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NTU: The Working Professional's University*

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The National Technological University was created in 1984 as a cooperative effort by many major engineering and management colleges in the United States for the graduate and continuing education needs of busy engineers, technical professionals and managers. Today, 52 university campuses are linked by 16 channels of new MPEG2/DVB compressed digital video technology to workplaces in North America, and since 1995, to nine countries in the Asia Pacific region. NTU's vision is to enable working professionals and managers to share premier educational resources globally via telecommunications. NTU is a private, non-profit, accredited university although it has no direct faculty or campus student facilities. Today, NTU offers thirteen MS degrees and a MBA, nearly 500 academic courses each year, and more than 450 non-credit continuing education courses to a customer list of more than 250 business and government organizations. NTU's brief history is punctuated with a number of innovations. These involve delivery technology, and more recently, the creation of a for-profit subsidiary for many support functions. This paper describes the organizational relationships with the 52 participating universities and their faculties. Academic program outcome measures are reviewed in depth. Current trends in continuing education service are described. The increasing role of the Internet and World Wide Web in all aspects of the operation is reviewed. NTU's latest delivery technology strategy is also highlighted.

THE NEED FOR ENGINEERING OUTREACH IN THE UNITED STATES

IN THE United States, the bachelor's degree has been the educational requirement for entry into the engineering professional for over a century. In 1900, medical education required only three years of post-high school study and law only two. Professional education has evolved with the complexity of practice so that today medical students require at least eight years and law students seven, both deferring professional study until graduate school. But US engineers today overwhelmingly enter practice with a BS degree after about 4.5 years of study. In Europe and Latin America, engineers usually study five or six years for their degrees.

Engineering educators are acutely aware that the baccalaureate can only provide an introduction to the fundamentals, but cannot provide in-depth specialized knowledge. The latter is usually the focus of a year or two of graduate study leading to a master of science degree in an engineering discipline. About 30 percent of today's graduates ultimately earn a MS degree in engineering and, for a growing number, this is a result of part-time study while being fully employed. Typically, these terminal master's degrees are intended for practicing engineers and are not part of the screening process for doctoral students.

Another driving force is complexity of technology and the rapid rate of technological change. Indeed, the way engineers work, their tools, and in many cases, their organizations are changing. International teams and complex business alliances are realities for many engineers today. Career-long education and continuous professional growth can help assure career security now that job security is rare. Employers may pay the direct costs, but individuals must make the commitment and schedule the study time. Working engineers not only demand instructional quality, but also flexibility and convenience that match their busy schedules.

US engineering educators were early adopters of telecommunications technologies that provided access anytime, and anyplace. In a 1985 study of education in the workplace, Nell Eurich observed that engineering faculty were 'light years' ahead of other academic disciplines in the use of technology to serve working adult learners [1].

REGIONAL ITV PROGRAMS

Several US engineering colleges had constructed instructional television (ITV) programs linking the campus with its neighboring employers in the mid-1960s. The ITV graduate courses were regularly scheduled, on-campus offerings attended by full-time students as well as by off-campus part-time students via ITV. The classes were held in specially equipped studio-classrooms so that, not only the lectures, but also the student questions and discussions were transmitted.

The primary goal of instructional television—candid classroom TV—is to provide access. The mature working engineer is a very motivated

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learner if the subject matter is related to the job. High production costs cannot be justified, because graduate classes are small, and the material must be updated each term. Faculty generally are comfortable teaching in an ITV environment that has evolved to support their work.

Today's candid classroom instructional television bears little resemblance to the chalk talks of three dozen years ago. New high-resolution color cameras, fully remotely controlled, look down on an area on the instructor's desk. Not only can notes be shown, but also models, photographs and excerpts from books. Multimedia, the blending of computer-generated graphics with video and data, is in operation at many campuses. Real-time programming, interactive displays of data files and computer-generated visuals can be blended with color slide files, video and motion picture files. Miniature chemical wet-lab facilities have been installed in the ITV classroom of the University of Delaware. Students, both on campus and off, view presentations greatly enriched by clear views and dynamic illustrations. Today's generation of ITV instructional facilities provide unparalleled opportunities for creative instructors to interact with students. A sophisticated multimedia instructional facility of this type is now in use at the University of Missouri-Rolla.

A variety of delivery technologies are successfully used to transmit the ITV signal from campus to the workplace. Synchronous, live transmission by point-to-point microwave and high frequency instructional television fixed service (ITFS) broadcast systems with a 50-mile radius for reception is widely used. Videotapes delivered by courier are also popular for asynchronous viewing. Adult learners especially appreciate the flexibility (videotape to uncouple schedules) and convenience (instruction at the job site). Employers sponsor these programs which minimally disrupt performance at work. A comprehensive study involving over 8400 grades of engineering ITV students at eight universities searched for how particular cohorts might be served using different candid classroom operating systems. 'As long as student/faculty interaction is at a tier both necessary and sufficient to support quality instruction, learning (1) will not decline in the absence of interactivity and, (2) may significantly improve for those who have a strong need to attune instruction to particular schedules' [2].

CREATION OF NTU

In August 1974, representatives from two dozen engineering colleges operating ITV programs, along with a cross section of their customers, participated in a workshop to discuss cooperative ways to improve continuing education service. This was a more difficult problem than adding part-time students to degree programs, because the short courses had to be created. Furthermore, schools that pioneered publishing of videotaped short courses reported that the cost of marketing their first few titles was daunting. Follow-up work led, in 1976, to the creation of a non-profit consortium, the Association for Media-based Continuing Education for Engineers (http://amcee.org). Initially, 12 schools adopted the goal 'to increase the national effectiveness of continuing education for engineers'. AMCEE members shared information on customer needs and encouraged the publication of short videotaped courses aimed at practicing engineers. AMCEE also served as a marketing cooperative to help reduce the distribution costs mentioned earlier.

By the early 1980s, AMCEE was filling many needs in continuing engineering education. The consortium's success strongly suggested that a place existed for a national university that taught students through the latest telecommunications technologies. With the increasing affordability of satellite communications, AMCEE members saw the possibility of extending the range of ITV systems to a coast-to-coast audience. Since less than half the US engineering work force was served by regional systems, there clearly was a role for a national, satellite-based organization to play.

The university advocates in AMCEE believed that the cooperative approach was the best way to meet the demand for quality graduate and continuing education instruction. In February 1982, the AMCEE Board of Directors agreed to investigate the feasibility of creating a national engineering college that would deliver its programs using the most advanced satellite telecommunications technologies available.

Major corporations and the Department of Defense funded a two-year planning process involving numerous consultants. These sponsors provided technical advice and met regularly to help shape the plan. By the fall of 1983, the decision to proceed was made unanimously by all 33 AMCEE representatives with confidence that the potential customers were supportive. These efforts led to the incorporation of the National Technological University (NTU) in January 1984. The rationale to create a new non-profit organization governed by a Board of Trustees was that a consortium was unlikely to earn accreditation, and the ability to award degrees in the name of NTU was essential to the business plan. Nonetheless, the cooperation of the AMCEE member schools was critical for a successful launch. In the first NTU term, fall term 1984, seven universities offered courses in a master's degree in computer engineering program. By spring 1985, eleven schools were active in NTU, and each term thereafter the cooperative effort grew.

VISION/MISSION/ACCREDITATION/CORE COMPETENCIES

The National Technological University's vision statement is simple and straightforward:

'Enabling working professionals and managers to share premier educational resources globally via telecommunications.'

It is this vision that led NTU to expand its operations into the Asia Pacific region in 1995 and to consider other regions as they are deemed to develop their needs for advanced engineering education. Similarly, it led to the acquisition of PBS: The Business Channel, in 1999.

The mission statement states that the National Technological University, a Colorado non-profit organization, was formed to award master's degrees in selected professional disciplines based upon course credits earned at participating universities. It limits NTU's degree-granting activity to the master's degree level, and specifies that instruction will be provided by video-, satellite- and Internet-transmitted courses, thereby creating greater access and flexibility for the non-traditional student.

During the years that followed, NTU put in place programs, academic procedures and processes, and delivery systems of high quality and integrity. The success of these efforts has led to the recognition of the University as a mature institution authorized to grant graduate credit and master's degrees and as a leader in educational technology.

The National Technological University's mission is to:

- serve the advanced educational needs of graduate engineers, technical professionals and managers;
- award degrees and certificates at the master's level;
- explore, develop and use advanced educational and telecommunications technologies to deliver instructional programs to students at their employment locations;
- provide a satellite network infrastructure linking technical professionals and managers nationally and internationally in research seminars, technology transfer activities and related technical exchanges.

NTU is unique in a number of ways and fills a special and important niche in the spectrum of higher education. Following is a partial list of significant factors that serve to distinguish it from other institutions.

1. Through its offerings, NTU gives equal attention to both the advanced degree and the continuing education needs of its working adult student body.
2. NTU consists of a partnership of universities that provide the graduate courses from their respective campuses via instructional television. This offers a wide base from which to draw the best of faculty and courses. As an accredited university, it is responsible for the design, creation and development of curricula. It develops faculty curricula oversight committees such as curriculum, admissions and advising committees. It solicits and selects courses appropriate to each curriculum from the best instructors at its participating universities. It grants course credit. It integrates the courses into the individual disciplines, and awards degrees. The non-credit continuing education courses, symposia, and teleconferences delivered and managed by NTU Corporation come from diverse sources, including universities, professional societies, industry and other for-profit and non-profit providers.
3. Carefully selected faculty consultants oversee the selection of credit courses and structure of academic degree programs.
4. As a university, NTU concentrates on education, focusing on the use of telecommunications to deliver education.
5. Primarily the technical educational needs and requirements of its customers in industry, government and other high-technology organizations drive NTU's programs.
6. Since students are all working professionals and managers sponsored by their organizations, they are very selective and demand offerings of the highest quality, substance and pragmatic value.
7. NTU Corporation, an affiliated company, manages and operates a sophisticated satellite network infrastructure linking industry, government and the university community in an international setting.
8. Distance learning technologies centered on satellite transmission are used to deliver the course offerings and link the geographically dispersed students with the dispersed sources. Many courses are delivered in real time with interaction between the students and the instructors. The Internet and the World Wide Web have become an effective and timely student- to-instructor and student-to-student communications facility in ways undreamed of just a few years ago. Continued improvements in both computing power and communications speeds will make the World Wide Web a central feature of NTU's course delivery and information services.
9. NTU has an effective and efficient decision-making process. This process enables NTU to bring together and manage meaningful programs in a timely fashion. Within the administrative headquarters of NTU, all academic support functions are concentrated within one group of seven individuals. Communication is easily facilitated. Academic decisions such as course selection, admissions, and grade problems can be accomplished in a timely manner. New degree programs can be developed as soon as a market is perceived and assessed.
10. NTU's lack of high investment in fixed assets such as dormitories, libraries, athletic facilities, etc. provides an exceptional level of operational flexibility. At the same time, NTU's

students still require access to technology, library resources, and other services similar to students on traditional campuses. These challenges are met through the partnership of NTU and its sponsoring organizations.

11. NTU provides a unique, nationwide audience of working engineers that supplies an important external source of feedback on course content and emphasis to NTU and its participating instructors and universities.

NTU is accredited by the Higher Learning Commission and a member of the North Central Association. The university was first accredited in November 1986 at the time of its first graduate. Since then NTU has undergone two additional accreditation visits in 1992 and 1997. The next scheduled visit is in 2006. NTU is accredited to offer professional graduate degrees in North America, Asia, Australia and the Pacific Islands.

PARTICIPATING UNIVERSITIES/ CURRICULA

Fifty of NTU's fifty-two participating institutions provide academic courses and services. Two of the participating universities only contribute non-credit continuing education courses. Each participating university has formally agreed to be a participating institutional member by signing a participation agreement with NTU. Participating universities are shown below.

- Arizona State University
- Auburn University
- Boston University (contributes only to non-credit, short course offerings)
- Clemson University
- Colorado State University
- Columbia University
- Florida Gulf Coast University
- The George Washington University
- Georgia Institute of Technology
- Iowa State University
- Kansas State University
- Kettering University
- Lehigh University
- Massachusetts Institute of Technology
- Michigan State University
- Michigan Technological University
- New Jersey Institute of Technology
- New Mexico State University
- North Carolina State University
- Northeastern University
- Oklahoma State University
- Old Dominion University
- Purdue University
- Rensselaer Polytechnic Institute
- Southern Methodist University
- University of Alabama at Huntsville
- University of Alabama at Tuscaloosa
- The University of Alaska Fairbanks
- University of Arizona
- University of Arkansas
- University of California at Berkeley
- University of California, Davis
- University of Colorado, Boulder
- University of Delaware
- University of Florida
- University of Idaho
- University of Illinois at Urbana-Champaign
- University of Kentucky
- The University of Maryland at College Park
- University of Massachusetts at Amherst
- The University of Michigan
- University of Minnesota
- University of Missouri-Rolla
- University of Nebraska-Lincoln
- The University of New Mexico
- University of Notre Dame (contributes only to non-credit, short course offerings)
- University of South Carolina
- University of Southern California
- The University of Tennessee, Knoxville
- University of Washington
- University of Wisconsin-Madison
- Vanderbilt University

The appropriateness of NTU's programs as an institution of higher education is attested by the curriculum offerings—courses taught as part of on-campus graduate programs at participating institutions transmitted live via satellite television, via the Internet, or on videotape to the customer's sponsoring sites. Program designs are similar to those in quality institutions across the nation.

NTU offers credit programs leading to the master's degree in fourteen majors:

1. MS Chemical Engineering
2. MS Computer Engineering
3. MS Computer Science
4. MS Electrical Engineering
5. MS Engineering Management
6. MS Environmental Systems Management
7. MS Management of Technology
8. MS Manufacturing Systems Engineering
9. MS Materials Science and Engineering
10. MS Mechanical Engineering
11. MS Software Engineering
12. MS Special Majors Program
13. MS Systems Engineering
14. International Masters in Business Administration

The Curriculum Committee of the Graduate Faculty of each discipline develops the program content and requirements. Programs and program issues are reviewed and discussed by the Academic Executive Committee (Chairpersons of the Graduate Faculties) and by the Graduate Faculty at periodic (biennial) face-to-face meetings. Members of the Graduate Faculties interact often by electronic mail, telephone, and occasionally by video teleconferences.

Degree requirements, set by the Curriculum

Committee of each discipline, vary. Three (Computer Engineering, Computer Science and Environmental Systems Management) require a total of 30 semester credit hours. Seven others require, in addition to 30 semester hours, a three-semester credit hour capstone or individual study project (Engineering Management, Materials Science and Engineering), or an additional three-semester credit hour course (Chemical Engineering, Electrical Engineering, Manufacturing Systems Engineering, Software Engineering, and Systems Engineering). Mechanical Engineering requires 32 semester credit hours. The Special Majors Program and the International MBA require 36 semester hours. The former is designed to provide flexibility for students, with the advice and approval of their advisors, to emphasize interdisciplinary areas that meet their needs and interests.

The Management of Technology (MOT) is a two-year specifically defined program. The curriculum specifies a 36 semester credit hour requirement, which includes five four-day residencies, one two-week international study mission, and an individual field research project.

NTU also offers some undergraduate level bridging courses to enable students whose undergraduate degrees have not provided appropriate preparation for the NTU master's degree they seek, or who need to update their technical competence at the undergraduate level. These courses, which are available from NTU institutions via the satellite network, are for bridging purposes only and cannot be used to meet master's degree requirements.

NTU offers students an option to access credit courses for professional renewal and growth without seeking academic credit toward a degree. Students who enroll to audit an academic course must register. Auditors work under their own schedules and direction and do not interact with the instructor, have assignments evaluated, take examinations, or receive a grade or credit for the course. Audit registrations do appear on the student's NTU transcript.

STUDENT PROFILE/PERFORMANCE MEASURES/GRADUATES

All of NTU's students are fully employed working professionals. The average age of students who are admitted to a degree program is slightly more than 31 years old. Typically it takes about three and one-half years to complete a degree program so the average age of NTU's graduates is 35. This means that typically, the student has about eight years of work experience past the baccalaureate degree. About ten percent of the students have already earned a master's degree.

As of March 2000, 1,079 students were admitted to degree programs, and the applications of an additional 79 were in process. To date 1,488 have graduated; 1,016 have withdrawn, and 374 were denied admission. Most frequently students who withdraw from a program do so because they change their place of employment to one at which the NTU program is not available. It should also be pointed out that nearly one-half of each term's student registrations come from students not interested in pursuing a master's degree. These students may already have a master's or even doctor's degree and are only looking for a more in-depth continuing education course, for example, software project management, etc.

NTU's mission includes an explicit statement of the student population to be served. All students admitted to credit courses are employees of sponsoring organizations and are recommended by their employers. Generally they hold a BS degree in Engineering, or in a related science such as Chemistry, Mathematics, Physics, Computer Science or related fields and an undergraduate grade point average (GPA) of at least 2.9 on a 4.0 point scale. Some program committees have set additional admission criteria; for example, Engineering Management and the Management of Technology programs require evidence of two years of engineering work experience and two years of management experience, respectively. Thus, students are well-prepared and carefully screened. They are highly motivated and career oriented, and they are encouraged by their employers to continue their education.

Because all of NTU's constituents are remote, precise and accurate information is mandatory. Materials that may be misconstrued or misinterpreted only lead to prolonged interchange via telephone, facsimile, electronic mail or other forms of communication. For example, because students cannot simply walk down the halls and talk to faculty or even other students, the *Class Schedule* must include details far beyond the traditional university publication. Contact information for faculty and administrative contacts must be accurate and easily located. Each course syllabus must be detailed enough for a student to accurately determine what the course offers and how it operates. Details such as the course requirements, homework, projects, examinations, etc., calendar information (e.g. holidays the campus observes), any prerequisites, and textbook and notes information must be accurately described. As can be imagined, this is a tedious and time consuming process and procedures have been put into place over the years to minimize errors.

NTU has instituted a number of ways of gathering information in an on going and timely fashion so that problems can be addressed while they are going on. One procedure of this kind is the use of a 'Squawk Card' which NTU instituted in fall 1986. Until 1994, double postcards were sent to all enrolled students to elicit information about video and audio quality and about instructor's visuals and handouts. In 1994, the mailed squawk cards were replaced with an electronic

mail version called the Student Early Warning system that permits much more rapid response to student inputs. For example, the e-mail message is sent in seconds, the response returned in seconds, and problems can be immediately routed electronically to the appropriate and responsible organization or individual. This use of the Internet has taken days off problem resolution and response.

Several evaluative studies have been made to measure the quality of the NTU programs. These provide information about the success of the NTU delivery mode compared with traditional ones, feedback from site coordinators and instructors, student satisfaction, and areas of concern.

The most comprehensive of the studies is that made by the F & W Psychometric Consulting Group, who conduct 'an independent evaluation of the instructional systems employed by NTU' annually since 1984. The most recent survey solicited information from every student enrolled in an NTU credit course in 1998–99 (a total of 3,465), 486 site coordinators, and 425 instructors. Questionnaires were sent out to students, coordinators, and instructors, each of the four terms.

The major findings were:

1. An increasing majority of students, instructors, and site coordinators feel that major changes in the NTU system are unnecessary.
2. Advising continues to improve.
3. There has been continued improvement in the grading and return of homework and tests, although further improvement is indicated.
4. There is increasing satisfaction among site coordinators with the technical quality of NTU television signals.
5. There was unanimous agreement among instructors that NTU provides an important service. Only two instructors were unwilling to teach another NTU course.
6. The majority of students in eighty-six percent of their NTU courses felt that the courses were relevant to their present work. This response has been consistent for ten years.
7. The majority of students in ninety-four percent of their NTU courses said that the courses were relevant to their career objectives. This response has also remained consistent over ten years.
8. Seventy-nine percent of the students plan to pursue an NTU degree. Eighty-seven percent plan to take more courses.
9. The majority of the students agreed that their instructors were readily available for consultation, returned graded homework and tests quickly enough to benefit them, were considerate of TV students, and were among the best teachers they had ever had.
10. Site coordinators expressed noticeably more satisfaction with the timely delivery of instructional materials.
11. Over time there has been an improvement in the student response concerning the helpfulness of the NTU staff. Less than two percent were dissatisfied with the NTU staff.

Additional insight into the value placed on the programs by students is revealed in the results of the Annual NTU Alumni/Alumnae Survey conducted by the NTU staff. One hundred-thirty graduates responded to the questionnaire from the graduates of one, five and ten years previous. The respondents represented ten of the fourteen master's degree programs. Summarizing the results, seven percent said the program was a 'must have in their career.' Fifty percent said the program was 'very relevant to their work,' thirty-two percent said the program was 'relevant to their work,' nine percent said the program was 'of some relevance' and only two percent indicated that the program was 'of little relevance or unnecessary.' Overall, they said their program had proved to be very important to their work, that they were satisfied with their skills' development in the program, with NTU operations and with NTU instructors. Ninety-eight percent said the program met their expectations, and half of them could have earned a degree without NTU but with greater difficulty. Remarkably, nearly ninety-eight percent said that they would advise, or already have advised, others to seek an NTU degree.

NTU compares the grades earned by NTU students, NTU admitted students, on campus students and local ITV students. This study was began under the direction of Dr. Douglas Sjogren, in 1990, who compared the grades earned by these groups of students by comparing NTU, ITV and on-campus students taking the same classes each year during the four-year period 1984–1988. NTU has continued accumulating these comparable grades since Dr. Sjogren's original study. In 1984, about 80 NTU student grades in 14 courses were compared with the on campus students as well as the local, regional ITV students taking the same courses. These data are shown in Fig. 1. By 1998, the data represent 5900 NTU student grades in 460 courses from 37 universities compared to thousands of students taking these courses either on campus or through the university's local ITV system, in other words, each data point is significant and represents the average of thousands of grades. As can be seen, NTU students consistently outperform the on-campus and regional ITV students by as much as 0.3 of a grade point. Even the local ITV students perform better than the on campus students. Why is this? Obviously, NTU students are mature, full-time working adults as usually are the local ITV students. All NTU students have undergraduate Bachelor's degrees from many of the finest universities and institutions in the world. Maturity and motivation are certainly the key factors, but it does illustrate that televised learning for engineering education for working adults is effective and distance learning for these students meets their academic needs.

Anecdotally, nearly all of the 1488 NTU

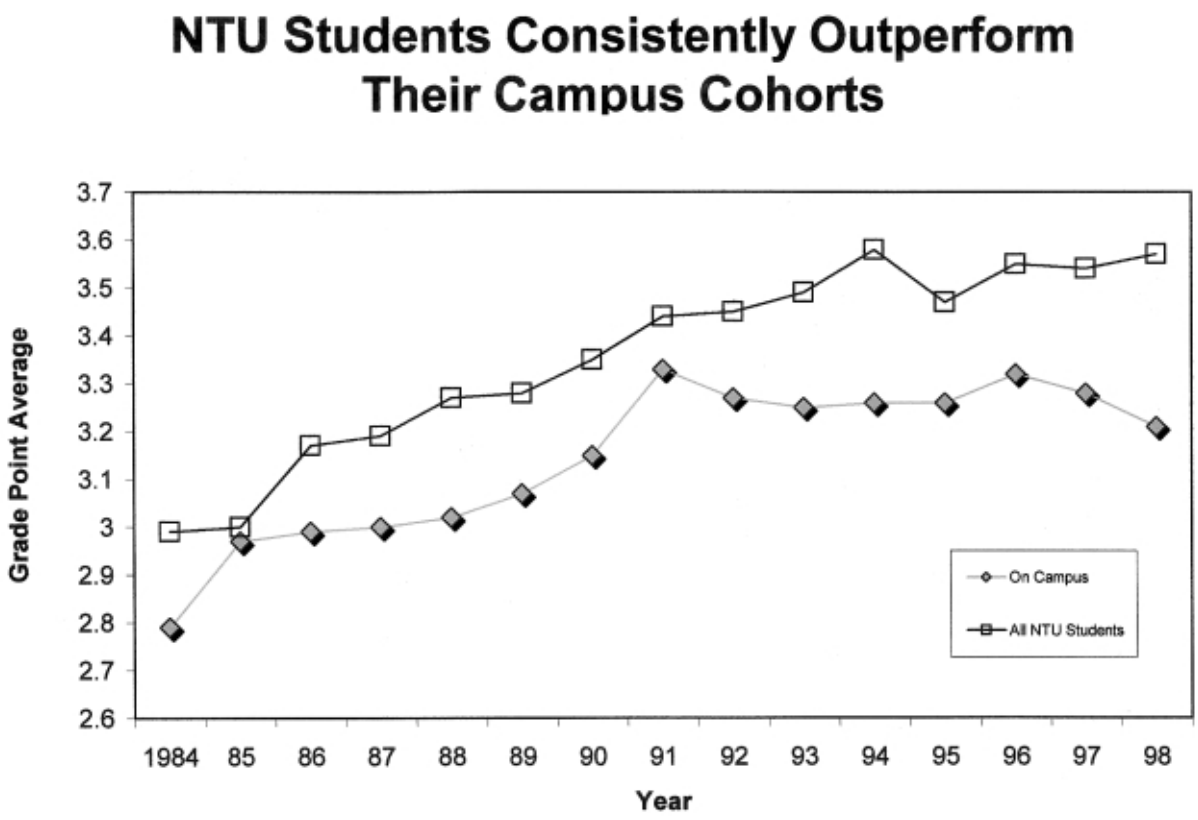

Fig. 1.

graduates to date express themselves by stating that except for NTU, they would not be obtaining a MS degree. This indicates that NTU attracts students who otherwise would not be continuing their education. Direct delivery to their place of employment is the key flexible idea that enables them to continue to learn while maintaining a full-time job.

DELIVERY TECHNOLOGIES

Since its inception in 1984, National Technological University has been recognized worldwide as a technological leader and innovator in distance education. Combining the technical resources of the nation's leading engineering universities, NTU became the first organization in the world to distribute graduate level engineering courses via satellite. NTU pioneered the use of split transponder, analog satellite delivery in 1984; an innovation later adopted by many other networks. In 1991, NTU once again pioneered new technology by becoming the world's first compressed digital video satellite network. NTU continues this tradition of technical innovation with its most recent technology replacement strategy, opening the doors for delivery directly to the student's desktop.

NTU recognized the need to leverage emerging technologies to improve the educational experience and foster increased access and convenience for its students. New features, such as delivery to the desktop, file and IP delivery and unattended recording of courses to video and file servers have become critical to continue NTU's tradition of technological leadership.

A key goal with the new system is to be able to deliver television programming to existing sites, in the traditional manner—television broadcasting live to satellite receivers feeding local viewing rooms and banks of VCRs—while in addition adding the capability for delivery to the desktop. In order to avoid the cost and complexity of running each course in several different delivery standards, one for set top television receivers and one for PC server based systems, a system compatible with both, traditionally very separate, technologies was found. This compatibility exists within NTU's new MPEG2/DVB network.

NTU's first compressed digital delivery system, while an innovative technology for 1991, required a site coordinator at each receive location to handle administrative duties such as setting up VCRs for program recording, hosting student viewing hours, etc. The new computer-based delivery system eliminates a large portion of the labor required to support NTU courses. Programs may be automatically stored on large file servers within the corporate environment. NTU's control and conditional access system handles the authorizations for digital recording. Notes and other

materials may similarly be delivered to the local PC receiving system, which will be accessible by the students enrolled in the NTU program. Virtually all of the responsibilities of the human site coordinator may be converted to computerized processing and delivery, thereby saving administrative overhead costs to the customer.

All of these new capabilities are made available due to the extremely rapid growth of computer technologies, significant decreases in local storage system costs and new wide-band delivery pipes. These new pipes include Internet 2 to which most of NTU's 52 major engineering universities and many major NTU corporate subscribers will be connected. The very wide bandwidths available on Internet 2 will further increase the effectiveness and efficiency of this new computer based educational environment.Today, NTU operates 24 hours a day, seven days a week, broadcasting on sixteen channels—360 hours of available broadcast time in each 24-hour period. NTU is the largest educational satellite network in the world. The NTU Satellite Network operates in the Ku-band on the GE 3 satellite, positioned at 87° west longitude in geo-stationary orbit 22,600 miles above the equator. In the Asia Pacific region, NTU contracted for one compressed digital video channel on PanAmSat 2 located at 192° west longitude; it is also in geo-stationary orbit. The two satellite footprints are shown in Fig. 2.

CREATION OF NTUC

NTU grew rapidly in its first decade, but revenue flattened in 1993 and remained in the range of $12–14m annually through 1998. Tuition from the academic programs is the largest portion; continuing education courses contribute about two-thirds as much as academic; and a variety of grants mostly from the government account for less than ten percent. NTU operated on a balanced budget, but did not generate sufficient funds to invest in promotion nor to test new technologies. With average academic class sizes of twelve students, there was clearly underused capacity. Continuing education courses attract an average of seventy participants and could serve many more. The NTU administration and the Trustees were frustrated and explored ways to renew the growth. After all, in the late 1990s, education delivered via telecommunications was widely accepted and growing rapidly in corporate training organizations.

To attract investment capital that would fuel growth, NTU created a for-profit subsidiary called National Technological University Corporation or NTUC [3]. NTUC was formed on July 1, 1998, with the initial ownership about two-thirds NTU and one-third Olympus Partners, a private equity firm in Stamford, CT. For its portion of the ownership, NTU contributed licenses, satellite leases and control systems, several employees and

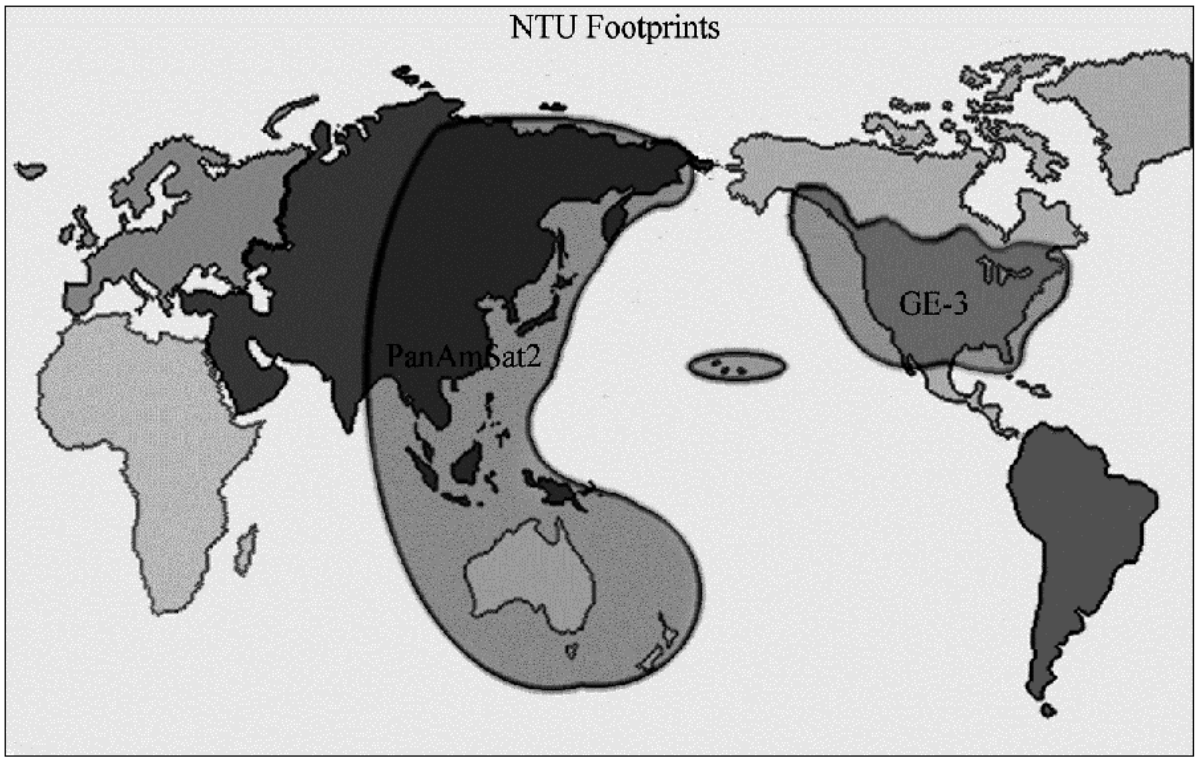

Fig. 2.

the value of the name and intellectual property. The new for-profit corporation is jointly owned by a non-profit and a for-profit. Such arrangements are common in the US health care industry, and many universities have entered into similar joint ventures to undertake commercial research. However, the division of duties defined by a services agreement between NTU and NTUC is probably unique. NTU maintained its academic core including curriculum design, admission standards, agreements with universities and faculty, granting degrees and accreditation. NTUC assumes all the non-academic functions for NTU including sales and marketing of academic courses, collection of revenue, operating the delivery systems, customer service, public relations and the offering of continuing education short courses.

Over the past 18 months, NTUC has focused its efforts on building the infrastructure to support rapid growth. NTUC also built a sales and marketing organization including an experienced field sales force. In addition, NTUC recently completed an overhaul of its content delivery strategy. As described earlier, it has successfully deployed a new broadcast platform based on MPEG2/DVB digital standards and is rapidly expanding its desktop delivery capabilities.

In another significant development, NTUC recently acquired the assets of The Business Channel, a wholly owned subsidiary of the Public Broadcasting Service (PBS). Through this acquisition, NTUC holds exclusive worldwide rights to the PBS brand name for distributed business and technical learning to the corporate and government markets. In addition to the licensing rights for one of the most recognized brand names in media, the acquisition also provided a broad portfolio of business and management content and affiliations with many of the world's most prestigious corporate training organizations and business thought leaders. These complement NTU's already rich content offerings in technology and engineering and its unsurpassed network of university content partners. In addition, the acquisition doubled NTUC's revenue base in continuing education short courses and increased NTU's installed customer base by approximately one-third.

On May 24, 2000 the National Technological University Corporation, announced it had received $20m in additional equity financing and commitments. Participating in this round were SG Capital Partners LLC, an affiliate of Société Générale and Olympus Partners, which had previously invested in the company. NTUC intends to use these proceeds to rapidly expand its online course library and fund increased sales and marketing efforts.

Given the core content and distribution assets of National Technological University, the new state-of-the-art distribution technology, a stable of premier educational brands and the many enhancements to an already strong operating model, NTUC is now well positioned in the large and fragmented fields of corporate training and distributed education.

In summary, NTUC has three goals for the next few years: to increase enrollments, to earn a profit, and eventually to go public in an IPO, allowing NTU to establish an endowment of marketable securities.

PROFESSIONAL DEVELOPMENT SHORT COURSES

Creating the relevant short courses and seminars in today's rapidly changing technology and management environment is a challenge. On-campus students do not need continuing education, so these teleconferences must be created specifically for NTU customers. In 1987 when NTU began a new service that was called the Advanced Technology and Management Programs (ATMP), only IEEE and a handful of universities had ever prepared and delivered a continuing education teleconference. Furthermore, these early efforts were generally far too expensive to reach more than the privileged few. NTU opened 'a bookstore' without any experienced 'publishers' ten years ago. Nurturing ATMP so that now over 70 producers create continuing education telecourses is a major NTU accomplishment. Each producer owns the intellectual property and copyright, and licenses NTU to market and deliver the instruction to its customers.

ATMP teleconferences may be an hour long, or more often three to five hours in length. Most continuing education telecasts are one day long or five hours of instruction with the half-hour breaks. Series of four to twelve days spread over a month to six months are offered in some topics. In 1998–99, almost 500 short courses were delivered to over 35,000 participants.

The acquisition of The Business Channel enlarged the scope of NTU's professional development offerings. To delineate the new range of programs, effective January 1, 2000, the combination of ATMP and PBS The Business Channel has been renamed 'PBS: The Business & Technology Network.' Short courses are now arranged in three programming streams as follows:

- The Business and Management Channel will deliver approximately 150 courses in the year 2000. Topics will include business practices; change and innovation; economic development; economics and finance; engineering management, human resources and personnel issues; leadership and management development; management practices; marketing; professional development; safety practices; sales and customer service.
- The NTU Information Technology Channel will consist of 150–175 courses in 2000. Topics will include: applications programming; computers and technology; computer systems and

software; databases; data and telecommunications; enterprise technology; internet; intelligent systems; multimedia; networking and computer communications; object oriented; programming languages; software engineering; systems programming.

- The NTU Engineering Channel will carry 75–100 courses in the year 2000. Topics will include: aerospace engineering; client/server; computer hardware; electrical engineering; electromagnetics; environmental; integrated circuits; image processing; interconnection and packaging technology; mechanical engineering; manufacturing; materials science; new technologies; optics; quality; signal processing technical operations.

Detailed course descriptions may be viewed on NTU's home page (http://www.ntu.edu). Customers are encouraged to view the teleconferences as they are being taught. In addition, many firms also videotape the courses and use the tape for 45 to 90 days for additional students. Each short course is documented with a set of visuals and suggested readings; the materials are posted on the Internet for authorized downloading. Increasingly, electronic forums to enhance asynchronous interaction among students and faculty support NTU's courses. The average cost per participant in a course is $110 and, most importantly, there is no lost time or expense of travel.

ASIA PACIFIC SERVICE

In 1995, NTU began broadcasting both academic and non-credit short courses into the Asia Pacific region. Distributors were established early in Australia, Thailand, Malaysia, Taiwan, Japan, Indonesia and the Philippines. Three master's degree programs were offered: the MS in computer science, electrical engineering and engineering management. One of the first requests from this region was for a MBA degree and it was this impetus that moved NTU to develop and offer the International MBA as the first program designed for an international audience and with the possibility that international institutions could also become academic course providers.

Thirteen years following NTU awarding its first degree in the United States, in August 1999, the first NTU Master's degree was awarded to a student in Asia, in his case, Thailand. Students from Japan, Korea and Thailand are currently working on MS degrees.

FUTURE DIRECTIONS

Over the coming years, NTU will continue to diversify its offerings that are available over the Internet. Already, the requirements for four MS degree programs (computer science, computer engineering, software engineering and systems engineering) may be met completely by courses without using satellite television technology. During the coming year, the electrical engineering degree program and the MBA degree program will become available over the Internet. Software is now being tested to provide significantly enhanced interactions using synchronous web delivery and voice over Internet Protocols (VoIP) enabling students to actively participate in courses as if in the same classroom. Such technological advances will only continue.

However, NTU will always be dedicated to providing premier educational opportunities to the working professional no matter where new technologies take the university. Technology must never interfere with the delivery of education, rather it must be used to augment and support the learning activity.

REFERENCES

1. Nell P. Eurich, *Corporate Classrooms: The Learning Business*, Carnegie Foundation for the Advancement of Teaching, Special Report, Princeton University Press, 1985.
2. Harvey R. Stone, *A Comparative Analysis of Interactive and Non-Interactive Video Delivery of Off-Campus Graduate Engineering Education*, Newark: University of Delaware (1990).
3. Daniel Gross, *Not for Profit? Not Exactly*, University Business (April, 1999) pp. 31–36.

Lionel V. Baldwin, President, National Technological University, Fort Collins, Colorado. Prior to creating NTU and becoming its President in 1984, he was Dean of the College of Engineering at Colorado State University for 20 years. He joined Colorado State University in 1961 as an Associate Professor of Civil Engineering; he worked for NASA in Cleveland, Ohio for six years. Dr. Baldwin received his BS in Chemical Engineering from the University of Notre Dame in 1954 and his MS. in Chemical Engineering from Massachusetts Institute of Technology in 1955. In 1959, he earned his Ph.D. degree at Case Institute of Technology. He has published over 50 technical papers in turbulent diffusion in the atmosphere and educational technology. He has served as principal investigator on projects sponsored by the Office of Naval Research, NASA, NSF, DoD, the Alfred P. Sloan Foundation and numerous corporations. Dr Baldwin was honored by NASA in 1964 for his plasma research. He was one of seventeen inducted into the Engineering Education Hall

of Fame at the Centennial Meeting of the American Society for Engineering Education in 1993. Dr Baldwin has been a leader in developing linkages between industry and universities. In 1967, he created the first ITV program in the US employing courier-carried videotape to deliver CSU graduate classes to seven Colorado industries. The NTU national satellite network today provides advanced education to technical professionals at more than 1000 sites. NTU coordinates instruction offered by 52 major universities. In 1985, the Congressional Caucus for Science and Technology cited him 'for outstanding leadership in fostering industry/university relationship and training via telecommunications technology.' He was Honor Alumnus in 1984 of the College of Engineering at the University of Notre Dame. The American Society for Engineering Education gave him the 1987 Chester F. Carlson Award for these innovations. In 1990, Baldwin was named 'Engineering Manager of the Year' by the American Society for Engineering Management, and he received a 'Major Educational Innovation Award' from the IEEE. In 1996, Baldwin co-shared the Kenneth A. Roe Award of The American Association of Engineering Societies.

On 1 July 2000, Dr. Lionel V. Baldwin retired as the founding president of the National Technological University. NTU's Board of Trustees announced that Dr. Baldwin would be succeeded by Dr. André G. Vacroux, the Dean of Engineering at Southern Methodist University. Dr. Baldwin continues, part time, as president of the NTU Foundation, a not-for-profit organized on behalf of NTU for building an endowment and for raising funds for special projects such as the recently announced Center for Research on Technology-based Education to be located adjacent to NTU's headquarters in Fort Collins, Colorado.

On 1 December 2000, the Board of Directors of the National Technological University Corporation, NTUC, the affiliated for-profit entity, changed the name of the organization to Stratys Learning Solutions.

Gearold R. Johnson is the Academic Vice-President of the National Technological University (NTU) in Fort Collins, Colorado. He holds a B.S. in aeronautical engineering, a MS in engineering, and a Ph.D. in mechanical engineering from Purdue University. He joined NTU in July 1994. Before joining NTU, he was on the faculty at Colorado State University (CSU) from 1971. In the ten years before his retirement from CSU in 1994, he held the George T. Abell Endowed Chair in Engineering, Colorado State University's first endowed chair. He was a NATO post-doctoral fellow at the von Karman Institute for Fluid Dynamics in Rhode-Saint-Genese, Belgium. He has been a visiting professor at the University of Kent in Canterbury, England and the California Institute of Technology in Pasadena, California. Dr Johnson also spent a year as a visiting researcher at Shape Data Ltd in Cambridge, England. Dr Johnson served as a member of the International Committee on Engineering Education (ICEE) that advised the Director-General of UNESCO in Paris, France. His research interests over the years have focused on computing environments to assist engineering analysis and design, technology in support of engineering education and embedded control systems.