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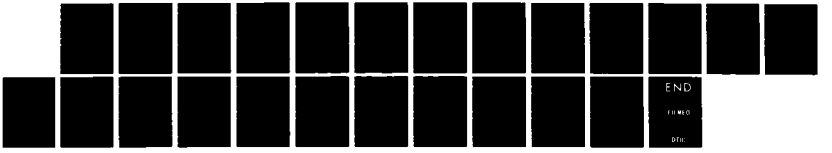

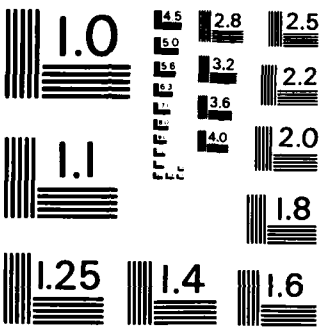

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COSTCASTER, COST-PREDICTION AND TRADE-OFF MODEL FOR AIR FORCE GROUND C-E EQUIPMENT: MICROCOMPUTER FEASIBILITY STUDY

by

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Gregory J. Zunic

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Applied Research in Statistics - Mathematics - Operations Research

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I. INTRODUCTION

COSTCASTER, a cost-prediction and trade-off model being developed by Desmatics, Inc. under Air Force Contract No. F33600-82-C-0466 is intended for use as a decision aid in determining whether to retain, modify, or replace Air Force ground communications-electronics (C-E) equipment. Specifically, COSTCASTER is designed to provide the user with: (1) forecasts of future operating and support (O&S) costs at the Type Model Series (TMS) level and (2) estimates of savings associated with potential modification/replacement decisions. The forecasts will be based on historical O&S cost data obtained from the C-E subsystem of the Air Force VAMOSC system [3]. This report describes Desmatics' investigation of the feasibility of implementing the COSTCASTER methodology on a microcomputer for use by the Air Force.

The methodology underlying COSTCASTER is described in detail in Desmatics Technical Report No. 118-4 [1]. A second report, Desmatics Technical Report No. 118-8 [4], describes computer programs which incorporate that methodology. These programs, which are prototypes developed to demonstrate the feasibility of the COSTCASTER methodology, have been implemented on a large IBM mainframe computer using a small sample data base.

Desmatics was also tasked with examining the feasibility of implementing COSTCASTER on a microcomputer. This investigation

consisted of an examination of various microcomputer software and hardware alternatives, including the Air Force standard microcomputer, the Zenith Z-100. As part of this effort, Desmatics has developed a prototype version of COSTCASTER on a Z-100 computer using Lotus Development Corporation's 1-2-3 software.

Section II of this report outlines the microcomputer hardware and software requirements which Desmatics considers necessary to implement the COSTCASTER methodology outlined in Desmatics Technical Report No. 118-4. Section III provides a discussion of various software packages and presents the software and hardware configuration which best meets the criteria outlined in Section II. Section IV gives a description of the prototype microcomputer version of COSTCASTER developed by Desmatics. Finally, Section V presents Desmatics' conclusion regarding the implementation of COSTCASTER on a microcomputer.

II. REQUIREMENTS FOR IMPLEMENTING COSTCASTER

The COSTCASTER methodology outlined in Desmatics Technical Report No. 118-4 [1] can be thought of as having two parts: (1) a database management system and (2) a cost-prediction and trade-off model. The database management portion of COSTCASTER will contain a historical data base of C-E operating and support (O&S) costs from the VAMOSC system [3], and will allow the user to select certain TMSs from this data base. With these selected costs the user will then be able to use the model to make O&S cost predictions and perform trade-off analyses.

The mathematics underlying the COSTCASTER methodology and the amount of historical O&S cost data obtained from the VAMOSC C-E system are the primary constraints on microcomputer implementation of COSTCASTER. This section describes the requirements necessary to implement the database management system and the cost-prediction and trade-off model. In addition, it provides a list of desired hardware and software capabilities.

A. DATABASE MANAGEMENT SYSTEM

The requirements necessary for implementing the database management portion of the COSTCASTER methodology are relatively straightforward. The computer hardware selected and the software developed must be capable of storing the C-E system data, which can

include up to 10 years worth of O&S cost data for several hundred TMSs [2]. As new cost data is generated by the C-E system, COSTCASTER must be easily updatable.

For each TMS and fiscal year the cost data will be presented in 19 cost categories which correspond to the C-E system O&S cost categories [3]. In addition to cost information, the C-E system will provide National Stock Number (NSN), Standard Reporting Designator (SRD), inventory, acquisition cost, and nomenclature for each TMS. To accommodate this information for each fiscal year and TMS, the database system will require a minimum of 26 fields of information for each record. Assuming there are 500 TMSs and 10 years of cost data, the database system will have to store at least 5000 records.

Of the hundreds of TMSs in the data base, the user will probably be interested in cost predictions and trade-off analyses for only a few at any one time. The user must be able to query the data base in order to specify TMSs of interest. For selected TMSs, the user must be able to move information easily from the database system into the cost-prediction and trade-off portion of the model.

B. COST PREDICTIONS AND TRADE-OFF ANALYSIS

Cost predictions and prediction diagnostics are made using weighted least squares regression. The trade-off analysis calculations require

the use of financial concepts such as discount rates and the present-value of money. Therefore, the software must be able to perform these procedures.

Because primary output products of COSTCASTER are graphic representations of the cost-prediction and trade-off analysis tables, selected hardware and software must have graphics capabilities. In addition, the user should be able to easily input various parameters and compare alternative outcomes. This capability is commonly referred to as "what-if" analysis.

C. DESIRED HARDWARE AND SOFTWARE CAPABILITIES

One of the primary considerations in evaluating hardware and software options was the typical microcomputer equipment configuration. Since the Air Force standard microcomputer is the Zenith Z-100, the software search was concentrated in applications and languages available for this machine. However, the search was not limited to this area. Similarly, the software search was initially confined to the more popular applications which the "typical user" is most likely to have.

In determining the feasibility of implementing COSTCASTER on a microcomputer, the software is more critical than the hardware. Based on the requirements of the COSTCASTER methodology, Desmatics considers the following software considerations essential to implementing

COSTCASTER:

1. built-in mathematical functions,
2. capability to interact with, and select from, a large data base,
3. database management facilities capable of efficiently handling a minimum of 26 fields per record and at least 5000 records,
4. graphics,

and 5. ease of use.

Although ease of use is not a specific requirement of the methodology, it has been included because a good model that is cumbersome to use will not be fully exploited by users. It is Desmatics' intention that COSTCASTER be easy to use even for those persons with minimal computer experience.

Additional desirable, but not essential software considerations include portability between machines (e.g. IBM and Zenith computers) and speed of processing. The software selected must also be flexible enough to incorporate a variety of printer, disk drive and memory configurations. It is assumed, however, that the typical configuration would have, as a minimum, 256K of memory, 2 disk drives (floppy or hard disks), and optionally, a printer. The actual hardware requirements for implementing COSTCASTER follow from the software requirements.

III. EVALUATION AND RECOMMENDATION

This section evaluates the applicability of three different types of software for implementation of the COSTCASTER methodology. Based on this evaluation, software and hardware recommendations are given.

A. EVALUATION OF AVAILABLE SOFTWARE

Three types of software products were evaluated for use in implementing COSTCASTER: (1) high-level programming languages, (2) stand-alone applications software packages and (3) integrated applications software packages (which generally include some programming capability). From the user's point of view there is a hierarchical relationship among these types of software. A simplified model of this hierarchy is shown in Figure 1. Generally, the higher the level of the software, the less the user will need to know about the computer hardware and its operating system.

Stand-alone applications and integrated applications are referred to as higher-level applications since they are generally written in a high-level programming language or assembly language. As can be seen from Figure 1, higher-level applications put more distance between the user and the computer hardware than do high-level programming languages. The following subsections evaluate the applicability of

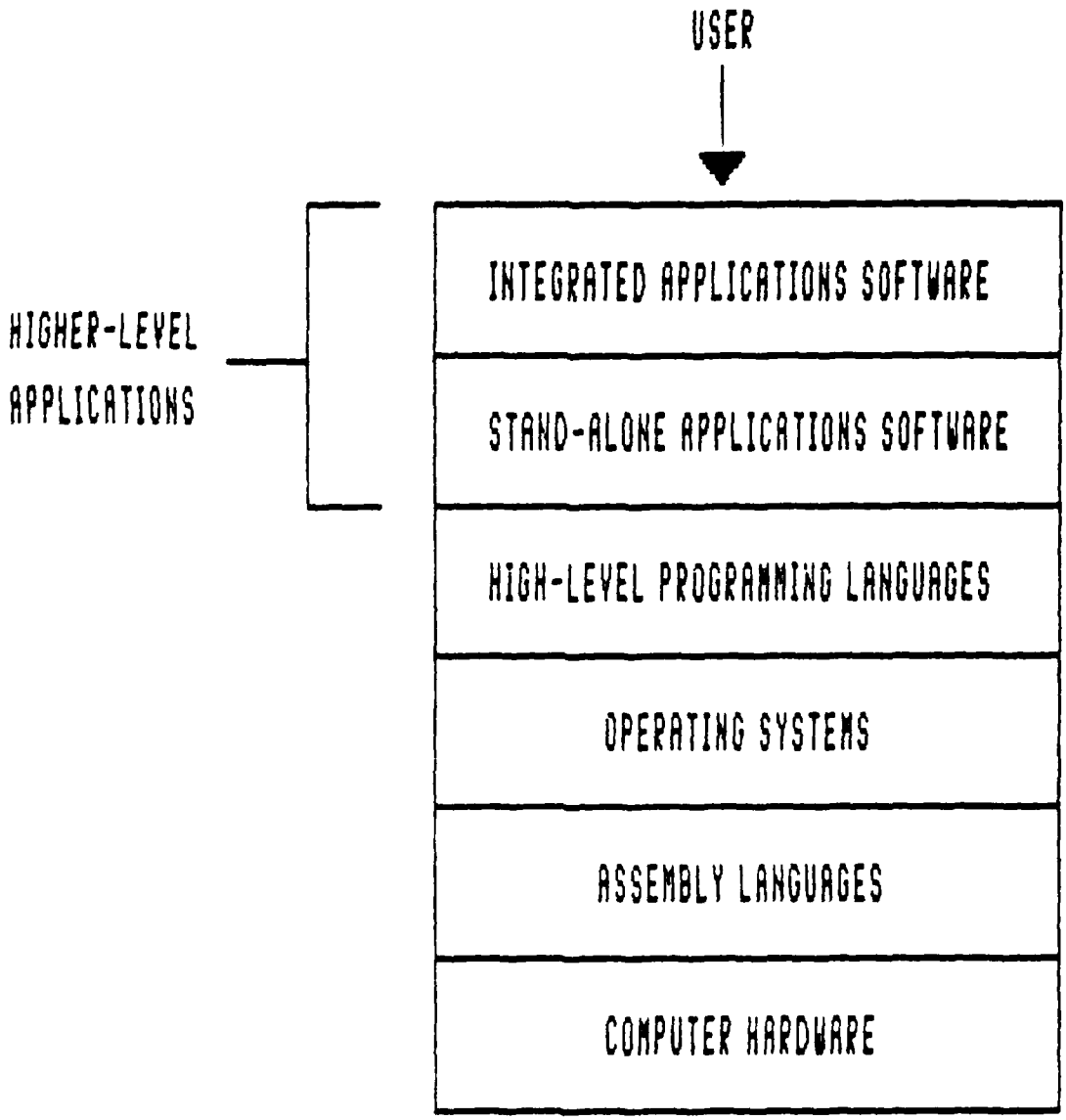

FIGURE 1. VARIOUS LEVELS BETWEEN THE USER AND THE COMPUTER HARDWARE

high-level programming languages, stand-alone applications, and integrated applications to the COSTCASTER methodology.

1. High-level Programming Languages

Programming languages are designed to allow the programmer to instruct the computer on any number of tasks. High-level programming languages, like FORTRAN, Pascal and BASIC, are those which use English-like command statements. These were considered for implementation of COSTCASTER, but were eliminated for a number of reasons. Chief among these are unsophisticated graphics features, lack of user friendly features, and lack of portability among various manufacturer's microcomputer hardware. There would be a long development time using a high-level programming language because of a lack of programmer utilities and the necessity to include options for various hardware configurations. For the implementation of COSTCASTER, programming languages were also judged slower than some higher-level applications written in assembly language.

Developing COSTCASTER in one of these high-level languages would require the user to learn more about the workings of the computer than otherwise might be necessary. In addition, potential users are less likely to currently own and use programming languages than applications packages.

2. Stand-alone Applications Software

Stand-alone applications packages such as database management systems, statistical packages, graphics applications and spreadsheets were also considered, but were rejected because the COSTCASTER methodology could not be wholly implemented in any one single package. Stand-alone applications software is designed to accomplish a specific task, whereas the COSTCASTER methodology incorporates a number of tasks, e.g. statistical analysis and graphics. Ease of use would be substantially reduced by implementing COSTCASTER on a combination of these packages because of general incompatibility among them.

3. Integrated Applications Software

Integrated applications software combines functions from several stand-alone packages into one package. In addition to incorporating graphics, database management features and mathematical functions, many integrated applications software programs include programming features which allow customized menus and input screens. These features allow users to be led step-by-step through the model. Because these packages incorporate a programming language within a higher-level application, development time is substantially reduced when compared to traditional programming languages. For these reasons, integrated applications software packages were deemed to be the best choice for implementing

COSTCASTER.

Other advantages to developing COSTCASTER within a higher-level application, such as an integrated package, are portability from machine to machine and flexibility of hardware configurations. Even though the Zenith Z-100 is the Air Force standard microcomputer, there are many others in use, and all Z-100 users do not have the same hardware setup. By developing an applications template, i.e. a customized model, within an integrated package, any computer which can run that package can also run COSTCASTER.

B. RECOMMENDATION

Of the integrated software packages currently available, Desmatics recommends the use of Lotus 1-2-3 from Lotus Development Corporation. Although a number of other integrated applications software packages (such as Knowledgeman from Micro Data Base Systems, Inc., Framework from Ashton-Tate, Inc., or Symphony, also from Lotus Development Corporation) would work as well as Lotus 1-2-3, these packages are unavailable for the Zenith Z-100 or are absent from the Air Force Zenith price list. Desmatics considers this a drawback, as these other packages would not be readily available to the Air Force user.

The spreadsheet orientation of Lotus 1-2-3 makes it ideal for "what-if" scenarios during cost predictions and trade-off analysis. The database feature within Lotus, and the ability to include data

from other program files and worksheets will facilitate development of the COSTCASTER database system, and allow the user to easily look at a subset of TMSs.

In order to run COSTCASTER as a Lotus 1-2-3 template on a Zenith Z-100 computer system the MS-DOS operating system, Lotus 1-2-3, and at least 256K of random access memory (RAM) would be required. A hard disk system is preferable but a system with two floppy drives could be used. Although a Z-100 is recommended since it is the Air-Force standard microcomputer, any computer system with Lotus 1-2-3 and the appropriate hardware configuration could run COSTCASTER.

In order to determine actual memory and storage requirements for implementing COSTCASTER, Desmatics has developed a prototype version of COSTCASTER using Lotus 1-2-3 and a Zenith Z-100 configured as described in the previous paragraph. This prototype is discussed in the next section.

IV. COSTCASTER MICROCOMPUTER PROTOTYPE

As mentioned in the previous section of this report, Lotus 1-2-3 and an adequately configured microcomputer provide the capabilites needed to implement COSTCASTER. Desmatics has constructed a prototype version of COSTCASTER using Lotus 1-2-3 on a Z-100 in order to determine several things, among which are:

1. the amount of memory required for such a version,
2. the processing speed of COSTCASTER,

and 3. the ease of use of a Lotus 1-2-3 based model.

The prototype COSTCASTER template developed by Desmatics consists of three main portions: input assumptions, operating and support cost predictions, and trade-off analysis. These parts are based on the methodology developed by Desmatics in Technical Report No. 118-4 [1].

It should be noted that the functions described in Technical Report No. 118-4 which depend on the existence of a tailored C-E system data base link with COSTCASTER were not implemented, since such a link does not currently exist. These database functions include development of the break-even reduction point (BERP) table, production of the maintenance data tables, and the ability to access cost data easily for any TMS in the C-E system.

In order to fully implement the COSTCASTER methodology, it will be necessary for the C-E system to provide cost data to the COSTCASTER

database management system in the form of an annual custom file which would be designed concurrently with the development of the microcomputer data base management functions of COSTCASTER. The updated data base would then be distributed annually on floppy disks to the users, possibly by the Office of VAMOSC.

In Desmatics' opinion the best method of production for the BERP tables would be on a Z-100 using the COSTCASTER data base and cost-prediction methodology. This function would need to be performed annually, once again, possibly by the Office of VAMOSC. The BERP tables could then be printed and distributed to users as required. This method of distribution is preferred since there is no inherent advantage to having these tables in interactive form.

The maintenance tables, however, should be provided directly from the C-E system. Indeed, the maintenance table function is already partially implemented in the C-E system since depot maintenance cost tables for components are produced. The capability to produce the table of base maintenance man-hours by Work Unit Code (WUC) outlined in Technical Report No. 118-4 would need to be added to the C-E system. The level of detail of the table (five-digit WUC, two-digit WUC, etc.) would need to be established by consulting with potential users.

In Desmatics' opinion this particular data-oriented function is best handled by the larger computing and storage facilities available to the C-E system. Selected maintenance tables could be distributed on request to COSTCASTER users. These tables provide valuable infor-

mation, but are not required for the interactive cost-prediction and trade-off functions of COSTCASTER.

A Lotus 1-2-3 template can be constructed to allow access to the cost data base. This template would load the requested cost data from the data base into the cost-prediction and trade-off portions of COSTCASTER. The cost data base and access template would constitute the database management portion of a microcomputer-based COSTCASTER.

The prototype COSTCASTER template developed by Desmatics is easy to use because it is menu-driven. This means that the choices for the various operations which COSTCASTER performs are always available to the user throughout a session. It is not necessary to memorize any commands. This feature also allows the user great flexibility in the way a session with COSTCASTER is conducted. At any point in a session, the user may obtain printouts, save the model for later use, choose another TMS for analysis, or exit COSTCASTER.

In addition, the user may readily modify the cost data and any assumptions and perform "what-if" analysis. The calculations performed by the Lotus-based model, including the calculation of cost predictions and prediction diagnostics, are rapid. Minimal familiarity with Lotus 1-2-3 and the Zenith Z-100 is required for use of the model. These aforementioned features should encourage use of the model.

The COSTCASTER prototype makes use of several input screens, each of which directs the user to make a choice from the options presented on the screen. When the COSTCASTER session is started, the

user first chooses a TMS to analyze, and then the cost categories to be used in the analysis. The cost input data for the selected TMS may be modified by the user. In addition, the user may choose to input his/her own cost data.

The cost data which is incorporated in the current COSTCASTER template is simulated data for four TMSs. This data allows for demonstration of the capabilities of the current version. Printouts of an Operating and Support Cost Summary and an accompanying graph are available.

Once the cost data is selected, the user can proceed to the cost-prediction and trade-off functions of COSTCASTER. Costs are predicted using weighted least-squares regression for a ten-year period, beginning after the last available data point, for the total costs within the cost categories the user has chosen. The user may choose one of four available weighting schemes (equal, linear, geometric, or user-supplied) for use in the predictions. Printouts of the cost prediction table and the graph of the predicted costs and prediction intervals are available. Prediction diagnostics can also be viewed [1,4].

Once cost predictions have been calculated, the user may proceed to the trade-off portion of COSTCASTER. The user may accept default assumptions for the trade-off calculations, or may easily change any or all of the defaults. Three principal outputs are produced based on these calculations. These outputs are:

1. the Payback Table and Graph,

2. the Life Savings Table and Graph,

and 3. the Displacement Table and Graph.

The Payback Table and Graph, which furnish the cumulative savings provided by the replacement item over the lifetime of the current item for varying reductions in O&S costs, allow the user to determine the payback period for the replacement or modified item. The Life Savings Table and Graph show the sensitivity of total savings for varying reductions in O&S costs to various replacement item lifetime assumptions. Finally, the Displacement Table and Graph indicate how savings are affected by delaying purchase of the replacement or modified item.

The COSTCASTER template in its current form occupies approximately 80K of memory, in addition to the 128K used by Lotus itself. For the database management system, preliminary studies by Desmatics indicate that the cost data for ten years for about 75 TMSs could be accommodated by one Lotus 1-2-3 template on a 256K machine. It is estimated that the entire database management system and the cost-prediction and trade-off model could be contained on three or four floppy disks.

The current prototype version of COSTCASTER may be considered a precursor to a production version which could be distributed throughout the Air Force. Once the prototype has been demonstrated to potential users, any suggestions for improvements which they have may be incorporated into a production version of the model. In this way the highest degree of user satisfaction may be obtained.

V. CONCLUSION

Based on the study described in this report, Desmatics concludes that it is feasible to implement COSTCASTER in a microcomputer environment. In fact, as described in the previous section, Desmatics has implemented a prototype version.

Desmatics has found that implementing COSTCASTER in an integrated applications software package will result in the shortest development time and maximum ease of use, while satisfying the requirements of the methodology. An applications template developed for an integrated software package also has the advantage of portability among various manufacturers' hardware.

Of the integrated software currently available, Desmatics recommends the use of Lotus 1-2-3 on a Zenith Z-100 computer system, although any system with the appropriate configuration could be used. The prototype version of the COSTCASTER model, which has been demonstrated to the Office of VAMOSC, will also be shown to potential users to obtain feedback regarding the model's capabilities and ease of use.

Although at this writing Desmatics considers Lotus 1-2-3 and a Zenith Z-100 to be the best choice for implementing COSTCASTER, it should be noted that technology in the field of microcomputer hardware and software is advancing very quickly. Therefore, depending on the date of COSTCASTER implementation, further examination of the types of hardware and software which are available may be warranted.

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COSTCASTER is a computer-based system developed by Desmatics, Inc. for the U.S. Air Force. Its purpose is to aid in making economic decisions regarding replacement, modification, or retention of Air Force ground communications-electronic equipments. This report describes the development and future implementation of a microcomputer-based COSTCASTER prototype developed in Lotus 1-2-3 on a Zenith Z-100 computer.

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