THE DEVELOPMENT OF A COLOUR GRAPHICS INTERFACE
FOR A CORPORATE MODEL OF BRITISH TELECOM

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ABSTRACT

With the prospect of considerable changes in the field of telecommunications, in 1976 British Telecom (then part of the British post office) commissioned the development of a long range planning model. The LRPM allows the user to interactively alter the assumptions and interrogate the results, thus permitting quick and efficient evaluation of many alternative policies for the next 30 years.

After 30 years in operation and 3500 runs conducted using a simple alphanumeric type display, it was felt that the range of users of the model could be increased by making the form of the output more directly suitable for management interpretation.

The paper describes the development of a colour graphics interface for the model and goes some way to evaluating the relative merits of the old and the new. The development work fell naturally into three phases:-

1. Design of a videotex page editing system.

2. Development of a command structure with menu selection.

3. Design of graphical display options to allow comparison of alternative futures.

The new interface is removing the alienation often felt by users of the model, and seems to bring us one step nearer to 'the model for the manager'.

RÉSUMÉ

En prévision de l'évolution rapide des télécommunications, British Telecom (qui fait alors partie du British Post Office) demande, en 1976, que l'on procède à l'élaboration d'un modèle de planification à long terme. Ce modèle permet à l'utilisateur de modifier les hypothèses et de demander les résultats, par voie interactive, en vue d'évaluer rapidement et efficacement un grand nombre de lignes de conduite possibles au cours des trente prochaines années.

Après trois années d'exploitation et 3500 passages exécutés avec un simple affichage de type alphanumérique, on a pensé qu'il serait possible d'élargir l'éventail d'utilisation de ce modèle en modifiant le format des résultats de façon que les gestionnaires puissent les interpréter plus facilement.

Ce mémoire décrit les travaux de développement d'une interface graphique couleurs pour le modèle en question et tente d'évaluer les avantages relatifs de l'ancien et du nouveau format. Les travaux de développement ont naturellement comporté trois phases:

1. Conception d'un système d'édition de pages pour le vidéotexte.

2. Développement d'un ensemble de commandes à sélection par menus.

3. Conception d'options d'affichage graphique visant à permettre la comparaison de scénarios possibles dans l'avenir.

La nouvelle interface supprime l'impression d'aliénation que ressentaient souvent les utilisateurs du modèle et semble nous rapprocher un peu plus du modèle destiné au gestionnaire.

1. OVERVIEW OF THE LONG RANGE PLANNING MODEL

The LRPM is an interactive dynamic simulation model that combines all aspects of the business. It can operate under a wide range of assumptions thus permitting the analysis of the effects of various strategic issues on the business as a whole in the quickest and most efficient manner. It has been operational for over three years, during which time around 3,500 simulations have been conducted. The program is written in FORTRAN and is about 5,000 statements in length, which are split up into around 50 subroutines. It is currently based on an IBM 3033 time sharing system and takes between 5-10 secs c.p.u. time for execution over a 30 year time horizon, according to the user options which are selected. The LRPM is initialised with data for 1977 and subsequently generates its own future guided by the flexible core of policy parameters.

1.1. Input Options

Considerable effort has been put into the creation of a number of input modules which enable the LRPM to be used in a variety of modes. We shall now discuss the main features of these modes:-

a) Parameter Mode:- At the core of the model are around 400 parameters split roughly equally between the four key component modules - Demand/Supply, Equipment, Manpower, Finance, (see Fig 1). Sets of the parameters may be stored as named corporate scenarios. In this mode the user has access to each individual parameter to specify a value. Typically he will select an existing scenario and alter up to 10 policy parameters relevant to the strategic issue under study. The LRPM is then run for 30 years to produce the results of the chosen policy.

b) Index Mode:- In many studies it was found that certain groups of policy parameters were in constant use. It seemed natural to cluster such parameters to form a small set of 'macro-policy levers' which we refer to as policy indices. Such indices are usually used in preliminary studies when we are confronted with a new issue. The indices are normalised between subjectively chosen extreme values of +10 and -10, with +0 representing no departure from the current scenario. We have so far defined 11 policy indices which are passed through a policy expander to be disaggregated to around 150 policy parameters. The policy indices include aggregate levers for altering market growth, traffic, manpower mobility and

productivity, technology and the rate of modernisation, market share, quality of service, and certain aspects of corporate finance.

c) Control Mode:- This is the most sophisticated mode and yet it is also a natural extension of the index mode. Instead of the analyst adjusting the index settings, the control module itself manipulates their values in order to achieve yearly targets defined on a similar sized set of key output indicators. These include total manpower, new demand, the waiting list, government loans, total connections, market share, total calls, profit and other financial indicators. We have found the controller particularly useful in studies of robustness. The analyst first sets up a series of 'shocks' using the indices which constitutes a form of corporate crisis of a chosen magnitude. The control module is then asked to control the business back to some previously defined, desirable base projection, if this is at all possible. The resulting series of policy index settings (control levers) is of value in formulating contingency plans which would minimise the impact of such crises. The aim is thus to design a corporate future which is both desirable and yet is also robust against unforeseen environmental or corporate 'shocks' so that we have a form of 'ultra-stability'.

1.2. The Core Model   (see Fig 2)

It is split into the same key operational modules as previously defined. We shall briefly describe each in turn:-

a) Demand/Supply:- This models 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 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) 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.
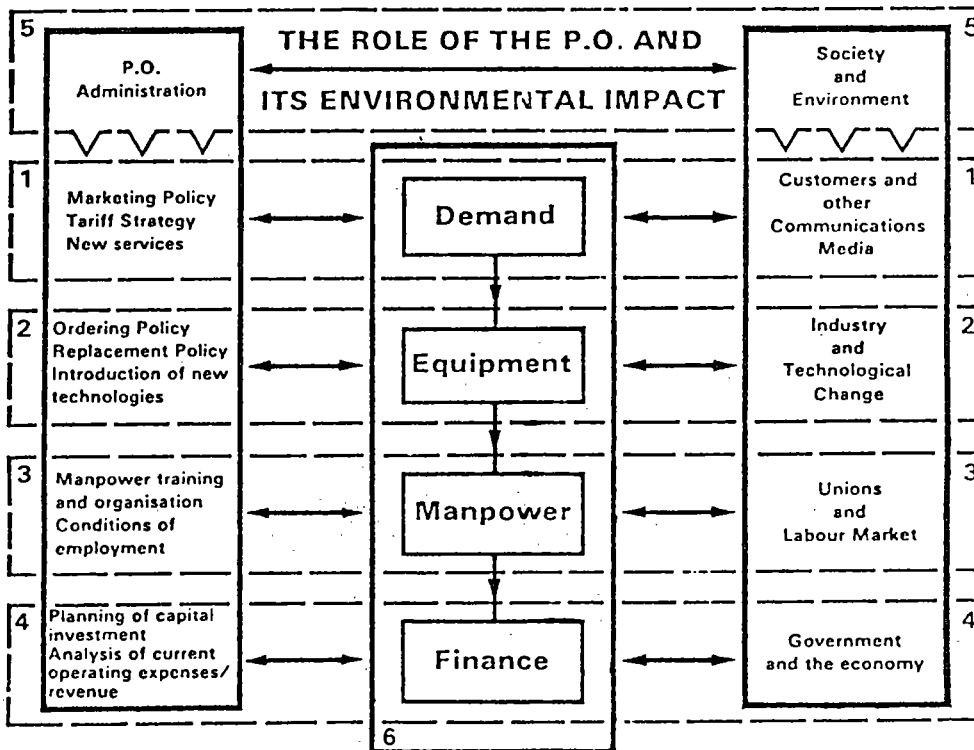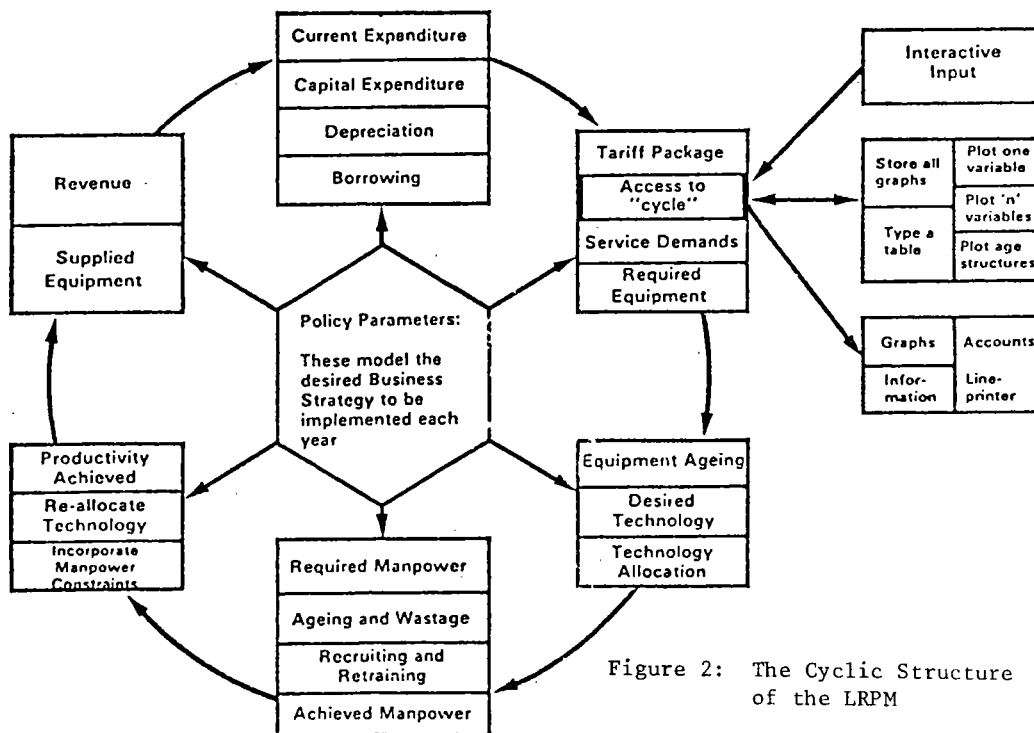
THE ROLE OF THE P.O. AND ITS ENVIRONMENTAL IMPACT

P.O. Administration		Society and Environment
1 Marketing Policy Tariff Strategy New services	**Demand**	**1** Customers and other Communications Media
2 Ordering Policy Replacement Policy Introduction of new technologies	**Equipment**	**2** Industry and Technological Change
3 Manpower training and organisation Conditions of employment	**Manpower**	**3** Unions and Labour Market
4 Planning of capital investment Analysis of current operating expenses/revenue	**Finance**	**4** Government and the economy

Figure 1: The Abstract Foundation of the LRPM

Figure 2: The Cyclic Structure of the LRPM

Current Expenditure — Capital Expenditure — Depreciation — Borrowing

Revenue — Supplied Equipment

Tariff Package — Access to "cycle" — Service Demands — Required Equipment

Interactive Input

Store all graphs	Plot one variable
Type a table	Plot 'n' variables
	Plot age structures

| Graphs | Accounts |
| Information | Line-printer |

Policy Parameters:

These model the desired Business Strategy to be implemented each year

Equipment Ageing — Desired Technology — Technology Allocation

Productivity Achieved — Re-allocate Technology — Incorporate Manpower Constraints

Required Manpower — Ageing and Wastage — Recruiting and Retraining — Achieved Manpower

c) Manpower:- The manpower skills map onto the 10 equipment categories but are split also between construction and maintenance for each technology. A particular features 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.

d) Finance:- This provides comprehensive details of current and capital account expenditures, together with the standard financial indicators. In addition, the Newton-Rapheson algorithm is used to produce a tariff package which achieves the desired financial targets on either profits or real return on assets, as set by the government, subject to imposed constraints on possible tariff movements.

2. THE OLD-STYLE INTERFACE

The previous user-interface of the Long Range Planning Model had two major drawbacks. Effectively one was connected with the input, the other with the output.

The problem with the input developed over the first two years that the model was in use. Gradually, through continued experience and consequent development further facilities were added which presented themselves to the user as an increasing list of options. Options were presented as questions, all of which needed an answer. Questions often concerned the more complex options, and the inexperienced user was just advised to give a standard reply.

This list can be tedious, particularly as, during a series of related model runs, the answers to the majority will often be the same each time. Also, should one accidentally give an incorrect answer, there is no opportunity to change it without going right through the model and starting again; a process which, on a slow terminal, can take five or ten minutes.

The second problem is the form of the graphics output. The output was designed to use a standard alphanumeric terminal. Each line on a graph is plotted using a two letter code to represent the particular business indicator. The letters are plotted alternatively each year on the graph according to the value of the indicator that year. As the model runs, it produces all of the data for each year in turn. Because of this, time penalties in manipulating the data produced, and more general constraints

on character positioning on alpha-numeric terminals, the graphs are plotted across the width of the page with the time axis going downwards. Thus, they are effectively rotated by 90°. These two factors caused considerable confusion in interpreting the results particularly among just the sort of managers at whom the model is aimed. In addition to the form of the individual graphs, considerable inflexibility ensued from the necessity to pre-define the tables that the model produces, and to select the desired tables by code numbers. The increase in flexibility that could be gained by interactively setting up a table to contain exactly that information relevant to the user was considered highly desirable.

In general, these problems caused the impression that the model is very complex to use. This produced a significant barrier to its acceptance and use and it was this fact that provided the main motivation for the recent changes to the user-interface.

There were two basic requirements for the updated interface. First, it should facilitate use by inexperienced users by providing help where necessary, and by not presenting the user with irrelevant details and complicated jargon. It should also be attractive and maybe even 'fun' to use, hopefully so that managers will 'want' to use it and not just feel that they 'have' to do so. The second requirement was to provide a quicker and more convenient mode of use for the experienced user. He will generally know more exactly what he wants and should be able to select his options and set up his input assumptions with a minimum of fuss.

To a certain extent these requirements are incompatible, but it is felt that the new approach does go a considerable way to satisfying both. It is also hoped that as a result of these developments, the model will gain a wider acceptance throughout the business and the modelling group will shed the role of an agency for potential model users and adopt one of advisors to users in many parts of the organisation.

3. THE HARDWARE

Because of declining costs and indications of very widespread use in the near future, it was decided to purchase a colour graphics terminal in order to exploit the latest in readily available display technology. The terminal chosen was the SIGMA T5674, which has four pixel planes for graphics information, together with a variable height alpha-scroll.

In order to aid in presentations of the model, a SIGMA RGB colour monitor was purchased, as well as a grey-scale hard copy unit for producing material for inclusion in reports. The T5674 is available with a joystick control. This is currently used for controlling the cursor in menu item selection, although in the near future it is hoped to replace this with a digitiser pad, (see Fig 3).

The main features of the graphics terminal include a resolution of 768 pixels wide by 512 pixels high. The four pixel planes allow sixteen colours defined in a look-up table. There is hardware vector plotting and rectangular block drawing in either outline or solid mode. All drawing functions may be selected as solid or dashed to a user-definable dash pattern. The terminal allows any binary code to be written to any pixel of a chosen subset of the four planes, thus allowing selective erasure. Additionally, graphics text of 25 different sizes may be written in four rectilinear directions. The terminal does not allow, through its internal facilities, arc drawing, generalised polygons or area colour fill.

4. THE SOFTWARE

The development of the improved interface software fell very neatly into three stages. These are described in detail in the following three sections.

4.1. The Graphics Database

The intention here was to produce a database of pages of graphics information. These should be selectable by a single page number and should be allowed to be of any length.

In order to facilitate the entry of the information, a comprehensive page editor was produced allowing the writing and indexing of new pages, insertion and addition of lines to existing pages, manipulation of the index as well as interrogation of complete pages or individual lines.

There are three basic types of page used. First, simple pages of information and graphics act as a help facility. These may be accessed as appropriate at various points in the interface. Also included in this category are a number of pages which act as a short presentation on the Long Range Planning Model. This was previously given using overhead projector slides. Second, there are the background designs for the dynamic graphics. These

include for instance, grids and axes for output graphs or table outlines for data presentation. The third category comprises the various command menus required through the model. These are described further in the next section.

4.2. The Command Structure

As described above, the old version of the Long Range Planning Model comprised a list of questions regarding options available for running the model. The conversion to a command structure involved the untangling of the various options and structuring in a fashion suitable for selecting through command menus.

Initially, a list approaching 40 commands long was drawn up. From this it was decided that the whole structure should be rationalised so that at any one time, only a reasonable number of options presented themselves to the user. This process lead to the identification of

1. Six basic active commands.

2. Many active commands that all fell naturally under the basic commands.

3. A number of passive commands. These are effectively conditions which have to be set to one of a number of allowable values. These are now called 'status flags'.
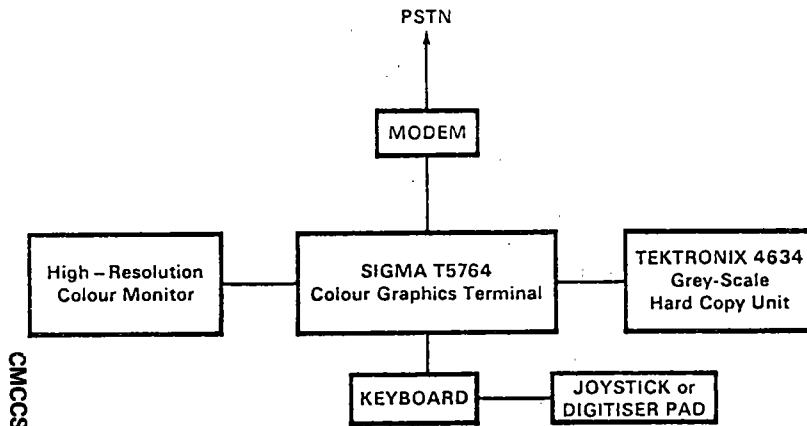
This led naturally to the menu structure now used. The 'main menu' contains the six basic commands together with a command STATUS to access the status flags and HELP and END. A number of these commands led to a second menu for further specification of the command chosen.

All menus contain a HELP command. Selecting this causes a general help page to be displayed for that menu and invites selection of other commands for more detailed help on each. Selecting END returns to the appropriate command menu, (see Fig 4).

The menus are thus arranged in a hierarchy of two levels plus one for the help menus. Three levels is felt to be the maximum that such a structure can usefully support. It has been arranged such that at any time, all commonly used functions are accessible with at most one change of menu. Any more is both tedious and confusing for the user, (see Fig 5).
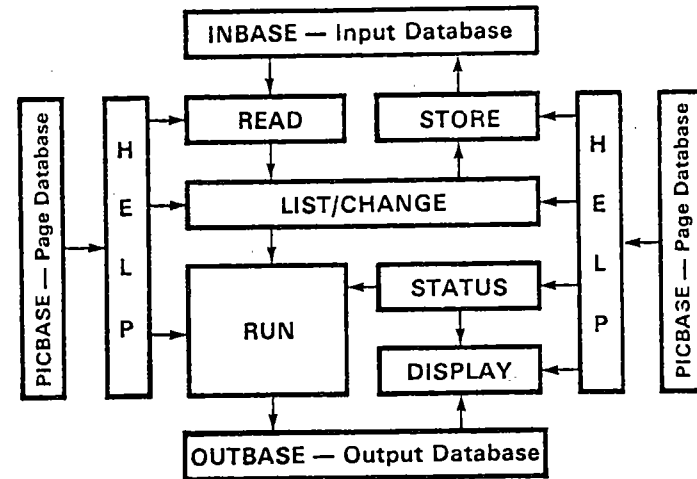
The user should be able to tell at a glance, where in the menu hierarchy he is currently sitting. As an aid to this, the name of each

COLOUR GRAPHICS WORK STATION

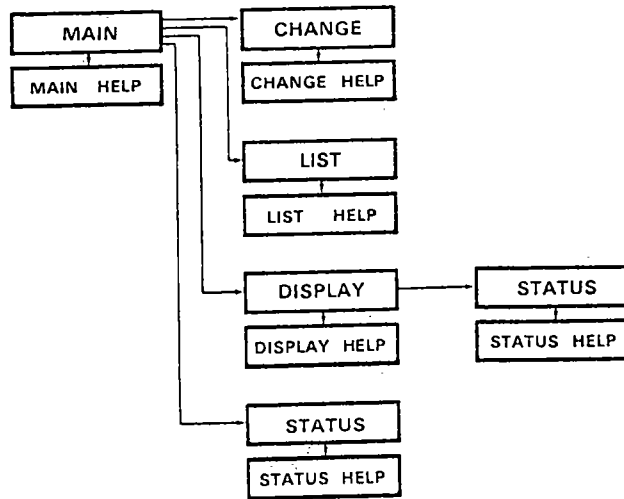## LRPM BASIC COMMANDS

THE MENU TREE

Figure 3: (top left). This shows the configuration of the hardware units which make up the colour graphics work station.

Figure 4: (top right). This shows the commands which appear in the main menu and their relationship within the interface structure.

Figure 5: (bottom left). This shows the hierarchical configuration of the various menus used within the interface.

menu is displayed immediately below it. This helps alleviate any confusion that may arise from certain menus looking identical, eg each menu and its corresponding help menu.

4.3. Display Graphics

The routines within the display graphics module are currently the most advanced aspect of the colour interface.

The corporate model produces results for 120 variables over a planning horizon which is usually set to be 30 years. The nature of long range planning requires us to closely examine and compare the outcomes from many alternative scenarios which will 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 senior 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. We were influenced to some extent in this design by features available on the numerous commercially available packages. However, much of our effort was placed in formulating a framework which would make scenario comparison as straightforward and rapid as possible. This had to take account that we were working over the telephone network to a distant IBM main-frame using computer transmission/reception speeds of 1,200 bits/75 bits per second which is also the same speed used for the Prestel viewdata service. This required us to ensure that the graphics package was robust against transient noise and also that selections from the command menu did not have to be made too frequently. At the end of this design phase we had fixed the screen layout together with the data structure for the output results file. We were now led on to drawing up the list of options to be included within the display menu which we shall now proceed to discuss.

a) Plotting Variables:- The user may select the colour for a plot from the 13 available on the display menu. Two basic options exist for plotting. First, the plot may be a curve or a bar chart. Bar charts may be drawn with selectable width either solid, shaded or outline. Second, the plot may be absolute on predefined scales or as a

percentage deviation from a chosen base projection. The latter facilitates detailed results comparison. Plots may also be switched on or off rapidly in order to isolate the essential details on a graph.

b) Multi-Variable Bar Charts:- A more powerful way to depict such results as capital investment or manpower skill profiles is to plot bar charts incorporating many variables each in a different colour and, possibly, shading pattern. The user may choose either to draw such profiles either as absolute values or else normalised so that, for example, the percentage of each man-power skill is clearly depicted.

c) Rescale Command:- The rescale option allows the user to rescale any variable which is currently displayed. Use of the rescale option first deletes the previous plot for the chosen curve before redrawing it using a selected multiplication factor.

d) Numeric Option:- An area at the bottom of the screen is allocated for the numerical values of the plots on the display. This option may be selected with the plot command or else subsequently as a separate command. Irrelevant numerical values may also be deleted. The values are printed using the colour of the associated plot, as are the scales and labels. This allows easy identification of all features linked with a given variable.

e) Hard Copy Command:- It was decided at an early stage in the project not to use colour copies because of its very considerable expense. In addition many of the graphics are destined for quite large circulation within British Telecom for which a Black/White photo-copying machine is the most efficient means of reproduction. On selection of the copy command the user is invited to type a title to the page. All colours are then converted to white and the page is copied. Dashed lines and shaded bar charts are the default option to distinguish different plots on the copies.

f) Status Command:- This allows access to the status flags, as is often necessary whilst in display mode, without having to return to the main command menu.

g) Wipe Command:- This clears the display screen and resets all screen status flags. It makes no changes to the display options.

Some examples of the display graphics are shown in Fig 6 to Fig 9.

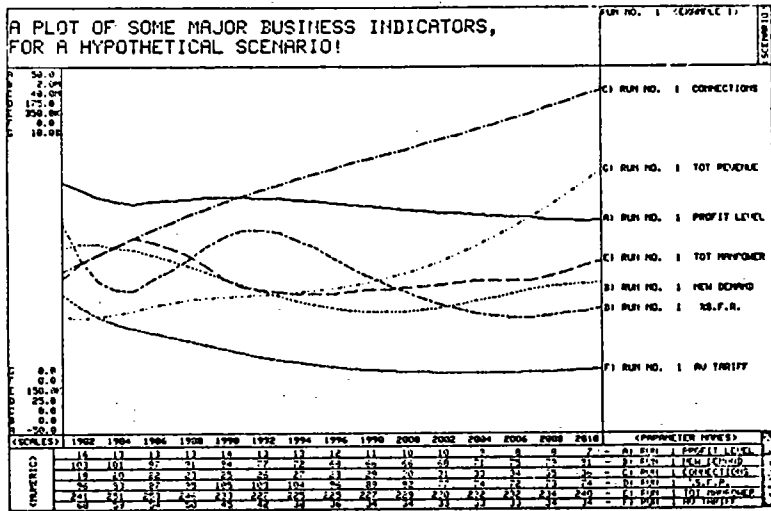Results contained in these graphs do not constitute real forecasts nor do they represent official British Telecom policy.
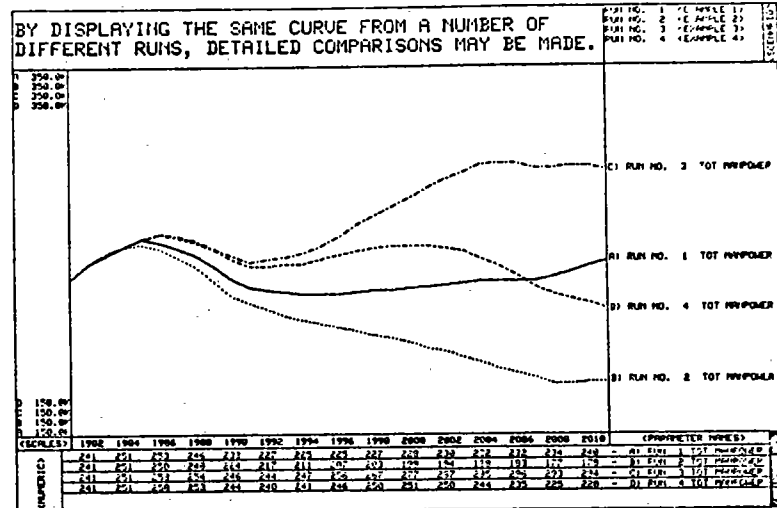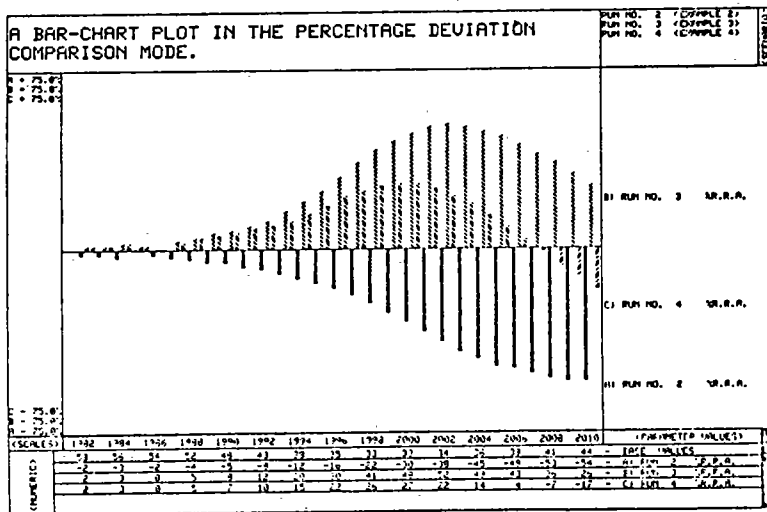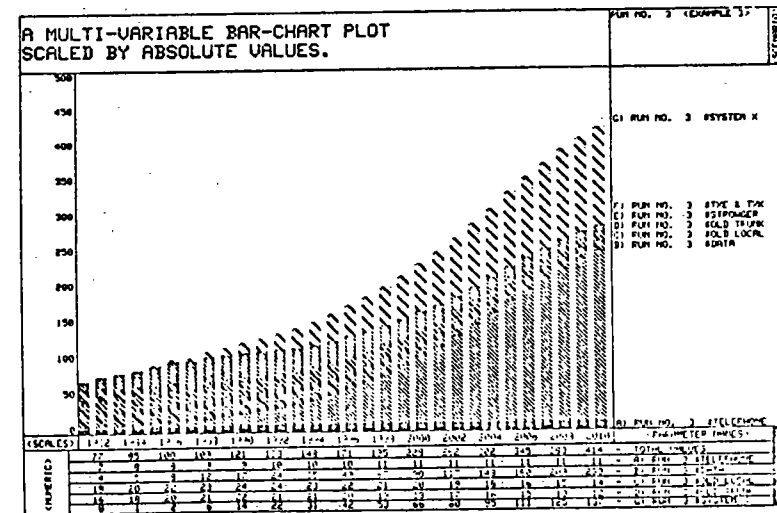
Figure 6

Figure 7

Figure 8

Figure 9

5. COMPARISON OF THE ALPHA-NUMERIC AND COLOUR INTERFACES

The former alpha-numeric interface was used over a period of 2½ years and was in many respects quite successful in presenting vast amounts of information in a quasi-graphical form. However, we now find that colour graphics is far more than just a novel way of presenting information but that to a large extent it provides a considerable enhancement to our understanding of the dynamics of a large corporation such as British Telecom. The one danger is that the quality of the graphics may lead the naive user to suppose that we are able to forecast with precision even 20-30 years hence. In contrast, the crudeness of the graphics in the alpha-numeric interface conveyed an immediate sense of uncertainty when looking into the longer term. However, we have found that the use of bar charts is also a useful way of denoting uncertainty whereas the use of curves seem to imply a higher level of understanding and modelling precision.

Most of the colour graphics options discussed in section 4.3 were not available in the alpha-numeric interface which held tables of graphics in preset formats without any possibility of rescaling or switching selected curves on/off for comparison. However, one feature which was formerly present and which is not lost in the possibility of storing and printing the absolute and comparison graphs relating to all output variables on a remote line printer. Such a 'dump' of the total results was useful for enabling analysts to scan through the full details of each scenario. It is now felt that it is more fruitful to perform such analysis at the terminal in order to cut down on the production of too much unwanted information. We are now working on techniques whereby the computer is able to search through results and bring features of interest to the attention of the analyst as a form of pattern recognition for corporate behaviour. Thus we are attempting to create an 'expert system' which itself can perform a preliminary analysis on the scenario outcomes in which we are entering the domains of artificial intelligence.

6. FUTURE WORK

The next phase in our implementation of the colour graphics interface is the addition of a graphics tablet for menu selection. This will be used in particular for selecting those policy assumptions for which changes are desired and also for the selection of variables for

plotting. The aim is to transform the current input interface for setting up a scenario for the existing sequential question/answer mode to a command input more akin to that for the display graphics. Thus we hope to create a more natural mode of policy selection than the current sequential input allows. In addition we hope to be able to display the key features of a given corporate policy using a screen management framework which has yet to be designed.

Looking to the longer term we will try to demystify the use of dynamic computer models. When we were restricted to using rather unwieldy alpha-numeric interfaces it proved difficult for anyone apart from the modelling specialist to use such computer tools. This can be thought of as corresponding to the age of the telegraph during the last century before the advent of the telephone with its far more natural communications interface. The telegraph systems required a highly skilled operator for the transmission and reception of messages just as the majority of corporate models today require highly trained planners. However, we believe the terminal technology now available can, and should, be used to create user interfaces which may be used to overcome the alienation previously produced by models when presented to management. Thus we see models as developing into forms of intelligent databases within a distributed computer/communications architecture, which may be downloaded to local terminals as telesoftware. In this sense, models are merely an extension of our current and essentially 'dumb', videotex databases which may be used by operational management as a further potential source of corporate insight and information. In summary, we believe that computer modelling has become too closed and specialised, with insufficient attention being paid to creating the 'user friendly' interface, so frequently quoted as a key goal in the literature on CAD/CAM. Computer modelling is actually only an extension of our own 'mental modelling'. Thus, successful implementation can only occur if we devote adequate resources to bridging the gap between the models held by computers and the 'mental models' of the decision makers. Intelligent colour graphics, coupled with a sound understanding of the ergonomics of interactive interface design, should allow us to narrow this gap to a significant extent over the next decade.

The views expressed in this paper are those of the authors and not necessarily shared by British Telecom.