SAS® QUOTE: SAS WITH COSTING/PRICING SYSTEMS
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**ABSTRACT**

SAS® QUOTE is a set of programs and procedures developed at E-SYSTEMS, ECI Division, using SAS to access the Division costing/pricing database and process this data to meet many internal and customer decision support and analytical needs. It makes extensive use of the SAS MACRO Language, looping capabilities, PROC TRANSPOSE, and SAS/GRAPH. The potential for growth and additional applications is vast.

1.0 INTRODUCTION

SAS QUOTE is the name given to a set of SAS programs and procedures developed at ECI Division of E-SYSTEMS, Inc. to process data from the Division’s automated cost proposal quote system, ostensibly for output to SAS/GRAPH. Charts and graphs are then produced for price reviews and for submittal to customers. In addition, there have been substantial amounts of by-products of equal value.

E-SYSTEMS is a major developer and producer of advanced technology systems and hardware for the defense and aerospace market. The ECI Division is an acknowledged leader in the design and development of communications and data systems for spacecraft, shipboard, aircraft, and ground installations.

The primary computer resource for management information systems (MIS) is the E-SYSTEMS, Florida Operations IBM Installation, which also supports the Communications Manufacturing and Membcor Divisions. The mainframe is an IBM 3083 Model E Processor which has 16 megabytes of main memory and executes the System/370 instruction set. The Operating System is VM/SP which is currently hosting both CMS and MVS. Software may be developed interactively in one of three environments: CMS, ROSECO, and TSO.

The system presently installed has over 12 gigabytes of direct-access, real disc storage and four multi-density, high-speed tape drives. Work is in process to provide a link between virtual machines of ROSECO, CMS, and TSO.

2.0 FRAME OF REFERENCE

As in all industries, there is a major amount of esoterica which must be examined briefly in order to provide the reader with a cursory understanding of the problems confronting a user within the Defense and Aerospace fields. Accordingly, we will now explore two such subjects: the Work Breakdown Structure (WBS) and the Cost/Price Breakdown.

2.1 THE WORK BREAKDOWN STRUCTURE (WBS)

In most programs, costs are estimated, priced, and managed according to a WBS. Figure 1 illustrates a basic WBS down to Level 2. In practice, the WBS for a major program can extend to Level 6, 7, 8, or even lower. For example, in Figure 1, Level 3 could be used to divide hardware/software design tasks into major equipment types as to type (prime vs support). Then Level 4 could break down into the various equipments to be developed. Level 5 could provide module breakdown, etc. The production tasks could be broken down in a similar fashion.

Figure 2 is another example WBS showing production of four space systems. Here, Total Space Flight Systems is Level 0 and each Flight Unit (FU) is at Level 1. All succeeding references to the WBS in this paper are to Figure 2.

2.2 THE COST/PRICE BREAKDOWN

Cost/Price Breakdowns are necessary for two basic reasons. First of all, in most solicitations from governmental agencies or prime contractors, the customer will request cost breakdowns in a certain format, usually according to types of costs that a contractor discloses in his Cost Accounting Standards (CAS) Disclosure Statement. Figure 3 shows a CAS Disclosure format.
The second purpose of cost breakdowns is to facilitate review of costs prior to submittal of the proposal and management of costs after award of contract. The reason for such an analysis is to assure management that the labor hours, material, and other direct costs (ODC) are proper, reasonable, and in line with what is necessary to perform the contract. In the highly competitive defense electronics industry, this means at the lowest reasonable cost. One way to perform this type analysis would be to display costs and hours by functional departments and business areas as shown in Figures 4 and 5.

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### Figures 4 and 5

**Figure 4**

**Cost Breakdown - Space System Separate Material Costs**

<table>
<thead>
<tr>
<th>Material</th>
<th>FLY UNIT 1</th>
<th>FLY UNIT 2</th>
<th>FLY UNIT 3</th>
<th>FLY UNIT 4</th>
<th>TOTAL FL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>1,450,047</td>
<td>1,375,043</td>
<td>1,375,047</td>
<td>1,375,047</td>
<td>5,975,244</td>
</tr>
<tr>
<td>MAN HRS</td>
<td>150,047</td>
<td>150,047</td>
<td>150,047</td>
<td>150,047</td>
<td>600,047</td>
</tr>
<tr>
<td>COMHRS</td>
<td>289,047</td>
<td>289,047</td>
<td>289,047</td>
<td>289,047</td>
<td>1,156,184</td>
</tr>
<tr>
<td>APE HRS</td>
<td>112,047</td>
<td>112,047</td>
<td>112,047</td>
<td>112,047</td>
<td>448,184</td>
</tr>
<tr>
<td>ENG/HRS</td>
<td>345,047</td>
<td>345,047</td>
<td>345,047</td>
<td>345,047</td>
<td>1,380,184</td>
</tr>
<tr>
<td>MBAHRS</td>
<td>586,047</td>
<td>586,047</td>
<td>586,047</td>
<td>586,047</td>
<td>2,344,184</td>
</tr>
<tr>
<td>ODC</td>
<td>112,047</td>
<td>112,047</td>
<td>112,047</td>
<td>112,047</td>
<td>448,184</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,612,047</td>
<td>6,612,047</td>
<td>6,612,047</td>
<td>6,612,047</td>
<td>26,448,184</td>
</tr>
</tbody>
</table>

**Figure 5**

**Cost Breakdown - Space System Separate Service Costs**

<table>
<thead>
<tr>
<th>Service</th>
<th>FLY UNIT 1</th>
<th>FLY UNIT 2</th>
<th>FLY UNIT 3</th>
<th>FLY UNIT 4</th>
<th>TOTAL FL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA STEP</td>
<td>21,047</td>
<td>21,047</td>
<td>21,047</td>
<td>21,047</td>
<td>84,047</td>
</tr>
<tr>
<td>PROC SORT</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
<tr>
<td>SAS MACROS</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
<tr>
<td>PROC FOCUS</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
<tr>
<td>PROC GPRINT</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
<tr>
<td>PROC PRINTTO</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
<tr>
<td>PROC TRANSPOSE</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>12,047</td>
<td>48,047</td>
</tr>
</tbody>
</table>

3.0 E-SYSTEM, FLORIDA QUOTE REPORT SYSTEM

The E-SYSTEMS, Florida Operations Quote Report System (1) has evolved over a span of 10-15 years, into what is generally regarded as a very flexible, efficient system for inputting cost data (labor hours, material, and ODC) into the computer. Labor rates are applied to the hours and the various overhead rates and factors are applied to arrive at the total selling price, including profit. Reports at any level of the WBS are available to facilitate review, analysis, proposal submission, and negotiation of contracts. Written in COBOL, the Quote System uses packed decimal format.

Raw cost data may be input into the quote report system either by key punch, for large amounts of data, or from the terminal using the ROSCOE Programming Facility (RPF) interactive panel entry feature in MVS. This RPF program (MB.QUOTE) provides the price analyst with a conversational tool by which to input, shift, and change cost data and also to order reports for reviewing by terminal screen or by hard copy.

One of the reports output by the MB.QUOTE System provides cost data for use with SAS QUOTE in preparing SAS/GRAPH charts, plots, and graphs for presentations, untouched, as the saying goes, by human hands, obviating the typing process. The role of SAS QUOTE in processing this data is the subject of this paper. But, first, we will examine the SAS connection.

4.0 THE SAS CONNECTION

If an objective survey were to be made of all producers within this industry, E-SYSTEMS, Florida Operations would have to rank as a very heavy SAS user. In the past five or six years, there has been a plethora of applications developed for use in such fields as production control, reliability, procurement, cost control, pricing and estimating, etc. In fact, Figures 1 and 2 were produced with PROC Hier, and this entire paper was drafted using File Print.

Because of its flexible data formatting capabilities, SAS is used in the retrieval and presentation of data from the Florida Operations Quote Report System. Although many applications for descriptive or inferential statistics exist in costing/pricing, (e.g., standard error of the estimate, regression analysis, probabilistic risk analysis, etc.) SAS tools used with SAS QUOTE are mainly from the data retrieval, transformation, maintenance, manipulation, graphics, and report writing arena as follows:

- **SAS DATA STEPS**
  - PROC SORT
  - SAS MACROS
  - PROC FOCUS
  - PROC GPRINT
  - PROC PRINTTO
  - PROC TRANSPOSE

Jobs are submitted in batch and run under MVS. If only graphs or bar charts are required, temporary SAS datasets suffice; however, if the data is to be used with PROC GPRINT or with customized costing/pricing models, then permanent SAS datasets are created and stored in SAS data libraries on disc volumes. These datasets can be accessed via ROSCOE in batch, or via CMS for interactive or batch processing.

The next part of this paper deals with submitting a batch job to write SAS datasets on disc. Then, we will examine how this data is retrieved.

5.0 THE DATA STEP

An abridged version of a program used to translate data from the quote system for SAS/GRAPH and customized cost models is seen in Appendix 1.

Note that the JCL contains instructions for the disc volume on which to write permanent SAS datasets to be retrieved in subsequent operations.
The **INFILE** statement, prior to the **INPUT** statement, identifies the data from the external quote report data file mentioned earlier. The **INFILE** statement and the **JCL DD** statement after the program link the program and the data.

The **INPUT** statement identifies each portion of data from the quote output as shown below in Figure 6. Note that the total WBS occupies columns 1-18 and must be character, whereas the LI-L5 variables must be numeric. This is necessary as LI-L5 are index variables used in iterative execution of "DO LOOPS" which break out costs at various levels of the WBS. In the example shown, Level 6 contains characters as it is used for another application in the quote system.

The other variables in the **INPUT** statement are cost element (CE), identifying the type of cost, hours (HRS), and direct costs (DIR).

![Figure 6](image)

**SAS MACRO LANGUAGE**

Next all the macro definitions are found. Even a cursory examination of the program listing will reveal that SAS QUOTE relies extensively on the SAS Macro Language. You will see shortly that iterative processing of the **DO** loops would be extremely cumbersome without the use of macros.

### 7.0 BREAKOUT OF COSTS USING ITERATIVE DO LOOPS

Figure 7 shows a representative Level 1 subsetting **DO** loop. Of course, dataset QX must have been sorted by the **BY** variable, in this case LI.

The statements setting up the character variables W23, W24, W25, W26, are required to permit transposing the data set, as addressed in the next paragraph.

Next you will find the **DO** loop statements. Now you can understand why the LI-L5 variables mentioned earlier had to be numeric format. They are index variables to control the looping of the **DO** loops, and, as such, must be numeric.

![Figure 7](image)

**PROC TRANSPOSE**

PROC Transpose is necessary for two very important reasons. First, the cost breakdown requires that variables be listed vertically. Without Transpose, variables would be displayed horizontally.

Second, by transposing the datasets about the character ID variables set up in the previous step, something wonderful happens (If I may be permitted to depart briefly from the cool, crisp prose of a technical paper). That something wonderful is that, because former observations are new variables, we can now consolidate WBS items merely by adding them together in any manner we choose. We can also subtract one from another. In fact, we can factor them or operate on them as one would with any variable. Please refer to figure 8.

![Figure 8](image)

**PROC TRANSPOSE**

PROC Transpose takes place at each level of the WBS. We see, in Figure 8, only Level 1. The variable names are dropped, and we will now address them by labels set up by **ZMACRO LAB**. By convention, transposed datasets have "TR" as the first two letters of their names. Note that the ID character variable WB conforms to its WBS identity and that cells have been created that may subsequently be callerd out in other expressions. Here again, note the **TR** macros. By referring to the program listing, we can see that these macros control the type of cost breakdown.

### 9.0 CREATION OF PERMANENT SAS DATASETS

Permanent SAS datasets, containing all the various WBS items (cells), effectuate quick retrieval of this data for SAS/GRAPH or cost/price models. The data may be accessed by another batch operation (MVS) or interactively (CMS).

The first step in the creation of permanent datasets in a SAS library is to merge all levels (or those levels that may be required) of a given breakdown in one dataset as shown in Figure 9. One subsetting data step is required for each breakdown format. Obviously, we cannot mix cells from different formats.

![Figure 9](image)
Figure 10 shows how permanent datasets may be stored on disc. The first 3 letters make up the first of a two-letter name and conform to the DD Name in the JCL.

10.0 PRICE/COST MODELS AND CUSTOMIZED REPORTS

The purpose of all of the preceding steps has been to write transposed SAS datasets in a SAS library on disc. As this operation may take as long as 3-5 minutes, it is usually best to do it in batch. The process of accessing these datasets to roll up costs is usually performed in a second step using a SAS QUOTE program referred to as a cost/price model. Accessing the datasets may be done interactively or in batch. The examples in this paper have been prepared using batch MVS and RSCOE.

A means for preparing customized reports is necessary because data requirements differ from one proposal solicitation to another. It is impossible to anticipate each potential requirement through applications programming. Customers tend to appreciate extra effort in fulfilling their needs. Flexibility is paramount, and SAS gives us this flexibility.

A cost/price model always eases the process of analyzing and preparing cost proposals. In some applications, such a model is a sine qua non. The examples used next should convince you of this point.

Let us now refer back to Figure 2; the WBS for the 4 Space Flight Systems. The total price for the four flight units is $16,239,986, as can be seen in Figure 3. The customer tells you that he doesn't have $16,240, but can scrape up some amount two or three million dollars less. He asks you to develop alternate scenarios that will put you within range.

One such scenario would be the multi-year procurement, one of the classic methods used in such situations. In this scenario, parts material used in producing the flight units, sizing to mature with Flight Unit 1, the prototype. The scenario we choose combines material buys for Flight Units 2 through 4.

Now refer to Appendix 2, which is a listing of the program used as a cost and price model for this exercise.

Note that the JCL contains instructions for the disc volume from which the SAS datasets are to be retrieved, the same DD Name with which the data was written. Note the same section for SAS macro definition seen earlier.

The first Macro definition is %MACRO WBS which is used to modify the WBS. Here we will change the WBS to allow us to break out the material costs based on a combined buy for each of Flight Units 2-4 and substitute the lower costs of a combined material buy. See Figure 11.

The variable TFL is the sum of each of the flight units. Refer to Figure 7, the DO Loop, to review the derivation of the variables W23, W24, W25, and W26. Fortunately, we were used enough to provide for this exigency when we made up the lower levels of the WBS. We proceed to break out the material costs, W23M, W24M, W25M, and W26M, in %MACRO WBS. Having done this, we arrive at the production costs W23P, W24P, W25P, and W26P, by subtracting material costs from each of the total flight unit costs.

In place of separate material buys for Flight Units 2-4, we substitute the costs for a combined material buy (W040) obtained from a procedure similar to that employed in the first step, but on a much smaller scale. W040 is introduced into this problem when we merge permanent datasets (See Figure 12).

The effects of these and the rest of the WBS revisions are seen in Figures 13 through 15. In actual practice, we would perform this and every other reasonable "What If". Only one is shown and that entails combining the purchase of parts (material) for Flight Units 2-4, thereby yielding a reduction in price from $16M (Figure 3) to $14M (figure 15).

It should be noted that, at this point, we could also introduce other data such as actual job order costs which can be formatted the same way. SAS is also used at E-Systems, Florida, for accessing Master job order files (2).
11.0 PRODUCING PRICE REVIEW CHARTS WITH GPRINT

SAS/GRAPH charts for price reviews or submittal to the customer may be produced very easily by adding the proper JCL and SAS/GRAPH statements to the cost model that was discussed in the last section.

There should be a separate unit for each slide to be produced in a single job or else the GPRINT's will replicate. Following is the JCL:

```
Figure 14 and 15 show price review charts made with PROC GPRINT, accessing data in the same manner as was seen with the cost/price model.

Following are the SAS statements used to create Figure 14:
```

```
12.0 PRODUCING FOLKLQAD CHARTS WITH GCHART

SAS/GRAPH is used to produce various vertical and horizontal bar charts from the quote data file directly.

The following statements will produce folkload and hour charts as seen in Figure 16 and 17:
```

```
13.0 PRODUCING EXPENDITURE CHARTS WITH GPLOT

Figure 18 shows the expenditure schedule of the SAS QUOTE Space Systems as proposed and the alternative scenario wherein material is combined for systems 2 through 4.

Note that proposed expenditures exceed the funding available at the end of the program, whereas the combined scenario puts us within negotiation range.

Expenditure charts are produced using a specialized cost model that is a subset of the same program used in the translation of data from the quote report system to SAS/GRAPH. Monthly cost expenditures are formed from the total cost plus fee calculation and broken out by month. These monthly figures are then "cum'd" and plotted as shown in Figure 18.

The expenditures in Figure 18 include material as vendor billings. In actual practice, financial exposure (commitments) and financial risk (termination liability) would also be shown in order to facilitate the financial management of the program.
14.0 SUMMARY: THE PROMISE OF AN EVOLVING PRODUCT

To computer purists, there is, at once, something sublime about a process that causes the conversion of raw data directly into charts and graphs, suitable for formal presentation without typing or manually entering the presentation data. That this conversion occurs and manifests itself in "living color", alone, proves its worth.

For pragmatists, the satisfaction of having used these same aids in a well-received presentation to top management is also conclusive that these systems more than pay for themselves. There is also nothing quite like the sense that one derives when a customer realizes, from the charts, that he is getting a fair and reasonable price. Professionalism is, indeed, enhanced.

Yet, what we have seen in this paper are mere scratches in the surface. There is a vast potential for SAS applications in other WBS-oriented disciplines as cost/schedule control systems and project control/critical path (CPM/PERT) systems that might benefit from customized reporting. Also the use of other SAS products, such as SAS/ETS \(^{16}\) with its econometric time-series capabilities, would also enhance MIS capabilities.

It is good to be where the action is!

REFERENCES:
1. M.S. Bogart: 'E-SYSTEMS Computerized Quoting System'
2. R.C. Morris: 'SAS Access To Master Files'

APPENDICES: (Both Abridged)
1. Program Listing: SAS QUOTE Data Retrieval
2. Program Listing: SAS QUOTE Data Retrieval

For additional information contact:
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