MISTELA- AN INTEGRATED SIMULATION MODEL FOR TELEFONICA DE ESPAÑA SA.

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ABSTRACT[1]

The main objective of the MISTELA model is to integrate the different aspects of strategic planning of TELEFONICA DE ESPAÑA into one single unit. By so doing one is obviously forced to give up many of the small details in order to be able to look at the larger picture. MISTELA uses a systemic approach to construct the model described in this paper, Systems Dynamics was chosen, since this technique permits straightforward combination of different modelling procedures such as statistical inference, calibration by trial and error, linear and/or quadratic programming, etc. To give an idea of the size of the model, it handles about 1,500 equations, definitions and identities. There are some 700 conceptual variables, and because many of these are vectors, in effect there are about 4,000 scalar variables.

GENERAL STRUCTURE OF MISTELA

Strategic planning is by definition a process with a long time-scale. At the same time, planning increasingly implies marshalling a series of complex numerical systems capable of taking into account the many inter-relationships between the objects being planned. As a result, simultaneous equation mathematical models are usually appropriate tools to help build the quantitative support for this planning. The fundamental idea in a strategic planning model is to integrate in a single calculation procedure the essence of each different aspect of the planning process. The model presented here, known as MISTELA[2], is made up of twelve sub-models, each a relatively self contained entity per se. These are:

01 Exogenous variables
02 Prices
03 Demand for access and use
04 Objectives (quantitative business objectives)
05 Construction Investment Required
06 Plant (technology evolution)
07 Personnel
08 Revenue
09 Finance (including Company Accounts)
10 Costs (of Networks and of Services)
11 Financial Results (of Networks and of Services)
12 Investment optimisation.

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1 The model has been realized by Martínez, Silvio; Alvarez, Nelson; Barrón, Antonio; Rayego, Pablo; González, Germán; and Gala, Marta, all of the Quantitative Methods Department of Telefónica de España. Translation by Graham Johnson.

2 MISTELA stands for "Modelo Integral de Simulación para Telefónica", that is Integrated Model of Simulation for Telefónica.

In the following pages a description will be given of the principal sub-models, pointing out in turn each one's principal interconnections with the others. To begin with, Figure 1 gives a global overview of MISTELA, showing all the sub-models. The main thing to note here is the large number of feedback loops between the various parts. In other words, this is a model with a high degree of interrelationship and strong simultaneity.

The Demand sub-model distinguishes between demand for access (that is, connections), and demand for use (that is, revenue earning traffic). A typical schematic can be seen in Figure 2-a. As the figure shows, the relationship between the various access demands (net orders and ceases) is expressed as two behaviour equations, calibrated by statistical inference from monthly data. These in turn determine the identity "net demand".

There is a set of two such equations for each Service Group. Generally speaking the explanatory variables can be grouped into two classes: variables relating to economic activity (GDP, Industrial Production Index, External trade, Tourism, Telephone density etc.) and prices. Furthermore, loss of market share is taken into account exogenously as a fraction of the total or cumulative demand. For each separate Service Group access demand variables are determined in consultation with areas responsible for the servi -

THE MISTELA MODEL

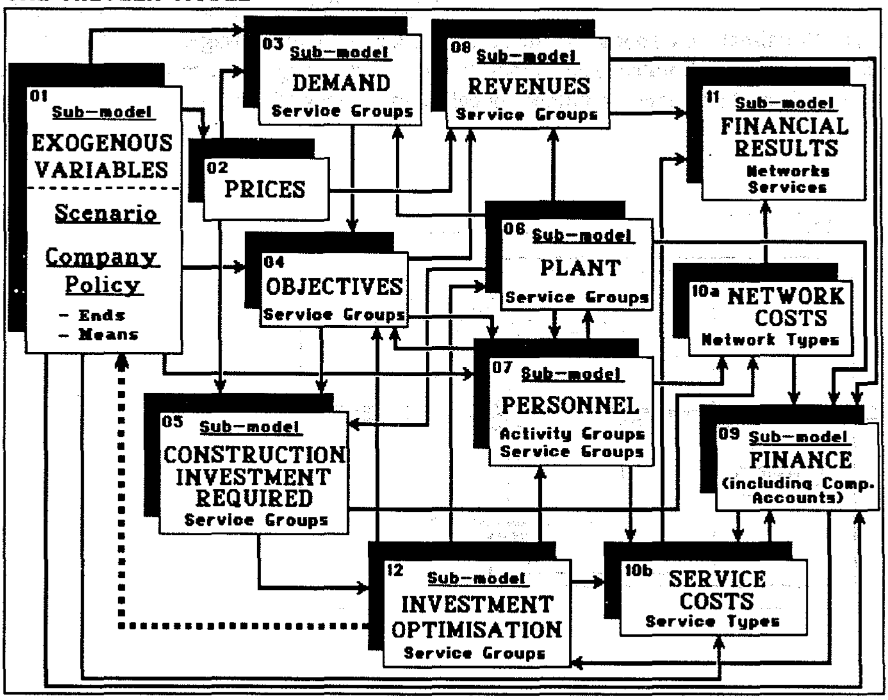
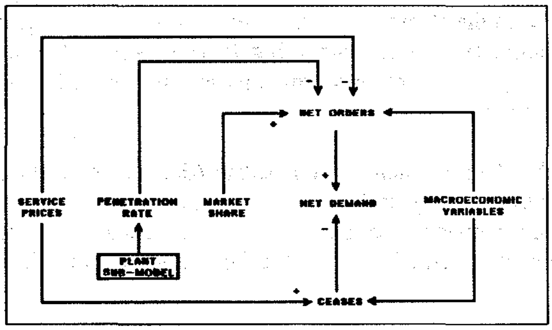


Figure 1

ACCESS DEMAND MODULE



ces, and further ad-hoc studies. Reliance on expert judgement of this kind is particularly important when complete historical data is not available, for example in the case of new products and services. Typical pairs of equations in this part of the sub-model are:

Figure 2.a

$$NETORDERS = f(prices) * MARKET\_SHARE \ldots\ldots [1]$$

$$CEASES = g(prices) * MARKET\_SHARE \ldots\ldots\ldots\ldots [2]$$

The module (figure 2.b) which deals with use, that is revenue earning consumption, contains a section dedicated to telephone usage by Service Group (i.e. Basic Telephony, Packet Switching, Mobile, Calling Office and Coin Operated Phones in Private Premises) and another element for Packet Switching usage. The first part combines stochastic equations calibrated using monthly data (local, long distance and international use for each Service Type)[3] expressed as number of calls and minutes of calling.

USE DEMAND MODULE

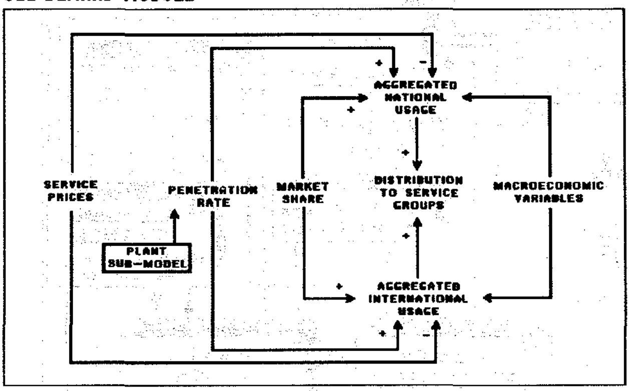
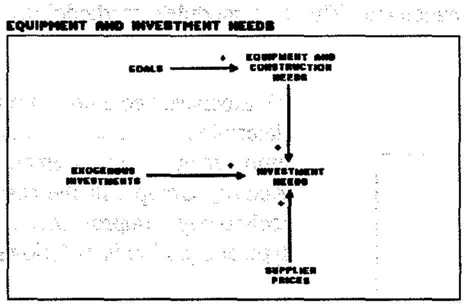


Figure 2.b

[3]Service Type is a more detailed sub-division of Service Group.



The Construction Investment Required sub-model's first task is to "translate" objectives into physical requirements, and then convert these into investment needs by multiplying by the corresponding unit prices. Figure 3 gives the schematic of this sub-model, a typical equation being as follows:

Figure 3

$$INVESTMENT = \Sigma\, EQUIPMENT_i * PRICES_i$$

Figure 4 shows the basic schematic of the Plant sub-model. The basic unit used in this module is the Service Group. The mathematical relationships used in this sub-model are basically level equations[4], typically:

$$CONNEX_t = CONNEX_{t-1} + NEW\_CONNEX_t - DECOM_t$$

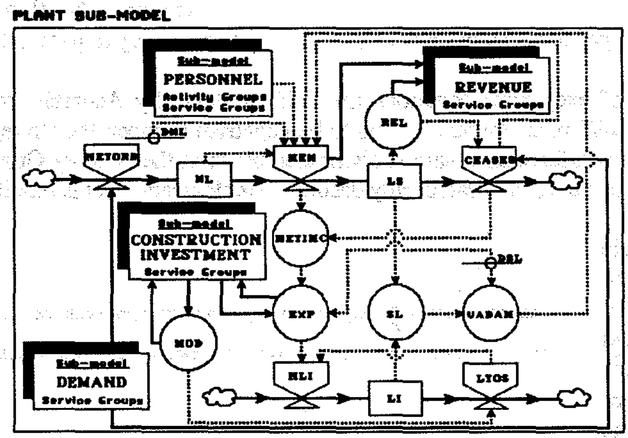


Figure 4

Schematics of the Personnel sub-model are given as an Employment module (Figure 5) and a Personnel Cost module (Figure 6) The first of these deals with workforce size, taking into account

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[4] "Level Equation" is Systems Dynamics terminology for the expression which governs the "level" of stock in a reservoir.

both what is theoretically necessary and what will actually exist. The second deals with the costs of that workforce, in terms of manpower and management. The first module's methodology can be summarised as follows:

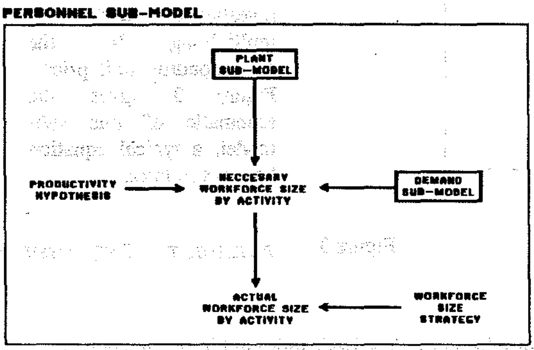


Figure 5

1) Stochastic equations are used to determine the theoretical employment requirements by Activity Group[5], in the absence of technology improvements. A typical equation is as follows:

$$NECE\_WORKFORCE = F(CONNEX, QUAL\_OBJ)$$

2) As the estimating equations were obtained using cross-section data, they don't take account of technological progress. It is therefore necessary to adjust the figures for the workforce necessary using the effects of two sets of variables: firstly, the degree of digitalisation; secondly, in effect exogenously, through the use of time-series tables. This generates adjusted values of workforce necessary to pass to the next stage.

3) Through the use of exogenous equations the total strategically desirable workforce size is established. Then, the difference (assuming this to be negative) between the strategically desirable workforce size and the workforce necessary is distributed between the Activity Groups. In the case where the difference is positive, the strategically desirable employment level is modified downwards.

The second module calculates the costs of the workforce, in terms of manpower and management. It begins by calculating workforce costs according to the following relation:

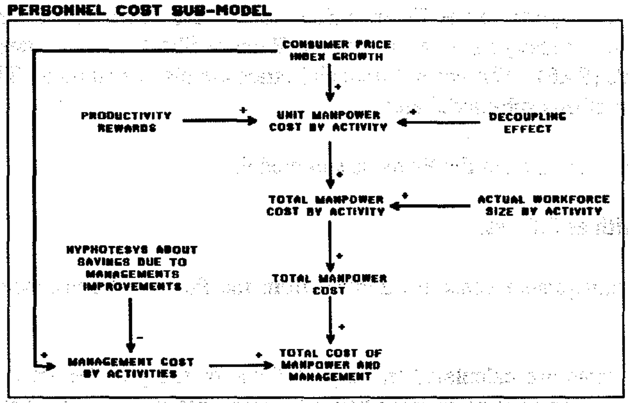
$$MANPOWER\_COSTS = \sum_{K} REAL\_WORKFORCE\_SIZEk * UNIT\_WORKFORCE\_COSTS \qquad [1]$$

$$UNIT\_WORKFORCE\_COSTSt = UNIT\_WORKFORCE\_COSTSt - 1 * CPI * INTR * PRODUC\_INC \qquad [2]$$

Were INTR measures the effect of intrinsic wages cost increases (seniority etc.) and PRODUC_INC captures the effect of salary increases for increased productivity. Management costs are estimated using the following definition:

$$MGT\_COSTSt = MGT\_COSTSt - 1 * CPI * \Delta PLANT * MGT\_COST\_SAVING$$

[5]Activity Group are a cost accounting sub-division of activities, for example, maintenance, administration, etc.



Figue 6

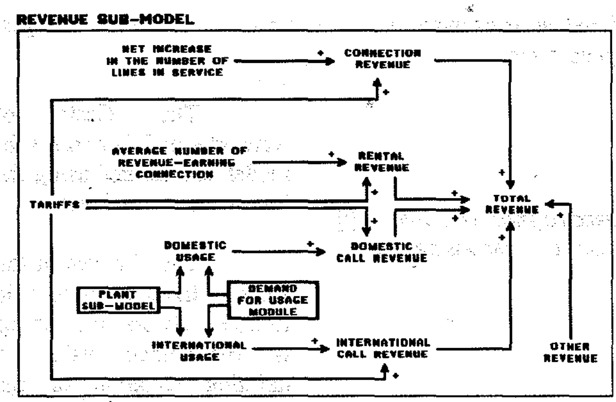


Figure 7

The fundamental objective of the Revenue sub-model (Figure 7) is to calculate revenues earned by Service Type and by tariff item (connection charge, rental charge, maintenance, equipment sales, other sales, etc.). Connection revenues are obtained by multiplying the net increase in the number customer lines in service by the corresponding average prices; rental revenues from the product of average number of revenue-earning connections and average annual rental charge; call revenues by multiplying usage (for telephony: calls in each of the four categories - metropolitan, provincial, inter provincial and international; for packet switching: Packet Switching Tariff Units) by the corresponding average prices. In addition, the revenue from sales and maintenance of terminals is calculated for each Service Group, and also the revenue from radio-paging, maritime services, and directories.

There are three parts to the Finance Sub-model: the Profit and Loss Account (with the same entries as in the company's annual report), the Balance Sheet, and the statement of Source and Application of Funds (SAF). The normal financial ratios are also calculated. The key points which govern the operation of this sub-model are:

1) Operating revenue comes from the Revenue sub-model.

2) Costs are dealt with as follows:

• Manpower and management costs are derived from the Personnel sub-model and its associated costs

• Other operations costs are calculated by varying those of the year before according to the CPI (Consumer Price Index) and the plant evolution rate (measured as an incremental weighted average of the connections installed by Service Group). The possibility of increases less than the CPI and/or the rate of plant evolution is catered for.

3) Further, the value of provisions for exchange losses is given exogenously.

4) Both normal and extraordinary depreciation are taken into account.

5) Lastly, certain variables are considered as exogenous, such as: financial revenues, charges, extraordinary revenue, extraordinary expenses, etc.

The Costs of Networks and Services sub-model are defined using the following expressions:

$$C\_SPECIFIC = C\_PERSONNEL, EXTERNAL, ... + C\_DEPREC + C\_FINAN + C\_ADMIN \quad ....[1]$$

$$C\_PERSONNEL, EXTERNAL, ..._{t} = C\_PERSONNEL, EXTERNAL, ..._{t-1} * \Delta F\_ASSETS \quad ....[2]$$

$$C\_DEPREC = F\_ASSETS * (1/LIFETIME) \quad ....[3]$$

$$C\_FINAN = TOTAL\_FINAN\_EXP * f(F\_ASSETS) \quad ....[4]$$

$$C\_ADMIN_{t} = C\_ADMIN_{t-1} * \Delta F\_ASSETS \quad ....[5]$$

The changes in the value of fixed assets specific to each network and service is determined using a defining equation of the usual type, in this case:

$$F\_ASSET_{t} = F\_ASSET_{t-1} + GROSS\_CAP\_OUT - DEPREC$$

The cost of "purchasing" from other networks is obtained from the following formal relation:

$$C\_PURCH\_NWKS = \sum_{1}^{K} UNITS\_PURCHASED_{i} * PRICE_{i}$$

"Purchases" from services are given by an analogous equation. Networks don't "purchase" from services, so this concept only applies to service costs. Network revenues are calculated according to the following expression:

$$NWK\_REVENUE = \sum_{1}^{L} UNITS\_SOLD_{i} * PRICES_{i}$$

The required margin can be different for each type of network. Clearly, the unit margin actually achieved may not be the unit margin desired. The above relation, in words, says that the "selling price" of circuits of each type of network attempts to reflect the unit cost (networks "sell" - though it would be better to say "rent" - circuits to other networks and to services). This unit cost is obtained by increasing last year's by a cost increase forecast. In time, the margin could become zero or negative.

Different Service Types sell different types of units. For instance the Service Access Network rents circuits, and the Provincial Switched Telephony Network sells minutes of medium-distance telephone communication. These "sales" are made to customers or external users (that is clients strictu sensu) and also to other services, such as Telephone Kiosks and Calling Offices. Fundamental idea is to analyse the problem as a square matrix of inter-relationships between networks and services. Furthermore, the various specific costs mentioned form a matrix of "primary inputs" with customer demand forming a corresponding vector. There are really two sets of relations of this kind: the first expresses a physical trade (links leased or "sold", minutes of use sold, etc.) while the second deals with the financial effects of this trade. These effects are calculated from tariffs and transfer-prices as appropriate.

Lastly, the Investment Optimisation sub-model uses as its optimising methodology quadratic programming, with linear constraints. The squares of the differences of required and possible investment, and of desired and achievable objectives, are minimised bearing in mind the relationships which exist between investment and achievement of objectives, expressed as linear or linearisable equations.

In mathematical terms, using matrix notation:

$$\begin{aligned}
&Min:\\
&1/2*[(I-I_D)]'*[(I-I_D)]+[(I-I_D)]'*[(O-O_D)]\\
&Subject_to:\\
&O=M*I+N
\end{aligned}$$

Where I is the vector of possible investment (about 20 elements) generated as a result of quadratic programming. I_D is the vector of required or desired investment (calculated by Sub-model 5), with the same number of elements as I. O is the vector of achievable or possible objectives, which is also the result of programming (about 10 or 15 elements). O_D is the vector of desired objectives (calculated by Sub-model 4). A is a square matrix which fits I, which, subjectively, allows one type of investment to take priority over another.

BUILDING THE MODEL:[6]

We have selected as the tool to build the model ***MISTELA*** the software ***DYNAMO for WINDOWS 3.1***, because its flexibility to maintain and add new questions and equations, "builder' s reason", and also for its easy use (friendly interface and integrated environment of windows software.).

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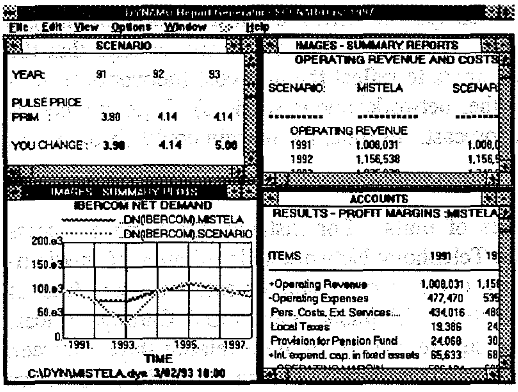
[6] Dynamo for windows is copyright of PUGH ROBERTS ASSOCIATES. Windows and MS-DOS are copyright of MICROSOFT CORPORATION.



When is running the model, it opens *four windows*:

The first is ***decisions***, where you can change the values of variables and build new scenarios in a few seconds. The second shows the results as ***graphics***, and other two as a ***numeric*** display (tables, balance sheet,...). You can include comments and helps about the model everywhere.

The Dynamo can include saved scenarios to compare results with the actual hypothesis. Also you can print, save and export screens to others programmes, fax or files.

The requirements to work with MISTELA are:

A personal computer 286/386/486 with 4 (8 better) Mbytes of memory. VGA resolution.

Software: MS-DOS, WINDOWS 3.1, DYNAMO for WINDOWS , *and* MISTELA MODEL.

DECISIONS AND RESULTS

Main groups of variables which constitute "scenarios" (simulation hypothesis):

1.-Macroeconomic environment

Rate of GDP growth (VIPIB)
Rate of CPI growth (IPC)
Interest rate (INTERES)
Industrial Production Index (IPI)
Tourism (TURIS)
External trade index (COMEX)
Exchange rate (CAMBIO)

2.-Tariffs

Connection charges [7] (CC) & Rental charges [7](CA)
Usage charges (telephony)
- Metropolitan (PRIM & VMETRO)
- Provincial (PRIM & VPROVI)
- Inter-provincial (PRIM &VNACIO)
- International (PRIM & VINTER)

3.-Quality

Waiting list, or mean waiting time [7] (DWL=LED)

4.-Competitive environment

Market shares of connections [7] (PCMPN)
Market sahres of revenue-earning traffic (domestic and international) (ANALY0,...ANALY3)

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[7] By Service Group.

5.-Business Actions

Saving in investment through improvements in management (INVEMAE)
Savings in external purchasing and supplies (EDESL & FCOGO)

Main groups of variables which constitute "images" (simulation results):

1.-Markets

Demand for conncetions [7] (DN)
Demand for use [7] (CONAGS, COINGS)
Waiting list [7] (WL=LE)
New connections [7] (NEW=ALTAS)

2.-Plant evolution

Installed lines [7] (WL=LI)
Lines in service [7] (LS)
Revenue-earning lines in service [7] (RFL=LF)
Lines of spare capacity [7] (SL=VAC)
Degree of digitalisation (DD=GD)

3.-Investment necessary by programme (PRGXX)

4.- Workforce size by activity type (EMPREAL)

5.- Profit & loss account, balance sheet and S.A.F.

6.- Cost accounting by network and service (under revision).

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He is the author of the three books on System Dynamics, and of several other books on Regional and Agricultural Planning.

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Experience in a few Areas of TELEFONICA DE ESPAÑA S.A. during 15 years: Specificator, informatic consultant and support, management, new services designer, documentation writer.

Member in the C.C.I.T.T., in Normalization groups. Inner teacher for the telephon workers.

Reference: SDC93.DOC