Chapter 1

INTRODUCTION, PROBLEM STATEMENT AND METHODOLOGY

1.1 INTRODUCTION

This dissertation discusses various aspects of technology based training (T.B.T.) systems and describes the development of an RF bandwidth switch, that performs the functional characteristics of T.B.T. systems, without reliance upon personal computer technology.

Advances in computer technology such as faster processors and better data compression schemes have made it possible to integrate audio and video data into the computing environment. An alternative type of lecture material, namely desktop multi-media, has become possible. Unlike conventional media centres, which requires specially equipped rooms with expensive media, desktop multi-media may be obtained by adding software and hardware to standard desktop computers.

One benefit of desktop multi-media is the convenience of not having to physically move to a special location. Another benefit is the ability to incorporate data from other desktop computer applications into the lecture delivery. Desktop multi-media systems should cost only a few thousand rand to set up, which is significantly less expensive than room media centres which typically cost a minimum of R100000 to set up [1].

The information technology explosion renders an enormous amount of multi-media, available on several media formats such as CD-ROM and magnetic tape. The bandwidth required for transmission remains, however, in direct proportions to media capabilities achieved.

Computer aided instruction and PC driven T.B.T. systems appear to offer instantaneous solutions to our educational problems. However, computers cannot be effectively used for lecture delivery in South Africa, because of embedded social and cultural disadvantages.

The problem of delivering media to students is firstly complicated by the fact that the majority of students in South Africa are not computer literate, and may remain so for the near future. The second complication is one of language. Educational software in English cannot be effectively applied in a culture of ethnic diversity with eleven spoken languages.

It is believed that the many people in South Africa that are not regarded as computer literate, may indeed be at ease with other forms of media technology, such as the radio frequency (RF) format of television and video equipment. This belief suggests that an alternative approach may be, to attempt to obtain the functional characteristics of T.B.T. systems, utilising such existing technology that people are familiar with.

For the interim, the PC should merely be regarded as a multimedia input device. This will allow the system to be used by people that are not computer literate, although the system will allow computer literacy training. The system should furthermore be dynamically designed, so that it may be adapted to computer control with minimum effort, if so required at a later stage when computer literacy prevails.

1.2 PROBLEM STATEMENT

1.2.1 The application requirement

A requirement for a technology based training system was identified at the South African Weather Bureau's Irene Weather Station. The experiential training class was proposed as a suitable group to use for learning system experiments based upon T.B.T. principles. Students in this class work in teams to conceive, design, develop, implement and maintain laboratory grade meteorological instruments and systems.

An important part of this class is the periodical seminars given by speakers on combined meteorological issues. Normally these seminars are held in an auditorium, but problems are experienced when practical demonstrations are required which involve scientific instruments.

Such demonstrations require that the number of students attending be limited and to attend as smaller teams rather than as a group, due to limitations imposed by geographical distribution of facilities, as seen in Figure 1.1.

A second aspect to keep into account when considering a T.B.T. solution at Irene, is the occurrence of localised radio frequency interference caused mainly by the HF transmitting station (1). The station operates four 10-kW single sideband transmitters, with the main building situated within a few wavelengths from the transmitting antennae.

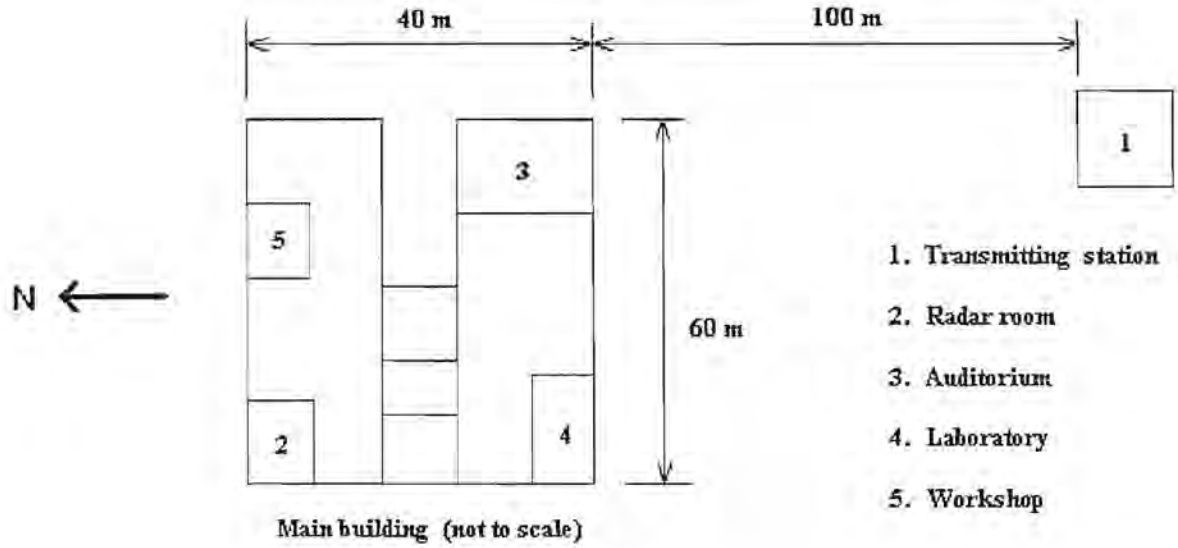

Figure 1.1. Geographical distribution of facilities at Irene weather station.

Additional sources of radio frequency interference are the various microwave systems at Irene such as the upper air balloon tracking equipment, as well as an Enterprize DWR93 meteorological radar (2). Interference is acutely observed on the southern side of the main building, including within the vicinity of the auditorium (3) and the development laboratory (4). Any electronic system required to operate within these vicinities require additional attention during construction to minimise the effects of external interference.

Also, with electronic systems proposed to be utilised at the Weather Bureau's premises, the interference radiation should be kept to a minimum and should not cause any interference with systems currently in use. All new RF products are tested rigorously to ensure conformance and compatibility.

Preliminary tests were conducted with several different brands of audiovisual equipment such as television receivers, video cassette recorders and compact disc players. Only a small percentage of the equipment that was tested did not noticeably display effects of interference, notably the higher priced examples.

The effects of interference observed with some of the other brands are audio distortion and foreign signals introduced to the audio stages, as well as video interference manifesting itself as visible lines and spots on display screens.

Corrective measures such as earthing, or screening of components yielded limited success, although in a few cases the effects of interference were totally eliminated.

1.2.2 The aim

The aim of the study is to develop an RF bandwidth switch, for multi-media transmission within a technology based training system, without reliance upon personal computer technology.

1.2.3 The objectives

The first objective is to define the functional characteristics of technology based training systems that must be obtained by the RF bandwidth switch, as well as the distribution network structure within which the RF bandwidth switch may be deployed.

The second objective is to specify a format for primary transmission, as well as a suitable frequency plan.

The third objective is to specify and develop the electronics to devise a suitable bandwidth switch capable of obtaining the functional characteristics of technology based training systems, primarily enabling the user to select any one of a minimum number of four RF bandwidth inputs, to be presented at the output port for transmission. Typical full-bandwidth inputs are personal camera, workbench camera, video cassette recorder and personal computer.

1.2.4 The hypotheses

The first hypothesis is that the functional characteristics of technology based training systems, as well as the network structure required, may be specified after a literature study of PC driven technology based training systems.

The second hypothesis is that a suitable frequency plan and format for primary transmission may be specified after a literature study of ITU (International Telecommunications Union) specifications.

The third hypothesis is that the electronics may be cost-effectively specified and developed to render a suitable bandwidth selector, once the primary transmission format as well as the functional characteristics for technology based training systems are known.

1.3 REVIEW OF THE RELATED LITERATURE

1.3.1 Video transmission theory

Books, publications and papers published in scientific journals such as the IEEE proceedings provided information on video transmission theory. The literature on video transmission theory provided useful information on transmission formats and techniques of transmission. Specific attention is drawn to an article *Some broadband transformers* by C. L. Ruthroff, published in the Proceedings of the I.R.E., in August 1959, and referred to in Annexure A.

1.3.2 Educational requirements and social issues

Papers presented at the following conferences contained data related to educational parameters like human-computer interaction and lecturer/student interaction:

1.3.2.1 National Forum on Communication Technology for Effective Learning and Information Exchange, which was hosted by the FRD at the CSIR on 27 March 1996.

1.3.2.2 The Technology Based Training Conference, which was hosted by the INSTITUTE FOR INTERNATIONAL RESEARCH, at the BIFSA Conference Centre, Midrand, on 23, 24 and 25 February 1998.

1.3.3 Video transmission standards

The purpose of creating a standard algorithm is to ensure world-wide compatibility of dissimilar systems. The international body that defines the standards for video transmission was the International Telegraph and Telephone Consultative Committee (CCITT). This committee ratified standards in four year periods, beginning in 1984:

1.3.3.1 1984 Recommendations in CCITT "Red Book".
1.3.3.2 1988 Recommendations in CCITT "Blue Book".
1.3.3.3 1992 Recommendations in CCITT "White Book".

Recommendations were also adopted between plenaries through accelerated procedures every two years. The CCITT was replaced by the International Telecommunications Union (ITU), incorporating the Telecommunications Standards Sector (TSS), in March, 1993.

1.3.4 Electronic product descriptions and application notes

Technical literature on components was supplied by their respected manufacturers. This service is extensive for the larger manufacturers like Alcatel, Philips and Sanyo. Product descriptions, technical specifications and detailed application notes were obtained with ease utilising the internet.

1.4 METHODOLOGY TO SOLVE THE PROBLEM

1.4.1 The data

The data used was historical in nature at the time used, and was obtained from the literature reviewed as well as a number of standards doctrines and other publications. The data reflected the following:

1.4.1.1 Video transmission theory applicable to modern information technologies.

1.4.1.2 Educational concepts and applications of technology based training systems.

1.4.1.3 International transmission standards, recommendations and specifications.

1.4.2 The sample

Data was drawn from the literature reviewed in chapter 1.3, as well as from papers presented by discipline related experts at conferences, referred to in chapter 1.3.2.

1.4.3 Administration

The following steps were taken in the execution of the development:

1.4.3.1 A literature study of video transmission theory and communications technologies was conducted, to consider all options before specification of the primary transmission format.

1.4.3.2 The educational requirements for technology based training systems were specified based upon data obtained from publications and conferences reviewed in paragraph 1.3.2.

1.4.3.3 The primary transmission format was specified, based upon data obtained from the literature study and publications referred to in paragraph 1.3.1, as well as transmission standards referred to in paragraph 1.3.3.

1.4.3.4 The functional characteristics of technology based training systems were specified, and the communications medium to serve as network interconnections was selected, based upon data obtained from the literature and publications referred to in paragraph 1.3.

1.4.3.5 The electronics was developed to render a suitable RF bandwidth switch to be deployed in an experimental set-up.

1.4.3.6 Identical RF bandwidth switches were connected into a network configuration to test the main hypothesis. This configuration forms the basis for the academic evaluation and future research.

1.4.4 The delimitations

The study covered the working prototype development of the electronics for the switching and transmission apparatus, including the signal conditioning of inputs or outputs to and from the primary transmission format.

The study only considered the following factors:

1.4.4.1 Measurable specifications set after completion of the literature study.
1.4.4.2 Performance specifications obtained from analysis of prototype apparatus.
1.4.4.3 Informal testing of the switch within a local distribution network.

The study will not consider the following factors:

1.4.4.4 Contents of programmes switched.

1.4.4.5 Encryption of programmes switched.

1.4.5 Assumptions

The first assumption is that components for development are available for the format and frequency bandwidth selected for primary transmission, and the second assumption is that all multi-media formats are convertible to the format and frequency plan selected for primary transmission and vice versa.

1.4.6 Definition of terms

1.4.6.1 RF bandwidth switch. An electronic device that is capable of selecting any one of a number of different RF bandwidth signals presented to its input, and configuring it to its output port for distribution.

1.4.6.2 Primary transmission format. The format at which information bandwidth is manipulated to perform the function of switching.

1.4.6.3 Electronics. All products, equipment and systems manufactured for the purpose of processing, storing or transferring information, data or images by means of electro-magnetic phenomena, but excluding the raw materials from which such items are manufactured.

1.4.6.4 Encryption. Any method to encode or decode transmitted or distributed signals to prevent unauthorised monitoring.

1.5 PROJECT DOCUMENTATION

The research project will be thoroughly documented in accordance with the University's "Guidelines for study leaders, promotors and students", as well as the department's proposed format of theses and dissertations.

1.5.1 Overview of the chapters

Chapter 1 sets out the nature of the problem investigated.

Chapter 2 considers human factors and issues involved with multimedia lecture delivery.

Chapter 3 describes all factors considered for the selection of the primary transmission format, as well as the medium that may be used for network interconnection. This chapter also contains the frequency plan for the primary transmission format.

Chapter 4 describes all the factors considered for prototype development, and defines minimum specifications. The prototype RF bandwidth switch is described, as well as assembly and test procedures.

Chapter 5 defines the experimental network structure within which RF bandwidth switches are demonstrated to perform the functional requirements of technology based training systems, as well as the evaluation thereof.

Chapter 6 draws conclusions and provides recommendations for future work.

Chapter 2

EDUCATIONAL REQUIREMENTS, HUMAN/MACHINE INTERACTION AND SOCIAL ISSUES

When evaluating the use of technology based training (T.B.T.) systems, there are important non-technical aspects to consider. Specifically, systems must support the way people work or they will not be successful [2].

2.1 EDUCATIONAL REQUIREMENTS

2.1.1 Components of an interactive T.B.T. system for educational purposes

To deliver interactive multimedia services, the video server (i.e. lecturer) must communicate with other key components of the system. See Figure 2.1 below.

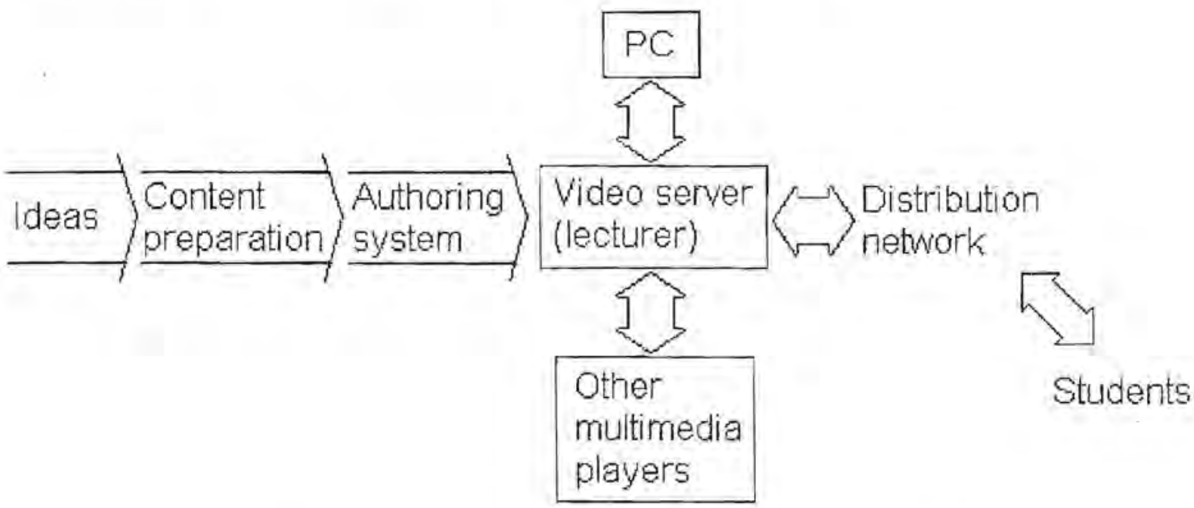

Figure 2.1 Components of an interactive T.B.T. system

Delivering interactive multimedia requires a system that integrates media preparation and authoring tools, a video (or media) server, a distribution and access network, and receiving equipment at the student workstation.

The integration of media preparation and the authoring system may to a large extent be initiated by educational entities themselves. This conclusion was drawn from case studies and papers presented at the "National forum on communication technology for effective learning and information interchange", hosted by the F.R.D. on 27 March 1996 (See para. 1.3.2.)

2.1.2 Functional requirements of T.B.T. systems for educational purposes

In his paper "How to make interactive television interactive"[3], Professor J Cronje of the Department of Didactics, University of Pretoria, argues that the strength of interactive television for distance learning lies therein that the student can talk back to the lecturer via the multimedia display unit, and that systems for education should be designed specifically for this purpose.

He stated that only three T.B.T. (technology based training) systems existed in South Africa at that point in time [3], namely:

i. The S.A.B.C. learning channel, through non-interactive television with broadened lessons, with occasional telephone feedback.

ii. The Africa Growth Network that follows a similar non-interactive system, although courseware and even CBT (community based transmission) may also be deployed.

iii. The University of Pretoria has a system with direct video broadcast in lecture mode, but with only telephone feedback.

While some degree of interactivity is obtained by these three systems, none of them achieve the real-time interactivity required by institutions of tertiary education.

2.2 HUMAN/MACHINE INTERACTION

There are two distinct paradigms to consider with the educational requirements for technology based training systems: *lecture mode* and *collaboration mode*. These modes differ by the type and amount of interaction that takes place among the participants. It is important to understand the difference between these modes because each require the technology based training system to support different types of interactions.

2.2.1 Lecture mode

Lecture mode is typically a one-to-many interaction. There are distinct and unequal roles of the participants. There is typically one lecturer and multiple students. The lecturer is in control of the conference. The lecturer may ask for interaction from the students in the form of questions or discussion. Students may indicate their desire for interaction by raising their hand. Lecture mode utilises asymmetric communication among the participants.

2.2.2 Collaboration mode

Collaboration mode is typically a many-to-many interaction. Each participant is a peer who participates in the conference equally, although in some cases there may be a facilitator who manages the conference and keeps the agenda flowing smoothly. Collaboration mode utilises symmetric communication among the participants.

Users will be frustrated if the system does not support their required mode of interaction. For instance, in lecture mode it may be difficult for students to indicate that they have a question if the lecturer can not see the student or if the interface does not provide a way to "raise a hand".

Another problem is that of language or social culture. Collaboration mode suffer difficulty when education across these barriers are considered.

2.2.3 The value of audio

The importance of good quality audio in a conference can not be overstated. Since not many of us can read lips, effective communication can not occur without intelligible audio. Audio delay can make interaction difficult. Audio that is not synchronized with video can be distracting. However, some studies suggest that users prefer having audio with minimal delay over having audio in sync with video if a noticeable delay is imposed [4].

2.2.4 The value of video

Intuitively, it seems that video adds value to a conference. Video enhances communication by creating a sense of presence. Video allows for communication through gesturing. Objects can be shown to other participants by holding them up in front of the camera. Video from auxiliary sources (such as a VCR) can be included in a conference. Video allows for interpretation of what is going on in the environment of other participants. For example, long pauses may not be perceived to be unusual if video information gives some indication to the meaning of the pause (for instance, the other person is looking for a particular slide in a stack of papers) [4].

One of the author's personal observations is that it seems easier to concentrate on what the lecturer is saying (i.e. stay awake) if visual information is present. Perhaps this is a side-effect of a generation that grew up with television.

2.2.5 The value of integrated computer applications

Anyone that has tried to explain something to someone over the phone (for example, give directions) has probably experienced the desire for some sort of shared drawing surface to supplement communication with sketches and annotations. Most desktop videoconferencing applications have a shared whiteboard capability.

In the lecture environment, it is very helpful to have a good view of the speaker's written materials. It is also very helpful to be able to save a copy of the visual material and/or print it out. In conference mode, feedback on visual materials such as annotations is very useful.

Application sharing is another useful feature of desktop videoconferencing. A common example used to illustrate this capability is participants collaboratively editing a spreadsheet or word processor document.

2.3 SOCIAL ISSUES

Our world of human diversity motivates that existing systems used to train humans be examined, and placed within social and sometimes cultural aspect. It is therefore necessary to also examine the videoconferencing model of technology based training systems within the South African scenario, also due to the limited success that this model appear to achieve.

2.3.1 Benefits of the videoconferencing model of T.B.T. systems

Room videoconferencing systems typically offer two way real-time audio and video. In addition, they usually have the capability to send high quality still images to remote sites. However, surveys of room videoconferencing system users have identified additional desired features such as a shared drawing area, ability to connect multiple sites, and ways to incorporate computer applications into the conference [4].

These types of features can be provided with desktop videoconferencing systems. Perhaps the most important aspect of desktop videoconferencing is not that it is on the desktop but that it is integrated into the computing environment that the user may already be familiar with. This opens up the possibility for data conferencing as well as videoconferencing.

2.3.2 Disadvantages of the videoconferencing model

Room videoconferencing systems have scheduling and booking problems. Time slots sometimes have to be booked well in advance. With desktop systems, more impromptu and informal interaction can take place. Users will be more likely to use a system if they have easy access to it. However, this can be a disadvantage since on the desktop there are likely to be more distractions than in a conference room setting (for example, incoming email, phone calls, etc.), and also due to the fact that participants' attention is divided between the desktop hardware and the actual conference proceedings.

2.3.3 Social issues within the South African scenario

The problem of delivering media to students is firstly complicated by the fact that the majority of students in South Africa are computer illiterate and this is expected to remain unchanged for the foreseeable future.

This observation was made by Peter T. Knight, Chief: Electronic Media Centre of The World Bank Group at a recent conference held at the CSIR.[5]

The second complication is one of language. Most educational software is written for high level English, and cannot be effectively applied in a culture of ethnic diversity with 11 spoken languages.

The situation suggests that T.B.T. systems for the South African market should support computer literacy training, without being dependent upon computer technology to function. Thus computer technology should for the interim merely be regarded as a multimedia input source.

2.3.4 The Forum prototype

Some research has been done by Sun Microsystems toward developing an application that is suited to delivering interactive presentations to distributed audiences. This research prototype is called Forum [6]. Forum attempts to address many of the problems that are encountered during the lecture delivery via a technology based training system.

Forum is specifically designed to facilitate lecture mode interactions. Roles of lecturer and student are clearly defined, and the two types of participants have different user interfaces and different capabilities.

Students receive audio, video and slides from the lecturer. They are able to interact with the lecturer through a poll, a spoken question, or written comments. Lecturers receive audio and a still snapshot of a student asking a question. Both the lecturer and students can see a list of who is in attendance and the results of polls.

Some valuable features found on this prototype model are:

1) the ability for students to queue up to indicate they wish to ask a question,

2) the ability for students to "raise their hands" by the poll function,

3) the ability for students to send in written comments without disrupting the lecturer, and

4) the ability for students to send messages to other students. These features are valuable because they increase the amount and ease of interaction between the lecturer and students as well as interaction among students.

2.3.5 Problems to overcome

With T.B.T. systems that rely upon PC technology, it takes time to compress video and audio and transmit it. This lag can contribute to a loss of interactivity as experienced with videoconferencing systems [7].

There is a learning curve involved with effectively utilising new tools. Some people are not yet computer literate and may be wary of using educational media that relies on personal computer technology.

Unforeseen circumstances are bound to happen, especially when computers are involved. The new replacements for excuses such as "my dog ate my homework" may be; "the network was down" or "my computer crashed in the middle of the lecture".

2.4 NETWORK TOPOLOGY FOR SYSTEM DEVELOPMENT

This subsection discusses the network topology for system development. Both methods of deployment are addressed, namely simplex (lecture mode) and duplex (collaboration mode) operation.

2.4.1 System overview for simplex delivery.

Figure 2.2 describes a single bandwidth switch network that may be deployed for simplex operation (lecture mode), or one-way delivery of multimedia. Inputs allowed for are personal computer (PC), video cassette recorder (VCR), personal camera (PCAM) and workbench camera (WCAM).

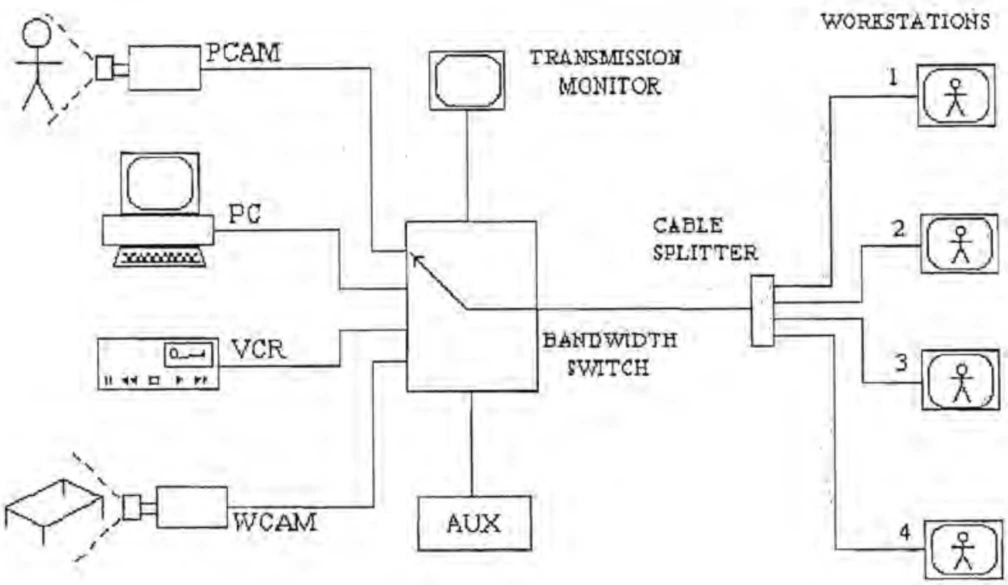

Figure 2.2 Simplex (lecture mode) network topology

The minimum system described in Figure 2.2 allows for multimedia delivery to 36 - 60 individuals, when considering conventional television monitors at the student workstations. Alternatively, large-screen projection units may be used in larger auditoriums. Picture sizes of up to a few metres may be obtained by these units, which require a standard PAL or NTSC composite video input [8].

2.4.2 System overview for duplex delivery

Fig. 2.3 describes a full-duplex system, utilising two separate bandwidth switches BS1 and BS2. With this configuration, full interactivity is obtained by the added feature that any workstation may be selected by BS2 and connected to the auxiliary input of BS1. The lecturer may switch BS2 to receive any workstation's camera to answer questions any individual may have, and configure the said workstation's input to be broadcast over the network, if so desired. With this configuration the student has no control over the flow of information, other than contributing localised audiovisual information when so configured by the lecturer.

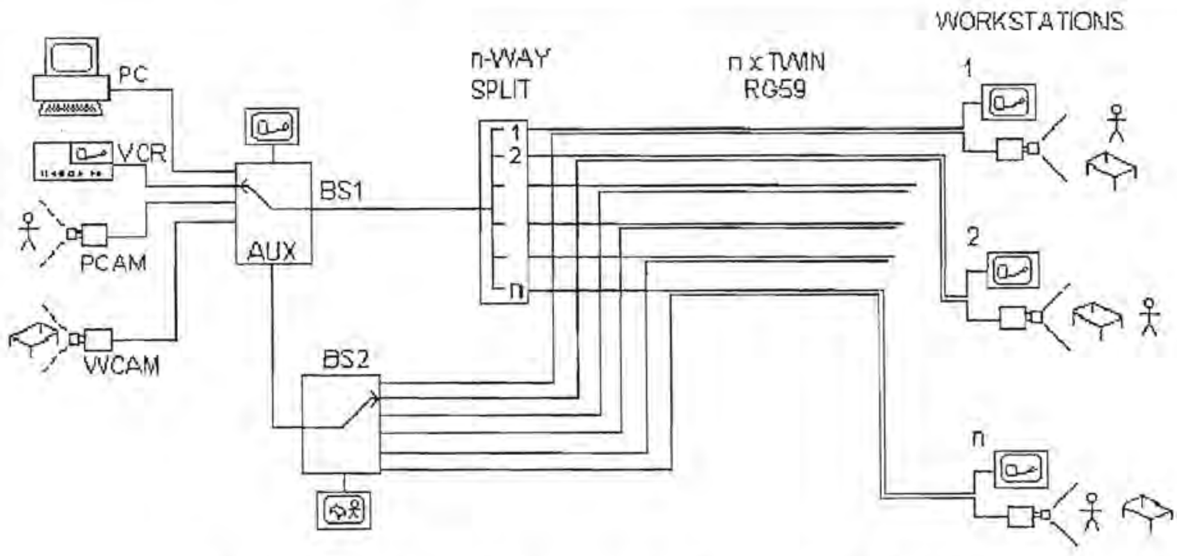

Figure 2.3 Duplex (collaboration mode) network configuration

2.4.3 The functional requirements of the transmission apparatus

The RF bandwidth switch for development must be able to obtain the following functional requirements of technology based training systems, without reliance on computer technology:

2.4.3.1 *Combination and Selection function :* The operator must be able to select one of a minimum number of four RF bandwidth inputs, to be presented for transmission, by depressing a single button.

2.4.3.2 *Activation function:* The operator must be able to activate transmission of the switched input by depressing a single button, from a warm standby condition. In the deactivated transmission mode, a station ID, or colour bars must be displayed.

2.4.3.3 *Multiple forward connections:* Multiple forward connections are required to distribute the switched input to several display units simultaneously.

2.4.3.4 *Two feedback connections:* Two feedback connections are required for interactive operation, one from the display stations to the operator, and a second connection from the operator to the display stations. The second connection may share the forward transmission links.

Chapter 3

THE PRIMARY TRANSMISSION FORMAT

This chapter describes all factors considered for the selection of the primary transmission format, as well as the medium that may be used for network interconnection.

The chapter is concluded with a broad specification of the primary transmission format, also in terms of its frequency plan and channel separation.

To perform the functions of a technology based training system, it is necessary that information be exchanged within the system. The term *primary transmission format* shall specifically refer to the information format chosen to be manipulated by the RF bandwidth switch.

3.1 FACTORS CONSIDERED FOR THE SELECTION OF THE PRIMARY TRANSMISSION FORMAT

Several factors were taken into consideration before choosing the primary transmission format as PAL system I composite baseband for analogue video and audio, with its corresponding CCITT frequency specification for 6 MHZ sound IF (intermediate frequency):

3.1.1 The standardized free network

The idea of a 'standardized free network' was first propagated by Dr. Hiroshi Harashima, Professor of the University of Tokyo [9]. He considers that a fundamental solution to standardisation may only be obtained when network systems are developed to a form that requires little or no standardisation.

A practical solution would be to choose a standard compatible with a large percentage of existing technologies, yet adaptable with ease to emerging standards. It is the author's belief that such a system standard should also be understood by the user, as referred to in the second paragraph on page 2 in the introduction to this dissertation.

3.1.2 Media players

If images or visuals are stored on CD's or magnetic tape, then the players for these media are recognised to be multimedia players or input devices [9]. The T.B.T. system, and consequently the RF bandwidth switch, should therefore be fully compatible with all the input devices of multimedia, including unintelligent players of 4 track magnetic tape (audio), VHS magnetic tape (audiovisual), CD (audio), CDROM (audiovisual), laser diskette (audiovisual).

3.1.3 Communication networks

For broadband analogue video, also referred to as the composite baseband for video and audio, 6MHz of RF bandwidth is required for each channel when considering PAL system I.

Transmission channels should be placed two frequency channels apart, to minimise adjacent channel interference. Relatively large RF bandwidth is thus required when planning several channels operating simultaneously.

Coaxial cable and optical fibre are most suited for local area transmission networks supporting multimedia, when considering their wide bandwidth capabilities. Coaxial cable carries a relatively large RF bandwidth, from DC to upwards of 750 MHz [10]. The added advantage of conventional coaxial cables is tremendous industrial support, whilst remaining fully compatible with optic fibre cable and microwave radio via suitable translator interfacing, as well as cost-effective.

3.1.4 The Radio Act (Act 3 of 1952)

The Radio Act, Act 3 of 1952, regards "wired or cabled systems for the reception and distribution of sound and television transmissions in the frequency bands 87,5-108 MHz 174-254 MHz, and 470-854 MHz *not to be* radio apparatus for the purposes of the said Act", and therefore require no licensing in terms of the Act.

3.1.5 Availability of components for development

Components supporting PAL system I are freely available with favourable costing implications. This situation is expected to remain stable as long as PAL is retained as a world wide television standard.

3.1.6 Compatibility with associated technology

The advantages gained by desktop computer systems in terms of video compression and storage techniques is augmented when supported by realtime media players. PAL system I facilitates realtime video and corresponding FM quality audio information exchange with desktop systems.

3.1.7 Practical considerations

The primary transmission format accommodates composite RF transmission of video and audio per the specified frequency plan, as well as composite video an audio on separate cables. For transmission, the RF frequency plan is preferred, mainly because the video and audio information is integrated on a single medium, and thus eliminates echo's and delays as experienced with PC driven desktop T.B.T. systems.

3.2 SPECIFICATION OF THE PRIMARY TRANSMISSION FORMAT

The following specifications are adopted for system model development. Please note that these specifications will be used within the sphere of the development of the RF bandwidth switch, but may also be used for specification of the entire distribution network.

The selected primary transmission format, namely PAL system I [11], may be broadly specified in terms of its CCITT frequency planning per geographical destination and channel allocation, with the aid of two suitable tables:

3.2.1 PAL system I frequency plan/destination

DESTINATION	CTV system	CHANNEL		RF MODULATOR
		Band IV	Band III	
EUROPE	PAL I, BG	21 - 68	2 - 4, 5 - 12	30 - 39 (36)
EUROPE cable TV	PAL BG	21 - 69	2-4, X, Y, Z S1, S2, S3-S19, 5-12	30 - 39 (36)
UK	PAL I	21 - 69	-	30 - 39 (36)
HONG KONG	PAL I	21 - 69	-	30 - 39 (36)
AUSTRALIA	PAL BG	21 - 69	3 - 4	3 - 4
SOUTH AFRICA	PAL I	21 - 69	4 - 13	30 - 39 (36)
MALAYSIA	PAL BG	21 - 69	2 - 4, 5 - 12	30 - 39 (36), 3 - 4
IRELAND	PAL I	21 - 69	A - C, D - J	30 - 39 (36)
NEW ZEALAND	PAL BG	21 - 69	2 - 3	2 - 3
INDONESIA	PAL BG	21 - 69	1 - 3, 4 - 9	2-3 IND, 3-4EUR

Table 3.1 PAL system I frequency/destination

Table 3.1 sets out the PAL system I frequency planning for destinations as indicated. It is interesting to note similarities between Europe, Hong Kong and South Africa, which implicate favourable availability of similar components at these destinations.

Table 3.2 sets out channel spacing with corresponding frequencies allocated. Vision carrier frequencies are expressed in MHz, and in each case the sound IF is 6-MHz higher than the indicated vision carrier.

3.2.2 PAL channel spacing and frequency planning

CHANNEL	VISION CARRIER	CHANNEL	VISION CARRIER	CHANNEL	VISION CARRIER
A	53,75	21	471,25	49	695,25
B	62,25	22	479,25	50	703,25
C	82,25	23	487,25	51	711,25
D	175,25	24	495,25	52	719,25
E	183,75	25	503,25	53	727,25
F	192,25	26	511,25	54	735,25
G	201,25	27	519,25	55	743,25
H	210,25	28	527,25	56	751,25
H1	217,25	29	535,25	57	759,25
H2	224,25	30	543,25	58	767,25
1	41,25	31	551,25	59	775,25
1A	42,25	32	559,25	60	783,25
2	48,25	33	567,25	61	791,25
2A	49,75	34	575,25	62	799,25
3	55,25	35	583,25	63	807,25
4A	62,25	36	591,25	64	815,25
4	175,25	37	599,25	65	823,25
5	183,25	38	607,25	66	831,25
6	191,25	39	615,25	67	839,25
7A	192,25	40	623,25	68	847,25
7	199,25	41	631,25	69	855,25
8A	201,25	42	639,25		
8	207,25	43	647,25		
9	215,25	44	655,25		
10	223,25	45	663,25		
11	231,25	46	671,25		
12	239,25	47	679,25		
13	247,43	48	687,25		

Table 3.2. PAL channel/frequency planning