

# SYSTEM DYNAMICS MODELLING WITHIN THE BRITISH TELECOMMUNICATIONS BUSINESS

*Dr. D.E. Probert, Long Range and Strategic Studies Division, British Telecom.*

*D.E. PROBERT is currently Head of the Strategic Modelling Group within British Telecom's Long Range and Strategic Studies Division which is located at Cambridge, England. After obtaining his BSc degree in Mathematics from the University of Bristol in 1973, he spent three years undertaking research into the dynamics of self-organising systems at the Statistical Laboratory, Cambridge University, where he obtained his PhD in 1976. During 1976-1978, he was engaged by BT as a consultant to develop a comprehensive dynamic corporate model of the British Telecommunications Business, with a planning horizon of between 20 and 30 years.*

## ABSTRACT

British Telecom's Strategic Modelling Group has been actively involved in system dynamics modelling since 1976 when it was decided to develop a dynamic corporate model of British Telecom with a planning horizon of around 30 years. This research project was successfully carried out in collaboration with the Department of Control and Management Systems, Cambridge University. We have since developed a strategic control module which allows us to track a set of corporate objectives and also to analyse the robustness of the business under various imposed crises.

More recently an Integrated Communications Demand Model has been developed by a research team at Cambridge University, in close liaison with British Telecom. The conceptual framework of this model spans the entire marketplace for physical and electronic communications media. It is currently undergoing validation tests and tuning to the best available data, focusing upon the expected growth rates and market shares for new services.

We have placed considerable emphasis on the development of a "user friendly" interface for all our dynamic models, in which we now use an intelligent colour graphics terminal linked to a mainframe computer. All commands and policy options are entered through a menu pad which means that our models are evolving into being more permanent forms of decision support system, which can be used by the non-specialist user.

## 0. INTRODUCTION

### 0.1 BACKGROUND

System dynamics modelling has been used in the formulation and implementation of strategic planning models for nearly five years within the Long Range and Strategic Studies Division of the British Telecommunications Business. This modelling has proceeded in close collaboration with the Department of Control and Management Systems of Cambridge University.

It was decided in 1976 that with the rapid changes in the telecommunications marketplace, which have since led to a new Telecommunications Bill, it was essential to have a dynamic computer-based representation of the corporation.

Such a model was developed using the methodologies of system dynamics and became operational early in 1978. This corporate model has been actively used for over four years during which time several thousand computer runs have been conducted under a range of policy assumptions. More recently we have developed a strategic control unit which allows us to track a set of objectives placed on key business indicators. In addition, the control unit is frequently used to evaluate the response of the business to selected crises in which the corporate objectives are usually those of the current British Telecom Corporate Plan. Thus we are able to design both a desirable and robust corporate future which can act as the basis for more detailed studies.

The corporate model is now run on an intelligent graphics terminal linked to a main-frame IBM 3033 over the public telephone network. A central theme of this paper is that of interfaces in which we emphasise the importance of creating a "user friendly" interface if the manager is not to be alienated by computer models. During the last 18 months during which the colour graphics interface has been operational, we have found far wider acceptance of the model through numerous successful "live" demonstrations to senior managers.

The success of the corporate model (commonly referred to as the Long Range Planning Model or LRPM) led us to take the Marketing Module as the starting point of a new research project. This new model is known as the Integrated Communications Demand Model (ICDM) in which we have now completed the development of the conceptual framework and its implementation in FORTRAN using the same colour display package. We are currently devoting most of our effort to "tuning" up the ICDM to produce an acceptable base projection for future market studies. The demand model includes the demand for all communications media in which the focus is upon the possible substitution of physical media such as transportation and postal systems by electronic media.

### 0.2 INTERFACES

An important role for any model is that it creates a unified language in which to discuss issues which cut across a multitude of operational boundaries. We must note that the LRPM is a comparatively large dynamic model occupying around

7,000 lines of FORTRAN code, despite a "compact representation". There are around 300 policy levers available to the analyst which lead to around 200 output variables which can be plotted over a planning horizon of 30 years. It is certainly a challenging exercise to structure the input/output interface of the computer package to create a coherent display which allows the rapid comparison of alternative corporate futures under a range of policy assumptions. We have found colour graphics linked with a command menu pad to be more than adequate for this task, although we are still attempting to realise the full potential of such an interface.

### 0.3 CONCEPTUAL FRAMEWORK

We spent nearly 50% of the development time for the corporate model on the conceptual framework which eventually led to the detailed structure of the subroutines. We explored the corporation from numerous different viewpoints making use of relevant business statistics together with the extensive literature on general systems theory. In particular, we emphasised the notion of the corporation as an evolving system<sup>1</sup> in a dynamic and uncertain environment in which we should be prepared for large scale structural changes in addition to local parameter fluctuations. This led to the concept of a strategic control unit which is able to respond to imposed corporate shocks, which would otherwise lead to potential corporate disaster in the absence of any mechanism of adaptation.

Although the model structure was initially drawn up using the traditional system dynamics terminology, we found that this was largely not understood by operational management. So in order to "market" our ideas we produced a simplified cyclic structure in order to convey the concept of the corporate model generating its own future guided by the chosen policy assumptions. Over a period of several months, the model structure was continually refined in which the main problem was in keeping the number of policy parameters and the dimensions of the model to a manageable size.

In writing reports for management or giving presentations, we are wary of leaning too heavily on mathematical or computer oriented concepts since they immediately create a modelling mystique. Instead we attempt to relate to the "language of the decision maker" in which we are now aided to a large extent by the production of high quality colour graphics which would appear to destroy, to a certain extent, the mystique of modelling. We now try to convey the idea that dynamic models should be viewed merely as alternative forms of information and subsequent insight rather than as the corporate "oracle" which necessarily represents any absolute truth.

This has bearings on the theme of model validation in which we have "tuned" the aggregate corporate model to the more detailed forecasts produced by econometric and time-series models. These often go back twenty years into the past using relevant historical data and are developed within other analytical support units within the corporation. However, for the period ten to thirty years ahead there are no forecasts on which any absolute reliance can be placed. So we make use of the best available estimates of parameters which can be achieved through long term market research, literature searches, and liaison with colleagues in the research and development functions of the Business.

### 0.4 THE CORPORATE MODEL IN USE

The corporate model is generally used to investigate strategic issues at the policy level in which a question will be passed down for analysis from senior management. We must first "translate" this question into the "language" of the policy levers incorporated within the modules before proceeding to set up a simple framework for the investigation of a number of scenarios. We will frequently conduct up to around 50 simulations when analysing a particular issue before attempting to draft a set of recommendations for management. The task of translating the results from the model back up to the language of the decision maker is usually far from straight-forward and will in general require a certain amount of judgment based on the experience of previous policy investigations.

This paper treats system dynamic modelling from the viewpoint of an active practitioner in a large public corporation employing around 250,000 staff and with assets totalling around £14,000 million. Clearly policy decisions in such an environment will have consequences for the nation as a whole as well as for the corporation itself, so insights gained through modelling can be of great value to the community. The close collaboration between the Long Range Studies Division of British Telecom and Cambridge University is certainly an important feature of our path to model formulation and successful implementation. Such a relationship allows us to rapidly exploit innovations in academic thinking within the modelling community so that our tools represent the state-of-the-art.

## 1. THE LONG RANGE PLANNING MODEL (LRPM)

### 1.1 AN OVERVIEW OF THE FRAMEWORK

Over recent years, technological and political developments have been causing considerable changes in the operations of telecommunications administrations. This prompted British Telecommunications (then Post Office Telecommunications) in 1976 to commission the development of a Long Range Planning Model<sup>2</sup>. The requirement was for a dynamic model that combined all aspects of the Business, that could operate under a wide range of assumptions in order to allow the analysis of the effects of various strategic issues on the corporation as a whole. An outline of the developments in systems dynamics modelling within British Telecom since 1976 is roughly as follows:—

- 1977 — Long Range Planning Model (LRPM) developed under contract by the Cambridge University, Management Systems Research Unit.
- 1978 — The LRPM becomes operational and is used to analyse "Alternative Corporate Futures".
- 1979 — A strategic control unit is developed for tracking corporate objectives and for the study of crisis.
- 1980 — Research commenced on an Integrated Communications Demand Model (ICDM) at Cambridge University and a colour graphics interface is implemented for the LRPM.
- 1981 — The ICDM becomes operational as a tool for the exploration of marketing strategies for new services in a competitive arena.
- 1982 — Research commenced on a dynamic model which

will be used to investigate the flow of information within organisations. This will be integrated within an "Expert System for Market Analysis" (ESMA) which will also include a relational database and an expert query system.

The conceptual framework (figure 1A) is split into four key modules: "Marketing – (Demand/Supply)", "Technology – (Equipment)", "Personnel", and "Finance". The outline structure of the model is essentially cyclic in nature (figure 1B) and the full computer package, including the user interface amounts to some 90 FORTRAN subroutines and over 7,000 lines of code.

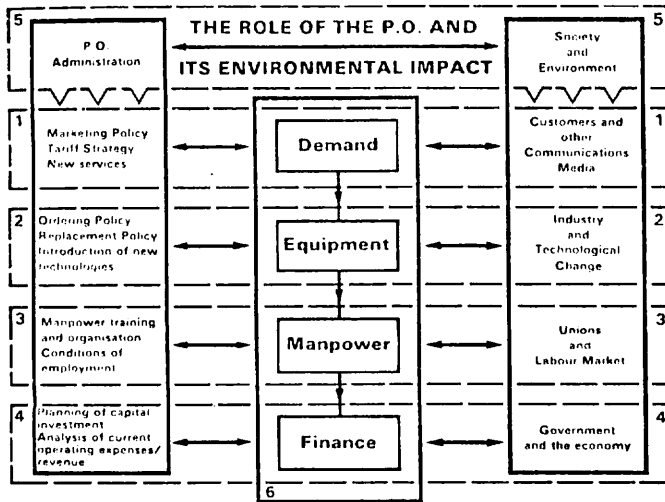


Figure 1A – The Conceptual Framework for the BT Long Range Planning Model

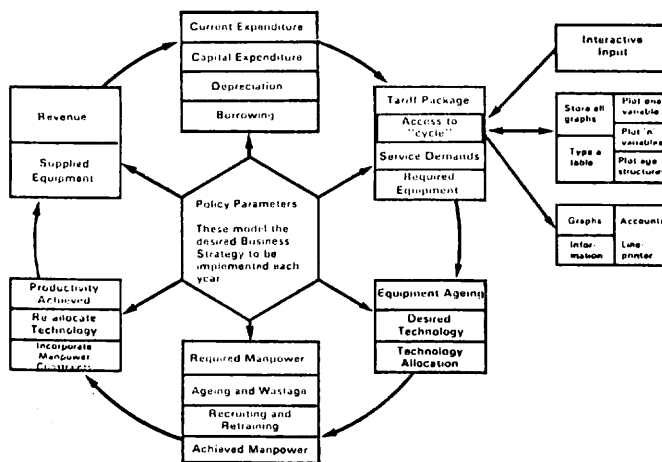


Figure 1B – The Cyclic Structure of the LRPM Computer Package

The core dynamic model itself takes up around 50% of this total package, whilst the major part of the user interface can be "hooked" onto other dynamic models such as the ICDM. We shall now proceed to discuss the nature of the four operational modules.

a) **The Marketing Module – Demand/Supply for BT Services**  
This models the aggregate demand/supply for telephony, data and wideband services together with traffic volumes split into local, trunk and international calls. Tariff/demand elasticities

are used in the usual econometric sense to take into account the details of changing tariff structures. Competition for terminals and traffic is taken into account through allowing a diffusion of customers between suppliers according to a weighting of tariff relativities and an aggregate coefficient representing service attractiveness.

b) **The Technology Module – Provision of Equipment**  
This models the dynamics within the entire corporate base of capital assets split between terminals, local and trunk transmission networks together with switching equipment. The required new equipment volumes are assigned to desired technologies but may have to be re-allocated if manpower skills are found by the LRPM to be inadequate in certain sectors. Thus we are able to explore the impact of resource requirements under alternative rates of introducing optical fibres and digital exchanges within the BT network modernisation program.

c) **The Personnel Module – Manpower Skill Requirements**  
The manpower skills map onto the ten equipment categories but are split also between construction and maintenance for each technology. A particular feature of this module is a retraining matrix which specifies whether it is deemed permissible to retrain between particular skills. Clearly constraints may lead to a mis-match between achieved and desired skill levels which in turn would lead to constraints on equipment provisioning. Policy parameters are used to explore recruitment, wastage, retirements and possible redundancies under a range of construction and maintenance productivity trends over the next 30 years. In addition we can study the impact of competition on skill requirements and also of changes in the length of the working week.

d) **The Finance Module – Capital and Current Accounts**  
This provides comprehensive details of current and capital account expenditures, together with the standard financial indicators. In addition, the Newton-Raphson algorithm is used to produce a tariff package which achieves the desired financial targets on either profits or real rate of return on assets, as set by the British Government. Particular policy domains of interest are those of depreciation strategy, determination of borrowing requirements, equipment lifetimes and unit costs, and assumptions concerning economic growth.

## 1.2 THE EXPLORATION OF ALTERNATIVE CORPORATE FEATURES

There are around 300 policy parameters available to the user which are split almost equally between the above four operational modules. Sets of these parameters are stored as named corporate scenarios of which the most frequently used is the standard projection, which is tuned to the current Business Plan. The analyst will select a scenario and probably alter up to 10 policy parameters relevant to the strategic issue under study. The LRPM is then run for 30 years in order for the analyst to compare the relative merits of the chosen policy. The analyst will then repeat this procedure several times with different policy settings in order to develop into the range of feasible Business responses to the issue. Occasionally new strategic issues are encountered which require us to add additional policy parameters to an operational module. This will involve us either in defining existing internal variables as policy variables or else in modelling certain corporate

dynamics in greater detail using additional subroutines. We have so far encountered no significant difficulties in expanding the LRPM in this way since its modular structure gives us the required degree of flexibility.

### 1.3 POLICY INPUT AND STRATEGIC CONTROL MECHANISMS

In this section we shall briefly describe a variety of policy input modes which may be used for modelling the implications of those strategic issues which are currently under discussion. The control and spike interfaces jointly allow the analyst to explore the possible implications of corporate crisis. The strategic control unit was developed initially in order to reduce the number of simulations required to achieve both a desirable and feasible future for the corporation. However, since the controller was implemented, we have used it mainly to gain insight into the mechanism of corporate crisis and possible plans for recovery. We shall pursue this more fully later in the paper.

There are four modes of policy input in the LRPM Package which we shall now discuss in turn:—

#### a) Policy Parameter Interface

This allows us to display and change any one of around 300 detailed policy parameters which fall within the four modules discussed earlier in this section. We can store up to 20 sets of such variables as individually named corporate scenarios which will include a base projection tuned to current British Telecom plans.

#### b) Policy Lever Interface

In order to simplify the task of performing an initial policy analysis we have defined 11 "macro policy levers" each of which is an aggregation of up to around 25 of the micro policy parameters. Thus, for example, the technology lever allows us to speed up or slow down all modernisation of the networks and also the terminal devices themselves.

#### c) Control Interface

The strategic control unit allows us to place objectives on any of 13 key indicators of corporate performance<sup>3</sup>. A non-linear transformation of the error function is then calculated and applied to the macro policy levers in order to reduce the departure from the desired performance targets. The inter-

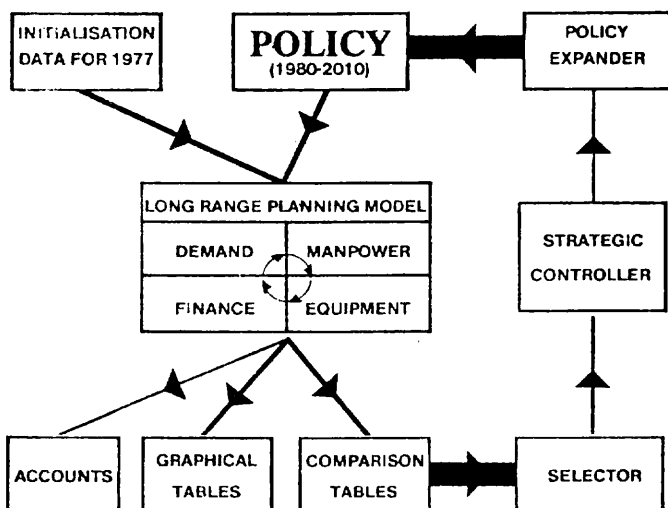


Figure 1C – The Relationship between the LRPM and the Strategic Control Unit

action between the LRPM and its associated control unit is depicted in figure 1C, whilst the control inputs and outputs are summarised in figure 1D.

### CONTROLLER INPUTS & OUTPUTS

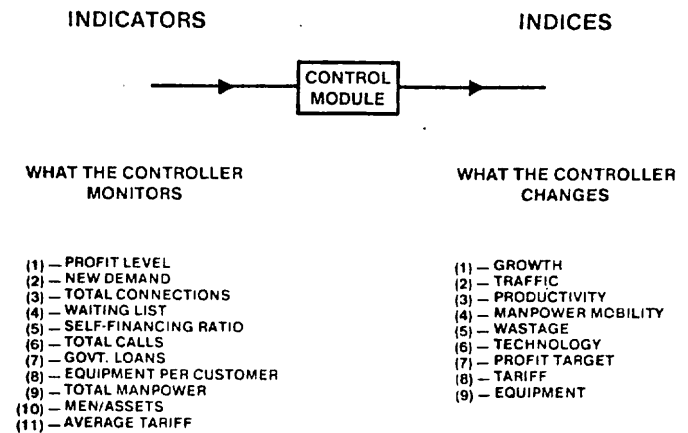


Figure 1D – The Input/Output Interface of the Strategic Control Unit

#### d) Spike Settings

In order to model the impact of discontinuous changes of policy upon the Business we have the facility of entering abrupt changes on any of the policy parameters or policy levers for some fixed duration. Such spike settings may represent some degree of crisis within particular domains of corporate activity or possibly a switch in government policy. Such spikes are also clearly of use in allowing us to get a better fit of the model to historic data, without having to incorporate too many additional dynamic relationships.

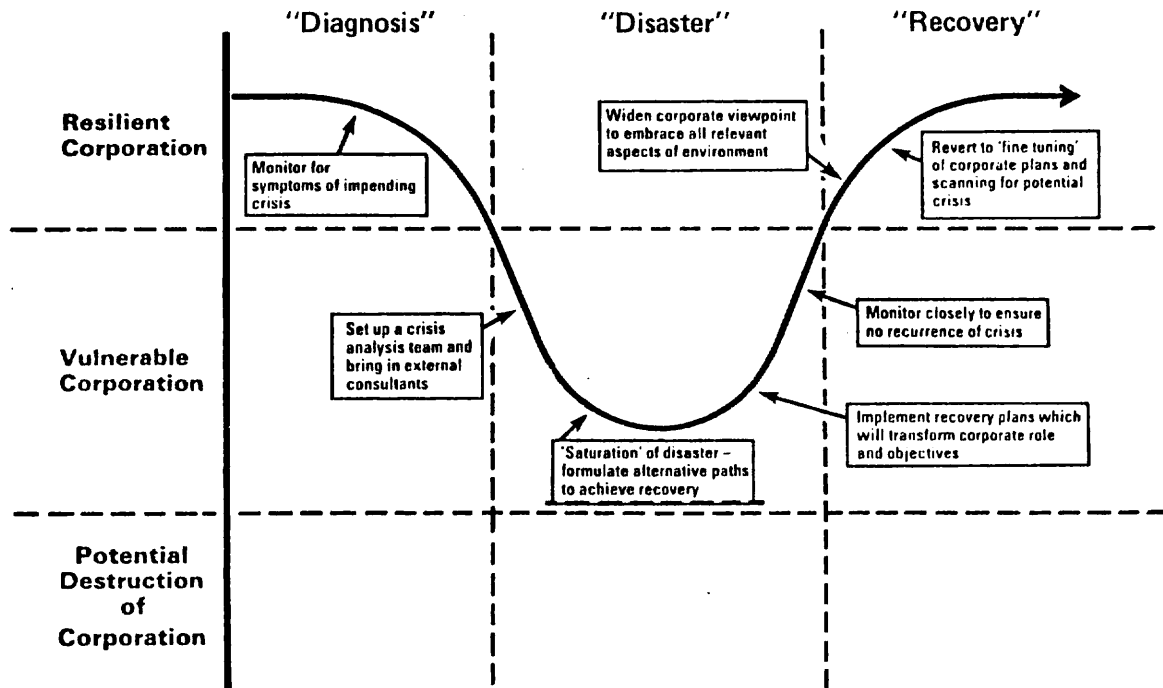
## 2. THE ANALYSIS OF POTENTIAL CORPORATE DISASTER

### 2.1 PHASES OF DISASTER

We shall now explore the conceptual framework which we have developed for the study of crisis. A crisis is not normally the result of a fluctuation in a single parameter, which may itself be diagnosed and corrected. It is more likely to be an advancing front of a number of unhealthy fluctuations which together generate a disaster when the frontier exceeds some threshold strength. So even though it may appear that a disaster, such as a volcanic eruption, almost instantaneously achieves its major impact, there will always be some build-up of pressure along a number of dimensions which we hope will act as our early warning signals.

Society is currently undergoing a major transformation in which all existing industrial corporations will continue to be severely challenged over the next two decades. This process appears to have properties more akin to the transition from an agricultural to industrial society than that of the traditional 5 and 50 year cycles in industrial production. The emergence of an information society will create major structural upheavals for British Telecom in which large scale perturbations from base-line projections are to be expected, some of which may be potentially disastrous. In addition, we should note that the duration of corporate disasters is, in general, measured in years rather than months so that the analysis of corporate robustness should lie at the core rather than at the periphery of our strategic thinking.

We first examine the emergence of disaster in which we split



## THE PHASES OF DISASTER

Figure 2A – Phases of Disaster

the complete disaster cycle depicted in figure 2A into three main phases: “Diagnosis”, “Disaster” and “Recovery”. The LRPM allows us to simulate the diffusion of crisis, starting with local unhealthy fluctuations which may potentially diffuse and span all corporate activities, if the core problems remained undiagnosed. We also introduce the ideas of

corporate resilience and vulnerability which also play an important role within our framework. So we begin by describing the effects to be observed within each phase of disaster together with the nature of corporate activity:—

## THE DYNAMICS OF CORPORATE RESILIENCE AND VULNERABILITY

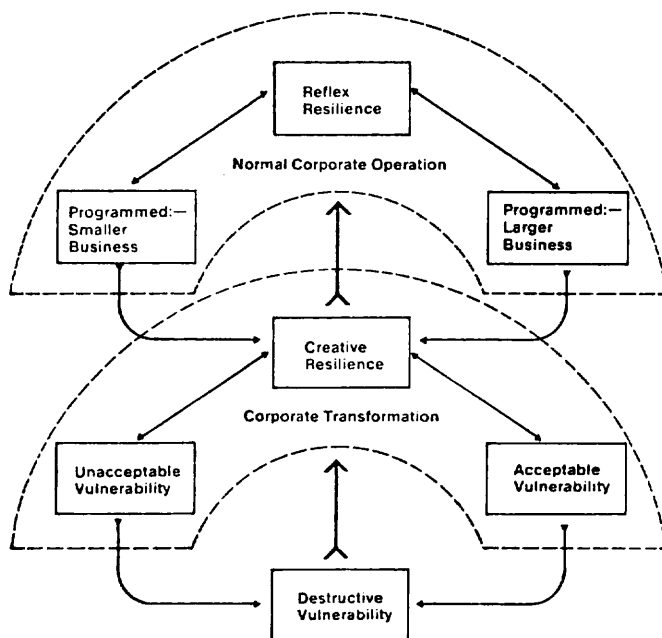


Figure 2B – The Dynamics of Corporate Resilience and Vulnerability

a) “**Diagnosis**”. The business is assumed to remain within this phase so long as it is resilient to applied shocks such as strikes, cash limits, loss of market share and equipment supply delays. Resilience will in general require British Telecom (BT) to remain flexible so that adaptation, with a reformulation of corporate objectives is always possible. Any mild crisis should be monitored closely in case it becomes entrenched with risk of potential disaster. However, BT’s planning viewpoint should be wide in this phase encompassing all relevant components of the external environment. BT currently seems to fall within the category labelled “creative resilience” in figure 2B in which large scale transformations of organisational structure are being implemented.

b) “**Disaster**”. If all strategies fail then we enter the zone of vulnerability in which the Business would certainly set up a dedicated crisis analysis team as well as calling in external consultants. The corporate viewpoint will decrease in range within this phase for it may well be the very survival of the Business which is at stake. The principal corporate objective is here to achieve recovery through formulating a number of possible survival plans using the LRPM to explore the implications of alternative options. It is important that the Business does not become overcommitted to a single recovery policy since a relapse with complications has been observed in many of the dynamic LRPM simulations.

c) “**Recovery**”. As soon as the Business enters the zone of resilience it is once again expected to be able to adapt to mild crises and also to open up its corporate scanning activities

to embrace most environmental sectors. However, this is also a period of convalescence to allow the numerous corporate activities to lock back into phase after the major structural transformations. It is likely that the Business now has a rather different role in the telecommunications arena so that time is required for both the internal and external corporate interactions to crystallise as new economic and political interfaces. Now at the end of the "disaster cycle" the Business is once again scanning for further potential crisis which constitutes normal corporate operation.

In figure 2C we summarise the modes of corporate resilience and vulnerability together with the objectives under each regime and the role of dynamic computer models.

Mode	Corporate Objectives	Role of Model
1 Reflex Resilience	Achieve Targets	Sensitivity Testing
2 Programmed Resilience	Achieve Alternative Targets	Robustness Analysis
3 Creative Resilience	Diversify and Compete	Design
4 Acceptable Vulnerability	Maintain Market Shares	Increase Market Shares
5 Unacceptable Vulnerability	Quality of Survival	Policy for Recovery
6 Destructive Vulnerability	Survival	Avoid Corporate Decay and Collapse

Figure 2C – The Modes of Corporate Resilience and Vulnerability

## 2.2 POSSIBLE PATHS TO DISASTER

In figure 2D we show in outline several possible paths to disaster which have all been explored in some detail using the LRPM strategic control unit. These scenarios are given as examples which demonstrate the use of the methodology and are in no way intended to reflect official BT policy.

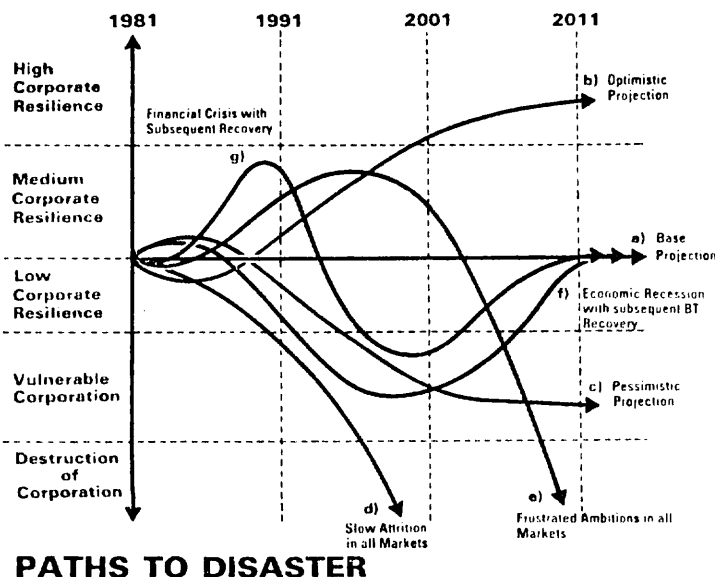


Figure 2D – Paths to Disaster

a) **Base Projection** – This corporate future is "tuned" to the 1982/1992 Business Plan, and from 1992 onwards we use the best policy information and long term forecasts available.

b) **Optimistic Corporate Future** – This acts as an optimistic base-line with rapid network modernisation and expansion into new market sectors. However, we note that this entails a decreased resilience during the 1980's due to the additional capital requirements and risk on entering new markets.

c) **Pessimistic Corporate Future** – This acts as a pessimistic base-line with slow network modernisation and an emphasis on existing services rather than embarking on new ventures.

d) **Slow Attrition in all Markets** – This scenario is utterly disastrous in which LRPM simulations indicate that recovery rapidly becomes more difficult as our market share declines.

e) **Frustrated Ambitions in New Markets** – Here the Business implements marketing plans in new sectors but encounters fierce competition which could, for example, flood the market with even cheaper products and services.

f) **Economic Recession with subsequent corporate Recovery** The corporate objectives are those of the Base Projection but these are frustrated by a severely depressed economy. This in turn leads to decreased company profits, union turbulence and decreased demand for both existing and new services, resulting from a drop in real disposable income.

g) **Financial Crisis with subsequent Recovery** – In this corporate future the Business expands into new services too rapidly leading to the classic cash flow crisis as experienced by many new commercial ventures.

The formulation of contingency plans as "follow-up" to potential crises should constitute an important part of our strategic planning activity for a corporation can only rarely be expected to follow some narrowly defined trajectory. If we merely define "good" Business Plans as an integration of responses to strategic issues without taking account of their robustness then the Business is "walking on a tightrope" of potential instability. The concepts outlined in this section have allowed us to place more emphasis on the production of robust responses to strategic issues, including a full dynamic stability analysis of the resulting integrated Business Plan.

## 3. THE COLOUR GRAPHICS INTERFACE

### 3.1 AN OUTLINE OF THE INTERACTIVE INTERFACE

We have recently devoted very considerable effort in attempts to develop an appropriate user interface<sup>5</sup> for our dynamic corporate models. The new graphics workstation includes an intelligent graphics terminal linked to a high-resolution colour monitor, hard-copy unit, and command menu pad. The workstation itself is linked to an IBM 3033 main-frame over the public telephone network, at a speed of 1.2Kbits/sec. We usually study alternative strategies in direct communication with the corporate model (figure 3A) in which several analysts may participate at once, grouped around the workstation.

The development of this new user interface falls naturally

# THE USER INTERFACE FOR STRATEGIC MODELLING

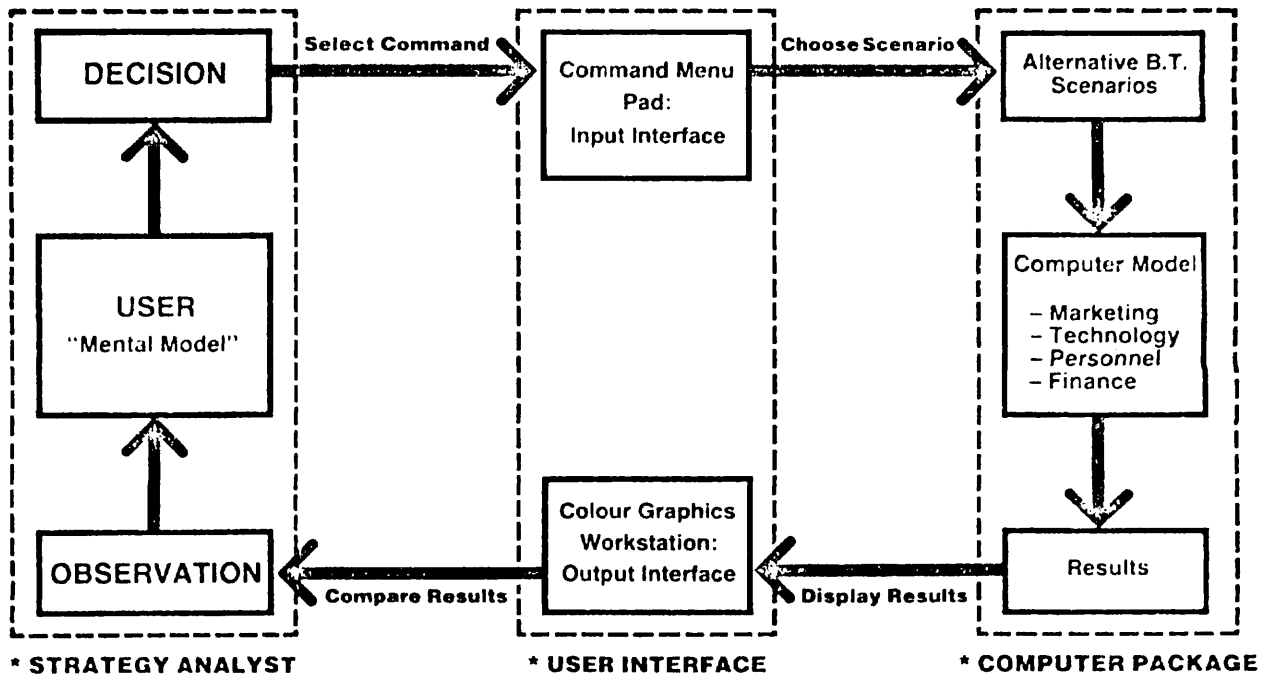


Figure 3A – The User Interface for Strategic Modelling

within three main phases:—

- The design of a videotex page editing system.
- Development of a command interface with menu selection.
- Design of graphical display options to allow simultaneous comparison of up to around ten alternatives futures.

We now think of such interactive modelling as a natural extension of current videotex systems such as Prestel (U.K.) and Telidon (Canada) in which we attach intelligence to clusters of information pages. This is likely to mean that models become far more acceptable as just another source of information rather than as a tool specifically for the trained modelling experts. The aim underlying these ideas is that we should integrate the computer model as closely as possible with the user's "mental model" so reducing the alienation so often experienced when attempting to decipher reams of computer output. We hope that we will then succeed in achieving the penetration of such telesoftware into the executive suite as a natural extension of current decision support systems.

## 3.2 THE INTERFACE COMMAND STRUCTURE

Particular attention was given to the definition of the basic commands within the user interface, in order to increase the ease and effectiveness with which the analyst could simulate and compare alternative corporate futures. The full set of command options were split into four main domains (Main Menu, Policy Options, Status Flags, and Display Options)

before being carefully mapped into "menu cells" within a 14 x 14 graphics pad grid. We shall now give a short overview of the main features of this interface for systems dynamic modelling:—

### 3.2.1 Videotex Database

Here we include pages of information which describe the structure and conceptual framework of the models and which are used for presentations within the Business. We are also able to enter pages of text which introduce and explain the main conclusions to be drawn from graphical results being shown at presentations. This means that we can generate a form of computerised "slide show" for management. Finally, we include "help" pages for the command interface itself so that to a large extent the system is able to explain its own operation.

### 3.2.2 The Main Command Menu

We have defined a minimum of basic active commands which are summarised below:—

- Run** – This command will run the model under the currently defined policy for the desired planning horizon.
- Read/Store** – These commands allow the analyst to read or store up to ten sets of policy parameters as named corporate scenarios.
- Change/List** – These permit alterations in the current policy assumptions, corporate objectives and the control mechanism.
- Macro** – This command allows the user to store

sequences of selected commands within a file for "play-back" on future occasions. This facility is used mainly for giving pre-programmed presentations to management.

- (e) *Copy* – This command will produce hardcopy of the current display in a maximum of 16 grey scales.
- (f) *Picture Editor* – This is a full videotex editing package for the creation of the graphics/text database, which includes the help pages.

### 3.2.3 Display Menu

The LRPM produces results for around 200 variables over a planning horizon which is usually set to be 30 years. The nature of long range and strategic planning requires us to closely examine and compare the outcomes from many alternative scenarios which all have to be stored in some output file. We are thus confronted with the challenge of presenting the response to such analysis in a neat and compact manner which is acceptable to management. Our first step in setting up the display routines was to agree on the overall screen design and management framework which would allow the user to interactively plot curves, bar charts and numerical values in chosen colours and drawing mode.

There are 13 colours available for drawing graphs, which once defined, can be manipulated in various ways. This includes rescaling, switching the graph on/off and also displaying or

deleting the associated numerical values. It is currently possible to store ten full LRPM runs as named sets of results in which we can take percentage deviations between any two runs at any particular time. The graphical display options allow us to plot variables in a great variety of ways as shown in the examples of figures 3B, 3C and 3D. Possibly the most powerful way to represent variables such as capital investment or manpower skill profiles is to plot bar charts incorporating variables each as a different colour. Such profiles can be drawn either as absolute values or else normalised so that, for example, the percentage of each manpower skill is clearly depicted.

## 4. THE INTEGRATED COMMUNICATIONS DEMAND MODEL (ICDM)

### 4.1 INTRODUCTION

In the previous sections we have given a comprehensive overview of the LRPM. It was found that the weakest part of the structure was the marketing module which was becoming particularly important with the impending liberalisation of the marketplace under the 1981 U.K. Telecommunications Bill. The decision was taken during 1979 to begin developing an entirely new model which integrated the demand for all communications media, with the emphasis on competition for the provision of telecommunications services. The conceptual framework was developed by a research team at Cambridge University over a period of nine months, in close

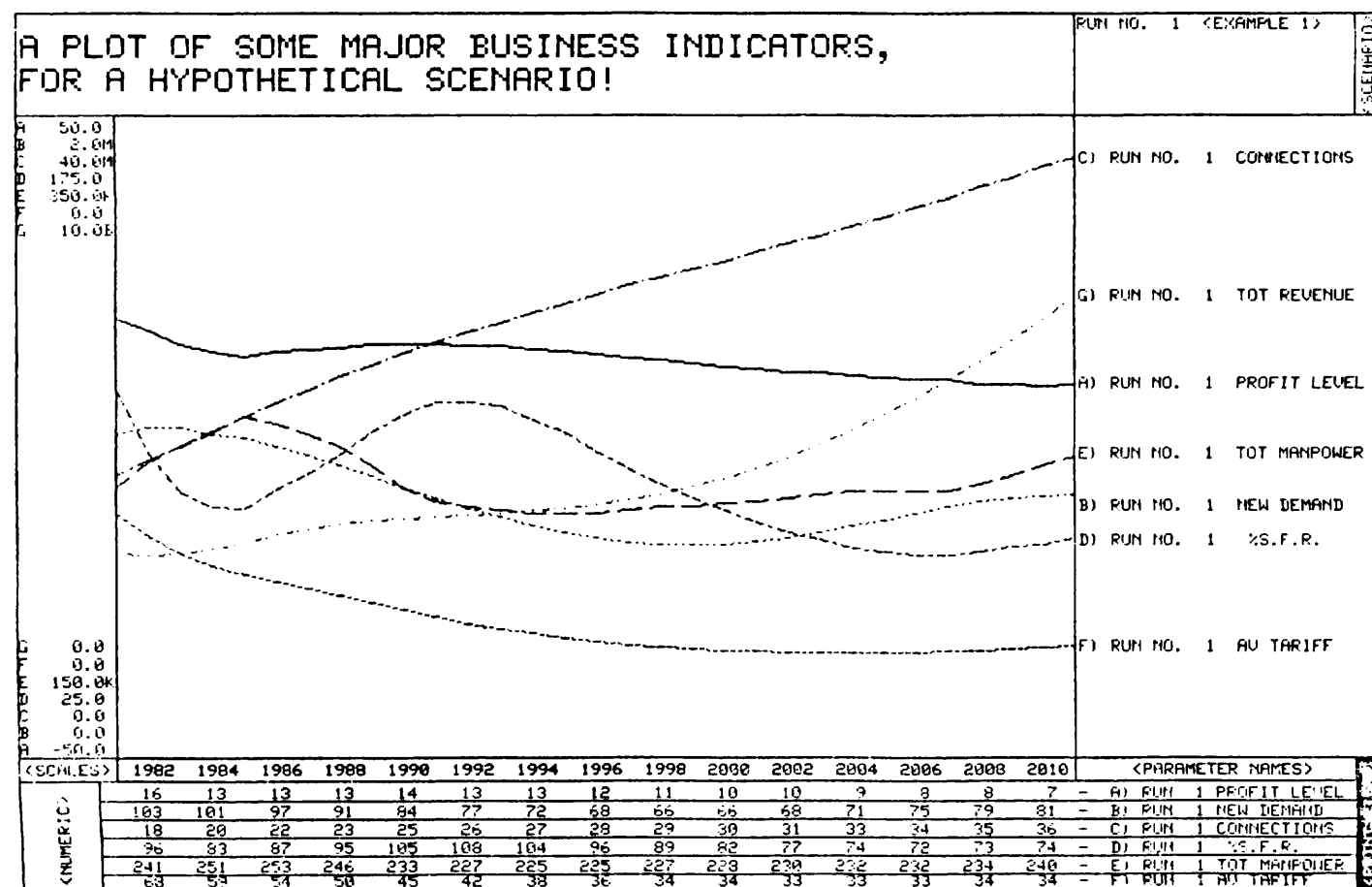


Figure 3B – A Demonstration Plot of Several Key Corporate Variables



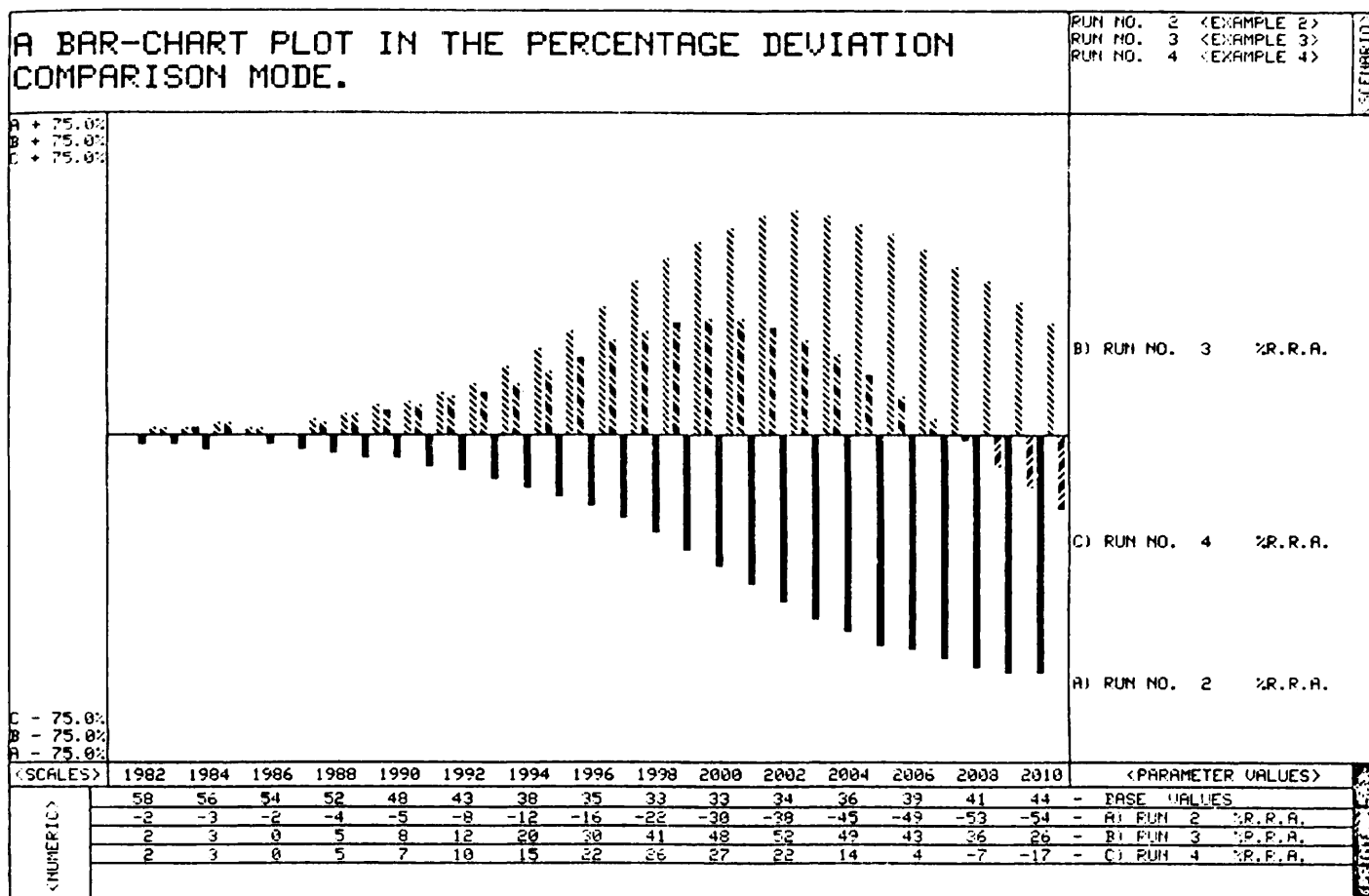


Figure 3C – A Demonstration Comparison Plot of % Return on Real Assets using the Bar-Chart Plotting Mode

liaison with the Strategic Modelling Group within British Telecom.

This led to the production of the Phase I Report 4 in which we note that the ICDM framework and the demand categories, as listed in Table 4E, are certain to evolve as we run the model and refine our insights into the demand generation mechanisms. Indeed, the project has already highlighted numerous areas in which there are severe data deficiencies which will enable us to proceed with greater confidence in defining market research studies over the next few years. This will aim towards the creation of a well defined database both as a source for the ICDM and also for more detailed market sector studies.

#### 4.2 THE USE OF THE MODEL FOR STRATEGIC ANALYSIS

In figure 4A we display the outline structure of the model with the three components of the telecommunications marketplace mapping onto the domains of policy and the relevant external environment. In figure 4B we fill out the three lobes of terminals, networks, and services to give a reasonably detailed idea of the linkages we shall be including within the model. We have summarised the main dimensions of analysis within the figure 4C which shows how we intend to apply the ICDM for the analysis of strategic issues within the Business.

The demand module utilises categories such as those defined

within table 4D in which we have attempted to capture the generation of demand from several different perspectives. Complications arise as a result of the evolution of terminals from those with single functions, such as the basic telephone, towards more advanced multifunctional terminals which can act as a complete office communications workstation.

##### 4.2.1 Policy Options

We shall now give examples of typical strategic issues:-

- Marketing Strategy** – What is the latest time that B.T. can enter a market and still gain a satisfactory share?
- Development Strategy** – How far should B.T. attempt to integrate office equipment with communication devices?
- Tariffs** – Should a loss-leading strategy be adopted to gain a high market share at the launch of a new service?

##### 4.2.2 Environmental Assumptions

We now give examples of some environmental assumptions:-

- User Characteristics** – Limits on the rate of substitution of physical communication by electronic media.
- Economy and Society** – Effects of major changes in the work/leisure split and the impact of increasing energy costs.

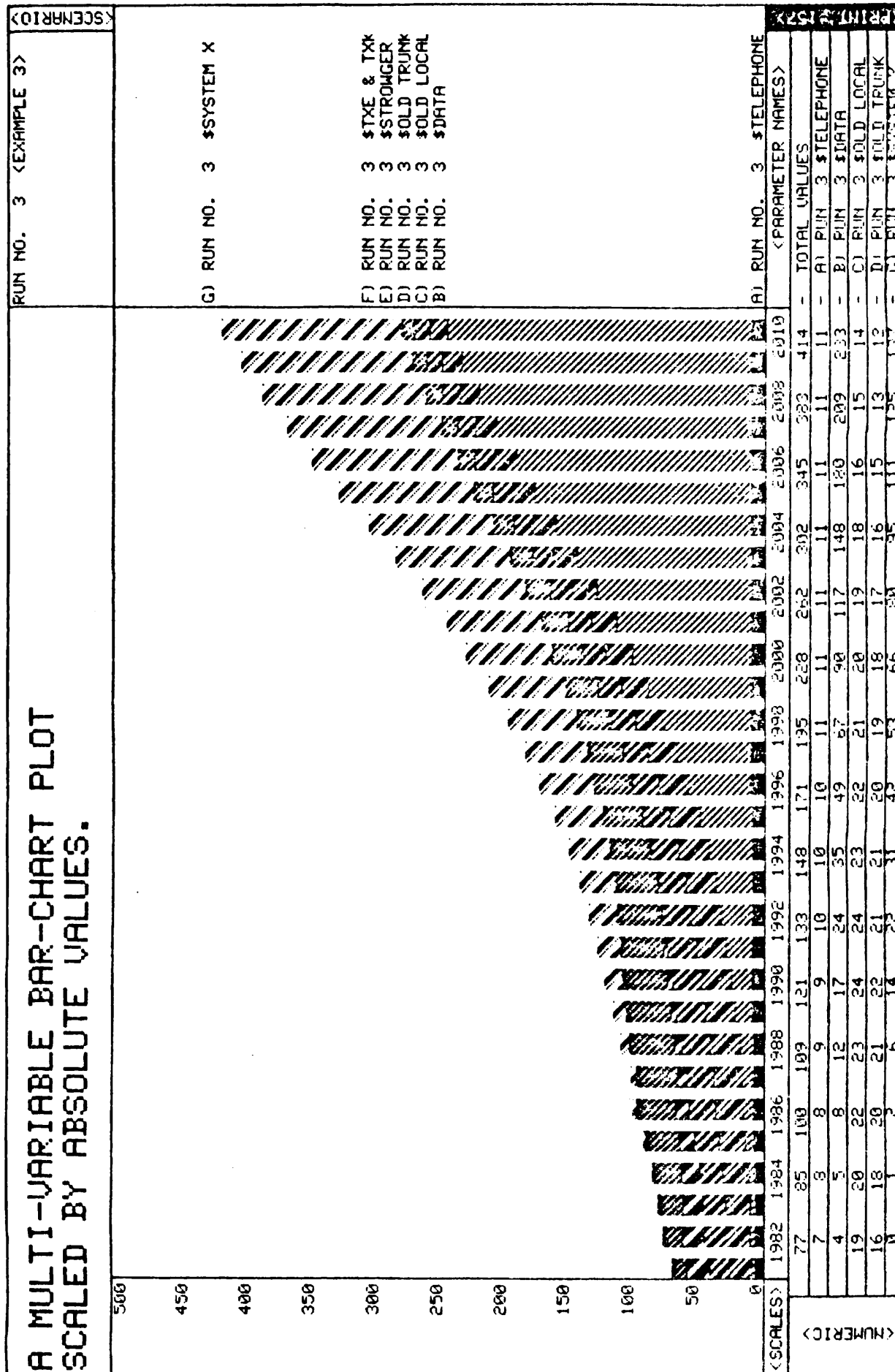
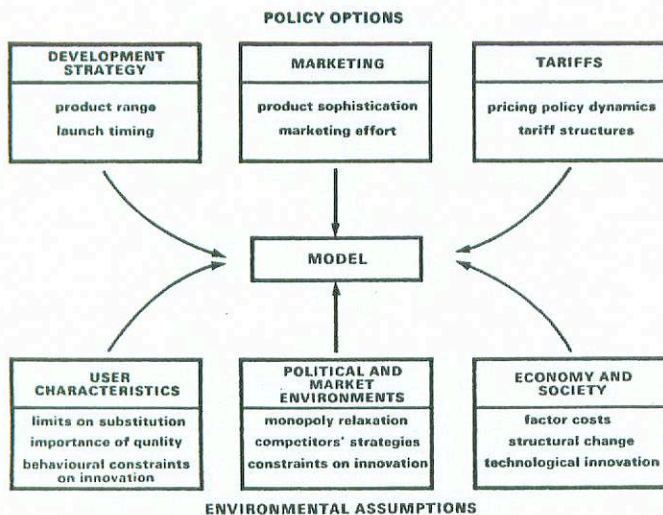


Figure 3D – A Demonstration Plot of BT Capital Assets using a Multi-Variable Bar-Chart.







Use of the model for strategic analysis.

Figure 4C – The Policy Domains and the Environmental Assumptions for the ICDM

- (c) *Political and Market Environments* – The timing of the relaxation of the monopoly and the action of competitors.

TABLE 4D – DEMAND CATEGORIES FOR THE ICDM

(a) "Communication Services"

- |   |                                |
|---|--------------------------------|
| 1. Physical Mail  | 2. Printed Media               |
| 3. Face-to-Face Meetings                                    | 4. Broadcast Media             |
| 5. Audio Communication                                      | 6. Video Communication         |
| 7. Electronic Mail (Messages)                               | 8. Electronic Mail (Documents) |
| 9. Electronic Information (Data Entry/Retrieval – Videotex) |                                |
| 10. Data Communications                                     |                                |
| 11. Electronic Funds Transfer Services (EFT)                |                                |

(b) "Terminal Devices"

- |                             |                                 |
|-----------------------------|---------------------------------|
| 1. Basic Telephone          | 2. Advanced Telephone           |
| 3. Television Monitor       | 4. Videotex Monitor             |
| 5. Teletype Terminal        | 6. Visual Display Unit          |
| 7. Telex                    | 8. Teletex                      |
| 9. Word Processor           | 10. Mini and Micro Computers    |
| 11. Facsimile               | 12. Advanced Facsimile          |
| 13. Viewphone               | 14. Telewriter                  |
| 15. EFT Point-of-Sale       | 16. Telephone and Facsimile     |
| 17. Viewphone and Facsimile | 18. Videotex and Word Processor |

Further categories include other multi-functional terminals

#### 4.3 EXTENSIONS OF RESEARCH INTO COMMUNICATIONS DEMAND

There are two natural directions in which we can pursue further research which are both currently areas of considerable interest within British Telecommunications.

##### 4.3.1 Information Flows within Organisations and the Home

We are intending to extend the demand and generation modules to include a far more detailed representation of the transformation of information flows within the office through the impact of electronic communications media. Over the last few years, a number of consultancies have undertaken market research studies in this area and we intend to develop a module which encompasses such results at a fairly aggregate

level. We shall then proceed to consider the possibly more difficult task of modelling the impact of information technologies within the 'Home of the Future'.

##### 4.3.2 The Impact of Telecommunications on Society

We are also exploring the possibility of enlarging the domains of the generation and demand modules to include a more complete representation of the role of information technologies within society as a whole. We are currently limited in achieving such a representation by a lack of data which gives us the detailed breakdown of information costs within the national accounts. What we wish to achieve is a dynamic representation of the transformation from the industrial economy to that of the information economy. Such a model would explicitly bring out the impact of new telecommunication services on industrial productivity within a wide range of economic sectors.

#### 5. THOUGHTS FOR THE FUTURE

##### 5.1 DYNAMIC MODELS AS THE BASIS FOR BUSINESS GAMES

In BT we are currently exploring how dynamic models can be used by teams of staff each representing different interest groups such as customers, suppliers, BT staff, the Government, and BT competitors. In general, the models described in the literature have been used only by modelling specialists. Through creating the LRPM as the core of some Business game, we hope to enable a wider spectrum of BT staff to gain experience of the analysis of alternative strategic options.

##### 5.2 INTELLIGENT MODELS

The question arises as to how much intelligence we should program into a dynamic computer model. It would be useful, for example, if the model could explain its own derivation of the results it produces since this would eventually lead to increased confidence in the model's structure. In a way we are asking for a means whereby a model can justify its validity to non-specialist users. Recent research into the design of expert systems has been pursuing such aims and it looks as if we can expect applications to dynamic corporate modelling within the next decade. Again, it is of little use increasing the intelligence within a package unless corresponding improvements are made in the user interface. Thus human factors research is also likely to assert its role in such extensions of the art of systems dynamic modelling.

##### 5.3 CONCLUSION

The aim of this paper has been to survey the dynamic modelling methodologies currently used within the Long Range and Strategic Studies Division of British Telecom. Space does not permit us to go into extensive detail concerning the structure and operation of the LRPM and ICDM, and for greater depth the reader is referred to the references at the end of this paper. The organisational turbulence both within British Telecom and its external environment will certainly result in our being confronted with a wide spectrum of new modelling challenges over the next decade.

#### 6. ACKNOWLEDGEMENTS

I should like to thank my colleagues in both British Telecom and at Cambridge University for the many ideas which they

have contributed to this programme of research into dynamic modelling during the last five years. In particular, I wish to express my sincere thanks to Bernie Allenstein (BT), Chris Doubleday (CU) and Geoff Walsham (CU) for many stimulating discussions on the art of computer modelling and

its implementation in a corporate environment. Finally, I wish to thank Dr Jim Cowie, Head of Long Range and Strategic Studies (BT), for his active interest and support for this work, and also Donald Wray, Director of Business Planning and Strategy, for permission to publish this paper.

## 7. REFERENCES

- 1 PROBERT, D.E., 1980, "Aspects of Evolving Systems in Telecommunications Modelling", Proceedings of the IEEE Conference on Cybernetics and Society, October 1980, pp. 452-458, Boston, USA.
- 2 PROBERT, D.E., 1981, "The Development of a Long Range Planning Model for the British Telecommunications Business — From Initiation to Implementation", J. of Opl Res Soc (UK) Vol. 32, August 1981, pp.695-719.
- 3 ALLENSTEIN, B.M. and PROBERT, D.E., 1980, "A Strategic Control Module for a Corporate Model of the British Telecommunications Business". Published in "Forecasting Public Utilities" (edited by Anderson, O.A.), North Holland Press, October 1980, pp.39-58.
- 4 DOUBLEDAY, C.F., 1980. "An integrated Communications Demand Model". Technical Report No. 205, November 1980, Dept. of Control and Management Systems, Cambridge, England.
- 5 ALLENSTEIN, B.M. and PROBERT, D.E., 1982. "The Integration of Business Graphics and Videotex for Corporate Planning: A Case Study". Published in the State of the Art Report on "Business Graphics" by Pergamon Infotech, June 1982, Maidenhead, England.

## EDITOR'S COMMENTS:

*The author has provided as much detail and information concerning this case study as can be reasonably expected given the nature of the commercial security and political sensitivity involved in a project of this kind.*

*Please note that the results shown in the figures provided do not constitute either real forecasts or represent British Telecom policy.*