

A CONCEPT PAPER FOR A VIRTUAL INSTITUTE OF TECHNOLOGY

Submitted to Directors of IITs and Secretary, DOE

by K.R. Srivathsan, IIT Kanpur

September, 1998

ABSTRACT: Besides taking steps to double their students' intake, IITs are studying alternate ways of further increasing the total students' intake. Considering the revolutionary progress in telecom, networking and computers, this paper study outlines the possibility of adopting unconventional methods based on the setting-up of virtual institutions. The Department of Electronics has approached the Directors of the IITs with a request to come up with a plan of action for setting up a countrywide virtual institution for the generation of large number of software and IT professionals at graduate level. In this paper the need, a methodology, capacity and cost estimates of establishing a viable countrywide virtual institution that can be run under the joint governance of all the IITs are presented. Considering the commitment of the IITs' to pedagogical standards and excellence in technology education, and the relevance of the virtual institution as a pioneering effort for similar ventures in other areas, the assumptions, premises, guidelines and architecture of the proposed virtual institution are stated.

I. INTRODUCTION

The Indian Institutes of Technology were set up through an act of parliament in the 1960s as centres of excellence in technology and physical sciences education. They have lived up to their expectation and are now well recognised both in India and abroad for the quality of their graduates at both the undergraduate and postgraduate levels. However, collectively, they are generating a total of less than 4000 graduates/post-graduates per year, a number that at best is comparable to the total of one of the large good universities abroad. Although there are a very large number of Engineering Colleges, number of good graduates coming out of them is possibly at best equal to that of the IITs put together. The majority of the post-graduates in technology come from the IITs. Although there are numerous Engineering Colleges, they often do not have adequate facilities, proper teacher-student ratio or sufficient number of well-qualified teachers. Thus, *although the total number of graduates in the country is large on paper, the number of competent and well trained graduates is of the order of 10,000 per year in all the Engineering disciplines, a number that is too small compared to the demand in our country.*

Almost all IIT graduates, independent of their discipline are proficient in computer programming and usage. *With their sound base in basic sciences, mathematics, and engineering, IIT graduates of any discipline are in increasing demand, in well paid non-engineering sectors such as commerce, management, administration or finance, beside the engineering sector.* Many of them are sought after by foreign universities and multinationals, contributing to the oft-repeated criticism of brain drain. A good percentage of the graduates are also entrepreneurs or self-employed. One hallmark of IIT education is that it enables the graduate to adapt to market or changes in technology or even disciplines and to perform well in the new

field. This is not merely because they get the “cream of the country” as their students. There are many bright students in many colleges as well. The IITs provide an academic ambience wherein student-teacher, teacher-teacher and student-student interactions, or late hours of study in library or computing centre is natural. This ambience and the environment are nurtured and guarded by the faculty and the system. In late 70s, Prof. A. Bhattacharya, former Director of IIT Kanpur and former President of the Institution of Engineers, was said to have remarked that the problem of this brain drain was because IITs produce graduates with the stamp of “export quality”, and if our country is willing to pay the right price and provide them with right opportunities, they would stay in India. Fortunately in the 90s, opportunities and emoluments in India for good engineers has become much better, and this drain is slowing down.

Over the years, the IITs have evolved a sound pedagogic system and have been able to protect themselves, at least in good measure, their autonomy and commitment to standards. Often, bodies such as AICTE have called upon the IITs to develop or advance the syllabi in new or rapidly changing subject areas and set the standards in the area for other colleges. The faculty in the IITs often have take several initiatives on their own and nurture the growth of education in emerging and new areas of science and technology.

Following a government directive, the IITs have set in motion the process of doubling their students’ strength by 2002-4 with respect to their strength as of 1994. However the demand for good engineering and sciences graduates is much higher. Although there are many universities abroad with residential campus with students’ strength of 10,000 or more, under the Indian socio-political climate, it will be unwieldy to have such large students’ population and at the same time maintain the standards at current level. Thus, once the current efforts at doubling the students’ strength is completed in the next few years, it will be difficult expand the IITs any further. On the other hand, it will be very expensive to create new IITs beyond the current six. The per capita cost per student per year is very high for a residential institution and it can not be borne by students or their parents. To a large extent it must be subsidised by the government or society at large.

With the revolutions in Telecom, Satellite Communications, Networking, Internet and Computing, IITs will have to seriously look at alternative structural models which can enable expansion of IIT quality education both geographically and to much larger number of students, at least in basic degree or masters levels, throughout our country. Traditional forms of distance education are weak in motivating students or teachers to perform effectively. One approach to recast distance education with quality of instruction and which can be very effective is to conceive the structure of a virtual institution with remote classrooms in several of our smaller towns. The problem is how to go about setting up such a virtual institution, with countrywide spread of remote classrooms, well managed, with capacity to deliver quality instruction, and the right kind of evaluation and monitoring system that encourages thirst for knowledge and provides hands-on practical experience. This concept paper explores the architecture of such a Virtual Institute of Technology (or VIT in short), under the overall governance of the IITs. The premises on which such a VIT will be based, a strategy of staging its growth and some cost estimates are also given.

In conventional models of Distance Education, central bodies such as IGNOU, or BITS–Pilani run the programme through correspondence courses. Some times this is reinforced by interactive presentations over TV channels. Often, *preparations of video lectures require highly specialised studios and are expensive to produce. It is not teacher friendly.* Internet and WWW based interactions are being added. However, the evaluation system is “distant” and monitoring system to encourage good students or pull up weak ones is almost non-existent.

In the proposed Virtual Institution concept, the academic programme is conducted, much as in a regular institution, with time table and regular classes. A group of institutions co-operatively participate in conducting the classes from their respective sites for different courses, live lectures (play-back if needed) are projected in several classrooms located in various cities and towns across the country and students from respective locations attend the classes. A Teaching Assistant or equivalent is available at lecture hours at each site who will answer students doubts after the lecture broadcast. The lectures are conducted by the best faculty available from sites managed by the best institutions equipped for such purposes. The Virtual Institution can be autonomous and administered by an apex co-operative governing body of academic experts from the group of organising institutions.

IGNOU has an ambitious proposal called INTEND to establish a nation-wide for teachers’ training at school levels and others. However there is no plan for quality “Distance Education” for higher education in Technology. It is not possible to impart quality higher education purely through correspondence, interactive TV lectures and examinations only. Most engineering institutions and teaching shops do not cover foundation concepts in sufficient depth, as most of them do not have good faculty. *Good faculty are not available easily and are attracted to institutions where they have scope for doing research and adequate freedom to evolve their pedagogy and evaluation systems. The goal of establishing a Virtual Institution is to provide quality instruction from the best faculty available and comparable to that for resident students in good institutions such as the IITs.* It should support robust evaluation and monitoring mechanisms to assess students’ progress and maintain academic standards. It should also provide the best possible infrastructure support such as good library, computing and laboratory facilities appropriate for the course contents. All the above objectives are to be realised with minimum cost per student.

Conforming to the above objectives, and considering the emerging IT centric era, this concept paper outlines the structure of a Virtual Institute of Technology that can be organised and administered jointly by the IITs.

II. SYNERGY BETWEEN HIGHER EDUCATION IN IT AND PROPOSED VIRTUAL INSTITUTION

The Indian Government has recognised the need for increasing manifold the number of quality software professionals graduating from good institutions. They are needed to sustain and accelerate the growth of IT in all sectors. The current scenario in the country related to this area is cited below and they all converge to highlight the above-perceived need in the country.

Recent years are witnessing the rapid growth of economic activities related to infrastructure, finance, commercial, social and services sectors, telecom, engineering, and strategic areas such as materials processing or defence. In almost all spheres of economic activity, usage of computers and communications in the form of Information Technology, Networking, Computer Aided Education, Design, Manufacturing, Digital Libraries, transactions processing, etc. have become essential means and infrastructure. ***One may even say that the IT is the paradigm of the emerging era and the fabric of future socio-economic activities.***

There is a rapid growth of software related industries to sustain this need for IT. The growth and assimilation of IT in all fields have resulted in ever growing demand for software professionals and IT friendly users. While there are a large number of institutions providing software education, the training provided is more at the low level of data entry and usage of applied packages. Even these institutions suffer from shortage of quality teachers or trainers.

Until now, India's software industry has grown mostly at the basic levels of data processing, retrospective data conversions, customisation of applied packages for foreign customers, Y2K solutions, software services for foreign customers, use of "body shopping" approaches etc. At the other end of software products level, there is hardly any "made in India" product. While there has been some India made application packages, there is nothing significant marketed internationally. ***It is these higher ends of outsourced software products, capacity to carry out complex system integration and competence to establish, run and maintain software related services for the corporate, services and government sectors which promise large returns and put India on the world map as a global player in IT.*** These activities and their associated marketing of software products, packages and services require highly qualified software professionals and centres of excellence which nurture sensitivity for trends in IT, seizing of opportunities and capacity for global reach with customer support.

To activate India's sleeping potential as a global player, we need to create two environments - (i) generate much larger number of highly qualified software professionals with strong roots in sciences, technology and management disciplines; and (ii) provide a countrywide IT atmosphere by generous access to Internet, wide availability of information and other network services, etc. to homes, colleges, institutions, or organisations at low costs. Indeed, the two can not be separated, as technology can not be developed or innovations sustained in isolation.

The number of persons graduating as quality software professionals are too few and mainly come from the IITs, some colleges, a few university supported MCA programmes and a few other specialised institutions. Some studies by Government estimate that for every \$1 billion increase of turnover in the IT sector, the country needs around 20,000 skilled persons and professionals in the area. As a guesstimate, one may assume that about 10% of them at least, or around 2000 per \$1 bn. turnover, will have to be IT oriented graduates. It is being said that India needs personnel in the IT area in millions. Hence the demand for quality software and IT friendly professionals, including teachers and those combining software background in applied fields is at least an order of magnitude higher than the present capacity available. The

shortage of quality teachers with IT orientation is a major handicap of most institutions. The country needs to do something drastic to change the approach to training graduates and make available instructions from good teachers and professionals to all those who register for the studies.

It is also important that professionals - graduating or already employed - in almost all fields get opportunity to reorient themselves through access to quality training – through self study or sponsorship - to become proficient with the usage of relevant IT tools needed in their profession. ***The government's new IT policy's emphasis on increasing both the quality and number of graduates turned out every year reflects the above needs.*** Much of the present higher education system in the universities and colleges lack purpose and direction consonant with excellence or relevance to national requirements. With the result, a larger number of students remain underemployed when compared to the degree they hold, while the demand for employment in emerging sectors such as IT is fast outpacing the supply. ***In achieving this objective of increasing the supply of quality graduates through existing and new institutional structures, one should be able to use the means of IT themselves to bootstrap from the present system and evolve the appropriate future edifice of higher education through a process of metamorphosis.***

The establishment of remote classrooms under a virtual institution requires extensive state-of-art multimedia network facilities. The VIT itself will be a major user of IT applications. There is a severe acute shortage of faculty in subjects related to IT. The practical training in the area requires extensive usage of computing and networking facilities, which will form a natural part of the VIT. ***Thus, under the VIT, graduate programmes in subjects under IT will benefit immensely from the synergy between its infrastructure that includes IT professionals, computing facilities and network services, and its academic programme.*** The VIT can serve as a model for similar institutions and academic programmes in other technology and sciences areas. All its graduates will benefit from the strong IT content and culture provided by the ambience of the VIT. While Computer Science and Engineering will form a natural part of its programme, several other subjects – theoretical and those with strong IT content such as CAD, CAE, CAM, MIS, etc. - in various disciplines can be offered as core or elective courses by faculty from many departments of IITs. Thus the best strategy to launch the VIT is to offer degree programmes, supplementary certificate/PG-diploma courses or continuing education in the IT related areas, and expand the scope in future years to cover other sciences and technology disciplines.

III. NEED FOR VIRTUAL INSTITUTION FOR HIGHER EDUCATION IN IT

The rapid growth and ever rising demand for professionals for the IT and other industries are not being met by the total turn over of graduates relevant to the area by all the IITs, Engineering Colleges or the MCA programmes of various universities and institutions. As a reaction, a large number of private organisations (some good and many poor) offering software training or education have cropped up. Several of them DOE 'O' level or sometimes 'A' level certification courses to cater to the jobs available at the low entry level in the software industry. Most of these institutions suffer from lack of good teachers or faculty resulting in poor quality of instruction or training offered to the candidates.

The demand for quality software professionals is partially being met by the industry through recruitment of engineering graduates from any branch and giving them in-house training and orientation. Recently, IITs are being started with some concern for proper quality and higher levels of training to meet the urgent needs of the software industry. It is not clear however, how good faculty can become available to these institutions or how they can be better than “teaching shops”. Some of them are trying to make up this shortfall by requesting the IT companies to conduct courses relevant for their products. Several hi-tech software and engineering industries require large number of IT persons at graduate or post-graduate levels for project management, development, planning marketing, etc. Several of the certificates type training institution provide essentially operational and usage-training of popular packages.

The distance education of the kind that exists today have a central command (e.g. IGNOU, BITS - Pilani, or some proposed under NIIT, etc.) with or without franchised centres. Most of them offer correspondence courses and candidates subscribing to them get the necessary certificates/degrees after passing some tests/examinations. In case of software education, organisations such as Aptech, NIIT, etc. offer some practical training in franchised centres equipped with computing facilities. The major lacunae in this training are: (i) non-availability of good faculty, (ii) inadequate interaction between students and the teachers, thereby resulting in inadequate motivation, (iii) mostly skills oriented training that does not cover fundamentals related to the underlying science and engineering principles, and (iv) little academic ambience of the kind seen in good colleges and schools that encourages self study and learning. It is a serious problem that most of these institutions lack adequate infrastructure such as library, quality computing facilities or laboratories.

In a nutshell, there are three major problems that seriously hinder the generation of quality manpower at appropriate levels of training. Firstly, the number of graduates from existing good institutions is too inadequate for current and projected demands. Secondly, most of the private institutions or even MCA programmes in various colleges and universities do not have the right faculty to maintain some standard in their education and training. Lastly, it takes several years and high levels of expenditure, if not decades, to initiate conventional type quality institutions.

In summary, neither the present college type educational system nor the loosely governed form of distance education or franchised training centres can generate quality graduates in sufficient numbers. ***To overcome the above problems, reduce gestation period for launching quality institutions and meet the growing demand for well trained manpower in the IT area, one will have to look for unconventional models. The approach should leverage both on the strengths of existing institutions and the unexploited potential in the application of state-of-art Networking and IT as a basis of future virtual institutions.*** The proposed VIT concept is likely to be a cost-effective approach in line with the trends and applications of IT to generate quality graduates in thousands every year.

The following sections of this paper present a vision and outline the architecture of a VIT involving a collaborative effort of all IITs using network centric architecture to support remote classrooms, library and other forms of multimedia

communications. The proposed VIT is expected to generate graduates of several thousands per year. It has the potential to maintain standards and turn out quality graduates. It can also admit several hundred engineering graduates and train them under a one-year PG diploma or other programs in IT to meet the immediate manpower needs of the IT sector. The VIT has the potential to grow into a full-fledged virtual university of technology in future and cover diverse engineering and applied science disciplines.

IV. STRENGTHS AND CAPACITY OF IITs TO RUN A VIT

Quality faculty, academic programme management and administration, commitment to a broad vision and values at all levels in the organisation, reliable and trust-worthy monitoring and evaluation mechanisms, excellence in pedagogy, proper teacher - student interaction, capacity to act constructively on feedback from students, faculty and staff, flexibility to evolve with technology trends and industrial needs, good library, laboratory and computational resources to all concerned and a rich academic ambience that encourages self-study and learning, nurturing of initiative and new ideas are some of the essential attributes of a successful academic organisation - be it an institution or a university. In these respects, to a good extent on the technology front at least, the IITs have collectively withstood the test of time and shown a resilience commensurate with the objectives originally envisaged by the act of Parliament which resulted in their creation as centres of excellence in technology and science education.

The IITs have also shown a capacity with unique co-operative leadership to collectively operate, administer and conduct national level JEE or GATE operations. They have strong articulate autonomous academic senates and other bodies, which protect and nurture the academic and research programmes and the freedom of the faculty to take new initiatives. ***They continue to attract highly qualified faculties in Engineering, physical sciences and some humanities departments.*** This is because, besides the academic programme, the faculty in the IITs are able to work in research projects, as advisors or members in various national and international bodies or undertake hi-tech Consultancy work. The IITs attract good PG students and this is a major incentive for the retention of good faculty. Given the right kind of infrastructure and funds, it is well within their capacity to establish, nurture and jointly manage a Virtual University of Technology and sustain their standards of pedagogy and training across small towns and remote places both within the country and the neighbourhood. ***In fact, as of today, there possibly exist no group of institutions other than the IITs in our country which can bring about a collective effort and organisation to pioneer the establishment of a virtual institution of the kind proposed.***

The best way to attract and retain highly qualified faculty to organise and conduct the academic programme of the proposed VIT, is to recruit them as IIT faculty. The IITs can lend the services of some of its faculty as part or full teaching load to conduct on-going courses under the VIT. In effect, the IITs will collectively own and operate the VIT as an autonomous organisation under the overall umbrella of the IIT Council under the purview of MHRD.

V. THE PREMISES OF A VIRTUAL INSTITUTE OF TECHNOLOGY BY IITs

India has been saddled with educational systems of the mass examination and certification type. There is little emphasis on encouraging true scholarship and proper values or equip them to apply the same in real life. Considering the present state of affairs, the metamorphosis in higher education calls for new approaches to combine quality of instruction and education with quantity of graduates being trained. The delivery mechanism must encourage students taking initiatives in applying what they learn and understanding the relevance of the subject to the socio-economic, technology needs or trade and commerce related contextual settings. The proposed virtual institution, if started with the right premises, proper vision and commitment, provides a unique opportunity for new leadership and relevant initiative for imparting education with commitments to excellence combined with relevance.

Every institution, be it academic or otherwise requires a long-term vision - one that is shared by all those governing its organisation. This vision acts as a guiding principle, helps those governing it to focus effectively and decisively act on issues of relevance to maintaining that vision. The VIT poses a unique opportunity and a major challenge for the IITs. Hence, there is a strong need to have a distinct vision accepted by all concerned consonant with its objectives. Some points relevant to this are outlined in this section.

As suggested already, the VIT will be a futuristic network centred virtual institution with all the IITs acting as organising centres and classrooms distributed at a large number of centres countrywide. In one sentence, its vision may be summarised as follows: ***The VIT will strive to maintain the best possible academic environment, the highest standards of pedagogy, support a flexible multidisciplinary curricula with strong foundations in science, engineering, management principles and values and turn out graduates of excellence.*** Today, graduates of excellence need to be sensitive to social and national needs while being competitive as well and hence they must keep the relevance of their employment as a major concern. While this vision can be said to be the hallmark of any good institution, its realisation depends on the commitment to the vision coupled with a working atmosphere, wherein good teachers, instructors and staff can enthusiastically participate, innovate and participate in the promotion of the institution. Needless to say that the vision and the commitment to it are the guiding principles for the structure and management of any organisation.

Combining the above vision and the attempt to create a network centric architecture and collective governance by all the IITs, several features of the VIT can be broadly stated. One other premise is that the VIT will leverage on the strength of the faculty and senior research staff of all IITs, co-opt competent qualified persons from other establishments on need basis and directly employ minimal number of engineers and support staff for its upkeep. ***The guiding principle is that if there is opportunity and appreciation for innovation and excellence of the work being done by all concerned and the society at large, the VIT can become an institution of excellence in its own right.*** There is a price for everything and it is expected that the VIT will be an institution with a distributed architecture, government with quality of instruction and training will not be that low cost. However, the cost per graduate is expected to be much lower than the current residential campus type institution.

As a by-product, it is expected that the countrywide network and IT infrastructure that will be part of the VIT will also provide support for IT services to other engineering and sciences institutions. This network can be a vehicle for digital library services, teachers training, new syllabi induction and curricula upgradation for these institutions. Here again is a synergy between VIT and the IT needs of existing institutions. By themselves, most institutions are very poor users of IT because they do not have the quality IT staff for its upkeep. Part of the network resources and the IT staff of the VIT can also support the IT needs of the institutions who host the remote classrooms.

VI. OUTLINES OF THE PROPOSED VIRTUAL INSTITUTE OF TECHNOLOGY

In arriving at the structural and governing outlines of the VIT, certain assumptions are being made. One is that a strong reliable and well-managed satellite based network will link all the organising IITs and the remote classrooms at participating colleges or centres. The network should support Digital TV broadcast, Data broadcast, VSAT and wherever possible broadband terrestrial connections (such as nation-wide ATM network) with sufficient capacity. The network will have strong Internet Gateways. Considering that barring television network, almost all other public networks are unreliable, this indeed calls for an efficient infrastructure management system and commitment on the part of communication capacity providers. However this challenge can and must be accepted by the IITs through implementation of a well-conceived management strategy for IT infrastructure maintenance and its operations. Some suggestions on the issue of network management and maintenance are given in a later section. It is also assumed that the remote classrooms in the various cities and towns will be set up in colleges or centres where good local teachers and support persons are available for additional part-time employment in the VIT.

Based on the above assumptions, the following points outline the structural and functional features of the proposed VIT.

- (i) The VIT will be an autonomous institution having a deemed university status. It will be administered and managed collectively by the six IITs through suitable constitution and statutes. It will be along lines similar to the jointly co-ordinated administrative mechanisms as in JEE or GATE operations.
- (ii) Each IIT will host an organising centre (OC) of the VIT. The dedicated facilities at each OC will include a VIT centre with some classrooms, satellite uplinking for Digital TV, data broadcast and VSAT, Internet Gateway and networking facilities. The VIT centre will include classrooms well equipped with video cameras, multimedia recording and projection facilities, office, computing, multimedia authoring and electronic library facilities.
- (iii) There will be dedicated remote VIT sites in several cities and towns distributed evenly across the country, preferably located in existing good colleges or centres where local faculty or technical staff are available and who can be co-opted to administer and manage the remote sites. Each such VIT site will have networked classrooms equipped with multimedia projection, etc. These sites will be called participating centres (PC). Each IIT will also host one PC besides taking the responsibilities of an OC.

- (iv) Each IIT will manage the infrastructure and programme of, say, 6 or 7 PCs in their respective geographical neighbourhood under the overall supervision of the co-ordinating institution.
- (v) The VIT will have its own governing council and a functional academic senate to monitor and approve issues of academic concern and approve structural changes.
- (vi) The VIT will be managed at each IIT by a small group of full-time members, referred hereafter as the Operations Council. The Operations Council members will be mostly from the IIT faculty. A Chairperson will head the Council. The members of the council and its Chairperson will be selected from time to time by the Directors of the respective IITs using appropriate guidelines. The duration of each member selected may be not more than two years. The Chairpersons and members of the Operations Council in all the OCs combined will govern the VIT operations and programme management tasks.
- (vii) Together, the members of the operations council from all the IITs and some additional nominees will constitute the academic senate of the VIT. As an apex body, a Governing Council will be set up similar to the BOG. Necessary other formal positions needed to meet the norms of a deemed university will be kept to minimum.
- (viii) The VIT will have a Programme Development & Services Centre (PDSC) at each of the IITs. Its functions will be several. Typically, its role will include, but not restricted to, maintenance and operation of multimedia authoring and distribution facility, electronic library and network services and maintenance. Its authoring and library services can be used by the IITs to generate course materials, package relevant referential materials, etc. It will be manned by highly qualified and well paid engineers, technical and support staff. The PDSC and associated facilities will be part of the OCs.
- (ix) At each PC, engineers stationed locally will maintain the infrastructure. A faculty advisor will be hired from the local centre or college on deputation terms if necessary. All of them will be associate employees of the PDSC of the OC in the IIT the PC is associated with.
- (x) The PDSC engineers should be provided with liberal perks such as hiring a car or taking a flight for site visits, allowances for special expenditures and authority for purchasing or quick transport of necessary materials needed for servicing the sites. The aim is to have no bottlenecks in getting needed things done to keep infrastructure downtime to minimum.
- (xi) It is suggested that of the Operations Council members, at least one or two persons are selected from the senior Engineers of the PDSC and who oversee the management and maintenance of the technology infrastructure. The Engineer-member may even be a standing member of the Council for a longer period than other faculty members.
- (xii) As in the case of JEE or GATE operations, each IIT will be the co-ordinating institution of the VIT by rotation on annual basis. This will help divide the responsibilities of planning for the next year (entrusted to the next-year

co-ordinating institute) and the administration of the on-going academic year (by the current co-ordinating institute) between two IITs.

- (xiii) The VIT will own and operate a satellite based hybrid network that consists of Digital TV and Data broadcasting with uplinks from all the OCs of the six IITs and a state-of-art VSAT with at least one IIT maintaining the VSAT hub services. The VSAT hub will include a strong Internet access link for Internet services to the VIT.
- (xiv) Each college or centre hosting a PC will have small earth station for Digital TV/ Data broadcast reception and VSAT link with the OCs. The PCs will have classrooms equipped with multimedia projection, some video conferencing with the OCs, a network access facility with strong servers, fair number of workstations for students' use and electronic library services.
- (xv) There will be a Memorandum of Association/Understanding and suitable financial agreement between the VIT and each PC to support the hosting, operations and cost of programme running. The host college or centre of the PC should have attractive incentives in both kind and cash forms. One is the rental and services charge for the PC. Second is to share the network gateway physical infrastructure for the host's Internet links. Third is to make available the expertise of the well trained PC site engineers to help maintain its IT services. The host PC may be encouraged to act as local ISP under ERNET Society to service local educational and R&D institutions. The hosting of the PC should bring prestige and publicity for the host institution.
- (xvi) The computing and network resources at each PC will be sufficiently large. First, they form the computing services for the students of the VIT. Secondly, they should have capacity to keep on-line lectures of the previous few days recorded in compressed form so that students can replay the same. To reduce communications load, they should have capacity for digital libraries needed for all the courses. In case of communication outages at any site, it should be able to download lectures from the concerned OC and play the lectures at a make-up class. The facility should have sufficient software packages needed for the students. The facilities should be open for at least two full shifts to enable computing services, submission of homework or interaction with course co-ordination team members through email, etc. by students. A Video conferencing facility with a few terminals will facilitate interaction with the OCs.
- (xvii) The VIT network will need at least one full satellite transponder (or two) reserved for the hybrid network. A single transponder is likely to support at least three digital TV channels and a good capacity VSAT. This capacity can be booked in the same satellite as that of the ERNET Society. This will help sharing the same ground segment infrastructure across all institutions and bring the experience and expertise of ERNET for network maintenance. More capacity may be added as the demand and course variety increase.
- (xviii) The ground segment infrastructure and the associated engineers involved in its maintenance at each of the PCs can be shared by the concerned host college for its Internet, e-mail and digital library services. However, its network services will be

routed via separate transponder capacity governed by an agency such as the ERNET Society.

- (xix) Classes will be conducted from the different OCs in the IITs and registered students at all PCs will attend them at the same time. Those who miss the lecture for any reason will be supported by local digital playback facility at each PC.
- (xx) For each course, local teaching assistants will be hired part time from the local host or from the neighbourhood.
- (xxi) IITs will design and implement an appropriate evaluation and monitoring system for the VITs which will ensure that good students are encouraged to explore on their own, weak students are identified and motivated to do better and instructors have a good feel of the pulse of the various centres so that they can correct problems of centres lagging behind.

The issues relating to the academic programme, size of the VIT, costs of infrastructure, budget estimates under non-recurring and recurring heads and how much of it can come from students' fees are presented next.

VII. THE ACADEMIC PROGRAMME OF THE VIT

There are many private and other ventures in running skills oriented training at DOE 'O', 'A' or 'B' levels equivalent certificates educational programmes. There are also NIIT type institutions being created. IT is a broad area and denotes more the paradigm in which most works, transactions, design and development, etc. will be conducted. The establishment and running of IT itself will be a major industry. Considering the strengths of IIT faculty and the need to protect the focus of IITs as leaders in education and research on technology and physical sciences related foundations and applications, the best option is to begin degree programmes in IT.

Two programmes can be started from the beginning. First, to get an early start, the VIT can start a one-year PG diploma programme on IT for graduates in engineering from the numerous engineering colleges. This will provide the industry the much needed manpower in the IT sector. Second is to offer 4-year degree undergraduate programmes with strong foundation in physical, engineering sciences and IT with electives /specialisation in several applied disciplines in the following areas. These can be typically CSE, Information and transaction systems, CAE, CAD/CAM, Communications and Networking, Microelectronics and VLSI design, Management, QC, Production and Reliability Engineering, Numerical Analysis, etc. IITs can work out the exact course structure and specialisation streams. The course structure is expected to be similar to the semester courses in the IITs – 40 lectures per semester, tutorials, and flexible evaluation system broadly conforming to some minimal requirements. The VIT management will have built in mechanisms to introduce new courses/ programs, update the syllabi of existing courses, and recommend the elective stream courses structure.

There is one major constraint and it is that of how many classes can be conducted over the sky. With one transponder, and requirement for VSAT capacity, it is estimated that 3 Digital TV broadcast channels will be available. This provides for

Three parallel lectures at any given time. Lecture duration is taken to be 1 hour and a gap of 30 mts. will be provided between lectures for synchronisation and interaction of local TAs with the class students. In non-lecture hours, the capacity will be available for data broadcasts. Data broadcasts will be used to support digital multimedia library services.

Over a 9 hour period, $6 \times 3 = 18$ lectures can be beamed. This provides for 90 lecture hours per 5-day week. A 4-year program will need 20 courses, a PGD programme about 4 courses. Three lectures per week per course, and plus problem solving tutorials will just about cover the available 90 slots in a week with few slots to spare. The spare slots, late hours or Saturdays can be utilised for special lectures and seminars. Other times of the day and holidays can be used by students for e-library study and use of computing facilities for homework.

Since a given course can have up to 4000 registered students, some careful planning of the evaluation and monitoring system is necessary. The monitoring should also enable spotting of weak students and counsel them. This is best done by experts from the IITs appointed for the purpose.

While computerised objective type papers can be used as feedback for monitoring student's understanding, they are not the best methods to evaluate their capacity for many analysis, design and synthesis type of problems or originality of approach. Good teachers often look for such strengths in the student. So. Well designed problem solving type examinations are essential. If we indeed look for IIT quality education, course instructors should have sufficient space for innovation in evaluation and judgement. The IIT system can spot outstanding students in their degree programs.

Some outlines of the evaluation mechanisms can be given here. Each IIT is responsible for 7 PCs and the students under them will be not more than 800 per course. To keep the evaluation system as close to IITs style as possible, for each course, we can have grading assistants (GA) from the faculty, Ph.D. scholars or other full time scientists or engineers in the IITs. About 8 GAs per IIT per course are likely to be needed. Together with the Instructors, each can grade about 100 answer books in a week's time. At least one of the GA in each IIT will be a faculty and he will act as the co-ordinator answerable to the chief instructor of the course.

Once established and running, the VIT can take up other engineering programmes with emphasis on IT training as a core component. If each IIT builds a transit hostel, students from the PCs can visit the associated IIT and undergo practical training programmes in the IIT laboratories during the spare hours. This paper leaves it to the IITs to study the methodology, costing and implementation of these engineering programmes.

VIII. BUDGET ESTIMATES FOR THE VIT

The estimates of various components of capital expenditures for establishing the VIT are given based on the following assumptions. All students of the VIT are strictly non-residential. Each OC or PC will have separate building isolated from the rest by a boundary wall and access gate within the existing campuses. This is needed

partly for their security and partly to insulate them and their operations from the problems the hosting college or surroundings may have. Every OC in the IITs will have the following infrastructure.

About 2000 Sq. meters of built up and furnished space to house 3 classrooms of 100 students capacity each, two computing laboratories with about 100 PCs, a servers room, a multimedia authoring, editing and development facility, a service room, an office, a meeting/conference room and office space for 10 persons. Besides these, space will also be needed outdoors for AC plant, parking, generator/UPS area, an annexe for students gathering in non-class hours and some green space. Total land area required is about 3 acres.

Cost of civil works	-	Rs. 400 Lakh*
Cost of AC plant, UPS, Generator, etc.	-	Rs. 30 Lakh
Computing and network facilities	-	Rs. 60 Lakh
Multimedia classrooms and editing facilities	-	Rs. 40 Lakh
Ground station, satellite uplinking facility	-	Rs. 300 Lakh
Other infrastructure	-	<u>Rs. 20 Lakh</u>
Total	-	Rs. 850 Lakh

* Remark: The civil works include furnishing, boundary wall, parking lot, approach road, annexe space, cafeteria and some green space. In comparison, it may be noted that the cost of building one students' hostel in an IIT is not less than Rs. 500 Lakh.

Total capital cost for the six OCs is Rs. 51.00 Crores. In addition, each IIT will be given a plan grant of Rs. 1 Crore every year to maintain and upgrade the VIT related infrastructure.

The above cost includes the establishment of the six PCs located in the IITs. For the PCs in locations other than the IITs, the cost estimates are as follows. The floor area required is estimated at 1600 Sq. meters. The structure is expected to be similar to that for the OCs. The land area required is 2.5 acres.

Cost of Civil works including annexe	-	Rs. 330 Lakh
Cost of AC plant, UPS, Generator, etc.	-	Rs. 30 Lakh
Computing and network facilities	-	Rs. 60 Lakh
Ground station, VSAT and related facilities	-	Rs. 30 Lakh
Multimedia classrooms and related facilities	-	Rs. 30 Lakh
Other infrastructure	-	<u>Rs. 20 Lakh</u>
Total	-	Rs. 500 Lakh

For 36 such sites (other than the IITs), the total capital cost is Rs. 180 Crores. Thus, for a total capital cost of Rs. 231 Crores, the VIT can support about 4000 students per year, or a total of 16,000 students in a 4-year programme. It may be noted that this total capital cost is possibly about the same as that for establishing a new IIT.

The recurring costs can be estimated into the two following major groups. First is the establishment maintenance cost. This consists of civil maintenance, electricity, water, PCs and equipment maintenance, communications overhead, etc. Second is the cost of running the academic programme. This consists of salaries /honoraria of people

employed or deputed, software, books, programme development, stationery, transport, etc. Annual recurring cost of the establishment has the following components.

Civil maintenance	-	Rs. 20 Lakh
Electricity, water, Diesel, etc.	-	Rs. 5 Lakh
Computers and equipment maintenance	-	Rs. 10 Lakh
Transport, contingency	-	Rs. 10 Lakh
Charges paid to host institution	-	Rs. 5 Lakh
Transponder rental, communications	-	<u>Rs. 10 to 30 Lakh*</u>
Total	-	Rs. 60 to 80 Lakh*

- Remark: The cost of communications reduces as the number of remote sites increase. If the VIT establishment is staged in phases, say with 12 PCs initially to 40 PCs in a few years, the fixed cost of satellite transponder rental at. 300 Lakh / year is more in the initial few years.
- As stated earlier, each IIT will be provided an additional annual plan grant of Rs. 1 Crore per year to upgrade the infrastructure in the OCs and PCs under its umbrella.

Thus, establishment costs total Rs. 9.60 Crore /year initially for 12 nodes to about Rs. 25 Crore/year when the VIT is fully established with 40 PCs. The academic programme costs can be arrived at as follows. First, the total full-time engineering staff for the services is expected to be 4 per OC and 2 per PC. Full time support staff are expected to be twice the number of engineering staff. Together with one Manager-cum-Secretary per OC and miscellaneous requirements, full time staff total is approximately 300 across the 40 sites. The total salary for full time staff is taken to be Rs. 7 Crore per year (at an average of Rs. 2 Lakh plus per person per year including benefits). In addition, part time students can be employed at all the sites for late-hours operations of the computing facilities.

Associated faculty required for the academic programme (at average of 2 faculty per course and maximum of 25 courses in a semester for 4-year degree programs) totals to about 50 at a given time. The cost per semester long course may be estimated as follows. Every course has two chief instructors from one of the IITs and one grading co-ordinator from each of the other IITs. Each IIT will typically have 7 other grading assistants for evaluation and monitoring. Each PC will have one teaching assistant associated with a course. This requires a total of around 80 persons associated to conduct a course. Of the 80, 50% directly interact with the students at the sites and the rest do the grading, evaluation and monitoring from the IITs. This will involve honoraria or payments for work of about Rs. 5.00 lakh + contingencies to the tune of Rs. 2 lakh per course in a semester. A total of 50 courses per year is expected to be conducted. These total to Rs. 3.50 Crore per year, a sum that is small in proportion to other recurring heads. At its full capacity, the VIT is expected to cater to a total of 16,000 students in all the 4 years. An additional 4000 students can be enrolled in PG level programmes if capacity can be augmented.

The expenditures for the electronic library, books, lecture notes, software and other contingencies are estimated at around Rs. 50 Lakh per year. Thus, total recurring costs estimate come to less than Rs. 40 Crore per year.

IX. THE PHASED ESTABLISHMENT OF THE VIT

A typical milestones chart for the VIT may look as follows. The major requirement is a full satellite transponder. It is expected that INSAT-3B will be dedicated for educational purpose. While it is sometime away, one can carry out system integration and trials of the VIT network infrastructure with the experimental transponder payload of the first GSAT of ISRO or use the simulcast facilities under Doordarshan. It is assumed that at least one dedicated transponder will be available within 6 months of application by the VIT. Year-wise the progress chart may be along the following lines.

- 1998-99: Discussions, modifications and approval of the proposal. Establishment of a trial network test bed at one of the IITs for the Hybrid network of Digital TV, Data Broadcast and VSAT; system integration trials and recommendations on services management.
- 1999-2000: Approval of the proposal. Funds released for establishment of the first 12 sites including the 6 OCs; Building plan approval and construction of buildings and erection of earth-stations. MOUs with PC host institutions. Approval of VIT constitution and statutes. Nomination of VIT Governing Council and Operations Council.
- 2000-01: Hiring of staff for the VIT's 12 sites. Classes begin in the first 12 sites. First year admissions include PG Diploma program in IT. Approval for expansion to the remaining 30 sites.
- 2001-04: Expansion at the rate of 10 new sites per year.
- 2005-ff: VIT operations to work at full targeted capacity.

The funds will be released so that the growth plan as above can be met. It is necessary that suitable guarantees of satellite capacity provision be given. In case additional capacity is needed to cope with the expansion plans or technical hurdles, it should be made available at the earliest.

X. COST ADVANTAGES AND STUDENTS' FEES OF THE VIT

The total recurring cost of between Rs. 35 and 40 Crore per year is comparable to that for running one IIT. Since the number of students is about 4 times as large, the recurring cost per student is that much less. Under full capacity, the recurring cost works out to less than Rs. 25,000 per student per year under full capacity. In the initial stage of its establishment, the VIT can expect to recover 50% of its recurring expenditures through fees alone. Under full strength, recurring cost can be recovered in full.

Considering that education is a national obligation for future generations and a large number of students from the economically weaker sections may find the fees a little too high, it is recommended that the VIT be allowed to raise endowments from industry, or public donations with tax incentives, matching grants from the government with liberal provisions for scholarships and interest free loans. With interests from endowment building up over time, more scholarships can be offered or the proportion of fees to the recurring costs can be reduced.

XI. OPPORTUNITIES & CHALLENGES

About half the capital infrastructure is IT specific. It encourages the penetration and application of IT in education. This is a much-needed investment in our country. It lays the foundation for India for its IT oriented future. Experience in the proposed VIT operations and management will lead, over time, to establish similar institutions in other disciplines such as agriculture, medicine and health care, continuing education and other sectors. Industries may also be encouraged to provide attractive packages for purchase of home PCs to students and establish service centres in the concerned towns for their maintenance at concessional rates.

The proposed VIT attempts not merely an increase in capacity of students' intake or quality of education. The VIT takes the classrooms to interior cities and towns – 40 of them in one stroke almost – places where from good students need not migrate to big cities in search of quality education. The capacity of the VIT will equal that of the combined intake of all the existing IITs at a cost equivalent of one IIT today.

Since all the students are non-residential, there is a lot less establishment cost and problem when compared to residential campuses. Almost all the students will be coming to their respective VIT centre from home. This costs a lot less to the parents. Many of them will be from smaller towns where the transportation bottlenecks are hopefully less than those in the metropolises.

The presence of a VIT offers opportunities to introduce several IT services as by-products for other institutions in the city. The ground segment infrastructure can be shared and managed on behalf of ERNET Society. An ISP can be co-located and Engineers from ERNET Society can manage it on behalf of other higher academic institutions in the city. The VIT can be used for conducting teachers training and other continuing education programmes. However, these are not the primary role and can be accommodated on the basis of surplus resources available. Norms for conducting any such additional programmes or services should have the approval of the VIT Board.

A major challenge to the IITs is to come up with proper students' evaluation and monitoring system. While implementing an evaluation system, its purpose should not be lost. Unlike the IITs residential classes, the instructor and his team of teaching assistants and grading assistants face very large classes. The chief instructor should have the flexibility to come up with suitable schemes depending on the nature of the course. Problems can be distributed in advance over the net, students asked to solve selected problems and submit solutions over the net. These can be quickly analysed and reported to monitor the progress of each student.

Due to large numbers, some classification of students in different categories is essential. Feedback to students with help to improve their performance should be provided. Methods to spotting of bright students, weak ones and indifferent ones who do not attend classes regularly should be developed and implemented. Students should be encouraged to ask questions over the net to instructors and be responded to. Additional reference materials, importance and purpose of the content of each lecture be given ahead in electronic form. Help to local TAs with supplementary materials for answering students' doubts be available. Many such issues need to be discussed, analysed and implemented in functional form.

Considering such complex issues requires very responsive collective team effort of all faculty from the IITs who are associated with the course. It is recommended that while one IIT is co-ordinating the current year, the IIT that is to take up the co-ordination in the following year also co-ordinates advance planning, progress analysis of on-going programme, recommend and implement suitable changes in content, delivery, evaluation and monitoring mechanisms. It is expected that extensive deliberations by faculty of all IITs will lead to appropriate solutions. Some of these deliberations should be ongoing and some should precede and be reflected in the drafting of the VIT constitution and statutes, so that, the VIT is assured of a future where good faculty feel invited to experiment with pedagogy within limits, attractive monetary incentives be provided for all concerned to participate enthusiastically and thereby maintain the quality of graduates generated.

ACKNOWLEDGEMENTS: This report is the outcome of the decision on the part of the Directors of all IITs and the Secretary DOE to seriously consider establishing a virtual institution. The author has a large number of persons to thank for providing the motivation and thrust to complete this report. Specifically, he wishes to thank Dr. Vijay Gupta, Ms. Sandhya V. Sule of IIT Kanpur and Mr. S. Ramakrishnan, DOE for various discussions. It was Prof. R.C. Malhotra who more than a year ago kept expressing the need for IIT to operate distance education programmes and requesting the author and Dr. Vijay Gupta to come up with a working paper. The author has also enjoyed many discussions on pedagogical issues, educational paradigms and institutional constraints with Prof. V.P. Sinha and Prof. S.S. Prabhu. Both the authors are grateful to the ERNET Project, and its team of faculty and engineers in various IITs and IISc. The learning and management experiences of the ERNET Project have taught the strengths and weaknesses, in particular to those relating to network and services management. It would be difficult to have the faith and the confidence of achieving such a complex network and services architecture, as the VIT will need but for our firm conviction that it can be done.

PURPOSE: This document is being submitted to the Directors of all IITs and the Planning Commission through the Secretary, Dept. of Electronics for further elucidation and approval for funding.

Submitted by:

(K.R. Srivathsan)
Professor, I.I.T. Kanpur