438).

Various reports on education tend to emphasise on-campus education and clearly delineate between it and other study modes, e.g. part-time, sandwich course arrangements and distance education (Campion & Kelly, 1988: 175). The later reports gave distance education greater credence and wished to see improved credit transfers, greater flexibility, and improved mechanisms of teaching strategies for more innovative and imaginative delivery - but without committing resource improvements to support the ideals (Campion & Kelly, 1988: 182). *There has also been an increased acceptance that traditional time-based approaches to education and training did not produce the best outcomes in the most effective way* (NTB, 1991: 2). This same theme was proffered in the Dawkins' induced educational rationalisation for establishing distance education centres, where the main goal was for an improved educational 'product' at a reduced cost (Dawkins, 1988: 46). Consequently, Australia has developed a campus-based and distance education integrated structure (Campion & Kelly,1988: 171-173, 192, 194 and 197), as opposed to an independent open university structure similar to that in the United Kingdom, to provide for an enhancement of distance education opportunities. While distance education opportunities in geomatics are still very limited, the campus-based structure of the existing opportunities has assisted in professional organisations recognition of this mode of learning. The Queensland surveying education articulation model is evidence of this acceptance (refer to 2.3.1) as is the accredited suite of USQ off-campus courses.

Distance education, within an educational context, is seen as a subset of techniques within the process of education and simply considered as educating at a distance (Shale, 1988: 26). Hence, today's philosophical approach is to provide an alternative mode of study with a complete learning experience in a unique educational subsystems: it is not an appendage (Campion & Kelly,1988: 190). Technologies are eroding the boundaries, or differences, between traditional and distant education (Shale, 1988: 31 and 34), breaking down the barriers characterised by the lack of employer interest and the previously second rate status given to part-time and distance education studies (Hubert,1989: 225 and McIlroy, 1989: 339). This has given rise to the open learning concept and subsequent need for institutions to provide structured opportunities for education and training from within full time accredited courses (Scriven, 1991: 299), such as at the University of Southern Queensland, not as a separate section (McIlroy, 1989: 343 and McDougall & Dowling, 1996: 438). To slightly adapt attendance student material, counselling structure, admission procedure, etc., has been shown to be inappropriate (Gough, 1980: 51). Hence, distance education is a mode of study in its' own right (Holmberg, 1989: 128 and McIlroy, 1989: 333) and a paradoxical combination of mass communication and individualisation. It is characterised by diversity rather than uniformity [some uniformity is required for administrative purposes] and nonconscious communication. It is one of a variety of learning environments of the open learning philosophy that provide equity of access for learning needs (Scriven, 1991: 299). The increase and development of these learning opportunities are necessary for the geomatics' concept to develop, particularly in the early stages, especially given the diversity of the student's background and location, and the demands of discipline amalgamation and merging (refer to 2.3.3 and 2.2.2).

The distance education system components can be considered as characterised (Coldeway, 1988: 50; Scriven, 1991: 303 and Shale, 1988: 28) by:

(i) printed course packages and other technical media used to unite teacher and learner and to transmit course content;
(ii) a set of distance education introductory materials;
(iii) arrangements for regular two way interactive communication for problem solving and teacher to provide extra declarative knowledge based on the students achievements and experiences;
(iv) teaching on an individual basis, but with the student seeking meaning from inquiry (a high level of student-centred learning); and
(v) a set of policies governing planning, material preparation, support provisions and general course administration from an institution.

Open access, and particularly the distance education elements, also provides for the following development opportunities:

(i) The compilation of all the learning content subject matter to be studied (Holmberg, 1989: 128) with further enhancement by computer simulations and computer interactive work (such as via software packages and CD-ROM learning and simulation systems). To that end, there can be a focus on the activity, rather than the teaching, by providing customised multimedia material packaging (Johnson, 1990: 5 and Johnson, 1991: 8).
(ii) The targeting of new groups; those who want to be independent and autonomous

and not repressed in a full-time environment, as well as those who can't attend but wish to study (Holmberg, 1989: 129 and Tight, 1989: 3). The Open University in the U.K. experienced a two fold increase in part-time studies between 1971 and 1986 with demand still increasing (Tight, 1989: 4). Similar increases have been experiences in the USA (Johnson, 1990: 7).

(iii) The employment of any methodology development for the opportunity to exploit and support student autonomy (Holmberg, 1989: 130).

(iv) The utilisation of all forms of communication technology in developing an upgraded technology-intensiveness and downgraded labour-intensiveness (Muspratt, 1992 :3).

(v) The strengthening and improvement of the effectiveness of the individual in his/her work environment through the continual improvements to the equity and access opportunities of this system.

(vi) The incorporation of local context learning and existing learning methodologies. This is particularly desirable given the diversity of employment situations and rapid technological changes within the geomatics' environment, and the need to develop an industry based training structure.

(vii) Continual utilisation of modern communication technology (hardcopy, electronic broadcast and various interactive teleconferencing) to maintain the provision of flexibility and teaching economies of scale with human and other resources, administration and services (Lundin *et al.*, 1991: 10).

(viii) An Australian wide delivery of material through the Internet. The limited development in Australia, in favour of CD Rom, has occurred because Australia has a significantly higher on-line user cost and fewer internet users. This is changing rapidly and is perceived as the major delivery medium to individuals in the near future. Short-term limitations for some geomatics areas include limited graphics speed, limited video capability and user preference for viewing information in hard copy: hence Internet information is currently treated as value-added information.

Students have their own position on things and should be allowed: to discover that there is not necessarily a single solution to a problem; to develop awareness; and to be encouraged to act independently, but with necessary guidance, to arrive at the objectives, content, sources and procedures. A single text, and including study guides, etc., tends to make a study programme teacher centred (Holmberg, 1989: 131), whereas it is desirable to have a learner centred learning structure (Tight, 1989: 3). This can be overcome by contract teaching, whereby a certain curriculum and assessment methods are agreed upon between teacher and student. Hence, the idea is for gearing the student to the search for knowledge, understanding and explanation (Holmberg, 1989: 132), and is a preparation for similar situations encountered in a geomatics' work environment. No programme can be totally 'open' as this would be extremely resource problematic (Johnson. 1990: 3). In addition, many geomatics' discipline and professional regulatory requirements have a specific needs core, reducing the opportunity of open learning in some areas.

Despite the opportunities, there are components of the distance education model which are quite volatile, and difficulties in any of the following elements will likely impact on the entire model (Roberts *et al.*, 1991: 56-59):

(i) student characteristics including family and home life;
(ii) the goals or reasons for studying;
(iii) the academic environment;
(iv) the home and work environments;
(v) the integration of the social and work environments; and
(vi) academic integration.

The students responding to the survey, from which these conclusions were drawn, were shown to vary significantly in a multitude of aspects at the commencement of the course and change and react differently during the programme (Roberts *et al.*, 1991: 63). Specific observations about the students include:

(i) 20% saw the subject material as irrelevant to their needs 50% of the time (Roberts *et al.*, 1991: 76).
(ii) They valued their independence and autonomy (Benson *et al.*, 1991: 44 and Roberts *et al.*, 1991: 63), but required interaction with the lecturer.
(iii) They preferred an informal or peer relationship with the lecturer (Benson *et al.*, 1991: 48).
(iv) They missed the interaction with fellow students.
(v) Opportunities for face-to-face contact is highly valued, e.g. the residential schools (Benson *et al.*, 1991: 47).
(vi) They valued the time spent at residential schools (Roberts *et al.*, 1991: 69).
(vii) They were indifferent to institutional support, eg. library.
(viii) Support (individually or in a study group) from fellow students, whether arranged privately or by the 'mother' institution, is highly desirable.

However, while they possessed determination, maturity, experience and organisation characteristics, the students still required to be directed in their learning (Benson *et al.*, 1991: 49). Those with a strong relationship to the supporting organisation, and an involvement with their studies, were found to be more efficient learners (Roberts *et al.*, 1991: 68). As an example, the University of Southern Queensland geomatics distance education students [the majority working in geomatics] demonstrate that: their on-the-job experiences enhance their ability to interpret theory; they are self motivated; they are independent in seeking out solutions; and they have an early development of professional attitude.

In developing a geomatics curriculum for an open learning environment, it should be remembered that distance education has different requirements and has previously been unfairly singled out when education is being assessed in economies of scale (Campion & Kelly,1988: 190). It has been noted for its' predominantly mass produced high-quality course material (declarative knowledge) with high initial cost, but is ultimately educationally advantageous and cost effective, except where quantities are relatively small (Back & Timmers, 1991: 39; Campion & Kelly,1988:190 and Shale, 1988: 29).

The Open Learning Institute in Hong Kong ascertained that the cost per student was half [the same relative cost for distance education in Australia after scaling for the student population difference] of that for conventional institutions (Back & Timmers, 1991: 35 and Johnson, 1990: 8). Hence, distance education is regarded as the most cost affective and viable platform from which to develop open learning alternative delivery (TAFE.TEQ, 1992: ix). To assist the open learning process, a cooperative Open Learning Centre Network (OLCN) was formed in Queensland utilising communication and computing facilities within established institutions (Lundin, 1990: 1-3). Similarly, use of the widely dispersed TAFE facilities provides economies of scale (Dawkins, 1988: 66). This is demonstrated by the Western Australia university sector and TAFE consortium (called the Western Australia Distance Education Consortium) approach which involves TAFE teaching selected first year university subjects, under a contract arrangement, and facilitating access to their study centres for university DE students (Atkinson *et al.*, 1991: 21). The supporting technological aspects and costs of video conferencing of this arrangement highlighted the need for an emphasises on equipment compatibility and cooperation between all parties: student to student usage was as valuable as the teacher to student mode (Atkinson *et al.*, 1991: 28). As students often can't access centres at convenient times, the use of such facilities should be on a voluntary basis or simply be available for learners when they need to interact directly with the course facilitators (within notified prior time limits), study supporting services, or peers. However, resource constraints do limit the techniques used in conducting distance education (Shale, 1988: 31), so, in broad principles, it should be ensured that:

(i) the application of this technology should be curriculum driven and not vice-versa;
(ii) equipment should be easy to use;
(iii) interaction between teacher and learner must be able to be achieved; and
(iv) the system must be viable in both capital outlay and in recurrent costs.

The relatively small geomatics' population also means that open learning opportunities must be carefully managed within highly developed cooperative arrangements, amongst academic institutions and industry, to ensure viability.

Communications technology is perceived as playing an increasing role in distance education and open learning in general (Moran *et al.*, 1993: 17 and Laurema, 1994: 119 and 189); one which will enable the realisation of geomatics education and training linkages and efficient resources utilisation (refer to 2.2.3 and 2.4.6). It was proposed by Moran *et al.* (1993: 67) that an electronic network be established to support the open learning system, and be managed by an Open Learning Electronic Support Agency (OLESA). The object was to centralise communication aspects of open learning support, using existing distance education facilities and public or private utilities; act as a friendly interface; provide a controlled system and to provide economies of scale for the open learning system. This network would receive 'requests' from students (for access to library services, administration assistance, peers and tutor assistance), teachers and administrators; the request would then be directed to the relevant participants of the network (Moran *et al.*, 1993: 71). This would be achieved for any communication form, e.g. real time (telephone or teleconferencing; computer based e-mail; internet inquirery facilities; hardcopy (letters and facsimile); or voice mail. This system was expected to change institutional culture towards a more market service (Moran *et al.,* 1993: 5) and, consequently be able to assist in developing those geomatics' industry linkage and resource arrangements, professional development, professional accreditation and curriculum developments (refer respectively 2.2.3 and 2.4.9(c), 2.4.4, 2.3.2 and 2.4.10) needed to sustain a geomatics curriculum. In Australia (in 1996) infrastructure to support internet users, and the number of users themselves, is undergoing a period of extensive growth. This system is perceived as becoming a major common technology and data source to support and deliver distance education.

The open access concept is a distinctive ideology of adult education, and the area of distance education within this ideology necessitates accessibility to all available subjects (or single subjects for credit) for studying by distance methods. Coupled with a facility to freely transfer between external and internal study modes, curriculum developers must overcome challenges caused by the varied environmental backgrounds of the learners and those of curriculum design for a different form of learning using a larger variety of teaching strategies, content presentation, assessment and evaluation. This applies to both the formal and hidden curricular aspects necessary to achieve societal, technical and professional goals.

(c) Open learning in geomatics education.

Part-time study arrangements, whether in a formal 'special need' or short 'update' course, have proven to be in demand (Anson, 1991: 67; Cassettari, 1991:71; Dowling, 1991:12; Hubert, 1989: 227 and Rhind *et al.*, 1991:1). This facility has helped to overcome the problems often experienced with full-time study and the commitments to employment and domestic environments (Hubert,1989: 227). Shorter periods of disruption and smaller 'grabs' on funds, and hence a spreading of expenses over a longer period, to achieve specific goals, allow for better planning and management to cope with the resources needs. However, short courses, in particular, have often been *ad hoc* , initiated by a perceived or actual demand to meet an academic or vendor commitment, or the availability of particular expertise. These courses are better suited to centres of large population where there is potentially a cluster of clients and easy client access. This is unsuitable to a large portion of the geomatics' industry population who do not reside in these centres, and for those who find it inconvenient to access the location where the course arrangements are taking place. Also, these short courses, especially the in-house arrangements, have proven costly, disruptive and rigid in content and time; can only attract limited numbers; and often not completely relevant to each individual (Scriven, 1991: 297). Hence, the expressed demand is for distance education (or open access) to be an integral part of the structure of all available courses (ACSQ,1991: 2; Dahlberg & Jensen, 1985: 179; Davies, 1991: 6; Hubert,1989: 227; Skitch, 1991:7 and Tight, 1989:4) that permits educational equity (Davies, 1991: 3) for those unable, or do not find it desirable, to study a course, or subjects within structured programme, in a full time mode. *Failure to offer a full external degree through UCSQ continues to discriminate against potential students resident outside south-east*

Queensland (ACSQ,1991: 2): this was remedied in 1996. The educational opportunity emphasis within Australia is still largely based on full-time attendance with all the requirements being completed at the learning institution. Foster and Williamson (1985: 431) also contend that distance education is essential for the survival of the geomatics' industry education in Australia. The retention of discipline sectors, or their relative strength, requires continuing professional development opportunities in knowledge updating or acquisition, and the opportunity for educational articulation, without jeopardising economic or employment situations.

Another aspect of distance education is that it facilitates the opportunity of retaining education in a university environment and training in the work place (Davies, 1991: 3 and 2.2.3), which is especially valuable for a paraprofessional education and training philosophy where the emphasis is to maximise training aspects (Coleman & McLaughlin, 1988: 25). This would enable the utilisation of the facilities of a capital intensive industry, reducing the resources burden on universities (McLaughlin *et al.*, 1991: 10), or the other available physical or communications facilities that exist (Groot, 1991: 373), e.g. Australian TAFE or established university external student study centres.

Another approach could be similar to that of the Canadian Open Learning Agency, which operates the British Columbia Post Secondary Credit Bank to facilitate the possibility of multi-institutional degrees (Bottomley, 1991: 74 and Johnson. 1990: 8 and 20). In this structure, the quality assurance is vested in the eventual degree awarding institution as, on entering a final year, the student may have had a varied and possibly unique background, e.g. they may only hold a diplomas, have extensive vocational experience, and may have completed some short courses or workshops, etc. Thus the credit bank, which would be an accumulation of credits from a number of sources, could lead to an award if the performance had been satisfactory and there had been sufficient coverage and coherence in the total of those credits. More likely though, a student would be able to use the credits for advance standing and with the individualised programme being determined for each student for this 'final' year, similar to the articulation process proposed by Young (1994: 9). Such open learning education possibilities offer the opportunity to develop undergraduates to fulfil personal, academic and professional needs in a viable and flexible environment. The Queensland surveying education articulation model has progressed part way along this concept through 'block' recognition, for credit, of courses within the model. This includes articulation from TAFE and other associate diploma qualifications to the USQ bachelor of technology courses, and the USQ bachelor of technology graduates into the QUT (or the USQ) bachelor of surveying final year. Other developments in end-on-education within Queensland, Victoria and Western Australia, are continuing to develop geomatics education towards an open learning structure (Dowling & McDougall, 1995: 53; Edwards *et al.*, 1995: 50 and Lodwick, 1995: 26)

Some of the problems experienced in open learning and in accepting a credit bank, can be overcome with a modular course system (Hubert, 1989: 219). Such a system also allows a student to choose an exit point (Anson, 1991: 68 and Johnson, 1990: 15) commensurate with the students' abilities or desires to be a paraprofessional or professional; an essential outcome within the geomatics' concept. Modular courses are generally more flexible, manageable and motivating (Johnson, 1990: 15), but run the risk of concentrating on specific objectives, a sub-discipline area, or small areas of learned knowledge. However, if the holistic geomatics' approach is implemented, task orientated modules can be devised so that all desired theoretical, practical and professional learning and testing can be achieved. These modules can occur at each 'level' of a course to facilitate different exit levels; achieve the desirable course outcome for the graduate 'professional'; and permit institutional autonomy and flexibility in facilitating and managing students study, even though there is commonality and equity for each level of study. The task orientated approach would also facilitate industry involvement and, within the period of a course, enable project work to be completed for any professional registration requirements.

A national accreditation body, required for the efficient operation of an open learning system (refer to 2.4.9(b)), is also essential to moderate the operation, openness and fairness (across institutions) of a geomatics' modularised system and the credit bank arrangements. Although academic institutions hold their autonomy and academic freedom in high regard; are normally conservative and need to maintain standards of knowledge and scholarship (Johnson, 1990: 25), they are receptive to course accreditation bodies (refer to 2.3.2). A single geomatics' authority could more easily coordinate and manage open access learning for geomatics education, at all levels of the professions' needs, by maintaining a consistency in the strategy without necessarily impinging on general institutional autonomy. The institutions would have to develop strategies that would deal with: any affect on work patterns, administrative structures and support and budgetary arrangements; the relinquishing of some power to students; any reduced distinction between teaching and support staff; and quota and selection criteria upheavals (Johnson, 1990: 21). With suitable linkages with the geomatics' industry, and because academics are already familiar with some of these issues by being facilitators and learning managers with higher degree students, these difficulties can be overcome.

Therefore, some of the advantages of open learning in the geomatics education environment include:

(i) the convenience;

(ii) the less forbidding or threatening nature of not having to comply with the requirements of full-time studies (Johnson, 1991: 8), especially for the mature aged students already in an employment situation;

(iii) the opportunities for 'self-paced' students to complete a course within a period of time dictated by their circumstances, i.e. earlier or later than the 'normal' expected duration;

(iv) a rationalisation of institution's human and financial resources where they are least viable, redirecting their efforts: to ensure teaching and assessment variety and appropriateness; to the development of a range of course content; and for the provision of counselling, support and extra declarative knowledge (Johnson, 1990: 13) needed for a rapidly changing technological environment and breadth of knowledge required by the geomatican; and

(v) provision of continuing professional education opportunities for the whole industry.

The open learning philosophy in Australia is gaining momentum in parallel with concern for equity, cost effectiveness, industrial competitiveness and the development of intellects and skills for the 'clever country'. The changes to open learning in the geomatics' discipline can be gradual or halting (through changes in only one sector, e.g. the educational institution), but it should occur so that students and the industry may benefit from the many advantages this structure offers the 'total' geomatics' industry. Preferably, there should be a more consistent and rapid adoption to the open leaning system in geomatics curriculum development, based on understanding and linkages within a single geomatics' discipline, and the establishment of a single discipline monitoring authority.

2.4.10 Curriculum development.

Exigent changes to professional education and training to accommodate current and future technological and methodological changes, the geomatics' philosophy and viability of the geomatics' industry, are increasing, but the messages for achieving a common goal are mixed. There are widespread Australian and Overseas concerns over the lack of an overall industry human resources strategy and consequent curriculum development (ACSQ, 1991: 4; Groot. 1991: 369; IEMSA, 1992: 1; McLaughlin *et al.* 1991: 2 and 15; Task Force, 1991: 14 and Williamson 1981: 300). There is agreement that there must be such strategies established to suitably resource the industry and to permit flexible long-term resource planning to occur. The curriculum element of a human resource strategy should be determined by a broad spectrum of stakeholders, either as a dynamic group or similar in concept to the Canadian National Surveying Education Committee; an education and standards promotion authority (Greenfeld, 1991: 36 and McEwen, 1990: 73). A national accreditation authority that could then be developed from this group would further develop or bond; industrial amalgamation; professional merging; process of monitoring deregulation; a geomatics undergraduate curriculum concept relevant to societal needs; and facilitate an economical open learning environment.

A multi-stakeholder inspired curriculum would presuppose a curriculum development that is largely market-driven (refer to 2.2.3) and, by inference, industry-supported in its implementation, evaluation, change and accreditation processes. Those opposed to a market-driven curriculum are generally academics or those who believe that academic institutions are unable to educate and train in the latest technologies (Carter & Moynihan, 1988: 290): a problem which is generally manifested by a lack of human and financial resources and administrative restrictions in academia. The demands for a market-driven curriculum are generally inspired because professional practice changes are not fully reflected in curriculum development, the industry perceived inadequacies in graduates education and training, or the apparent inability of academia to address the issues dictating curriculum change, within a suitable time frame. Often, the problem is the difficulty in understanding the academics inability to adopting today's changes rapidly and making educational processes future based. This was reinforced by Brunner *et al.* (1993: 3), after a curriculum development process, when they surmised that ... *the educational process must therefore be focussed at a point in the future* ... and that ...*determining a more appropriate approach to course revision has become a high priority.* If these messages were to come from an amalgamated industry, rather that the various sectors of a fragmented industry, many of the problems could be resolved or reduced. Other issues are also emerging, such as: the evolution of GIS courses becoming more popular due to industry and other discipline demands (refer to 2.4.5); changes that needs to occur because it fulfils part of the scheme in accommodating National Wage Case Decisions on 'structural efficiency' demands (Allaburton, 1990: 50-51); government policies on deregulation and competency standards in education (refer to 2.4.8); and government policy on micro-economic reform (refer to 2.2.3(viii)).

Professional and industry metamorphoses that curriculum must address include transitions induced by technology and its application; the blurring of discipline areas; the work percentage decrease in traditional discipline areas, e.g. surveying; and expansions in new sub-discipline guilds such as GIS and Land Information Management (LIM) (ACSM, 1993: 4; Dahlberg & Jensen, 1985: 173; Groot, 1989: 3; McLaughlin *et al.*, 1991: 8; Mitchell, 1993: 346; Ormeling, 1988: 528; Ormeling, 1992: 3; Task Force, 1991: 33; Williamson *et al.*, 1993: 307 and Trinder & Li, 1996: 95). Leis (1992) noted that the discipline boundaries were blurring and that the modular spatial information courses managed by that consortium (refer to 2.2.2) were to provide training for a variety of discipline areas: persons from those areas would then be able to meet the demands placed on their industry to meet national and international needs. The education and training structure is still largely based on the traditional separate discipline areas rather than reflecting an integrated multidisciplinary approach which industry is adopting to its work practices, *viz.* that of integrated data capture, processing, storage, management, representation and dissemination (ACSQ, 1991: 6; Bedard *et al.*, 1988: 105; Cassettari, 1991: 72 and Gracie, 1989: 259). The concept is for a curriculum to embody a common undergraduate programme and reflect a function (expertise in the production and management of spatial information), not a discipline knowledge (ACSM, 1993: 12; Foster & Williamson, 1985: 432 and Task Force, 1991: 87). This structure may not suit the single function professional, e.g. boundary definition surveys, but it appears that these individuals will fulfil a future paraprofessional role or exist as part of a larger enterprise. In recognising some of these changes, the ITC (Netherlands) has moved from a specialist end-on courses structure of Technician - technologist - postgraduate - masters, to create an integrated disciplines course followed by short specialisation studies (Groot, 1989: 3). Other curriculum developments embracing this task theme, and not individual discrete disciplines, have occurred to varying degrees by offering a geomatics course, albeit with several study streams (Laval University syllabus), or a separate surveying and cartography course with a high percentage of syllabi commonality and emphasising information management (Brunner *et al.*, 1993: 5; Williamson *et al.*, 1993: 310; and Lodwick & Wright, 1993: 299). From their structures, these curricula are well placed to develop full commonality and moulding of their syllabi to form a geomatics' approach curriculum. Curriculum development must also reflect professional body course accreditation requirements, with regard to syllabi content and relative course percentages (refer to 2.3.2 and 2.2.3), that manifest the needs and safeguards of the professional and societal sectors of the market place (Bretreger, 1993: 273; Colcord, 1988: 45; Greenfeld, 1991: 36; Leahy & Williamson, 1991: 5 and Williams, 1996: 30). Realistic accreditation requirements can only come from linkages and negotiations amongst professional organisations, practising industry and educational institutions: they should encompass all levels within the geomatics' field and be applied nationally.

The perceived deficiencies in undergraduate education, that are not fully addressed in curricula, are the needs for increased mathematics; social, land and applied sciences; personal and business management skills; law and computer skills (ACSQ, 1991: 4; ACSM, 1993: 7; Anderson, 1991a: 310; Bedard *et al.*, 1988: 108; Colcord, 1988: 43; Divett & Mawn, 1992: 441; Gracie, 1985: 372; Hannigan, 1993b: 1; Lodwick & Wright, 1993: 296; McEwen, 1990: 74; McLennan, 1992: 4; Morrison, 1985: 99 and Usher, 1985: 299). Written material and information collecting surveys of industry and recent graduates have reflected this feeling and a need for a reduction, or shift of subjects like geodesy and astronomy, from undergraduate to post-graduate studies (ACSQ, 1991: 4; Davies, 1991: 5; McEwen, 1990: 74; McLaughlin *et al.*, 1991: 13 and Williamson & Morrison, 1978:15 and 2.4.7). This elucidates the concept of education on the fundamentals, ensuring that superseded material is removed and replaced by current methodologies and techniques, and the amplification of the shifting industry emphasis from measuring to legal and management aspects (Brunner *et al.*, 1993: 6 and Greenfeld, 1991: 36): *Surveying education at university level requires a balance between science subjects, professional knowledge, surveying skills and attitude building* (Brunner *et al.*, 1993: 2). This reveals a desire to provide a broad and multi-discipline curriculum, strongly supported by those fundamental sciences and personal strengths knowledge, with some specific discipline material learnt later on in the course or as part of professional development (Brunner *et al.*, 1993: 4; Cooper, 1986: 262; Greenfeld, 1991: 34; Groot, 1991: 377; McLennan, 1992: 4; Miller, 1992: 18 and Ormeling, 1992: 5). This broad-based multidisciplinary curriculum philosophy is applications-orientated (Leahy & Williamson, 1991: 2) and has benefits in enhancing graduates' ability to adapt and adopt technology and technological practices (Gracie, 1985: 374 and Swiney & Sneddon, 1991: 9). The inclusion of this 'non-professional' subject material, if fully integrated with professional education should provide a more broadly educated graduate who: is able to communicate with other professionals and society in general; is better able to cope with any on-the-job training; can understand and adapt to technological developments; can enhance or support innovativeness; can readily form contextual understanding; has thinking skills and critical evaluation abilities; and can continue confidently in continuing professional development programmes. An enhancement in teaching professionalism should be, and is assumed to be, an integral part of teaching these attributes. The multidisciplinary nature of the graduate also addresses the fear that specialisation results in no motivation nor confidence to tackle issues related to technology which crosses several disciplinary boundaries (Prosser, 1989: 277): this should not be a problem for an individual with 'true' professional attributes. Students can no longer counsel an attitude of, that if it can not be resolved rigorously and conclusively, then it should be left alone or reduced to tangible elements. Nor is a 'technical fix' appropriate; a geomatics student must ask why problems arose and how to avoid or resolve future similar problems. Both the 'reduced to tangible elements' and 'technical fix' solutions are appropriate philosophy for a paraprofessional curriculum: the converse holistic solution and 'thinking' approaches define a 'professional curriculum' outcome.

This curriculum shift then reinforces the philosophy that education, and some training, is conducted at tertiary institutions with the bulk of training done in industry (Brunner *et al.*, 1993: 5; Hannigan, 1992: 3; IEMSA, 1992: 1; Miller, 1992: 18 and 2.4.3). ACSM (1993: 8) surmised that this shift to a broader more rounded curriculum will see, by necessity, the education/training separation grow. There are also alternatives to having training as an integral part of each topic in undergraduate studies or on-the-job training under the guidance of a 'master geomatican'. One proposal is to conduct training as a part of the specialist discipline preparedness near the end of a broad-based fundamentals undergraduate course (Carter & Moynihan, 1988: 287 and Wood & Forest, 1985: 166), similar to the task-orientated projects and camps [in place of continuous training assessment] structure at the University of New South Wales (Brunner *et al.*, 1993: 10) and the University of Melbourne. This would require greater linkages than exist between professional organisations, employers and higher educational institutions and should prove a more resource efficient, flexible and industry-wide valued arrangement (refer to 2.4.6). The Graduate Diploma in Surveying Practice (refer to 2.3.1(iii)) is a model of such an arrangement. Greater use of organised vacational employment can also provide a part solution.

Other curriculum developments to facilitate industry demands, resources difficulties and academic needs have been to develop specific but separate study streams, e.g. mathematics and science, plane and geodetic surveying, photogrammetry and cartography (Brunner *et al.*, 1993: 12; Cameron & Williams, 1989: 829; Lagerlow, 1988: 541; Leahy & Williamson, 1991: 8 and Williamson *et al.*, 1993: 310). The alternatives have a varying degree of common material but ensure education of the mathematics, sciences and humanities fundamentals and a balance of subjects from related disciplines while maintaining traditional discipline streaming (Leahy & Williamson, 1991: 10). Hannigan (1992b: 428), in the newly-proposed Queensland University of Technology four year undergraduate course, incorporated resource limits and professional body requirements by employing a syllabus with generic subjects located within other discipline programmes, e.g. mathematics, engineering, etc. [now a general practice in Australia], to provide a solid base of fundamental science knowledge and then a flexible range of options from which students select a path of study. These arrangements have adequately addressed contemporary structures and discipline

UNIVERSITY	GEOMATICS INDUSTRY DEGREE	OTHER DEGREE	COMBINED (OFFERED SINCE)	TOTAL LOAD IN TERMS OF A NORMAL LOAD
Curtin university of Technology	4*	N/A: Two degrees offered (with commonalities)		
University of Melbourne	4 4	3 3	5 (1988) 5 (1993)	5.15 5.15
University of Newcastle	4	4	5 (1988)	5.30
University of NSW	4	3	5 (1992)	5.30
QUT	3	3	4.5 (1990)	5.30
RMIT	4	Two streams - no additional load in surveying.		
University of South Australia	4	Under consideration.		
University of Tasmania	4	Two streams - no additional load in surveying.		

* denotes course duration in years

(Mitchell, 1993: 342 and 344)

Table 2.2 Double degree option at Australian universities.

divisions: they have not suitably reflected all the needs of students or the industry's needs in six to eight years hence.

A more global development and monitoring of curriculum is needed to address other issues as well. These include the need to develop curriculum incrementally (continuously and gradually), not in a stepped (large 'catch-up' change) regime (Dahlberg & Jensen, 1985: 179). This may requires a large resource commitment (smaller resource need but over a longer period) and require overcoming the problems associated with inflexibilities (Groot, 1991: 372 and Williamson, 1988: 554) within of educational institutions. While Foster and Williamson (1985: 432) noted that the doubling of subjects in syllabi (refer to 2.4.5), Brunner *et al.* (1993:6) emphasised the need to remove old material to reduce student workload and allow a curriculum to absorb technological and philosophical changes. If this problem is not addressed during a process of continuous evaluation and development of courses, then the recent increased offerings of double degrees (Table 2.2) would probably need to increase (double 'geomatics' degree) or to provide the time to cover the course content. This recent double degree arrangement is justified on the belief that it will enhance the employability of graduates and meet a perceived need based on the types of industrial environment in which a surveyor or land information specialist may work. It may also be considered that the industry has not acknowledged the changing and merging of the surveying and mapping disciplines and perceive the need justified on the basis that 25% of surveying graduates end up in a computer or GIS environment, or doing engineering activities (Mitchell, 1993: 346). This structure only increases the burden of undergraduate studies, and suggests the need for a single broader discipline concept. For academia there are definite economic benefits and, in a very competitive market, a method of maintaining student numbers. However, so far the worth of the double degree has not been established, as there are no statistics to validate this worth and because it has not been established (outside of academia) as a requirement (Mitchell, 1993: 347). Recent government policy placing a financial penalty on students undertaking a double degree also undermines the arguments supporting their usefulness.

As a short route to attaining professional membership to diverse professional bodies, double degrees may be desirable to increase employment options, but it does question the applicability of current surveying curriculum in preparing graduates for the market place. This would suggest that a closer inspection of existing curricula and modes of delivery is necessary to ascertain perceived shortcomings necessitating a full-time double degree structure. A reduction in largely superseded technological and methodological information and academics 'wish list' material could enable a synthesis of the double degree course into a single undergraduate degree: the remaining technician or paraprofessional 'tasks' and specialist topics, e.g. astronomy, could be located in a training environment, as continuing professional development, or as part of a post graduate specialist course. Time and content savings can also come from: the previously discussed concepts of training in industry, transferal of subjects into post graduate study areas and the savings from discipline integration. A single degree graduate could then have the same professional education qualities and usefulness of the double degree graduate. However, as a concept, double degrees do provide a structured credit transfer arrangement and fulfil some of the attributes of an open learning concept for those who detect deficiencies in existing courses in meeting their perceived needs.

As we are unable to know conclusively what expertise is required for the future, and hence ascertain the most appropriate construct to ensure that societal needs will be served, a general and fundamentals education course will best provide for graduates and the industry (Leahy & Williamson, 1991: 4). This would be achieved by having good communication skills; being able to adopt and adapt to technological developments and cope with lifetime continuing professional development; contextual understanding and an understanding of the 'broader' work environment; a high level of conceptual, thinking and critical evaluation skills; and administrative, management and human relations abilities (refer to 2.4.3 and 2.4.10). The realisation that this should occur is due to a perceived lack of relevance in education, a lack of adopting technological change and a lack of relevance with existing standards and resource planning (McLaughlin *et al.*, 1991: 2). Industry is also considered as being ahead of academia in technique and methodology, rather than academia providing the lead and anticipating change (Groot, 1991: 369). The latter is not congruent with industry's view that curriculum development is valuable in that it has the ability to change a static industry (Taylor, 1985: 3); it provides the academic leadership to a profession; and is potentially capable of rapidly incorporating the methodology and techniques changes the industry want to observe in the abilities of new graduates (Usher, 1985: 302). Hence, there is strong argument for multi-stakeholder involvement in curriculum development or, at least, the practising professionals, especially those more advanced in techniques and methodologies. Academics should also maintain close contact with industry so that changes in practice can be reflected in teaching. Other considerations for curriculum development are listening to the opinions of visiting Australian and Overseas academics, regular reviews, use of an advisory committee and continuous course evaluation and restructuring. A course, or areas of speciality, should be matched with staff, from within or outside the institution, who have relevant technical skills, experience, teaching ability and academic qualifications. There have been suggestions that a PhD and proven research and administration abilities should be the major considerations (Williamson *et al.*, 1993: 312). While the latter are highly desirable and useful, by endeavouring to fit people to an academic environment rather than an educational purpose, this view would appear to oppose good undergraduate curriculum development and teaching principles of providing an 'educated' person prepared for the market place. Both teaching and academic competence are required to prepare future professionals. This preparedness must enable the graduate to rapidly adjust to a work environment and any training requirements, be able to continue development through continuing professional development activities, and continually adapt and adopt changes in technology and managerial and professional methodology and techniques.

2.5 Conclusions: Chapter 2.

Advances in technology have resulted in changing work practices within the surveying and mapping industries and an increasing amalgamation of professional associations and multiple association memberships. A single discipline geomatics professional is the logical outcome of these trends for a more coordinated, complete and cost effective infrastructure. This would also meet changing government regulations, and education and quality assurance policy changes.

Geomatics provides a more complete 'spatial data-capture to presentation' information service in a broader, client orientated approach to work practices than currently exists. Developments of this significance require comparable education and training to provide an industry able to respond to market needs.

Society is increasingly demanding socially acceptable solutions and change: the technical expertise with which they are carried out is assumed and a natural expectation of a professional service. It is unacceptable to simply offer a unique skill to 'fix' a problem technically. Professional practitioners need to know the most recent professional advances, be able to understand the client perspective and to provide socially acceptable solutions. These changes required an increase in professional attributes and general education and a lessening of practical or tactile 'technician' training for professionals.

As paraprofessionals are increasingly performing tasks previously considered professionals' work, and professionals are becoming facilitators and managers, the ratio of paraprofessionals to professionals will increase within the industry. It is also estimated that the land surveying percentage will continue to diminish, despite an increase in industry employment over the next decade, opening up spatial information manipulation and management opportunities. This illustrates the need for specific professional and paraprofessional employment divisions within in the geomatics' arena, but articulation opportunities must exist within the profession and within education and training arrangements. These factors will require an industry-orientated human resource strategy, impacting on those within the industry, those entering the industry, professional organisational structure and curricula. This study will ascertain the perceived real needs and the preparedness of the whole industry to support these needs.

Demands for courses are created in the market place and graduate skills must reflect market demands. However, educational processes must place less emphasis on immediate practices and be innovative in addressing the wider issues concerned with continuing professional development and the continuing and long term preparedness.

A broader single discipline undergraduate education is appropriate to encompass both professional attributes and education. Course changes could include greater emphasis in social sciences and humanities studies and land and environmental development. There would be a corresponding lessening emphasis on the 'measuring sciences' of geodesy, astronomy and hydrography. The doubling of subjects in the syllabi over the past twenty years highlighted the need to remove superseded material and replace it with contemporary technologies, methodologies and techniques and to formulate a curriculum to absorb technological and philosophical changes.

The current education and training structure in Australia is still largely based on the traditional separate discipline guilds. Although contemporary curricular objectives generally do not reflect a sufficiently broad knowledge base, several undergraduate programmes had advanced some way towards achieving a course that reflects a geomatics' discipline function. Advancing towards a geomatics' concept will require industry wide understanding (of the need) and support.

A geomatics' curriculum presupposed an integrated and systematic approach to curriculum development that is largely market-driven and, by inference, industry-supported. The accountability for professional surveying and cartography education and quality of teaching currently rests with each academic school. Differences in curricula between schools reflected 'local' industrial needs and academic staff interests and expertise. This does not assist a national strategy in geomatics' human resource education and employment that is attuned to national needs and government policies on education and flexible employment opportunities. To achieve this, there is a need for a single unified national geomatics' accreditation authority with representation from all geomatics' stakeholders. This authority would coordinate and manage learning structures though national curriculum guidelines and monitoring, thereby maintaining consistency without impinging on the general autonomy of institutions.

The national authority would also be in a position to develop competency standards requirements from extra-profession pressures. Some increase in specified educational and training competency standards would support developments in training flexibility, equity, organisation and integration. They could help coordinate end-on-education and registration of education standards to overcome current restrictions on mobility in the workforce and facilitate articulation in employment. Additionally, clarifying career progression paths for students and the professional could also be addressed. While competency standards existed within the geomatics profession, government and employment agencies affecting policy changes will require a greater definition of each standard and an 'articulated' differentiation between paraprofessional and professional competencies.

Distance education is an educational mode that has proved to be educationally advantageous, and the most cost effective and viable structure on which to develop a broader open learning strategy. With communications technology and support infrastructures increasing, distance education can be an integral part of the full-time learning environment structure. Open learning is particularly appropriate for the geomatics' industry, given the diverse and remote individuals and small groups, and the relatively small and near static population of the industry. The choice of study mode can remove articulation barriers and facilitate continuing professional education. It also enables training to occur in the work-place environment, frees-up the education processes and provides a greater diversity of better resourced learning opportunities with greater relevance to the profession.

There is a need to ascertain the structure, principles and content of a geomatics' curriculum, including an open learning environment, that would enjoy the support and cooperation of the whole geomatics' industry. Such a study to determine the principles should aim at reflecting the industry's self perceptions regarding the future.