# A COMPUTERIZED INTERACTIVE FINANCIAL FORECASTING SYSTEM

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## ABSTRACT

A computerized interactive forecasting system has been developed for the Finance Department at the Semiconductor Products Division of Motorola Inc. While being basic in its operation, the financial forecasting system has permitted the analysis of large amounts of data on a timely basis. Interactive profit and loss forecasting models have been developed which represent the various operating levels of responsibility in the Division in both domestic and international areas. The financial analyst, from a remote terminal, can communicate with the computer to access, update and report forecast data as well as manipulate any or all of the financial models. The forecasting system was designed to place complete control of operation in the hands of the users, and also to provide flexibility in adapting to constantly changing financial forecasting requirements.

## INTRODUCTION

Prior to 1971, all financial forecasts at the Semiconductor Products Division of Motorola Inc. were generated manually. In general, profit and loss forecasts were prepared every month to project financial activity for the next three months, for the remaining quarters in the year, and for the next year. This was done for some sixty operating segments of responsibility within the Division.

Because these forecasts were prepared manually, many problems occurred:

1. The detail that could be considered in a forecast was limited.
2. Excessive time was spent generating and verifying numbers, thereby prohibiting detailed analysis in preparation of the forecasts.
3. Because of the excessive time spent in preparation of a forecast, errors in the forecast or changes in the assumptions could not be adjusted once the forecast preparation was near completion.
4. No valid procedure for measurement of forecast accuracy existed because of the excessive manual efforts required.
5. No historical data base existed which the financial analysts could readily use to prepare the forecasts.
6. Accountants were being used as clerks to run the calculators in order to prepare the required forecasts.
7. Few "What if" questions were analyzed.

The recognition of these problems resulted in the search for a better method. Since the basic forecasting formats could not be reduced due to the requirements of the Corporate Office, it was decided to computerize the financial forecasting process.

Several companies were visited to ascertain how they accomplished their financial forecasting; financial modeling seminars were attended; and a consulting firm specializing in financial modeling was investigated. Following a very thorough study, the decision was made to develop an in-house system which would facilitate interactive financial forecasting.

A system, called the Profit and Loss (P&L) Forecasting System, was developed through the joint efforts of the Planning Administration, the Financial Analysis, and the Management Science Groups. The

aim of this system was to provide a set of interactive timesharing computer models which would depict the P&L structure within the Divisions and which would permit the generation of financial forecasts within that structure.

The specific objectives to be met in developing the P&L Forecasting System were the following:

1. The System must be written in FORTRAN to be run on an in-house GE-430 timesharing computer.
2. The System must provide security.
3. The System must be flexible enough that organizational changes do not require re-programming.
4. It must be easy to set up and change report formats and then generate reports.
5. It must be simple to enter and retrieve large amounts of data from remote timesharing terminals.
6. The System must be general enough to facilitate other modeling efforts.
7. The System must be simple enough to use such that a programmer is not required to run the system.
8. The development and first implementation must not cost more than $25,000.
9. The System must be developed and implemented within 3 months elapsed time (7 man-months).

These objectives which were fulfilled resulted in a general Modeling System which has facilitated the development of other financial and also non-financial models at this Division.

## P&L FORECASTING METHODOLOGY

Each month, a P&L forecast is prepared for the Semiconductor Products Division. This forecast is divided into two major segments, Domestic and International, and is broken out for the next three months, for the remaining quarters in the year, and for the next year. Also contained in this forecast are historical results for the last month and year-to-date. This forecast is prepared at five levels of management under the Domestic and International segments (see Figure 1). Forecasts are prepared for approximately sixty operating segments of responsibility within the Division. Each of the reports contains approximately seventy line items covering sales, direct and indirect costs, and profit categories.

This monthly P&L forecast is a principal operating document for the Division. It provides goals and measures of performance for Division and Corporate

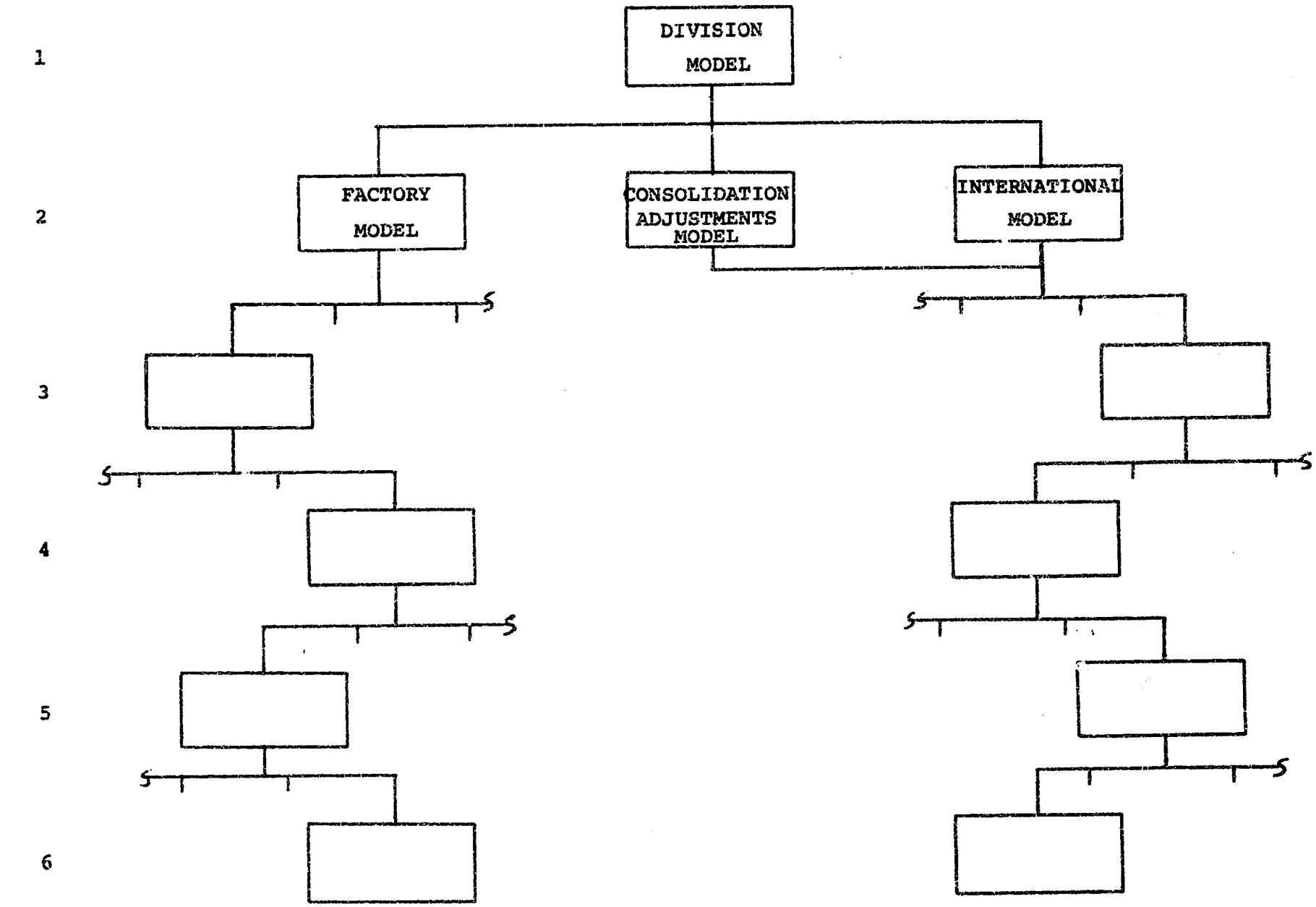



FIGURE 1

P&L FORECASTING SYSTEM MODEL STRUCTURE

management. It is also used for budgetary control.

The preparation of the P&L forecast is complicated by involved consolidation adjustments between the Domestic and International segments. Also, the Domestic P&L's represent complete manufacturing and sales entities while the International P&L's differ in that some represent such things as sales subsidiaries and assembly plants. In addition, actual results and forecasts are received from around the world that must be analyzed and validated as being reasonable. Another complicating factor is that, when a line item is forecast for as many as nine time periods (months, quarters, years), the coefficients in the function relating that line item to another line item may be different for all nine time periods. For some time periods, there may be no relationship at all; instead the analyst must input the forecasted value. The indirect costs provide additional problems in that suitable bases must be maintained to allocate these costs, and these costs must be forecasted and allocated to the various operating segments of the Division. Thus, because of the size and complexity of the monthly forecast and the fact that it was prepared manually using calculators, little simulation of alternate courses of action could be performed.

Furthermore, before the P&L forecast was modeled, many human errors were made which if detected too late, could not be corrected, or which would remain undetected. Also, the forecast required many weeks to be prepared; consequently, many of the figures were invalid by the time the Division forecast was released.

Once the P&L Forecast was modeled, several things have changed concerning the way a forecast is made and the amount of "what if" simulation that can be performed. The financial analyst has more time to prepare the forecast; therefore, more time can be spent in analysis. Also, a historical data base now exists to aid in the analysis and the measurement of forecast accuracy. More detail (more line items and time periods) is now included in the forecast; consequently, management has more visibility. "What if" simulations may now be run at any level modeled within the Division and the impact evaluated throughout the Division.

## THE P&L FORECASTING SYSTEM

Basically, the P&L Forecasting System is composed of a set of FORTRAN programs which are called the Modeling System, and another set of FORTRAN programs called the P&L Model Logic which are linked to the Modeling System to

perform the P&L calculations. The Modeling System is essentially independent of the P&L Forecasting Application; therefore, it can be utilized for other applications.

The Modeling System may be defined as an integrated set of computer programs which provide a user with capabilities for creating a structure of models and associated data files, for identifying and organizing the data within the data files; and for accessing, storing, and displaying the data from the data files. The functions of the Modeling System are very general. The P&L Forecasting System utilizes the Modeling System in conjunction with the P&L Model Logic developed for preparing financial forecasts. A general description of this System is given in Figure 2.

In the P&L Forecasting System, a model is a set of mathematical equations which represent the sales revenues and production costs of a segment of the Semiconductor Products Division such as Domestic Factory. The mathematical equations in a model define line items such as Direct Materials cost. Thus, given an expected sales level for a time period, each model will compute a profit forecast for the segment of the Division that it represents.

The models in the P&L Forecasting System have a specific arrangement, a model structure, defined according to their functional interrelationships. These interrelationships are defined by the management organization and by financial reporting procedures. The typical model structure is depicted in Figure 1. The location of a specific model in the model structure is controlled with a code (model code) associated with each model. Thus, the model structure is flexible and can be easily changed in the management organization and/or the financial reporting procedures should change.

Each model in the P&L Forecasting System has associated with it a model data file which is a location in the computer for storing an array of information. The array consists of rows which contain line items and columns which represent elements (time periods). A model data file organization is application dependent. Figure 3 depicts the typical organization of a model data file used in the P&L Forecasting System application.

The first 26 elements (1-26) of a data file comprise space allocated to history. Elements 27-44 are allocated to forecasts, and elements 45-60 are allocated to parameters used to calculate the forecasts. The parameter used to calculate a particular forecast is stored in the same row and 17 elements to the

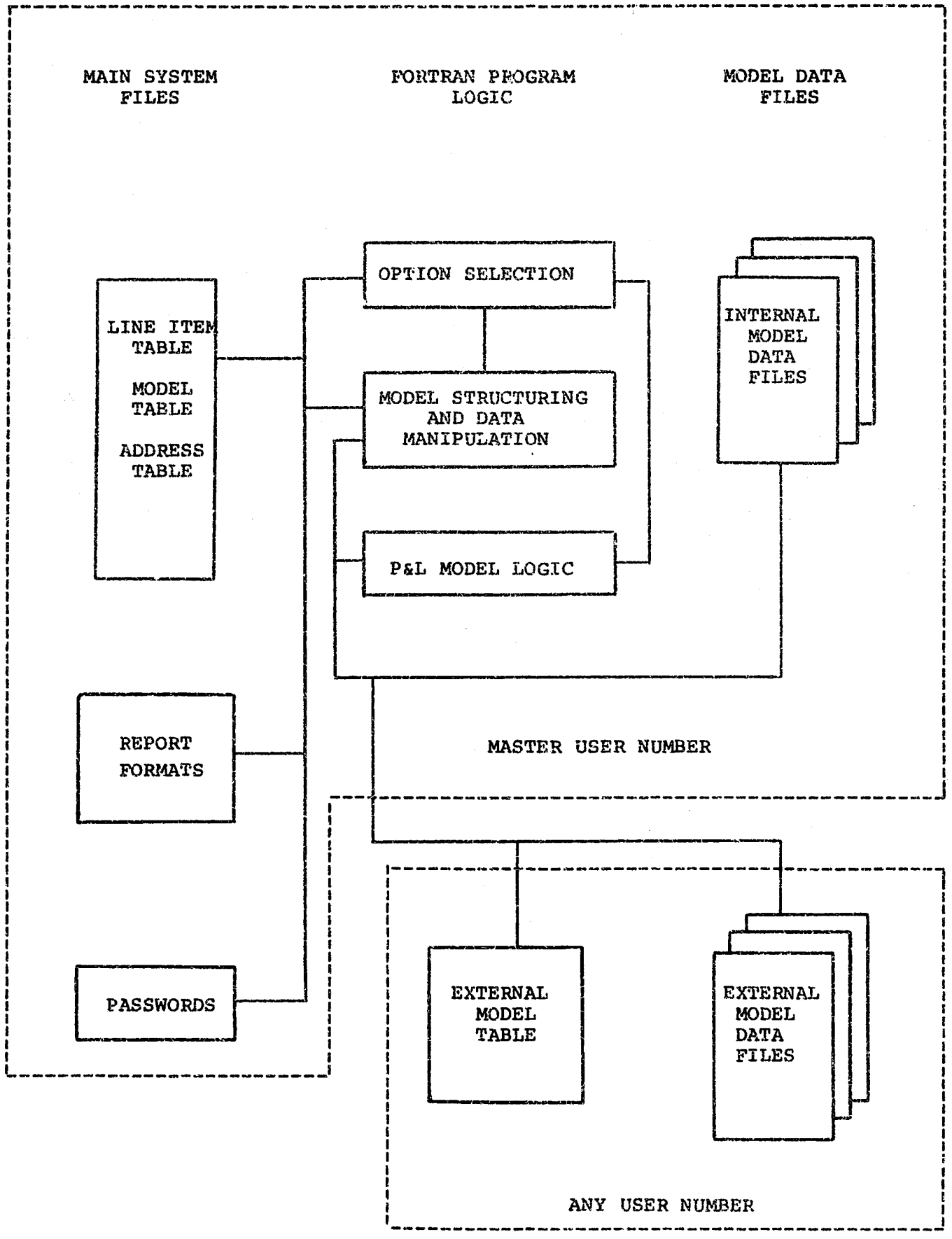
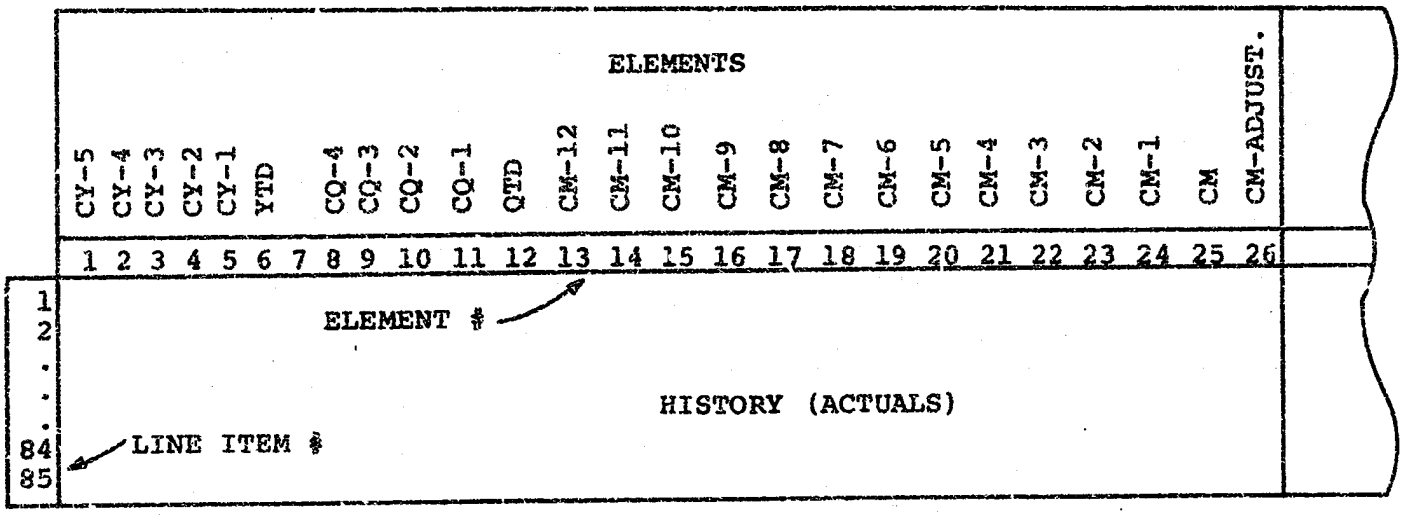
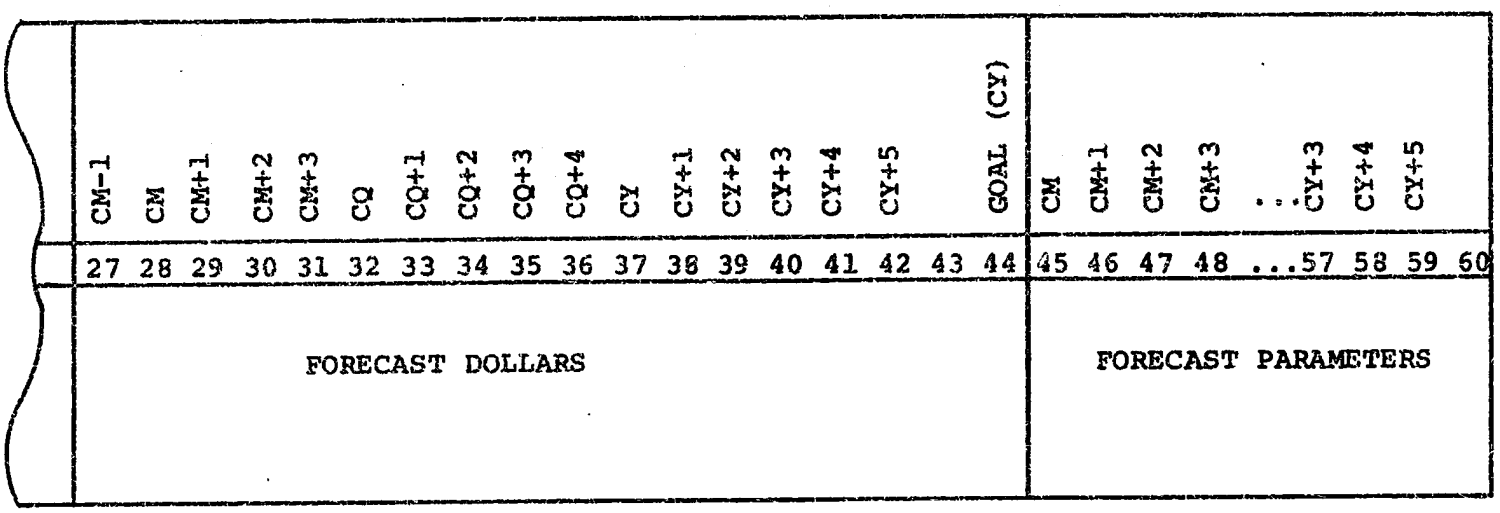



FIGURE 2

P&L FORECASTING SYSTEM CONFIGURATION




CY = CURRENT YEAR

YTD = YEAR TO DATE

QTD = QUARTER TO DATE

CQ = CURRENT QUARTER

CM = CURRENT MONTH

FIGURE 3

MODEL DATA FILE LAYOUT

right. Thus, if element 28 line item 15 contains the forecast for Direct Materials for the current month, then the parameter used to calculate the forecast is stored in element 45 line item 15. Some exceptions are elements 27 and 44 (CM-1 and Goal elements) for which no space is allocated for parameters.

The P&L Forecasting System is maintained under a master user number and is available to users under any other user number provided the proper access privileges have been given. Under the master user number are stored the main system files, the P&L Forecasting System programs, and the internal model data files which contain the master or permanent P&L information.

The Main System files contain information which identifies the line items, the models, and the report formats to be utilized in the operation of the Forecasting System, and also the passwords which provide access to the System for various users. These files are created through the Forecasting System with the exception of the password file which must be generated outside of the System.

A user from any other user number, if given a Modeling System password, may access the P&L Forecasting System. This access allows a user to perform many of the System functions under his own user number. Such a user may duplicate certain of the internal model data files under his user number and then operate on them independently of the internal model data files. These duplicate files are called the external model data files. It is also possible to transfer information back and forth between the internal and external model data files.

## WHAT CAN BE DONE WITH THE FORECASTING SYSTEM

### Modeling System Major Functions

The major functions of the Modeling System are described below:

1. Model Structuring
2. Data Storage and Retrieval
3. Model Execution
4. Report Generation
5. Sensitivity Analysis
6. External Model Capabilities
7. Security Procedures

### Model Structuring

This function entails creating the main system files and initializing their contents as well as providing the user with the facility of building and maintaining a structure of models. The creation of the main system files provides space for storing such things as line item and model descriptions, data file names, record addresses, and model structure codes. This function also

provides the facility for defining and changing line item and model descriptions, creating and deleting model data files, and listing existing line items and model data files.

Data Storage and Retrieval

The inputting, retrieving, and listing of data from the model data files is handled by this function. The data may be input through a terminal or from an existing file. Likewise, data may be retrieved from model data files to be listed at the terminal or placed in a file and listed later at the terminal or at an off-line high-speed printer.

Model Execution

The execution of a model involves executing the model logic (mathematical equations) that make up that model. Values are calculated for a specific time period for the appropriate line items.

In the P&L Forecasting application, some of the functions performed with model execution are:

1. Calculate a P&L for the lowest level model (level 6 in Figure 1).
2. Execute a P&L model above level 6 by executing the associated level 6 models, and calculate parameters for those models above level 6.
3. Calculate a P&L for a higher level model (levels 1-5) without first executing models at level 6.
4. Calculate consolidation adjustments for the Division.

Model execution is a function of the particular application.

Report Generation

The Modeling System permits the analyst to set up report formats interactively through a remote terminal and to write these reports either to a terminal or to a file. If written to a file, the reports can be printed later at a terminal or at an off-line high-speed printer. The report formats may be general with the user specifying what information is to be printed at the time a report is written, or the report can be so specific that the user only specifies what report is to be printed. Once a report format is created, it is saved and may be used again.

Sensitivity Analysis

Management may see the impact of changing the values of variables in the models. This may be done by changing a value in a model data file, then executing that particular model, and then by either listing out values for line items of interest either through a data file

list option or through a report print option. Another way is through a sensitivity analysis option which permits the analyst to specify a range of values for a particular line item that is to be changed and the increments of change. The analyst must also specify the line items of interest for which he would like to see values once the desired model is executed. The sensitivity analysis option does not disturb the contents of the data file associated with the model on which the analysis is performed.

External Model Capabilities

The Modeling System provides the capabilities of creating duplicates of the internal model data files under other user numbers. Data may be moved back and forth from internal and external files as well as between external files. Although anyone with the proper password clearance can move data from an internal file to an external file, only one password is cleared to move data into the internal files from external files. This controls the integrity of the internal data files.

Once external model data files exist, the analyst can perform desired "what if" analysis using these files. This permits extensive analysis with the capabilities of restoring a model data file to the initial status simply by recopying desired data from the internal model data files. Essentially, any analysis and report printing performed with the internal model data files can be performed using the external model capabilities of the Modeling System.

Security Procedures

A user must have a Modeling System password assigned to him. This password gives him access to specific models and options of the Modeling System. Thus, a user may have access to only one model and may only list information from the associated model data file using an external list option (see Modeling System Options), while another user may have access to all models and may manipulate the associated data and generate reports as he desires, using any of the external and internal options.

Modeling System Options

The major functions of the Modeling System are performed by the user specifying an option number when prompted by the System. There are twenty explicit options:

1. Initialize System Files.
2. Update Line Item Table. Permits adding, deleting and changing of line item descriptions.
3. Update Model Table. Permits adding, changing and deleting

of model data files, model data file names, and model descriptions.

4. Construct Report Formats. Permits definition of complete or partial report formats. Input may be via a terminal or a file.
5. List Model Table. Permits listing of a table containing names of all existing model data files and the associated model descriptions.
6. Update Model Data. Permits modifying data in any model data file, one or many values at a time. Also permits duplicating all or portions of one data file in another data file as well as resetting all or portions of any data file to zero. Input may be from a terminal or from a file.
7. Execute Models. Permits execution of model logic, which is dependent upon the application.
8. List Line Item Table. Permits listing of any or all existing line item descriptions.
9. List Valid Models. Permits listing of any or all models validated for the current user.
10. List Model Data. Permits listing of any data in a model data file; one or many values may be listed at one time. Output may be via a terminal or a file.
11. Print Reports. Permits the printing of reports whose formats have been defined throu. Option 4. Output may be via terminal or file with the capability of printing the file using an off-line high-speed printer.
12. Update External Model Table and Move Data Between Files. Permits the creation and deletion of external model files, the moving of data between internal and external files, and the moving of data among external files.
13. List External Model Table. Performs the same function for external models as Option 5 does for internal models.
14. Update External Model Data. Performs same function as Option 6.
15. List External Model Data. Performs same function as Option 10.
16. Execute Models From External Data Files. Performs same function as Option 7.

17. Perform Auto-Sensitivity Analysis. Permits varying any line item for any model over a range of values, executing the proper models, and then listing any desired line items after each model execution.

18. Print Reports From External Data Files. Performs same function as Option 11.

19. Update And Age Model Data. Updates the System time and ages data when the System time changes, i.e., shifts data to the proper elements within the model data file to reflect the correct relative time for that data.

20. Update And Age Model Data In External Files. Performs same function as Option 19.

Example: "What If" Simulation

Assume that for the Model 1, Silicon Transistors, it is desired to vary the Net Sales (line item 10), for the next month (element 28), between the values of $1,000 and $2,000 in steps of $500, and to recompute the complete P&L Statement for each sales value. However, because of the time required to print all the line items, only those specified will be printed, which in this case are line items 10, 15-20, 30, 50 and 82. Along with the forecast dollars, each line item value is computed as a percentage of Net Sales and is listed to the right of the forecast value. It is possible to perform this analysis using Option 17, automatic sensitivity analysis. The analysis is shown in Figure 4.

SYSTEM ACCEPTANCE AND ENHANCEMENTS

The initial P&L Forecasting application was not very sophisticated from a simulation viewpoint, although it did permit extensive "what if" sensitivity analysis. It performed the specific function for which it was developed. In addition, it brought more sophistication to the financial analyst and more accurate and timely reports to management. The acceptance by the users (financial analysts) was greater than expected a the first year billings (storage, connect time, and cpu time) were approximately $75,000 at the GE Mark II billings rate, but much less at the in-house rate.

A significant by-product of this effort was a sophisticated general Modeling System with the following special features.

1. Timesharing random access of data.
2. External model capabilities.
3. High-speed printer output.

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** OPTION ** ?17

ENTER MOD #; ELMNT #; L.I. # FOR ANALYSIS  ?1;28;10

ENTER START, END VALUES; INC; L.I. #S TO LIST
?1000,2000;500;10,15-20,30,50,82

MODEL   1: SILICON TRANSISTORS

ANALYSIS ELMNT 28, L.I. 10, VALUE          1000
FORECAST ELMNT 28

NET SALES                1000    100.0
DIRECT MATERIAL           110     11.0
FRT,SCRP,SHR,&OBS           6      0.6
DUTY                        1      0.1
DIRECT LABOR               80      8.0
DIRECT LABOR BURDN        150     15.0
DIRECT LABOR FRING          3      0.3
COMMITTED COSTS            21      2.1
TOTAL INDIREC COST        124     12.4
NET PROFIT (LOSS)         252     25.2

ANALYSIS ELMNT 28, L.I. 10, VALUE          1500
FORECAST ELMNT 28

NET SALES                1500    100.0
DIRECT MATERIAL           165     11.0
FRT,SCRP,SHR,&OBS           9      0.6
DUTY                        2      0.1
DIRECT LABOR               120     8.0
DIRECT LABOR BURDN         225    15.0
DIRECT LABOR FRING           4     0.3
COMMITTED COSTS             21     1.4
TOTAL INDIREC COST         124     8.3
NET PROFIT (LOSS)          415    27.7

ANALYSIS ELMNT 28, L.I. 10, VALUE          2000
FORECAST ELMNT 28

NET SALES                2000    100.0
DIRECT MATERIAL           220     11.0
FRT,SCRP,SHR,&OBS          12      0.6
DUTY                        2      0.1
DIRECT LABOR               160     8.0
DIRECT LABOR BURDN         300    15.0
DIRECT LABOR FRING           5     0.2
COMMITTED COSTS             21     1.0
TOTAL INDIREC COST         124     6.2
NET PROFIT (LOSS)          578    28.9
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FIGURE 4

AUTOMATIC SENSITIVITY ANALYSIS

4. User-controlled report generator.
5. Selective security procedures.
6. General sensitivity analysis.

The Modeling System has facilitated the development of other financial and non-financial models. This system has been used to develop the following interactive models:

1. Five Year Sales Forecast.
2. Production Control Sales Forecast & Billing Report.
3. Marketing Sales Forecast.
4. Corporate Consolidated Balance Sheet.
5. Budget System.

In addition, a batch version has been developed to run on IBM 360 equipment that is being used in Europe to prepare P&L Forecasts for the European subsidiaries. A batch version was necessary as the Corporation has no timesharing facilities in Europe.

Enhancements are periodically being made to the Modeling System. Statistical routines are being added to aid in forecasting, the report generation and writing has been made more general, and data storage has been made more efficient. In addition, a version is being developed to run on IBM's Timesharing Option (TSO).