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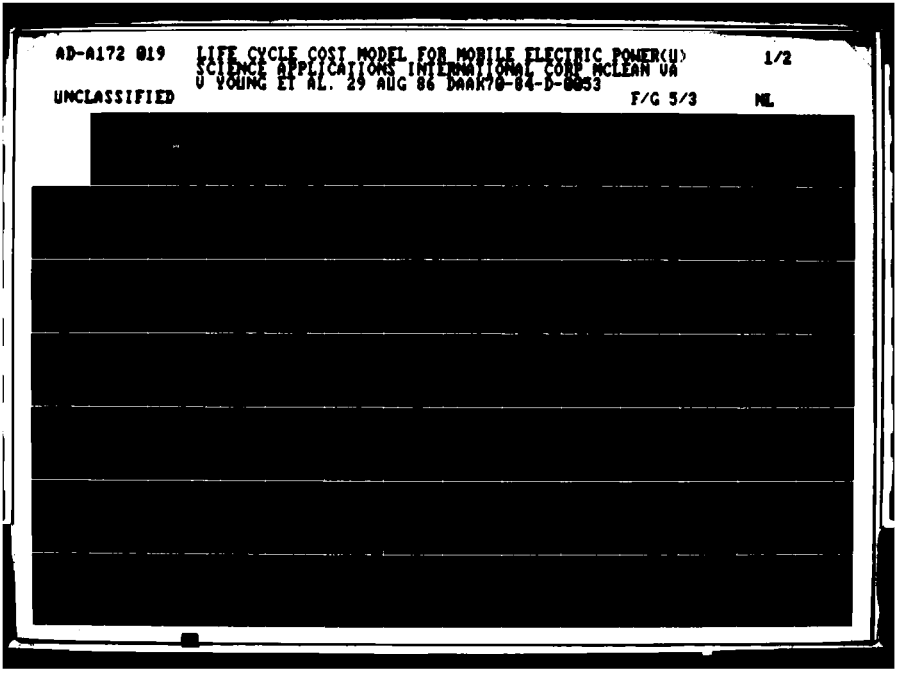

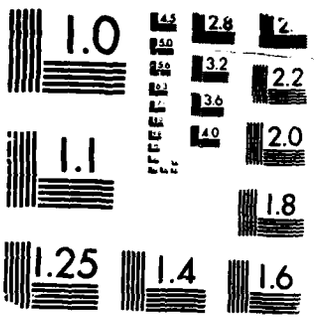

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AD-A172 019

FINAL REPORT

LIFE CYCLE COST MODEL FOR MOBILE ELECTRIC POWER

29 AUGUST 1986

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FINAL REPORT

LIFE CYCLE COST MODEL FOR MOBILE ELECTRIC POWER

29 AUGUST 1986

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Prepared for the
Belvoir Research, Development and Engineering Center

Under
Contract Number DAAK70-84-D-0053
Task Order Number 0020

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Military Operations Analysis Division
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This report contains the Users Guide to the Life Cycle Cost Model developed for Mobile Electric Power. The model was developed using SYMPHONY software and follows the Army 5 Phase Cost Methodology. Appendix A contains the Variable Input Sheets for each Cost Element in the model and Appendix B describes the menu tree structure of the model. The model is based upon the most widely used approach to costing the specific type of systems developed at Belvoir Research Development and Engineering Center.

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STUDY GIST

Life Cycle Cost Model for Mobile Electric Power

THE PRINCIPAL FINDINGS

A generalized life cycle cost model was developed for use at the Belvoir Research, Development and Engineering Center (BRDEC). A set of cost equations was identified and developed which can reasonably estimate cost elements within the Army 5 Phase Cost Model structure for systems developed at BRDEC. The model was implemented on the microcomputer using SYMPHONY software providing a major advantage of being able to tailor the model to a specific cost siutation. Sensitivity analyses can be performed which determine cost drivers.

THE MAIN ASSUMPTIONS

The main assumption made is that future cost requirements for BRDEC will not differ significantly from past practices. Therefore, cost equations were developed to represent the most commonly used methods for cost estimating BRDEC systems.

THE PRINCIPAL LIMITATIONS

The model requires an IBM PC or compatible with 640K RAM, preferably with a hard disk. SYMPHONY software, version 1.1, is required to run the model.

SCOPE OF EFFORT

The scope of the effort included evaluation of approaches for a BRDEC Life Cycle Cost Model with a resultant definition, design and computer implementation of the selected model.

OBJECTIVES

The objective of the study was to provide Government personnel with a Life Cycle Cost Model that would be useful in developing realistic cost asessments, evaluate support characteristics from a life cycle cost point of view and validate specific cost drivers of new developmental systems or equipment.

BASIC APPROACH

The approach included: Review and analysis, for technical feasibility, of both existing and new cost models and computer implementations; design and development of the selected model; implementation; validation; and documentation.

REASON FOR PERFORMING THE STUDY

Life Cycle Cost estimates for materiel acquisitons are required throughput the materiel acquisition process. Cost estimates must be performed for requirements documents, COEAs and System Concept Papers. Life Cycle Costs must be updated and refined throughout the development cycle with a validated estimate required to facilitate the investigaion of the cost impact of program alternatives. Major emphasis is being placed on the potential sustainment costs of new systems as well as acquisition and introduction costs. A method for developing full life cycle cost estimates that can be validated, easily updated and used for examining complete life cycle cost impact of program changes was sought.

IMPACT OF THE STUDY

The model will provide the BRDEC project engineers a method to develop better Baseline Cost Estimates than has been available in the past. The computer model also provides the capability to examine those cost factors which can be impacted by design changes and determine the total life cycle cost impact of the changes.

STUDY SPONSER

Belvoir Research, Development and Engineering Center

PRINCIPAL INVESTIGATOR

Principal Investigator:

Victoria Young
Science Applications International Corporation

COMMENTS AND QUESTIONS

Richard Jacobs, STRBE-FCA
Power Conversion and Distribution Division
BRDEC, AV 35-42676

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SECTION I
INTRODUCTION

PURPOSE

This Users Manual is to assist Belvoir Research, Development and Engineering Center (BRDEC) in using the general life cycle cost model developed by SAIC for BRDEC and implemented with SYMPHONY software. The Belvoir Cost Model (BCM) is designed to aid the materiel developer in preparing baseline cost estimates and life cycle cost estimates and in performing sensitivity analyses around uncertainty in cost data and parameters.

GENERAL

The BCM is based upon the Army 5 Phase Cost Model and includes the cost elements described in DCA-P-92(R), "Instructions for Reformatting the BCE/ICE". The format change revises and expands the Army 3 Phase Model (DA Pamphlets 11-2, "Research and Development Cost Guide for Army Materiel Systems", 11-3, "Investment Cost Guide for Army Materiel Systems", and 11-4, "Operating and Support Cost Guides for Army Materiel Systems") to five phases. The major change is the breakout of the funding appropriations into the 5 separate phases. The five phases are Development (RDTE funded), Production (procurement (PROC) funded), Military Construction (MCA funded), Fielding (OM funded), and Sustainment (PROC, OM, MPA funded). The previous references give detailed information about these phases and should be referred to for more detail. The cost elements which make up the 5 Phase Cost Model are shown in Table 1.1.

The BCM also includes the capability for presenting output and reports in the standard Army format described in DA Pamphlet 11-5, "Standards for Presentation and Documentation of Life Cycle Cost Estimates for Army Materiel Systems". Variable Input Sheets, Cost Data Sheets and 3 matrix formats can be printed. The matrices can be developed as cost element by work breakdown structure, as cost element by constant year dollars or as cost element by

Table 1.1 ARMY 5 PHASE COST MODEL

1.0 DEVELOPMENT
1.01 Development Engineering
1.011 Engineering
1.012 Producibility, Engineering, & Planning (PEP)
1.013 Tooling
1.014 Prototype Manufacturing
1.02 Data
1.03 System Test & Evaluation
1.04 System/Project Management
1.05 Training, Service & Equipment
1.06 Facilities
1.07 Other RDTE Funded Development

2.0 PRODUCTION
2.01 NonRecurring Production
2.011 Initial Production Facilities
2.012 Production Base Support
2.013 Depot Maintenance Plant Equipment
2.014 Other NonRecurring Production
2.02 Recurring Production
2.021 Manufacturing
2.022 Recurring Engineering
2.023 Sustaining Tooling
2.024 Quality Control
2.03 Engineering Changes
2.04 Data
2.05 System Test & Evaluation
2.06 Training, Service & Equipment
2.07 Initial Spares
2.08 Operational/Site Activation
2.09 Other Procurement Funded Production

3.0 MILITARY CONSTRUCTION
3.01 Test Construction
3.02 Production Construction
3.03 Operational/Site Activation Construction
3.04 Other MCA Funded Construction

4.0 FIELDING
4.01 System Test & Evaluation
4.02 Training, Service & Equipment
4.03 Transportation
4.04 Initial Repair Parts
4.05 System Specific Base Operations Support
4.06 Other OM Funded Fielding

Table 1.1 ARMY MODEL (cont.)

5.0	SUSTAINMENT
5.01	Replenishment
5.011	Replenishment Repair Parts
5.012	Replenishment Spares
5.013	War Reserve Replenishment Parts
5.014	War Reserve Spares
5.02	Petroleum, Oil, Lubricants (POL)
5.03	Ammunition
5.031	Training Ammunition/Missiles
5.032	War Reserve Ammunition/Missiles
5.04	Depot Maintenance
5.041	Civilian Labor
5.042	Materiel (O&M)
5.043	Materiel (Proc)
5.044	Maintenance Support Activity
5.05	Field Maintenance Civilian Laboratory
5.06	Transportation
5.07	System Specific Replacement Training
5.071	Ammunition/Missile/Equipment
5.072	Services
5.08	Military Personnel
5.081	Crew Pay & Allowances
5.082	Maintenance Pay & Allowances
5.083	System Specific Support Pay & Allowance
5.084	Trainer/Trainee Pay & Allowance
5.085	System/Project Management Pay & Allowance
5.086	Permanent Change of Station
5.087	Other MPA Funded Sustainment
5.09	System/Project Management (Civilian)
5.10	Modifications/Kits
5.11	Other Sustainment
5.111	Other OM Funded Sustainment (QMU)
5.112	Other Procurement Funded Sustainment

current (inflated) dollars. The provision for this standard format will allow standardization of data input and provide a more meaningful and usable format for validating cost estimates.

OVERVIEW OF BCM

The BCM contains four major functions as shown in Figure 1.1. These are data input, matrix development, sensitivity analyses and print output. The logical steps in using the model follow these functions.

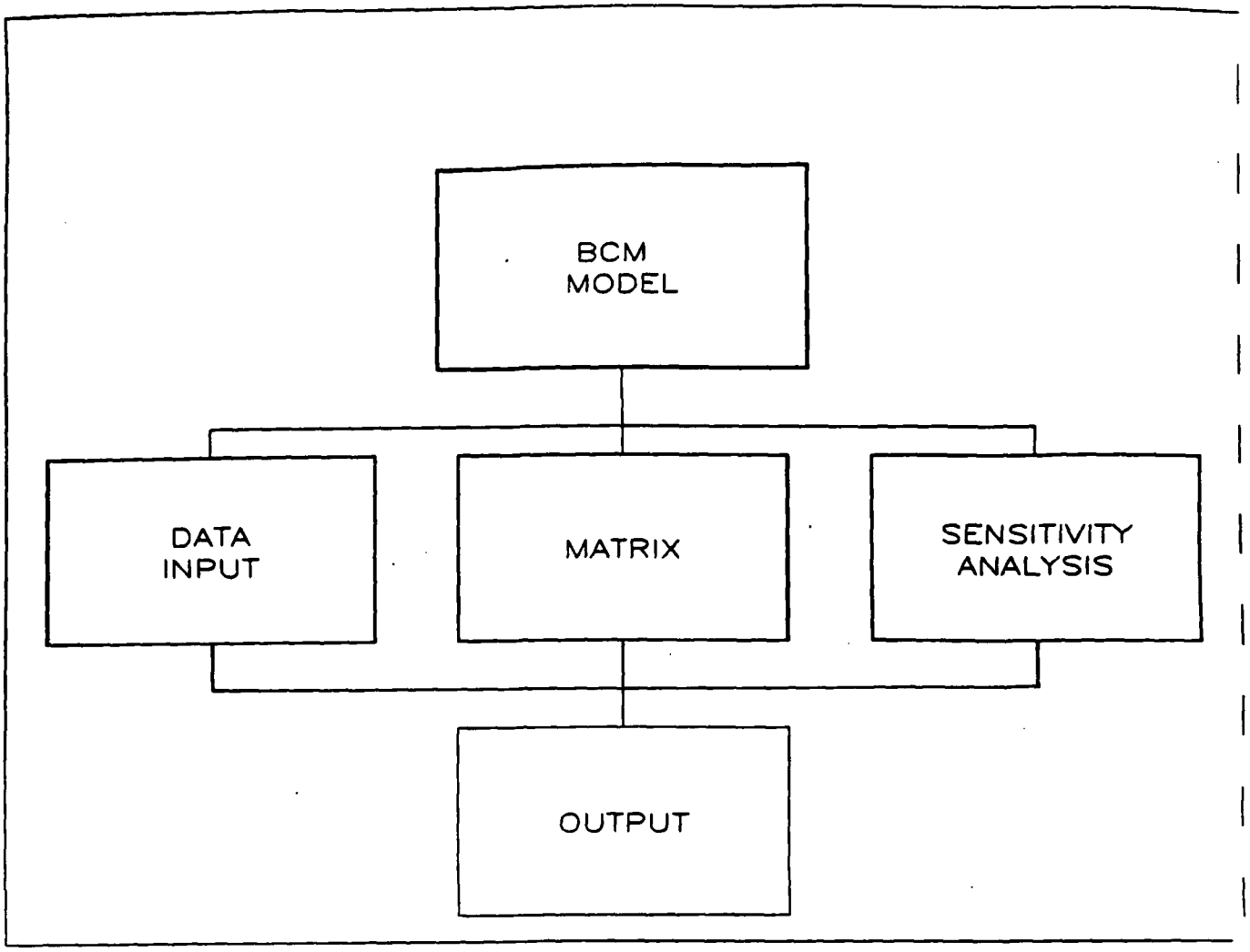

Figure 1.1 BCM Overall Functions

Data input is the first function performed. Cost equations have been defined to estimate each cost element in each phase. Data are input by cost phase for the variables contained in the equations. Four SYMPHONY worksheets have been developed for data input to correspond to the cost phases (Military Construction and Fielding have been combined into one worksheet). Data input follows the format of the standard Variable Explanation Sheet. Once data input for the cost phase is complete, cost element values and phase totals are calculated by SYMPHONY.

Cost Matrices are developed after the calculation of cost elements and phase totals. Four SYMPHONY worksheets have been developed for creating the matrices to correspond to each cost phase. The cost matrices consist of Work Breakdown Structure - Matrix, Constant Dollar Matrix, and Current Dollar Matrix. Each matrix shows the value of the cost elements by one of the three above categories. Matrices are first developed for each phase individually, then integrated into a Total Matrix which shows all cost phases by one of the three categories. The total matrix is contained in a separate SYMPHONY worksheet.

Sensitivity analyses can be performed around selected variables to determine the impact to life cycle cost if variable values are changed. Sensitivity analyses are performed after all data has been input and the baseline established. A separate SYMPHONY worksheet is available for performing the sensitivity analyses.

The final step in using the model is printing all the documentation required for a Baseline Cost Estimate. The Variable Input Sheets, Cost Data Sheets and matrices can be printed as a package or each printed separately.

The BCM also uses two SYMPHONY concepts which are menus and macros. Each worksheet has a series of menus that provide a means for selecting any of the options that can be performed within the worksheet. Additional functions that can be performed within a worksheet have been captured in macros which are the steps that carry out the function. These include bringing up the menu, printing, moving data between worksheets, and quitting a worksheet.

Each of these ideas will be discussed in further detail in the following sections.

SECTION II
METHODOLOGY

GENERAL

The BCM is designed to assist the materiel developer in preparing a baseline cost estimate of life cycle costs for a developing system. The BCM provides the framework for preparing a cost estimate by identifying the cost elements that must be addressed plus a default set of cost equations for estimating those cost elements. The equations have been developed based upon guidance from the BRDEC Cost Analysis Division and evaluation of cost estimating factors and equations most generally used in costing systems developed at BRDEC. The model provides the capability to perform sensitivity analyses around the data variables that are uncertain or which can be impacted upon by design decisions or changes. Most importantly, the implementation of the model allows it to be tailored to a specific costing situation, if appropriate. It also provides a format for describing the logic and documentation of the cost estimate for required validation by BRDEC Cost Analysis Division.

The model can accommodate up to 35 years of life cycle costs. Development, Fielding and Military Construction are limited to 9 years each. Production and Sustainment can each span up to 20 years. The first program year that is being estimated is assumed to be the base year. This is generally the first non-sunk year of Development. Sunk costs for Development can be included but must be input in base year dollars.

The model can estimate costs for a work breakdown structure of up to 3 subsystems. The completed cost estimate can be displayed by work breakdown structure, or by total system costs in constant year dollars or in current year dollars (inflated). Costs in each phase are inflated by the appropriate category of inflation indices.

The equations found in the model for estimating the cost elements have been developed with guidance from the BRDEC Cost Analysis Division and are those most generally used in cost estimation of BRDEC systems. The BRDEC Cost Analysis Handbook contains rationale and guidance for determining and finding cost data used by the BCM and should be used when developing a cost estimate. All equations in the model include an "Other" category for additional costs that are not specifically identified. If the equation is not appropriate for the particular cost application, it can be changed. See Section 5, CHANGING EQUATIONS, for more details.

The remainder of this section contains a brief description of each cost element. A table is provided for each phase which describes the equation used to estimate each cost element in the phase. For more information, see DA pamphlets 11-2 through 11-5 and DCA-P-92(R), "Instructions for Reformatting the BCE/ICE".

COST ELEMENTS

1.0 DEVELOPMENT. Development costs are the research and development costs funded by the RDTE budget for the development or modification of a system. The projected costs are estimated based upon cost factors or engineering estimates. An appropriate default cost equation is provided for each cost element. In addition to the value of the variables in the equation, a projected spread of costs across the R&D years is required. Table 2.1 lists the cost elements and cost equations for 1.0 DEVELOPMENT. Development costs are the sum of the following cost elements.

1.01 Development Engineering. This cost can be input as a throughput value or it can be broken out as the sum of the next four cost elements. Development engineering includes the engineering, tooling, producibility planning and manufacturing of development prototypes.

TABLE 2.1 Equations for Estimating 1.0 DEVELOPMENT

	COST ELEMENT	EQUATION
1.0	DEVELOPMENT	Sum of 1.01 - 1.07
1.01	Development Engineering	Sum of 1.011 - 1.014
1.011	Engineering	Throughput or = Contract (Initial manyears * manyear $ + travel$) + material$ + transportation$) + (test equip$ + test equipment transportation$) + (Redesign as % of initial engineering) + In-House (manyears * manyear$ + travel$) + Other
1.012	PEP	Throughput or = Contract (# drawings * $ per drawing + manyears * manyear $) + In-House (# drawings * $ per drawing + manyears * manyear $) + Other
1.013	Tooling	Throughput or = Contract (hours * hourly rate + material $ + transportation $) + Other
1.014	Prototype Manufacturing	Throughput or = (manufacturing $ + spares as % of manufacturing + rework as % of manufacturing) * # prototypes + GFE + Other
1.02	Data	Throughput or = Contract (manyears * manyear $) + travel $ + material $ + In-House (manyears * manyear $) + travel $ + Other
1.03	System Test & Eval (RDTE only)	Throughput or = Contract (manyears * manyear $ + materials $) + In-House (manyears * manyear $ + travel$ + materials $ + DTI$ + DTII$ + OTI$ + OTII$) + Other
1.04	Sys/Proj Mgmt	Throughput or = manyears * manyear$ + Other

TABLE 2.1 Equations 1.0 (cont.)

	COST ELEMENT	EQUATION
1.05	Train, Serv & Eq (RDTE only)	Throughput or = Contract (manyears * manyears $ + travel $) + In-House (manyears * manyear $ for preparation) + (manyears * manyear $ for participation + travel$) + material $ + Other
1.06	Facilities	Throughput
1.07	Other RDT&E Fund Dev	Throughput

1.011 Engineering. This cost element encompasses government and contractor engineering and includes initial and redesign efforts, material and test equipment costs, and any travel and transportation costs. Initial engineering is based upon an estimate of manyears and redesign efforts are estimated as a percentage of initial design effort.

1.012 Producibility Engineering and Planning (PEP). This cost includes the planning efforts required for ensuring efficient and economic production of essential material. This cost element is estimated based upon projected manyears required for planning and/or by the number of drawings included in the Tech Data Package.

1.013 Tooling. Tooling costs include the costs associated with the design, fabrication, assembly, installation, modification, maintenance and rework of all tools and equipment necessary for the development of the materiel system. It is estimated by projecting contract manhours, materials and transportation required for tooling.

1.014 Prototype Manufacturing. This cost element includes all costs incurred in the development of the prototype. It is estimated by

manufacturing cost, spares cost, rework cost and GFE cost. Spares and rework are estimated as a percentage of manufacturing cost.

1.02 Data. Data costs include the cost of preparation, revision, and reproduction of drawings, specifications, parts lists, test plans, testing procedures, draft manuals and other documentation which is produced in support of project management, engineering, tooling, fabrication, and testing functions. It is estimated by the manyear effort plus travel and materials required by both the contractor and the government.

1.03 System Test and Evaluation. This cost element includes the cost of only system-related development and operational test activities (DT/OT I & II) including planning, conduct, support, data reduction and report preparation. It is estimated by projected contract and government manyear effort, materials, travel and by the projected cost of each test. This cost element only includes that portion of the total cost that is funded by the RDTE appropriation.

1.04 System/Project Management. This cost element includes the cost of the technical and business management effort expended by both the Government and contractor in the process of developing an integrated system. It is estimated by projecting the manyear effort required to perform the related tasks.

1.05 Training, Services and Equipment. The costs are estimated using projected contractor and government manyear effort for planning and preparation, and government manyears required for participation in training, travel and material costs. Maintenance and crew trained for testing purposes are included here.

1.06 Facilities. This cost includes the costs of any new building, conversion or expansion of facilities or sites, and the acquisition of real estate for development and testing of the system. This is a throughput value.

1.07 Other RDTE Funded Development. Any other cost funded by the RDTE appropriation should be identified and included here. This is a throughput value.

2.0 PRODUCTION. Production cost is the sum of all costs funded by the procurement appropriation to produce and introduce a new system into the Army inventory. These projected costs are estimated by engineering estimates, cost factors, or historical costs. Throughput values are provided for those costs that are generally not relevant to BRDEC systems while equations have been developed for those costs that usually can be estimated. In addition to the variables, a spread of costs across production years is requested for some cost elements. Table 2.2 shows the cost elements and equations for 2.0 PRODUCTION.

2.01 Non-Recurring Engineering. This cost element consists of all initial costs associated with starting production of a new system. It can be a throughput value or the sum of the next four cost elements.

2.011 Initial Production Facilities. This cost includes the initial hard tooling and production line set-up to support low rate and full production of the system. It can be input as a throughput value or as an estimate of manyears and materials required to set up a production facility.

2.012 Production Base Support. This cost includes the construction, conversion or expansion of facilities for production. It is a throughput value.

TABLE 2.2 Equations for Estimating 2.0 PRODUCTION

	COST ELEMENT	EQUATION
2.0	PRODUCTION	Sum of 2.01 - 2.09
2.01	Non-Recurring Eng	Sum of 2.011-2.014
2.011	Init Prod Facil	Throughput or = material $ + manyears * manyear $ + Other
2.012	Prod Base Supt	Throughput
2.013	Dep Mt Plant Eq	Throughput
2.014	Other Non-Recur Prod	Throughput
2.02	Recurring Production	Sum of 2.021-2.024
2.021	Manufacturing	Throughput or = (First unit cost of labor * Quantity * Quantity ^{B}) + (Quantity * material $ per unit) * OH * G&A * profit + GFE + Other (B=$\log_{10}$(learning curve factor*100) / $\log_{10}2$)
2.022	Recurring Eng	Throughput or = Contract (manyears * manyear $) + In-House (manyears * manyear $) + Other
2.023	Sustaining Tooling	Throughput or = Contract (% of 2.011 initial tooling) + In-House (manyears * manyear $) + Other
2.024	Quality Control	Throughput or = Contract (manyears * manyear $) + In-House (manyears * manyear $) + First Article Test + Other
2.03	Engineering Changes	Throughput or = Contract (% of 2.021 manufacturing) + In-House (manyear *manyear $) + Other
2.04	Data	Throughput or = Contract (manyears * manyear $) + In-House (manyears * manyear $) + # pages * cost per page + Other

TABLE 2.2 Equations 2.0 (cont.)

	COST ELEMENT	EQUATION
2.05	System Test & Eval (PROC only)	Throughput or = Contract (manyears * manyear $ + travel$) + In-House (manyears * manyear $ + travel$) + material $ + conduct of test $ + Other
2.06	Train, Serv & Eq (PROC only)	Throughput or = (manyears * manyear $ for preparation) + (class $ * # classes) + (manyears for participation * manyear $) + material $ + Other
2.07	Initial Spares (PROC only)	Throughput or = % unit manufacturing cost * AAO quantity
2.08	Operat/Site Activ	Throughput
2.09	Other Proc Fund Prod	Throughput

Production Calculation

Total requirement = initial issue systems + operational readiness float + repair cycle float + wearout quantities

Operational readiness float = operational ready rate * mean calendar time to repair / (mean time between failure + mean calendar time to repair) * equivalent operational units

Repair cycle float = mean calendar time to overhaul / mean calendar time between overhaul * equivalent operational units

Wearout quantities = total requirement - initial production
= ((annual operating time per system * weighted sum of fielded systems * number of operating years) / useful lifetime of system) - initial issue systems

2.013 Depot Maintenance Plant Equipment. Any specific equipment required to support depot maintenance for the system is costed here. This cost is a throughput value.

2.014 Other Non-Recurring Production. Any other procurement funded non-recurring production is costed here as a throughput value.

2.02 Recurring Production. This cost element includes all costs that are associated with the continuous production of a new system. It can be input as throughput or summed from the next four cost elements.

2.021 Manufacturing. All costs of material, labor and other expenses for fabrication and checkout of a production item are included here. Manufacturing can be estimated using first unit labor production cost with a learning curve factor and estimates of unit material cost, contractor overhead, G&A, profit, and any GFE. Production quantity and schedule can be input or can be calculated from a production schedule algorithm.

The production schedule algorithm calculates the total number of systems required over the life cycle based upon the issue requirement quantity, operational float, repair float and wearout. It also calculates a production schedule for years beyond the initial production. To determine the production quantity for the system, the algorithm requires the following input data:

Number of active systems deployed per theater, with usage rates--this is the number of systems to be put in each theater, not designated for reserve or training purposes, plus the expected percentage of full time hours they will be used
Number of reserve systems, with usage rates--this is the number of systems designated for reserve use, with the expected percentage of time they will be used, usually .25
Training systems, with usage rates--this is the number of systems designated for training, with the expected percentage of time they will be used
Ready rate--this is an operational parameter and is a percentage less than 1

Mean calendar time to repair (MCTTR)--this is the below depot time required to transport an item to be repaired, wait time in the shop, actual repair time and transport time to return it

Mean time between failure (MTBF)--this is the operating time between failures

Mean calendar time to overhaul (MCTTO)--this is the depot level time to transport an item to be repaired, wait time at depot, actual repair time and transport time to return it

Mean time between overhaul (MTBO)--this is the operating time between overhauls

Annual operating time--this is the time (usually hours) that a system used full time would operate per year

Useful system lifetime--this is the expected useful operating time for a system before it is replaced

Number of operating years--this is the number of years that the system is expected to be used in the inventory

The total required production is the sum of the active, reserve and training systems plus float and wearout systems. Float consists of both operational and repair float. The operational float (OF) factor is calculated as

OF factor = ready rate x MCTTR / (MTBF + MCTTR)

If OF is not desired, then MCTTR is set to zero. This factor is multiplied by the equivalent operational quantity to determine the number of systems required. The equivalent operational quantity is the sum of the number of active systems times their usage rate in active status and the number of reserve systems times their usage rate in reserve status.

The repair cycle float (RCF) factor is calculated as

RCF factor = MCTTO / MTBO

If repair cycle float is not desired, then MCTTO is set to zero. Otherwise, the repair cycle float factor is multiplied by the equivalent operational quantity to get the number of repair float systems required.

Wearout replacements are a function of the equivalent operational quantity, the useful system lifetime, the number of life cycle years, and the annual operating time. Total sets required are calculated by

Total sets = annual operating time / useful system lifetime x equivalent operational quantity x number of life cycle years

This number represents the number of systems required throughout the life cycle. Subtracting the initial issue (sum of active, reserve and training systems) from this number gives the number of replacement systems required due to wearouts.

The total production quantity is the sum of the initial active, reserve and training systems, the operational float requirement, the repair float requirement, and the replacement systems.

To complete the production schedule algorithm, the remaining input must be provided:

Number of initial production years
Total number of production years
Maximum production capability
Minimum economical production
Backorder quantity required to restart production

The production schedule can be calculated after determining the total production quantity. The schedule considers plant capacity or maximum production capability, minimum economical production quantities and backorder quantity required to start a new production run. The first year production must be input. Up to five years of initial production may be input by the user. A cumulative sum of the number produced each year is computed. This number is compared to the number remaining to be produced and production in each successive year is calculated using the following rules:

1. If the remaining number < annual wearout, then the remaining number is produced and production ended, ELSE

2. If the remaining number = 1, then the remaining number is produced and production ended, ELSE

3. If the remaining number / remaining years of production < minimum economical production, then zero is produced for that year, ELSE

4. If the remaining number / remaining years of production < annual wearout, then the wearout number is produced, ELSE

5. If the remaining number / remaining years of production < maximum production capability, then the remaining number is produced and production ended, ELSE

6. the maximum production capability is produced

This sequence of checks is computed for each year and the appropriate number of items are scheduled for production.

The results of the production schedule calculation are the total production quantity, annual wearout and the % of total production for each year over the production years. These figures are given at the bottom of the production calculation area and can be input into the equations as requested.

If all data required to calculate production quantity, annual and production spread are available, then the production calculation may be used. Otherwise, the values should be estimated by some other means and used in subsequent equations.

2.022 Recurring Engineering. This cost element includes all engineering effort expended in support of production, including maintainability/reliability engineering, maintenance engineering, value engineering, and production engineering costs for the system. It can be

estimated as manyears expended by both the contractor and government throughout the course of production.

2.023 Sustaining Tooling. Any maintenance replacement or modification of tools and test equipment after the start of production is included here. It is estimated by contract and government costs, where contract costs are estimated as a percentage of initial tooling (element 2.011) and any government costs are estimated by manyear effort.

2.024 Quality Control. The cost associated with the implementation of controls necessary to ensure that a manufacturing process produces a system which meets prescribed standards is included here. First Article Test (FAT) is part of this cost element. Quality control is estimated by contract and government manyear effort plus the anticipated cost of FAT.

2.03 Engineering Changes. Any official alterations to the system during production and prior to acceptance by the Army should be costed here. The costs are estimated by government manyear effort required and by contract costs represented by a percentage of manufacturing cost.

2.04 Data. All development, reproduction and dissemination of data is costed in this element. This includes both technical and managerial supportability data. It is costed by estimating contract and government manyear effort required for producing and managing data and/or by estimating the number of pages of data to be generated and the cost per page.

2.05 System Test and Evaluation. Any system related production test activities which are performed for system evaluation and are funded by the procurement appropriation are included here. An estimate of contract and government manyears plus travel, any materials for testing, and the cost of conducting any tests are used to estimate this element.

2.06 Training Services and Equipment. This cost element includes only those system specific costs for development of training devices, and the preparation and execution of training which are funded by the procurement appropriation. The training may include initial service instructors and initial crew and maintenance personnel for which the procurement funding is responsible. The costs are estimated in two parts. One part of the cost includes the manyears required for training class preparation and the cost of materials developed for training purposes. The second part includes the cost of holding the class and manyears required for attendance plus travel cost.

2.07 Initial Spares. All initial spare components, assemblies and subassemblies (reparable items) necessary to fill initial ASL/PLL stockage and the wholesale pipeline to support end item fielding throughout the system life cycle are costed here. These items are funded by the procurement appropriation and are separate from repair parts. It is assumed that these spares will support the Army Authorized Obligation (AAO) quantity. The cost of initial spares is estimated as a percentage of unit manufacturing cost. The number of systems requiring initial spares procurement is estimated by the AAO quantity.

2.08 Operational/Site Activation. The estimated cost of real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and/or launch prime mission equipment at the organizational and intermediate level is costed here. In the model, this element is a throughput value.

2.09 Other Procurement Funded Production. All other procurement appropriation funded production costs not included in the above elements should be identified and costed here. This is a throughput value.

3.0 MILITARY CONSTRUCTION. Any construction projects that are initiated because of the introduction of a new system are costed in this phase. Construction is not generally relevant to BRDEC systems so all cost elements

in this phase are estimated by throughput values. Table 2.3 shows the cost elements and equations used for 3.0 MILITARY CONSTRUCTION.

TABLE 2.3 Equations for Estimating 3.0 MILITARY CONSTRUCTION

	COST ELEMENT	EQUATION
3.0	MILITARY CONSTRUCTION	Sum 3.01-3.04
3.01	Test Construction	Throughput
3.02	Prod Construction	Throughput
3.03	Oper/Site Act Constr	Throughput
3.04	Other MCA Fund Constr	Throughput

3.01 Test Construction. This cost element includes any construction related to testing of a new or modified system.

3.02 Production Construction. This cost element includes any construction necessary for producing a new or modified system.

3.03 Operational Site Activation Construction. This cost element includes any construction of facilities for a new or modified system.

3.04 Other MCA Funded Construction. Any MCA costs not included in the previous elements should be identified and included here.

4.0 FIELDING. Fielding is the process of introducing a new system to a final user or place with sufficient resources to achieve the user's mission objective. All fielding activities are funded by Operations and Maintenance

(OM) appropriation. A cost element may be accounted for in the first year of fielding or it may be spread across the fielding cycle. Where appropriate, the spread will be input. Table 2.4 shows the cost elements and cost equations for 4.0 FIELDING.

TABLE 2.4 Equations for Estimating 4.0 FIELDING

	COST ELEMENT	EQUATION
4.0	FIELDING	Sum of 4.01 - 4.06
4.01	System Test & Eval (OM only)	Throughput or = Contract (manyears * manyear $ + materials $) + In-House (manyears * manyear $ + travel $) + materials $ + DTI$ + DTII$ + OTI$ + OTII$ + Other
4.02	Train, Serv & Eq (OM only)	Throughput or = (manyears * manyear $ for preparation) + (cost of class * # classes) + (manyears * manyear $) + material $ + Other
4.03	Transportation (OM only)	Throughput or = weight * packing factor * 1st dest cost * number of systems + weighted sum of 2nd dest cost + Other
4.04	Initial Repair Parts (OM only)	Throughput or = % unit manufacturing cost for repair parts * unit manufacturing cost * AAO quantity
4.05	Sys Spec Base Op Spt	Throughput
4.06	Other O&M Fund Field	Throughput

Some cost elements and cost equations will appear to be the same as found in other phases, for example, "System Test and Evaluation: cost of DT/OT I and II". It is important to note that the costs reflected here are the portion of the cost for this item that is funded out of the OM appropriation. In many cases, a differentiation must be made between the appropriations.

4.01 System Test and Evaluation. The OM funded costs of system specific development and operational test activities (DT/OT I and II) including planning, materials and participation are estimated in this cost element. An estimate of contract and government manyears plus travel, any materials for testing, and the cost of conducting any tests are used to estimate this element.

4.02 Training, Service and Equipment. The OM funded costs of developing training devices, and preparing and executing training classes or courses are included in this cost element. The training may include initial service instructors and initial crew and maintenance personnel, New Equipment Training Teams and one-time costs of establishing system specific individual training programs. One part of the cost includes the manyears required for training class preparation and the cost of materials developed for training purposes. The second part includes the cost of holding the class and manyears required for attendance plus travel cost.

4.03 Transportation. This cost element includes the first and second destination costs of transporting a newly introduced system. First destination is the movement of the system from the manufacturer to the CONUS depot or point of Army acceptance. Second destination is the movement of the system from the point of acceptance to the final user. Transportation costs are estimated based upon weight of the system and the cost per unit of weight (usually given in short tons) to transport to various locations. First destination costs are generally shipping costs within CONUS and second destination costs are costs to ship from CONUS to different theaters. The number of systems assigned to different theaters must therefore be known. Transportation normally lags the manufacturing schedule by one year so that transportation costs are estimated in the year following manufacturing.

4.04 Initial Repair Parts. All consumable (nonreparable) individual parts, assemblies or subassemblies required to support end items at the organizational level throughout the system life cycle are costed here. These items are funded by the OM appropriation and are separate from spares.

Initial repair parts costs can be estimated as a percentage of unit manufacturing costs. The number of systems requiring initial repair parts can be estimated by the AAO quantity.

4.05 System Specific Base Operating Support. Any OM funded costs associated with Base Operations/Real Property Maintenance Activities for site activation equipment installation are costed here. This is a throughput value.

4.06 Other OM Funded Fielding. Any other OM funded costs should be identified and costed here. This is a throughput value.

5.0 SUSTAINMENT. Sustainment covers the recurring process of operating and maintaining force structure and materiel systems to perform assigned tests and missions. It is assumed that annual sustainment costs are equal across all years of sustainment. For the estimation of this phase, there are a set of variables that are common to many of the cost elements. These variables are input prior to completing the individual cost elements and are:

weighted sum of the systems
annual operating hours of a fulltime system
maintenance manyears per system OR
    MTBF (Mean Time Between Failure)
    MTTR (Mean Time to Repair)
    MTBSM (Mean Time Between Scheduled Maintenance)
    MTTSM (Mean Time to Perform Scheduled Maintenance)
MTBO (Mean Time Between Overhaul)
MTTO (Mean Time To Overhaul)
annual maintenance manhours available
number of crew manyears per system
number of operating years (years of Sustainment)
unit manufacturing cost
MCTTR (Mean calendar time to repair)
MCTTO (Mean calendar time to overhaul)
useful system lifetime
units in training

The weighted sum of the systems is a calculation based upon the number of systems fielded and the expected usage rate of the systems. A weighted sum

of these systems gives an equivalent operational quantity of fulltime systems. This number is used in all calculations and eliminates the need to calculate each cost element across theaters with different usage rates. The annual operating hours for a system are the hours that a system used fulltime would be expected to operate in one year. Maintenance for a system can be calculated in either of two ways. If the prescribed number of maintenance manyears is the only data known, then this value is used to determine manyear costs for maintenance. An alternative method of calculating maintenance manyear costs depends upon the values for the various maintenance parameters. These maintenance parameters (MTTR, MTTSM, MTTO) do not include transit or waiting time, but only actual maintenance time. The annual maintenance manhours available are the manhours that make up a maintenance manyear. Crew manyears are the crew requirement to operate the system. Operating years are the expected sustainment years for the system. Unit manufacturing cost is the average cost to produce a system and was calculated in the production phase. Mean calendar time to repair and mean calendar time to overhaul are the times required for below depot and depot level maintenance. These differ from the previous parameters since they include the transit time and in-shop waiting time as well as the actual repair time. Useful system life is the expected lifetime of the system in hours. The number of units in training are the number of systems assigned to training.

Sustainment costs are funded from Procurement (PROC), OM, and Military Personnel (MPA) appropriations. Table 2.5 shows the cost elements and equations for 5.0 SUSTAINMENT.

5.01 Replenishment. This cost element includes the hardware costs associated with usage, maintenance and upkeep of a system. It may be a throughput value or the sum of the next four cost elements.

5.011 Replenishment Repair Parts. This cost element is funded by the OM appropriation and includes all consumable (nonreparable) individual parts, subassemblies, and assemblies for repair of spares or end items below depot level after fielding. Repair parts are estimated as both the average cost of repair parts (hardware) per failure and average cost of repair parts per scheduled maintenance action. The annual cost of this element is

TABLE 2.5 Equations for Estimating 5.0 SUSTAINMENT

COST ELEMENT	EQUATION
5.0 SUSTAINMENT	Sum of 5.01-5.11
5.01 Replenishment	Sum of 5.011 - 5.014
5.011 Repl Repair Parts (OM only)	Throughput or = weighted sum of systems * # repair parts costs as % of unit manufacturing cost * # operating yrs + Other
5.012 Repl Spares (PROC only)	Throughput or = weighted sum of systems * # spare parts cost as % of unit manufacturing cost * # operating yrs + Other
5.013 War Res Repair Parts (OM only)	Throughput or = (# repair parts required * average cost of repair parts) * # systems assigned to war reserve + Other
5.014 War Res Spares (PROC only)	Throughput or = # spares required * average cost of spares * # systems assigned to war reserve + Other
5.02 Petr, Oil, & Lube	Throughput or = average annual operating hours or miles * rate of fuel consumption * fuel cost * lube factor * weighted # systems * # operating years + Other
5.03 Ammunition	Sum of 5.031-5.032
5.031 Training Ammo/Missile	Throughput or = average annual consumption of ammunition * system ammunition cost * # systems in training * # operating years + Other
5.032 War Res Ammo/Missile	Throughput or = war reserve ammunition/missiles * ammunition cost * # war reserve systems + Other

TABLE 2.5 Equations 5.0 (cont.)

	COST ELEMENT	EQUATION
5.04	Depot Maintenance	Sum of 5.041-5.044
5.041	Civilian Labor	Throughput or = Mean time to overhaul * civilian labor rate$) * annual operating hours / Mean time between overhaul * weighted sum of systems * # operating years + Other
5.042	Materiel (OM only)	Throughput or = repair parts cost as % of unit manufacturing cost * (annual operating hours / MTBO) - annual wearouts * weighted sum of systems * # operating years + Other
5.043	Materiel (PROC only)	Throughput or = spares cost as % of unit manufacturing cost * (annual operating hours / MTBO) - annual wearouts * weighted sum of systems * # operating years + Other
5.044	Maint Support Activ	Throughput
5.05	Field Maint Civ Lab	Throughput or = (Mean time to repair for civilian labor * annual operating hours/(MTBF + Mean time for scheduled maintenance for civilian labor) * annual operating hours/MTBSM) * civilian labor rate per hour * weighted sum of systems * # operating years + Other
5.06	Transportation	Throughput or = Weighted sum transportation cost * weight * packing factor * 2 * (annual operating hours / MTBO) - annual wearout * # operating systems * # operating years + Other
5.07	Sys Spec Repl Training	Sum of 5.071-5.072

TABLE 2.5 Equations 5.0 (cont.)

	COST ELEMENT	EQUATION
5.071	Ammo/Missile/Equip	Throughput or = (maintenance manyears + crew manyears per system) * weighted sum of PROC funded replacement cost * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.072	Services	Throughput or = (maintenance manyears + crew manyears per system) * weighted sum of OM funded replacement cost * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.08	Military Personnel	Sum of 5.081-5.087
5.081	Crew Pay & Allowance	Throughput or = weighted sum of base pay and allowance * crew manyears per system * # operating years + Other
5.082	Maint Pay & Allowances	Throughput or = weighted sum of base pay and allowance * maintenance manyears per system * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.083	Sys Spec Supt P&A	Throughput

TABLE 2.5 Equations 5.0 (cont.)

	COST ELEMENT	EQUATION
5.084	Trainee/Trainer P&A	Throughput or = (maintenance manyears + crew manyears per system) * weighted sum of MPA funded replacement cost * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.085	Sys/Proj Mgmt P&A	Throughput or = manyears * manyear $ * # operating years) + Other
5.086	Perm Chg Of Sta (PCS)	Throughput or = (maintenance manyears + crew manyears per system) * weighted sum of PCS cost * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.087	Other MPA Fund Sust	Throughput
5.09	Sys/Proj Mgmt (Civ)	Throughput
5.10	Modifications/Kits	Throughput
5.11	Other Sustainment	Throughput

TABLE 2.5 Equations 5.0 (cont.)

	COST ELEMENT	EQUATION
5.111	Other O&M Fund Sust	Throughput or = (maintenance manyears + crew manyears per system) * weighted sum of QMU cost * # operating years + Other alternate calculation of maintenance manyears = (MTTR * annual operating hours / MTBF / total maintenance manhours per year) + (MTTSM * annual operating hours / MTBSM / total maintenance manhours per year)
5.112	Other Proc Fund Sust	Throughput

calculated as a percentage of manufacturing cost. An alternative estimation could be based upon repair hardware cost per repair, annual operating hours, MTBF and MTBSM.

5.012 Replenishment Spares. This cost element is funded by the PROC appropriation and includes all spares (reparable components, subassemblies, assemblies) needed to resupply the initial stockage used on a recurring basis to sustain major end items of equipment after fielding. The annual cost of this element is estimated as a percentage of manufacturing cost.

5.013 War Reserve Repair Parts (OM). OM hardware costs funded by the stock fund for sustaining combat operations until resupply can be obtained are accounted for here. This can be throughput or estimated by the number of repair parts per system, the average cost of the repair part and the number of systems assigned to the war reserve.

5.014 War Reserve Spares (PROC). Hardware costs funded by procurement for sustaining combat operations until resupply can be obtained is costed here. This can be throughput or estimated from the number of

spares per system, the average cost of the spare and the number of systems assigned to the war reserve.

5.02 Petroleum, Oils and Lubricants (POL). Fuels, oil and lubricants for the system are costed here. They can be estimated from the rate of fuel consumption, fuel cost, annual operation of a system in the same unit as fuel consumption and lube factor (which accounts for oil and lubrication as a factor of fuel usage).

5.03 Ammunition. This cost element includes the missiles and ammunition consumed by the system during training, service and combat. This is either a throughput value or the sum of the next two elements.

5.031 Training Ammunition/Missiles. Any ammunition and missiles consumed by the system during training or service are costed here. The costs can be estimated from the annual consumption of ammunition/missiles, the average ammunition cost and the number of training units.

5.032 War Reserve Ammunition/Missiles. The procurement funded costs for war reserve ammunition required to sustain combat operation of approved forces through the prescribed period are included here. The cost can be estimated by the amount of ammunition consumed during the combat period, the average ammunition cost and the number of war reserve periods.

5.04 Depot Maintenance. Depot Maintenance includes both hardware and civilian personnel costs incurred at the depot level. Depot maintenance involves the overhaul of systems. This cost element can be a throughput or can be summed from the next four elements.

5.041 Depot Maintenance Civilian Labor. The OM funded costs of civilian labor and overhead for the repair, overhaul and modification of the end item and components are included here. This element can be estimated by calculating the annual depot maintenance manhours as a function of MTTO, MTBO and annual operating hours and then multiplying by the civilian hourly labor rate and the number of equivalent systems.

5.042 Depot Maintenance Materiel (OM). This cost element is funded by the OM appropriation and includes all consumable (nonreparable) individual parts, subassemblies, and assemblies for repair or overhaul of end items at depot level. This cost is estimated as the average cost of repair parts (hardware) per overhaul. It is calculated based upon the repair hardware costs, the annual operating hours, and MTBO.

5.043 Depot Maintenance Materiel (PROC). This cost element is funded by the Procurement appropriation and includes all spares (reparable components, subassemblies, assemblies) needed for the repair, overhaul, and modifications of the end item and associated components at the depot level. Spares are estimated as the average cost of spares (hardware) per overhaul. The cost of this element is calculated based upon the repair hardware costs, the annual operating hours, and MTBO.

5.044 Maintenance Support Activity. OM funded support activities for the system at the depot level are costed here. This is a throughput value.

5.05 Field Maintenance Civilian Labor. Civilian labor that occurs below depot level is costed in this cost element. This cost is funded by the OM appropriation. It can be estimated by the civilian labor cost per hour and the percentage of below depot maintenance that is attributable to civilian labor. The cost element is calculated based upon MTTR, MTBF, MTBSM, MTTSM, the number of systems, the annual operating hours and the civilian labor costs.

5.06 Transportation. This element includes the OM funded costs of transporting items to depot maintenance facilities and back to operational units. The additional inputs for this element are the weighted sum of transportation cost to/from depot and the annual wearout number. The weighted transportation cost is calculated from the number of systems in each theater times the transportation cost associated with that theater. The annual wearout is determined in the production schedule calculation and can be taken from there if it is not a known value. This element is calculated based upon annual operating hours, MTBO, annual wearout (since these are not

overhauled), number of systems and round trip transportation costs.

5.07 System Specific Replacement Training. This element includes all replacement training costs that can be associated specifically with a system. It can be a throughput value or the sum of the next two cost elements.

5.071 System Specific Replacement Training Ammunition/Missiles/ Equipment. Any PROC funded system specific training ammunition, missiles, or equipment used during the training of replacement personnel is costed here. This element is estimated as the number of military personnel manyears associated with a system times replacement and training costs funded by the PROC appropriation. The military personnel manyears are calculated by summing crew manyears and maintenance manyears. The weighted replacement costs are calculated as number of systems in a theater times the usage rate times the attrition rate times the PROC funded training replacement cost.

5.072 System Specific Replacement Training Services. Any OM funded system specific training services for replacement personnel are costed here. This element is estimated based on the number of military personnel manyears associated with a system times replacement and training costs funded by the OM appropriation. The military personnel manyears are calculated by summing crew manyears and maintenance manyears. The weighted replacement costs are calculated as number of systems in a theater times the usage rate times the attrition rate times the OM training replacement cost.

5.08 Military Personnel. Military personnel which are funded by the Military Personnel Appropriation (MPA) are costed within this element. Most military personnel costs for crew and maintenance personnel are included here. This can be a throughput value or the sum of the next seven elements.

5.081 Crew Pay and Allowance. This element includes the MPA funded portion of the base pay and allowance, theater cost and special pay of military personnel whose primary function is to operate the materiel system being costed. This element is estimated from the number of crew manyears per system and the weighted sum of base pay and allowance. The weighted sum is

the number of systems in a theater times the usage rate times the average crew base pay plus theater cost summed over all theaters.

5.082 Maintenance Pay and Allowance. This element includes the MPA funded portion of the base pay and allowance, theater cost and special pay of those organizational, direct and general support military personnel below depot who maintain the system. This element is estimated from the weighted sum of base pay and allowance, MTTR, MTBF, MTBSM, MTTSM, annual operating hours and annual maintenance manhours available. The weighted sum is the number of systems in a theater times the usage rate times the average maintenance base pay plus theater cost summed over all theaters. The various maintenance parameters are used to calculate the number of maintenance manyears required.

5.083 System Specific Support Pay and Allowance. Any military personnel below depot who are charged to the system but are not crew or maintenance personnel are costed here. This is a throughput value.

5.084 Trainee/Trainer Pay and Allowance. The MPA funded portion of replacement training for a system is costed here. This element is estimated based on the number of military personnel manyears associated with a system times replacement costs. The military personnel manyears are calculated by summing crew manyears and maintenance manyears, where maintenance manyears are a function of failure and scheduled maintenance parameters. The weighted replacement costs are calculated as number of systems in a theater times the usage rate times the attrition rate times the MPA funded portion of replacement training.

5.085 System/Project Management Pay and Allowance. The MPA portion of any military personnel assigned to system project management is costed here. This can be estimated by the number of annual military manyears required and the manyear cost or input as a throughput value.

5.086 Permanent Change of Station (PCS). This element includes the MPA costs associated with the PCS of system specific replacement personnel to and from overseas theaters and within CONUS. This element is estimated

based on the number of military personnel manyears associated with a system times PCS costs. The military personnel manyears are calculated by summing crew manyears and maintenance manyears. The weighted PCS costs are calculated as the sum of the number of systems in a theater times the usage rate times the theater rotation rate times the PCS cost associated with the theater.

5.087 Other MPA Funded Sustainment. Any other military personnel costs associated with sustainment are costed here. This is a throughput value.

5.09 System/Project Management (Civilian). The OM funded portion of system project management includes any civilians assigned to such an office. This is a throughput value.

5.10 Modifications/Kits. This element includes the procurement funded costs of materiel associated with any official alteration made to a system after fielding by the Army. This is a throughput value.

5.11 Other Sustainment. Any other sustainment costs not captured by the above elements should be identified and costed here. This can be a throughput value or the sum of the next two cost elements.

5.111 Other O&M Funded Sustainment. Other O&M funded costs not captured above should be costed here. Included in this element are Quarters, Maintenance and Utilities (QMU). This can be costed by number of military manyears times the weighted sum of QMU costs. Military manyears are the sum of crew manyears and maintenance manyears. The weighted sum of QMU costs is the number of systems in a theater times the usage rate times average QMU cost per man within the theater.

5.112 Other Procurement Funded Sustainment. This element includes all other procurement funded system specific costs that are not included in the above elements. This is a throughput value.

INPUT VARIABLES

The input that is required for the BCM is listed in Table 2.6. Data is input to the model by cost phase and cost element. The table shows the variables that must be input for each cost element in each phase. Note that some phases use common variables and these are input together at the beginning of the phase.

TABLE 2.6 Input Variables for BCM Cost Elements

	COST ELEMENT	VARIABLE
1.0	DEVELOPMENT	Sum of 1.01-1.07
1.01	Development Engineering	Sum of 1.011-1.014
1.011	Engineering	Contract initial engineering manyears manyear $ travel $ materials $ material transportation $ test equipment $ test equip transportation $ redesign as % of initial eng In-House engineering manyears manyear $ travel $ % spread over R&D years Other costs
1.012	PEP	Contract # drawings $ per drawing manyears to develop software manyear $ In-House # drawings $ per drawing manyears to develop software manyear $ % spread over R&D years Other costs
1.013	Tooling	Contract total hours for tooling hourly rate tooling material $ tooling transportation $ % spread over R&D years Other costs
1.014	Prototype Manufacturing	prototype manufacturing $ spares as % of manufacturing $ rework as % of manufacturing $ # prototypes GFE % spread over R&D years Other costs

TABLE 2.6 Input (cont.)

	COST ELEMENT	VARIABLE
1.02	Data	Contract manyears to develop data manyear $ travel $ material $ In-House manyears to develop data manyear $ travel $ % spread over R&D years Other costs
1.03	System Test & Eval	Contract manyears manyear $ material $ In-House manyears manyear $ travel $ material $ DT I $ DT II $ OT I $ OT II $ % spread over R&D years Other costs
1.04	Sys/Proj Mgmt	manyears manyear $ % spread over R&D years Other costs
1.05	Train, Serv & Equip	Contract manyears manyear $ travel $ In-House manyears for preparation manyear $ manyears for participation manyear $ travel $ material $ % spread over R&D years Other costs
1.06	Facilities	Throughput
1.07	Other RDT&E Fund Dev	Throughput

TABLE 2.6 Input (cont.)

COST ELEMENT		VARIABLE
2.0 PRODUCTION		Sum of 2.01-2.09
2.01	Non-Recurring Eng	Sum of 2.011-2.014
2.011	Init Prod Facil	material $ manyears required manyears $ Other costs
2.012	Prod Base Supt	Throughput
2.013	Dep Mt Prod Eq	Throughput
2.014	Other Non-Recur Prod	Throughput
2.02	Recurring Production	Throughput or sum of 2.021-2.024
2.021	Manufacturing	First unit cost of labor Quantity produced learning curve factor (decimal %) material cost per unit Overhead % G&A % Profit % GFE % spread over production years Other costs
2.022	Recurring Eng	Contract manyears manyears$ In-House manyears manyear$ % spread over production years Other costs
2.023	Sustaining Tooling	Contract as % of initial tooling In-House manyears manyear $ % Spread over production years Other costs
2.024	Quality Control	Contract manyears manyear$ In-House manyears manyear $ FAT $ % spread over production years Other costs

TABLE 2.6 Input (cont.)

	COST ELEMENT	VARIABLE
2.03	Engineering Changes	Contract as % of manufacturing $ In-House manyear manyear $ Common Other costs Spread over production years
2.04	Data	Contract manyears manyear $ In-House manyears manyear $ # pages cost per page Other costs
2.05	System Test & Eval	Contract manyears manyear$ travel $ In-House manyears manyear $ travel $ material $ cost to conduct tests % spread over production years Other costs
2.06	Train, Serv & Eq	manyears for preparation manyear $ cost of class # classes manyears for class attendance manyear $ travel $ material $ Other costs
2.07	Initial Spares (PROC funded)	% unit manufacturing cost for spares AAO quantity Other costs
2.08	Operat/Site Activ	Throughput
2.09	Other Proc Fund Prod	Throughput

TABLE 2.6 Input (cont.)

COST ELEMENT	VARIABLE
Production Calculation	Distribution of systems Usage rates throughout distribution operational ready rate Mean calendar time to repair Mean time between failure Mean calendar time to overhaul Mean time between overhaul average fulltime operating hours average system expected lifetime number of operating years number of initial production years total number of production years first year production number optional production schedule for years 2-5 Maximum economic capability minimum economic production restart (backorder) quantity
3.0 MILITARY CONSTRUCTION	Sum of 3.01-3.04
3.01 Test Construction	Throughput
3.02 Prod Construction	Throughput
3.03 Oper/Site Act Constr	Throughput
3.04 Other MCA Fund Constr	Throughput
4.0 FIELDING	Sum of 4.01-4.06
4.01 System Test & Eval	Contract manyears manyear $ material $ In-House manyears manyear $ travel $ material $ DT I $ DT II $ OT I $ OT II $ % spread over R&D years Other costs

TABLE 2.6 Input (cont.)

	COST ELEMENT	VARIABLE
4.02	Train, Serv & Eq	manyears for preparation manyear $ cost of class # classes manyears for attendance manyear $ material $ travel $ Other costs
4.03	Transportation	weight of system 1st destination cost weighted sum of 2nd destination cost number of systems % spread across fielding Other costs
4.04	Initial Repair Parts	% unit manufacturing cost for repair parts unit manufacturing cost AAO quantity Other costs
4.05	Sys Spec Base Op Spt	Throughput
4.06	Other O&M Fund Field	Throughput
5.0	SUSTAINMENT	Sum of 5.01-5.11
Common variables for Sustainment		weighted sum of systems annual operating hours of system Maintenance manyears per system or MTBF (Mean time between failure) MTTR (Mean time to repair) MTBSM (Mean time between scheduled maintenance) MTTSM (Mean time for scheduled maintenance) MTBO (Mean time between overhaul) MTTO (Mean time to overhaul) annual maintenance hours available crew manyears per system number of operating years unit manufacturing cost MCTTR (Mean calendar time to repair)

TABLE 2.6 Input (cont.)

	COST ELEMENT	VARIABLE
Common variables (con't)		MCTTO (Mean calendar time to overhaul) Useful system lifetime # units in training
5.01	Replenishment	Sum of 5.011-5.014
5.011	Repl Repair Parts (OM)	% unit manufacturing cost for annual repair parts Other costs
5.012	Repl Spares (PROC)	% unit manufacturing cost for annual spares Other costs
5.013	War Res Repair Parts (OM)	# repair parts required average cost of repair parts # systems assigned to war reserve Other costs
5.014	War Res Spares (PROC)	# spares required per system average cost of spare # systems assigned to war reserve Other cost
5.02	Petr, Oil, & Lube	Annual operating units (miles or hours) rate of fuel consumption (miles or hours) fuel cost lube factor Other costs
5.03	Ammunition	Sum of 5.031-5.032
5.031	Training Ammo/Missile	average annual ammunition consumption per training system # units in training average ammunition cost Other costs
5.032	War Res Ammo/Missile	war reserve consumption system ammo cost # war reserve systems Other

TABLE 2.6 Input (cont.)

	COST ELEMENT	VARIABLE
5.04	Depot Maintenance	Sum of 5.041-5.044
5.041	Civilian Labor	civilian hourly labor rate $ Other costs
5.042	Materiel (OM)	% unit manufacturing costs for overhaul repair parts Other costs
5.043	Materiel (PROC)	% unit manufacturing costs for overhaul spares Other costs
5.044	Maint Support Activ	Throughput
5.05	Field Maint Civ Lab	civilian hourly labor rate $ civilian MTTSM Other costs
5.06	Transportation	weight (in short tons) weighted sum transportation cost to/from depot Other costs
5.07	Sys Spec Repl Training	Throughput or sum of 5.071-5.072
5.071	Ammo/Misl/Equip	weighted sum of replacement cost funded by PROC Other costs
5.072	Services	weighted sum of replacement cost funded by OM Other costs
5.08	Military Personnel	Sum of 5.081-5.087
5.081	Crew Pay & Allowance	weighted sum of base pay and allowance Other costs

TABLE 2.6 Input (cont.)

COST ELEMENT		VARIABLE
5.082	Maint Pay & Allowances	weighted sum of base pay and allowance Other costs
5.083	Sys Spec Supt P&A	Throughput
5.084	Trainee/Trainer P&A	weighted sum of replacement cost funded by MPA Other costs
5.085	Sys/Proj Mgmt P&A	manyears manyear $ Other costs
5.086	Perm Chg of Sta (PCS)	weighted sum of PCS Other costs
5.087	Other MPA Fund Sust	Throughput
5.09	Sys/Proj Mgmt (CIV)	Throughput
5.10	Modifications/Kits	Throughput
5.11	Other Sustainment	Throughput
5.111	Other O&M Fund Sust	weighted sum of QMU Other costs
5.112	Other PROC Fund Sust	Throughput

SECTION III
COMPUTER IMPLEMENTATION

GENERAL

One of the primary considerations in the development of the BCM was to provide a tool that was readily available and easy to utilize and maintain. Microcomputers with a standard set of commercial software are rapidly becoming available to BRDEC personnel and these are expected to become fully integrated into the work environment. After evaluating several alternatives available for implementing the BCM, a microcomputer approach using SYMPHONY was selected.

WHY USE SYMPHONY

The biggest advantage in using SYMPHONY for the BCM is flexibility. Every costing situation is unique and a programmed model will not fit every situation. With SYMPHONY, the user can easily change cost equations, variables or text to tailor the BCM to the specific system being costed. Since SYMPHONY is a software spreadsheet package and not a programming language, there is no need to link or recompile the program after making any changes.

SYMPHONY's capability allows development of a model that is user friendly. The BCM takes advantage of the "macro" feature which allows repetitive or difficult command sequences to be collected, named, stored and then recalled for use. SYMPHONY is menu driven and also provides the capability to create custom menus controlling the various worksheets in the model. The BCM uses this menu feature to guide the user through the worksheets and through the various steps in each worksheet. A user should be able to use the BCM and develop a cost estimate with the BCM Users Manual, the BRDEC Cost Analysis Handbook and minimal outside help.

KEYBOARD ORIENTATION

SYMPHONY and the BCM use different keys on the keyboard for special purposes. Not all keyboards are identical but most of them follow a general layout. The function keys are usually located in two columns on the far left side of the keyboard. They will be marked F1 - F10. Throughout the Users Manual, whenever function keys are referred to, they will be enclosed in braces. For example, function key F1 will be referred to as {F1}. The arrow keys are usually located in a block on the right side of the keyboard. They will be marked with arrows indicating the direction in which they move the cursor. The 'page up' and 'page down' keys are located in the same block as the arrow keys. The return key is usually a large key located to the right of the letter keys. The ESC key is usually located to the left of the number keys.

USING MENUS

Most of the functions for the BCM are menu driven. These menus appear at the top of the screen. When a menu is initially displayed, the first option on it will be highlighted. This is the position of the cursor. Above the highlighted option will be a description of what that option does. To move the cursor, use the right or left arrow keys. To select an option, position the highlighted cursor over the option and press return. Selecting an option from the menu starts a macro which performs the sequence of commands to carry out the option. To leave the menu and return to the worksheet, press the ESC key.

EDITING CELLS

A worksheet in SYMPHONY is essentially an array of cells identified by column (letter) and row (number). Each cell in the BCM worksheets may contain text, numerical values or formulas. A worksheet formula is an equation whose variables can be found in the cells referenced within the formula. The arrow keys and the page up and the page down keys provide the movement around the worksheet. The arrow keys will move one cell at a time. The page up key moves up 20 cells. The page down key moves down 20 cells.

To input data, move to the correct cell, type in the data and press return. To change information in a cell, move to the cell, type in the new data and press return. When the highlighted cursor is in a cell, the contents of the cell are displayed at the top of the screen.

HARDWARE REQUIREMENTS

The BCM requires SYMPHONY, version 1.1, a PC compatible microcomputer, 640K RAM, a dot matrix printer, preferably 132 columns wide, and a hard disk with a minimum of 800K available for the worksheet files. After SYMPHONY is loaded into the PC, there should be at least 326K of RAM available. This can be checked with the settings command in SYMPHONY. To have this much memory available, there cannot be any other programs running concurrently. To ensure this, boot up the system with a DOS disk in drive A which does not have an 'AUTOEXEC.BAT' file on it. DOS version 2.1 or higher must be used.

HARD DISK CONSIDERATIONS

The BCM worksheets are designed to run from the hard disk of a microcomputer. Besides being faster, some of the functions access several worksheets at one time. If they are not all on the hard disk, then an error occurs and the macros do not operate. To run from two floppy disks, the macros have to be modified and the order of the worksheets on the floppy disks carefully set up.

To operate most effectively with the BCM on the hard disk, a separate subdirectory should be created for the BCM worksheets for each specific project. Since the worksheet names cannot be changed, this will help to eliminate any inadvertent mixing of worksheets between projects.

BACK UP

It is advisable to back up all software, prior to starting work or making changes, either to another directory on the hard disk or to floppy disks. This prevents the total loss of work due to unforeseen failure of

either the equipment or the operator. The BCM worksheets are easily copied onto three floppy disks or onto a hard disk. The blank worksheets with the default should be copied onto floppy disks and kept to distribute as needed. Back up copies of project work with the BCM should be periodically updated so that recent changes can be reconstructed in the case of failure.

SECTION IV
BCM MODEL DESCRIPTION

GENERAL

The BCM uses the Army 5 Phase Cost Model consisting of Development, Production, Military Construction, Fielding and Sustainment cost phases. The worksheet structure of the BCM is based upon these five phases. The basic worksheets include the main menu worksheet, the data input worksheets, the matrix worksheets for each phase, the matrix worksheet for the total system, and the worksheets for sensitivity analyses, inflation indices and military personnel costs. Figure 4.1 displays the 13 worksheets that make up the BCM.

OVERVIEW OF WORKSHEETS

MAINMENU WORKSHEET (MAINMENU.WR1). The MAINMENU worksheet is used to tie the other 12 worksheets together. All other worksheets can be accessed from the MAINMENU worksheet. To list the options for MAINMENU, pr s function key (F7), type *M* and press return. Options for MAINMENU.WR1 are:

DATA INPUT MATRIX CDS SENS ANALYSIS TOTAL MATRIX

The 'Data Input' option will retrieve any of the 4 data input worksheets. The 'Matrix' option will retrieve any of the 4 matrix worksheets. The 'Sens Analysis' option retrieves the sensitivity analysis worksheet and the 'Total Matrix' option retrieves the total matrix worksheet.

INPUT WORKSHEETS. There are 4 input worksheets: DEVINP.WR1 for the Development phase, PRODINP.WR1 for the Production phase, MCFINP.WR1 for the Military Construction & Fielding phases and SUSINP.WR1 for the Sustainment phase. These worksheets contain the Variable Input Sheets for each of the cost elements in the phase. All the cost data will be entered here.

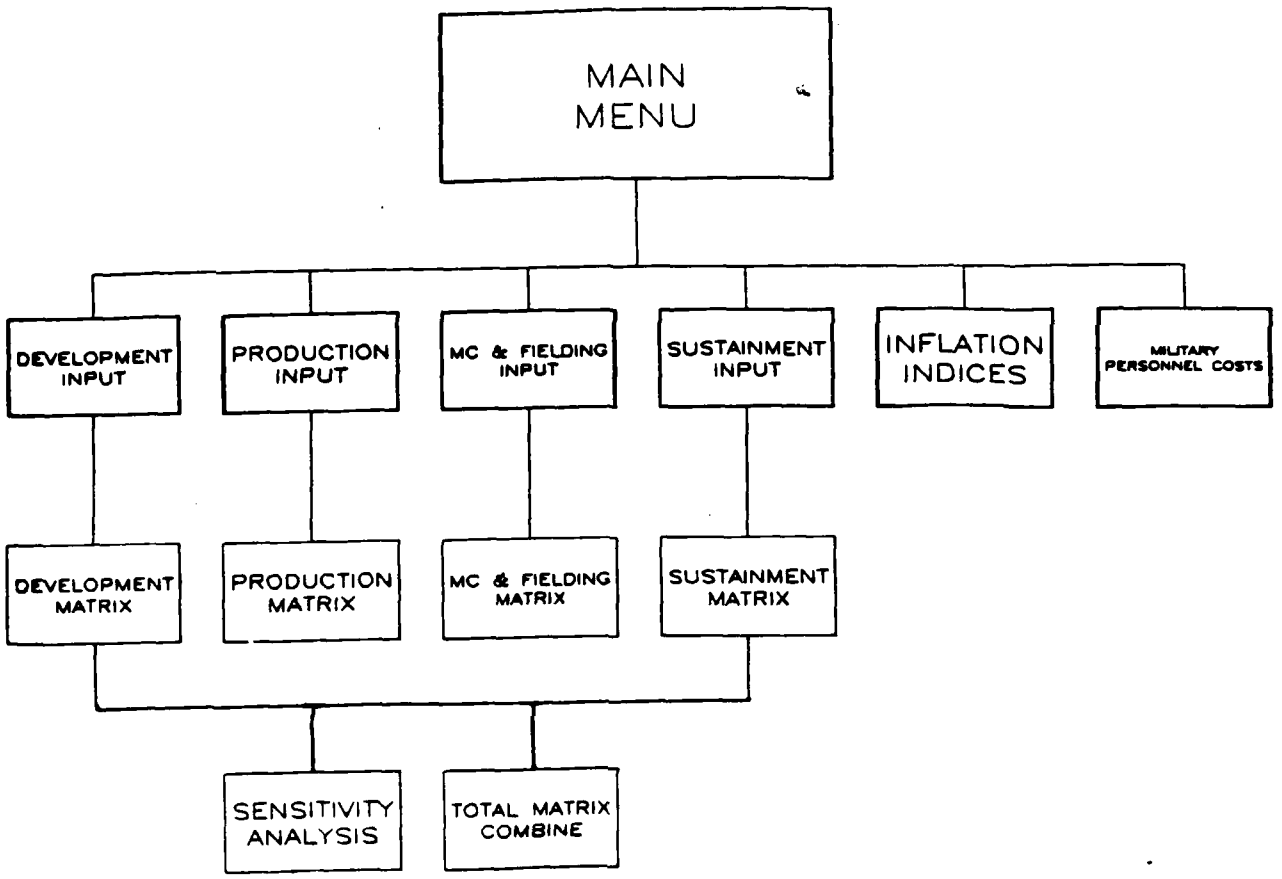

Figure 4.1 ORGANIZATION OF WORKSHEETS

The Variable Input Sheets contain an area for filling in the values of the variables, an area that describes the cost equation, an area for explaining the rationale for the values, and an area that describes sources of utilized data. Data can be entered for up to three subsystems.

Below the Variable Input Sheets is the area for calculating the costs of the phase. The table in this area will show the total cost values resulting from the data entered for each of the cost elements.

The PRODINP.WR1 and SUSINP.WR1 each have an additional area for calculating other information. The Production worksheet can calculate a production quantity and production schedule based upon various parameters. The Sustainment worksheet calculates weighted sums used in place of individually costing and summing systems across theaters. These weighted sums apply to both the number of operational systems and to various personnel costs.

DEVINP.WR1. The options for DEVINP.WR1 are:

EQUATIONS COST ELEMENTS SUNK COSTS TITLES START YEAR

The 'Equations' option moves to the section of the worksheet that contains the table of equations used in the Development phase and in the calculation of phase totals. These are cell reference equations. They contain the cell addresses of the variables used in the equation. The 'Cost Element' option moves to the Variable Input Sheet of the selected cost element within the Development phase. There is space within the Development worksheet to input sunk costs if appropriate. This area can be accessed by the 'Sunk Costs' option. The 'Titles' option allows the title of the system being costed and titles of the subsystems to be input. These titles will be reflected throughout the worksheet. The 'Start Year' option is used to input the starting year of the cost phase. In the Development phase, this will also be the first and base year of the cost estimate.

PRODINP.WR1. The options for PRODINP.WR1 are:

CALCULATE PROD INPUT SPREAD EQUATIONS COST ELEMENTS TITLES START YEAR

In addition to the four options found in DEVINP.WR1, PRODINP.WR1 has two options which may be used to determine the production quantity and schedule for the system. The 'Calculate Prod' option moves to an area where production quantity and schedule are calculated based upon the life cycle requirement and production parameters. The results of this calculation, production quantity and spread across production years, may be used as input to the Production cost elements. The 'Input Spread' option moves to an area where the percentage spread of production costs across production years is input. This area contains a column of years with blanks to be filled in with percentage figures for each subsystem. The numbers for percentage spread can be taken from the production schedule calculation, if it was used, or any other estimate of production schedule can be used for input. The 'Equations', 'Cost Elements', 'Titles' and 'Start Year' options in PRODINP.WR1 are identical to those in DEVINP.WR1.

MCFINP.WR1. The options in the Military Construction/Fielding worksheet are:

EQUATIONS COST ELEMENTS TITLES START YEAR

The 'Equations' option moves to the section of the worksheet that contains the table of equations used in the Military Construction and Fielding phases and where the phase totals are calculated. These are cell reference equations. They contain the cell addresses of the variables used in the equation. The 'Cost Element' option moves to the Variable Input Sheet of the selected cost element within the Military Construction or Fielding phases. 'Titles' allows input of system and subsystem titles and 'Start Year' allows input of the starting year of the cost phase.

SUSINP.WR1. The options for SUSINP.WR1 are:

COMMON VARIABLES EQUATIONS COST ELEMENTS WEIGHTED SUMS TITLES START YEAR

SUSINP.WR1 has two additional options besides the basic 'Equations', 'Cost Elements', 'Titles' and 'Start Year' options. The 'Common Variables' option moves to a table of variables that are common to one or more equations in the Sustainment phase. The user inputs values for these variables in the common variable table instead of entering them every time they occur in an equation. The 'Weighted Sums' option moves to a table that will be filled in with various data used to calculate weighted sums of military personnel costs and operational quantities. The weighted sums are used instead of calculating and summing all the cost elements across each theater of distribution.

'Common Variables' and 'Weighted Sums' must be completed prior to entering any data in any of the Sustainment cost elements.

'Equations', 'Cost Elements', 'Titles' and 'Start Year' are the same as in the other worksheets.

MATRIX WORKSHEETS. There are 4 matrix worksheets. DEV.WR1 is used for the Development phase, PROD.WR1 for Production, MCF.WR1 for Military Construction & Fielding and SUS.WR1 for Sustainment. These worksheets contain the WBS matrix, the CONSTANT matrix, the CURRENT matrix and the Cost Data Sheets for each element in the specific phase. The options for all four Matrix worksheets are identical. These are:

WBS MATRIX CONSTANT MATRIX CURRENT MATRIX COST ELEMENTS

Selecting the 'WBS' option moves to the WBS matrix. This matrix shows the total cost of individual elements by the work breakdown structure. The 'Constant' option moves to the constant dollar matrix. This matrix shows the cost element values for the total system (sum of the subsystems) for each year of the life cycle in constant or base year dollars. The first year of

R&D is considered to be the base year. Any sunk costs are shown prior to the base year.

The 'Current' option moves to the current dollar matrix. The appropriate inflation indices must be entered in the inflation row in order for the values to be correct. The values for the inflation indices can be found in the inflation worksheet, but care must be taken to ensure that these are the most current indices. The Cost Analysis Division can supply this information. The current matrix shows the cost element values for the total system for each year of the life cycle in current or fully inflated dollars.

The 'Cost Elements' option allows selection of a Cost Data Sheet for a cost element in a subsystem. The Cost Data Sheet shows the value of the cost element, the equation that was used to calculate the value and the yearly cost for the cost element.

SENSITIVITY ANALYSIS WORKSHEET. The Sensitivity Analysis worksheet, SENS.WR1, is used to perform a sensitivity analysis on a selected set of variables. This set of variables was chosen because of the potential impact on life cycle cost from these variables when changed due to engineering or design changes. The variables are primarily from the Production and Sustainment phases. The options for SENS.WR1 are:

INITIALIZE **SENSITIVITY**

The 'Initialize' option is used to retrieve all the data needed for the sensitivity analysis. A macro retrieves the data from each worksheet as necessary and sets up the initial sensitivity table. The 'Sensitivity' option starts the sensitivity analysis and changes all the variables. The default analysis has been designed to change the variables by decreasing them 25% and 50% and increasing them 25% and 50%. A final table showing the impact of these changes is generated. The variables are:

First unit cost of labor
Learning curve
Annual operating hours

MTBF
MTTR
MTBSM
MTTSM
MTBO
MTTO
Useful system lifetime
Fuel consumption rate
Fuel cost
Civilian labor rate at depot
Weight
Transportation cost
Repair cycle time (MCTTR)
Overhaul cycle time (MCTTO)

TOTAL MATRIX WORKSHEET. The Total Matrix worksheet, TOT.WR1, combines the cost elements of all five phases and creates three total matrix tables. The WBS matrix shows the total cost for all five phases by work breakdown structure. The constant dollar matrix shows the yearly life cycle cost for the total system in constant year dollars for all five phases. The current dollar table shows the yearly life cycle cost for the total system in fully inflated dollars for all five phases.

BCM MACROS

The BCM uses the macro feature of SYMPHONY to perform many of its functions. The macros have been set up to perform a sequences of commands automatically. The user is thus relieved of remembering and retyping a command sequence every time a function is desired. To invoke a macro, press function key {F7}, type in the *macro name* and press return. Macros can be invoked from anywhere in the spreadsheet. The macros in the BCM are described in the following paragraphs.

"M" -- MENUS. All 11 of the BCM worksheets use M as the menu macro. This macro will recall the main menu associated with the worksheet. To invoke the M macro, press function key {F7}, type *M* and press return. A menu will appear at the top of the screen which lists all the different options available in that worksheet. The first option will be highlighted. Use the left or right arrow keys to move the cursor. To select an option, move the

highlighted cursor to the option and press return.

"DATA" -- TRANSPORTING DATA. Each of the four Matrix worksheets has a DATA macro. This macro takes the variable values from the INPUT worksheets and puts them into the corresponding MATRIX worksheet. The DATA macro is automatically executed every time a MATRIX worksheet is brought up.

"NEWEQ" -- TRANSPORTING EQUATION TEXT. Each of the four MATRIX worksheets also has a "NEWEQ" macro. It is used to transport the text part of the equations from the INPUT worksheets to the corresponding MATRIX worksheets. This macro should be executed only when the user has changed one or more of the original equations. To invoke the NEWEQ macro, press function key (F7), type *NEWEQ* and press return.

"Q" -- QUIT. The Quit macro should be used every time a BCM worksheet is exited. The Quit macro will ask if the worksheet is to be saved. If the worksheet has not been changed or if the changed worksheet is not to be saved, then answer "no". If changes to the worksheet are to be kept, then answer "Yes" to save the worksheet. The Quit macro will save (or not save) the worksheet and will then retrieve the Main Menu worksheet.

"P" -- PRINTING. The Print macro may be invoked from all 13 of the BCM worksheets. To invoke the print macro, press function key (F7), type *P* and press return. A menu will appear at the top of the screen which lists all the items in the worksheet that can be printed by the macro. Make sure that the printer is on and that the top of the form is correctly positioned before exercising this macro. To choose an item, move the cursor over the item and press return. This item will be automatically printed. The print macro in the Main Menu worksheet allows printing from multiple worksheets at one time.

Pressing the 'ESC' key will end any macro and return to the worksheet.

SECTION V
USING THE BCM

GENERAL GUIDELINES FOR USING THE BCM

There are several guidelines that should be followed when using the BCM. All percentages must be input as decimals. The equations have been set up assuming that decimals are input. Dollars can be input in any unit as long as consistency is maintained throughout all worksheets. All equations have been developed to use either the variable values or a single throughput value. Do not fill in values for both or double counting will occur. Never add or delete any rows or columns in the worksheets. This destroys the macro cell addresses and they will no longer work properly. Do not move cells from one part of the worksheet to another. This changes the address of the cell and will cause problems.

It is recommended that whenever a new baseline cost estimate is being initiated, the blank cost worksheets be copied into a subdirectory for the specific project. This will guard against inadvertent erasure of worksheets from another project. If the worksheet names are changed within the BCM, the macros will not operate.

The main task for the user of the BCM is inputting data. Blank examples of the Variable Input Sheets for all five phases are provided in Appendix A. These sheets can and should be used to collect all of the data that is required for input to the BCM prior to using the model. Table 5.1 shows the required inputs and those inputs which must have specific or consistent units. The functions of the BCM will be explained using examples from the worksheets.

TABLE 5.1 Variables Requiring Specific Input

VARIABLE	TIME UNIT	VALUE
Production:		
MCTTR	hours	non zero, default of 1
MTBF	hours	non zero, default of 1
MCTTO	hours	--------
MCTBO	hours	non zero, default of 1
Annual operating time per system	must be same	--------
Useful system lifetime	unit	non zero, default of 1
# Operating Years		non zero, default of 1
B (learning curve factor)		non zero, default of 100
Sustainment:		
Annual operating time per system	must be same	--------
Useful system lifetime	unit	--------
Maintenance manyears per system	manyears	--------
Total maintenance man-hours per year	manhours	non zero, default of 1
MTBF	hours	non zero, default of 1
MTTR	hours	--------
MTBSM	hours	non zero, default of 1
MTTSM	hours	--------
MTBO	hours	non zero, default of 1
MTTO	hours	--------

STARTING SYMPHONY

The first step in using the model is to start SYMPHONY.

1. Change to the SYMPHONY subdirectory on drive C (the hard disk), place the SYMPHONY program disk in drive A, type in SYMPHONY and press return. When SYMPHONY starts, a blank worksheet will appear on the screen.

2. Press function (F9), type *F* for file. Then type *D* for directory. SYMPHONY will prompt for a current directory path. Type in the drive and path for the subdirectory where the current project cost worksheets are saved. This sets the default directory for data and the model will know where to look for the proper worksheets.

3. Press function key (F9), type *F* for file and type *R* for retrieve. A menu will appear at the top of the screen, listing all the worksheets in the data directory defined in step 2. A highlighted cursor will cover the first spreadsheet:

```
Name of file to retrieve C:\*.WR?
DEV.WR1      DEVINP.WR1     MAINMENU.WR1     MCF.WR1     MCFINP.WR1
--------A-----------B-----------C-----------D-----------E-----------F----------
1                                                                             |
2                                                                             |
3                                                                             |
4                                                                             |
```

Use the right or left arrow keys to place the highlighted cursor over the MAINMENU worksheet. Press return to retrieve the MAINMENU worksheet.

THE MAIN MENU

When the MAINMENU worksheet appears, the initial screen will display a brief description of the worksheets that make up the BCM.

MAIN MENU WORKSHEET

The SYMPHONY BCM is made up of 13 worksheets. There is one INPUT and one MATRIX worksheet for R&D, PRODUCTION and SUSTAINMENT. MILITARY CONSTRUCTION and FIELDING have been combined into 1 MATRIX and 1 INPUT worksheet. There is also a SENSITIVITY ANALYSIS worksheet, a TOTAL MATRIX worksheet and the MAIN MENU worksheet which you are in now. From this worksheet you can access all other worksheets in the BCM. To bring up a menu of options press function key (F7) and M, then return. The options are listed in the order in which they are generally performed. The first option, INPUT DATA, allows you to access all the INPUT worksheets. The second option, MATRIX CDS, allows you to access all the MATRIX worksheets. The next option allows you to do SENSITIVITY ANALYSIS. The last optior, TOTAL matrix, allows you to retrieve the TOTAL MATRIX worksheet which contains a combination of matrices from all 5 phases of the BCM.

1. To invoke the menu macro, press function key (F7), type *M* and press return. A menu will appear at the top of the screen:

```
RETRIEVE DATA INPUT WORKSHEET FOR A SPECIFIC PHASE                    MENU
DATA INPUT  MATRIX   SENS ANALYSIS  TOTAL MATRIX
--------A-----------B----------C----------D----------E----------F----------
1                                                                          |
2                            MAIN MENU WORKSHEET                           |
3                            ...................                           |
4   The SYMPHONY BCM is made up of 13 worksheets. There is one INPUT and one |
```

DATA INPUT

1. The first option in the MAINMENU worksheet is Data Input. Select this option by placing the cursor over the option and pressing return. A menu will appear listing the four Input worksheets:

```
INPUT DATA FOR THE DEVELOPMENT PHASE                                  MENU
DEVELOPMENT      PRODUCTION      MILC & FIELDING      SUSTAINMENT
--------A-----------B----------C----------D----------E----------F----------
1                                                                          |
2                            MAIN MENU WORKSHEET                           |
3                            ...................                           |
4   The SYMPHONY BCM is made up of 13 worksheets. There is one INPUT and one |
```

2. Select DEVELOPMENT to retrieve the input worksheet for the Development phase. The initial screen of DEVINP.WR1 will appear with general information on inputting data:

```
**************************************************************************
*          READ THIS SECTION CAREFULLY BEFORE BEGINNING                  *
**************************************************************************

WHEN INPUTTING DATA YOU HAVE THE OPTION TO ENTER EITHER

1) A THRU PUT VALUE FOR THE COST ELEMENTS
                    ***OR***
2) VARIABLE VALUES OF THE EQUATION FOR THE COST ELEMENTS

DO NOT ENTER BOTH THE THRUPUT VALUE AND VARIABLE VALUES OR YOU WILL
.....................................................
DOUBLE THE ACTUAL VALUE FOR THE COST ELEMENT.

YOU CAN ENTER DATA FOR ANY INDIVIDUAL COST ELEMENT OR PAGE THRU
ALL THE COST ELEMENTS AT ONCE.

****TYPE  (F7) M AND HIT RETURN TO BRING UP MENU****
```

3. Invoke the menu macro and select the TITLES option from the initial menu:

```
EDIT THE COST EQUATIONS                                              MENU
EQUATIONS  COST ELEMENTS  SUNK COSTS  TITLES   START YEAR
--------A-----------B----------C----------D----------E----------F----------
1                                                                          |
2  **************************************************************************  |
3  *         READ THIS SECTION CAREFULLY BEFORE BEGINNING                 *  |
4  **************************************************************************  |
```

The cursor will move to the area where the titles are stored such as this:

```
H2:                                                                  MENU

--------H-------------I-------------J-------------K-------------L-------------
2 SUBSYSTEM (1)  SUBSYSTEM (2)  SUBSYSTEM (3)                              |
3 MASTER SYS                                                               |
4                                                                          |
5                                                                          |
```

Type over the cells H2 through J2 to change subsystem names and type over cell H3 to change the system name.

4. Invoke the menu macro again and select the START YEAR option. The cursor will be moved to cell H1, where the start year of Development is input. For Development only, the start year is also the base year of the life cycle cost estimate. This should be the first year of estimated costs and should not be any year where sunk costs were incurred. Type over the cell and input the correct year. For all other phases, input the start year of the phase.

```
H1:                                                                    MENU

--------H-------------I-------------J-------------K-----------L-------------
1        1986                                                              |
2 SUBSYSTEM (1)  SUBSYSTEM (2)  SUBSYSTEM (3)                              |
3 MASTER SYS                                                               |
4                                                                          |
5                                                                          |
```

5. Invoke the menu macro and select the COST ELEMENTS option from the initial menu:

```
EDIT THE COST EQUATIONS                                                MENU
EQUATIONS  COST ELEMENTS  SUNK COSTS  TITLES   START YEAR
--------A-----------B----------C----------D----------E----------F----------
1                                                                          |
2  ************************************************************************  |
3  *  READ THIS SECTION CAREFULLY BEFORE BEGINNING                       *  |
4  ************************************************************************  |
```

6. A list of the first 6 cost elements in the Development phase will appear. The cost elements are identified by "E#.###". The numbers stand for the number of the cost element. The screen looks like this:

```
EDIT ALL COST ELEMENTS                                                    MENU
ALL COSTS  E1.011  E1.012  E1.013  E1.014  E1.02  E1.03   NEXT MENU
--------A---------B----------C----------D----------E----------F----------
1                                                                         |
2  ************************************************************************ |
3  *  READ THIS SECTION CAREFULLY BEFORE BEGINNING                       *  |
4  ************************************************************************ |
```

The first option on this list is ALL COSTS. This option is used for filling in all the Variable Input Sheets for the phase. Selecting the ALL option will move the cursor to the Variable Input Sheet for 1.011 Engineering, which is the first cost element in the Development phase.

7. This sheet is identical to the hard copy Variable Input Sheet for 1.011 Engineering found in Appendix A. Fill in the input sheet by using the arrow keys to move around the screen to the blank spaces and filling in the requested data. Move down the sheet to complete the explanations of the data and data sources sections. The Variable Input Sheet looks like this:

```
VARIABLE INPUT SHEET
____________________

                        1.011 ENGINEERING
                        _________________

VARIABLES
---------               SUBSYSTEM (1)  SUBSYSTEM (2)  SUBSYSTEM (3)

              THRUPUT =
CONTRACT:
            MANYEARS =
           MANYEAR $ =
            TRAVEL $ =
           MATERIAL $ =
    MATERIAL TRANS COST =
          TEST EQUIP $ =
  TEST EQUIP TRANS COST$ =
           REDESIGN % =
 IN-HOUSE:
            MANYEARS =
           MANYEAR $ =
            TRAVEL $ =
              OTHER  =
```

YEARLY BREAKDOWN:

1986
1987
1988
1989
1990
1991

EQUATIONS:

= CONTRACT (INITIAL ((MANYRS*MANYR$+TRAVEL)
*(1+REDESIGN%)+(MATERIAL$+TRANS$)+(TEST EQUIP
+TRANS$)) + IN-HOUSE (MANYEARS*MANYR$+TRAVEL)+OTHER

DESCRIPTION OF HOW VALUES WERE DERIVED:

ASSUMPTIONS:

SOURCE:

1.012 Producibility Engineering & Planning is the second cost element of the Development Phase. The Variable Input Sheet for Producibility Engineering & Planning is directly below the sheet for Engineering. Use the down arrow keys and move to the 1.012 Variable Input Sheet. Fill in the 1.012 Variable Input Sheet and move down to the third Variable Input Sheet. Continue this process until all ten Variable Input Sheets for the Development phase have been completed.

8. If there are sunk costs to be reflected, invoke the menu macro and select the 'Sunk Costs' option. This will move to a set of Variable Input Sheets very similar to the ones just completed. The only difference is that there are no variables and equations, just throughput values. Fill in the throughput values for these input sheets with the amount of the sunk costs appropriate to the cost element. These sunk costs must be inflated to the base year before being input.

9. To go back and check any specific Variable Input Sheet, invoke the menu macro and select the Cost Elements option again. This time, select the specific cost element to be checked. The cursor will move to the Variable Input Sheet of the cost element chosen and any editing or changing done.

10. Inputting data in any of the other Input worksheets is performed in a similar manner with some additional input formats in the Production and Sustainment phases, explained in the next section. The Variable Input Sheets within the worksheet for each phase are set up in ascending order just as they are in the hard copy found in Appendix A. When finished with data input and checking the Variable Input Sheets in DEVINP.WR1, exit the worksheet by invoking the Quit macro. The quit macro will ask if the worksheet is to be saved, process accordingly and return to the MAINMENU worksheet.

PECULIARITIES IN PRODUCTION AND SUSTAINMENT INPUT

PRODUCTION INPUT. In Production input, there are two additional options that may be used. These are calculation of the production quantity and calculation of the production schedule. In some instances, these values will be known or previously decided and this calculation not needed. In cases where the life cycle production quantity is not known, this calculation may be desired.

1. Invoke the menu macro in PRODINP.WR1 and select 'Calculate Prod'. This will move to the Production calculation area. This area is divided into three sections: input, calculation and results as shown below.

PRODUCTION SCHEDULE INPUT

Distribution	# of systems	usage rate	B x C
CONUS			
Active			0
Reserve		0.25	0
Training			0
Europe			0
Korea			0
Pacific			0
Alaska			0
South			0
Sum =	0	Weighted Sum =	0

Ready rate	=	Max prod. #	=
MCTTR	=	Min prod. #	=
MTBF	= 1	Backorder #	=
MCTTO	=		
MTBO	= 1	Year 1 prod.	=
Ann. operating time	=	Year 2 prod.	=
Useful system life	= 1	Year 3 prod.	=
# of operating years	= 1	Year 4 prod.	=
Initial prod years	=	Year 5 prod.	=
Total prod years	=		

PRODUCTION SCHEDULE CALCULATION

Repair float	0
Operational float	0
Total float	0
Annual wearout number	0
Total wearout number	0
Replacement number	0
TOTAL Production	0

YEAR	Yearly prod.	Cum prod.	Remain prod.
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0

16	0	0	0
17	0	0	0
18	0	0	0
19	0	0	0
20	0	0	0

RESULTS OF CALCULATION

Total Production Quantity = 0
Annual Wearout = 0

Spread over production years				
	1	0	11	0
	2	0	12	0
	3	0	13	0
	4	0	14	0
	5	0	15	0
	6	0	16	0
	7	0	17	0
	8	0	18	0
	9	0	19	0
	10	0	20	0

2. The user must input values in the input area. The first input is the number of systems that are to be deployed in each theater with expected usage rates. These go in the columns marked '# of systems' and 'usage rate'. The model will then calculate the weighted sum (or equivalent full time number) of systems. If float is a consideration for this system then the next set of variables should be input. These various maintenance parameters must be input so that annual wearout, float and replacement can be calculated. The variables 'ready rate' through '# operating years' are used for these calculations. Repair float can be turned off by setting MCTTO to zero. Operational float can be turned off by setting MCTTR to zero. These variables are explained in Section II of this guide. All of the variables that have been input so far are used to calculate what the production quantity over the life cycle should be.

3. The remaining variables in the input section are used to calculate the production schedule. The number of initial production years, the total number of production years available, the maximum production number, the minimum production number and the backorder quantity must be input to use the

schedule calculation. The quantity for the first year of production must be input. An additional 4 years of production schedule may be input as well. Any production numbers input for the first five years will not be subject to the constraints described in Section II of the guide. In this way, the user can set up an unique initial production schedule (possibly for contractual needs) and let the remaining years and production quantity be calculated.

4. After all these numbers have been input, the second section will be calculated. The production schedule can be adjusted to the most feasible schedule by changing the initial production numbers, the number of production years available and the three production parameters. By examining the yearly production column in the second section, the user can determine if these values need to be adjusted. Any zero values should be entered as zero and not a blank or an error will occur.

5. The third section displays the results of the quantity and schedule calculation. 'Total production quantity' is used as input to 2.021 Manufacturing. 'Annual wearouts' is a value shown for information only. The 'Spread over Production Years' is used to spread costs of 2.021 Manufacturing, 2.022 Recurring Engineering, 2.023 Sustaining Tooling, and 2.024 Quality Control. Notice that the spread results are in percentages. These values will be used when exercising the 'Input Spread' option. These results should be noted down so that they can be input in the worksheet when requested.

6. Invoke the menu macro in PRODINP.WR1 and select the 'Input Spread' option. The cursor will move to an area that looks like this:

	MASTER SYSTEM		
	SUBSYSTEM(1)	SUBSYSTEM(2)	SUBSYSTEM(3)
YEAR			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			

7. Input the production schedule spread percentages that were either just calculated in the production area or were derived in some other fashion. The production schedule is input as the percentage of the total production that is produced each year. The total for the years should add up to 1.

The remainder of the Production input worksheet is completed in the same way as the Development input.

SUSTAINMENT INPUT. The Sustainment phase has two unique input tables that should be filled in prior to completing the Variable Input Sheets.

1. Invoke the menu macro and select the 'Weighted Sums' option. The cursor will move to an area that has a table of values to be completed. This table is used to calculate weighted sums of various parameters that would otherwise have to be calculated separately for each theater of operation. The table, shown on the next page, requires input of various factors that can be obtained from the Cost Analysis Division.

In this table, the first two columns are the usage rates of systems in each theater and the distribution of the deployed units throughout the theaters. Fill in these two columns. If the production calculation was used in the Production phase, these two columns should contain the same values as used there.

WEIGHTED SUMS TABLE

MASTER SYS DISTRIBUTION	USAGE RATES	# UNITS	BASE PAY & THEATER COST	ATTRITION	TRAINING			ROTATION	PCS	2ND TRNS	QMJ
					OMA	OPA	MPA				
CONUS											
TRAINING											
ACTIVE											
RESERVES	0.25										
EUROPE											
KOREA											
PACIFIC											
ALASKA											
SOUTH COMMAND											
WEIGHTED SUM		0	0		0	0	0		0	0	0

The remaining columns contain standardized factors that the Cost Analysis Division can provide. Complete this section with their assistance.

2. Once the table has been filled in, the weighted sums will be calculated. These weighted sum values will be used as input in the following cost elements in the Sustainment phase.

weighted sum of systems	Common variable
weighted sum of base pay & allowance	5.081 and 5.082
weighted sum of training (OMA) (same as replacement)	5.072
weighted sum of training (OPA) (same as replacement)	5.071
weighted sum of training (MPA) (same as replacement)	5.084
weighted sum of PCS	5.086
weighted sum of 2nd Trans	5.06
weighted sum of QMU	5.111

3. Invoke the menu macro and select the 'Common Variables' option. The cursor will move to the Common Variables table. This table contains variables that are used in multiple cost elements and are entered once within this table. The table looks like this:

TABLE OF COMMON VARIABLES	MASTER SYS		
.....	SUBSYSTEM (1)	SUBSYSTEM (2)	SUBSYSTEM (3)
WEIGHTED # OF UNITS =			
ANNUAL OP HRS =			
MAINT MANYRS/SYS =			
or			
MTBF =	1	1	1
MTTR =			
MTBSM =	1	1	1
MTTSM =			
MTBO =	1	1	1
MTTO =	1	1	1
ANNL MAINT HRS AVAIL =			
CREW MANYEARS/SYS =			
# OP YRS =			
UNIT MANUF $ =			
MCTTR =			
MCTTO =			
USEFUL SYS LIFETIME =	1	1	1
# UNITS IN TRAINING =			

4. Fill in the values for the variables. 'Weighted # of units' comes from the weighted sums table. Maintenance manyears (below depot) can be input (in manyears) as 'Maint Manyrs/Sys' or it can be calculated by filling in the 'MTBF' through 'MTTSM' variables. Do NOT use both. If the maintenance parameter calculation is not used then leave MTBF and MTBSM with the default value of 1 or an error will occur. 'MTBO' and 'MTTO' are used to calculate maintenance effort at depot level. If there is no depot maintenance, leave these variables with the default value of 1 or an error will occur. These maintenance parameters are input as hours. 'Annl Maint Hrs Avail' are the number of productive maintenance manhours available per year and can be obtained from the Cost Analysis Division. '# Op Yrs' is the number of years that the system is expected to be sustained. This variable and 'Useful Sys Life' must be in the same units. 'MCTTR' and 'MCTTO' are the repair cycle time and overhaul cycle time and are input in hours. '# units in training' are the number of systems deployed for training purposes. 'Unit manuf $' was calculated in the Production phase and can be found in the equations table in that worksheet.

7. The remainder of Sustainment is completed in a similar manner as the Development example.

THE MATRIX WORKSHEET

The Matrix worksheets reformats the data from the Variable Input Sheet into Cost Data Sheets and three standard cost matrices.

1. After returning to the MAINMENU.WR1, invoke the menu macro and select the MATRIX option. A menu list of the four matrix worksheets will appear:

```
RETRIEVE MATRIX WORKSHEET FOR THE DEVELOPMENT PHASE                    MENU
DEVELOPMENT    PRODUCTION      MILC & FIELDING      SUSTAINMENT
--------A----------B----------C----------D----------E----------F----------
1                                                                          |
2                              MAIN MENU WORKSHEET                         |
3                              ...................                         |
4   The SYMPHONY BCM is made up of 13 worksheets. There is one INPUT and one |
```

2. Choose DEVELOPMENT to retrieve the Matrix worksheet for the Development phase. Before DEV.WR1 appears on the screen, a macro named DATA is automatically executed which transfers the input data from DEVINP.WR1 (input) to DEV.WR1 (matrix). When the Data macro is finished executing, the initial screen of DEV.WR1 will appear with a menu list at the top of the screen. The functions of these options will display the WBS Matrix, the Constant Matrix, the Current Matrix or the Cost Data Sheets:

```
GO TO THE WORK BREAKDOWN MATRIX                                        MENU
WBS MATRIX  CONSTANT MATRIX  CURRENT MATRIX  COST ELEMENTS
--------A----------B----------C----------D----------E----------F----------
1              WBS MATRIX                  SUNK      SUBSYSTEM   SUBSYSTEM  |
2                                                       (1)         (2)     |
3   COST ELEMENTS                                                          |
4   ========================================================================= |
5    1.01 DEVELOPMENT ENGINEERING              0.0         0.0         0.0  |
```

3. Select the first option, WBS MATRIX. The cursor will move to the upper left hand corner of the WBS matrix. The matrix looks like this:

WBS MATRIX	SUBSYSTEM 1	SUBSYSTEM 2	SUBSYSTEM 3	TOTAL
1.0 DEVELOPMENT	120.0	1200.0	12000.0	13320.0
1.01 DEVELOPMENT ENGINEERING	10.0	100.0	1000.0	1110.0
1.011 ENGINEERING	1.0	10.0	100.0	111.0
1.012 PEP	2.0	20.0	200.0	222.0
1.013 TOOLING	3.0	30.0	300.0	333.0
1.014 PROTOTYPE MANUFACTURING	4.0	40.0	400.0	444.0
1.02 DATA	26.0	260.0	2600.0	2886.0
1.03 SYSTEM TEST & EVALUATION	5.0	50.0	500.0	555.0
1.04 SYSTEM/PROJECT MANAGEMENT	6.0	60.0	600.0	666.0
1.05 TRAINING, SERVICE & EQUIPMENT	7.0	70.0	700.0	777.0
1.06 FACILITIES	8.0	80.0	800.0	888.0
1.07 OTHER RDTE FUNDED DEVELOPMENT	9.0	90.0	900.0	999.0

Move around the matrix by using the cursor keys. The cost elements are listed down the side and the subsystems across the top. The total cost values for each subsystem versus each cost element is found in the matrix. The last column totals the subsystem values for the cost element. The total for the phase is found in the first row cells for the top level cost element, in this case 1.0.

4. Return to the initial menu with the menu macro. Select the CONSTANT MATRIX option. The cursor will move the top left corner of the constant matrix which looks like this:

WBS MATRIX IN CONSTANT DOLLARS	1987	1988	1989	1990	1991	TOTAL
1.0 DEVELOPMENT	9745.8	532.8	532.8	532.8	821.4	1217400.6
1.01 DEVELOPMENT ENGINEERING	1110.0	0.0	0.0	0.0	0.0	1110.0
1.011 ENGINEERING	111.0	0.0	0.0	0.0	0.0	111.0
1.012 PEP	222.0	0.0	0.0	0.0	0.0	222.0
1.013 TOOLING	333.0	0.0	0.0	0.0	0.0	333.0
1.014 PROTOTYPE MANUFACTURING	444.0	0.0	0.0	0.0	0.0	444.0
1.02 DATA	288.6	288.6	288.6	288.6	577.2	1731.60
1.03 SYSTEM TEST & EVALUATION	55.5	55.5	55.5	55.5	111.0	1111.0
1.04 SYSTEM/PROJECT MANAGEMENT	66.6	66.6	66.6	66.6	133.2	133.0
1.05 TRAINING, SERVICE & EQUIP	77.7	77.7	77.7	77.7	155.4	155.4
1.06 FACILITIES	88.8	88.8	88.8	88.8	177.6	177.6
1.07 OTHER RDTE FUNDED DEV	999.0	0.0	0.0	0.0	0.0	0.0

The cost elements are listed down the left side and the years of the phase are listed across the top. The matrix consists of costs for the total system in constant year dollars for each year. The last column totals the yearly costs for the cost element. The total cost for the phase is found in the top level cost element, in this case 1.0.

5. Return to the initial menu using the menu macro. Select the CURRENT MATRIX option. The cursor will move to the top left corner of the current dollar matrix which looks like this:

INFLATION INDICES

RDTE FACTORS (20 FEB 1986)		1.1093	1.1425	1.1723	1.1999	
CURRENT $M	SUNK	1988	1989	1990	1991	TOTAL
1.0 DEVELOPMENT	10811.0	608.7	624.6	639.3	1008.3	33333.0
1.01 DEVELOPMENT ENGINEERING	1231.3	0.0	0.0	0.0	0.0	1231.3
1.011 ENGINEERING	123.1	0.0	0.0	0.0	0.0	123.1
1.012 PEP	246.3	0.0	0.0	0.0	0.0	246.3
1.013 TOOLING	369.4	0.0	0.0	0.0	0.0	369.4
1.014 PROTOTYPE MANUFACTURING	492.5	0.0	0.0	0.0	0.0	492.4
1.02 DATA	320.1	329.7	338.3	346.3	708.5	7708.5
1.03 SYSTEM TEST & EVALUATION	61.6	63.4	65.1	66.6	136.3	6690.0
1.04 SYSTEM/PROJECT MANAGEMENT	73.9	76.1	78.1	79.9	163.5	5549.0
1.05 TRAINING, SERVICE & EQUIP	86.2	88.8	91.1	93.2	190.8	3395.0
1.06 FACILITIES	98.5	101.5	104.1	106.6	218.0	2298.0
1.07 OTHER RDTE FUNDED DEV	1108.2	0.0	0.0	0.0	0.0	8890.0

The appropriate inflation indices must be entered in the row labelled RDTE FACTORS. First, enter the correct date corresponding to the date of the inflation guidance. Next, move to column C and enter the correct inflation index for the first year of Development (note that the Development matrix has a sunk cost column. Do not put inflation numbers in that column). Then, move to column D, etc. and enter the correct inflation index for the following years of Development. These indices may be found in INF.WR1, which is an information worksheet in the model. Care must to taken to ensure that

these are the most recent inflation indices. The BRDEC Cost Analysis Division can provide this information.

Once the inflation indices are entered correctly, the matrix will recalculate itself. The cost elements are listed down the side and the years of the phase across the top. The matrix consists of inflated costs for the total system. The last column contains the sum of yearly costs for each cost element. The total costs for the phase can be found in the first row for the top level cost element, in this case, 1.0.

6. Return to the initial menu with the menu macro and select CDS for Cost Data Sheet. The next menu will ask for the subsystem to be examined. Select SUBSYSTEM 1:

```
EDIT ELEMENTS IN SUBSYSTEM 1                                        MENU
SUBSYSTEM (1)  SUBSYSTEM (2)  SUBSYSTEM (3)
--------A-----------B----------C----------D----------E----------F----------
1              WBS MATRIX                SUNK       SUBSYSTEM   SUBSYSTEM   |
2                                                       (1)         (2)      |
3    COST ELEMENTS                                                           |
4    ================================================================       |
5    1.0 DEVELOPMENT                          0.0         0.0         0.0    |
```

The next menu will prompt for a cost element within this subsystem:

```
GO TO COST ELEMENT 1.01 DEVELOPMENT ENGINEERING
1.01  1.011  1.012  1.013  1.014  1.02   1.03   NEXT MENU
--------A-----------B----------C----------D----------E----------F----------
1              WBS MATRIX                SUNK       SUBSYSTEM   SUBSYSTEM   |
2                                                       (1)         (2)      |
3    COST ELEMENTS                                                           |
4    ================================================================       |
5    1.0 DEVELOPMENT                          0.0         0.0         0.0    |
```

Select cost element 1.014. The cursor will move to the Cost Data Sheet for cost element 1.014 in subsystem 1 which will look like this:

```
                COST DATA SHEET                    CELL NO:     1.014,1
                                                   DATE:         Jul-86
                                                   VALUE:      153450.0

ITEM:           1.014 PROTOTYPE MANUFACTURING SUBSYSTEM 1
                ----------------------------------------
EXPRESSION: = (MANUF$ + SPARES% * MANUF$ + REWORK% * MANUF$)
                * # PROTOTYPES + GFE + OTHER


                                TOTAL =     153450.0
```

Other cost data sheets can be examined by moving around the worksheet with the cursor movement keys or by returning to the menu and selecting the subsystem and cost element specifically.

6. Invoke the quit macro and return to the main menu.

SENSITIVITY ANALYSES

The sensitivity analyses can be accessed from the main menu.

1. Invoke the menu macro and select the 'SENS ANALYSIS' option. The next menu allows a choice of performing a sensitivity analysis on subsystem 1, 2 or 3. Select subsystem 1. The sensitivity worksheet will be retrieved and the first screen will be displayed which looks like this:

BELVOIR COST MODEL

SENSITIVITY TEST RESULTS
for SUBSYSTEM 1
of MASTER SYS

BASELINE COSTS	
RESEARCH & DEVELOPMENT	0 $
PRODUCTION	0 $
MILITARY CONSTRUCTION	0 $
FIELDING	0 $
SUSTAINMENT	0 $
TOTAL LIFE CYCLE COST	0 $
PROCUREMENT QUANTITY	1

2. The first step in performing the analysis is to initialize the sensitivity tables. Invoke the menu macro and select option 'Init' from the menu. This option starts a process which brings all the variables, equations, and data from each of the input spreadsheets into the sensitivity table. This process takes about 1 hour to complete so be prepared to leave the machine running during this time.

3. Once the initialization process is completed, the analysis can be performed. Page down the worksheet to cell A25 where the the screen looks like this:

A25:

	A	B	C	D
25		VAR PARM	PROCURE.	PRODUC.
26	VARIABLE PARAMETER	% CHANGE	QUANTITY	NEW VALU
27				
28	FIRST UNIT LABOR $	-50.0		
29	FIRST UNIT LABOR $	-25.0		
30	FIRST UNIT LABOR $	0.0		
31	FIRST UNIT LABOR $	25.0		
32	FIRST UNIT LABOR $	50.0		
33				
34	LEARN CURVE	-50.0		
35	LEARN CURVE	-25.0		
36	LEARN CURVE	0.0		
37	LEARN CURVE	25.0		
38	LEARN CURVE	50.0		
39				
40	ANNUAL OP HRS	-50.0		
41	ANNUAL OP HRS	-25.0		
42	ANNUAL OP HRS	0.0		
43	ANNUAL OP HRS	25.0		

The sensitivity variables are listed in the first column of the sensitivity table. The next column shows the change in percent that is calculated for each variable. The default changes are +25%, +50%, -25% and -50% from the original value. There is also a zero value change which shows the baseline value of the variable. The increment change to any of the variables can be modified. Move the cursor to the percentage and change it to the desired value. Do not change the zero value or the value of the baseline variable will be lost. The changes can be all positive values, all negative values or any combination of positive and negative values.

4. After all modifications to the increment changes have been made, the analysis can be performed. Invoke the menu macro and select the 'Sensitivity' option. The increment changes listed in the table will be calculated and the results listed in the remaining columns of the table. This process takes between 15 and 30 minutes to complete. When it is finished, the table can be examined to see the impact that the changes had on Production, Sustainment and Total Life Cycle Cost. This table can be printed by invoking the print macro or the increment changes modified and the analysis rerun. The table looks similar to the one shown on the following page.

BELVOIR COST MODEL

SENSITIVITY TEST RESULTS
for SUBSYSTEM 1
of MASTER SYS

BASELINE COSTS

RESEARCH & DEVELOPMENT	0 $
PRODUCTION	0 $
MILITARY CONSTRUCTION	0 $
FIELDING	0 $
SUSTAINMENT	0 $
TOTAL LIFE CYCLE COST	0 $
PROCUREMENT QUANTITY	1

VARIABLE PARAMETER :	VAR PARM % CHANGE	PROCURE. QUANTITY	PRODUC. NEW VALU	PRODUC. % CHANGE	FIELDING NEW VALU	FIELDING % CHANGE	SUSTAIN NEW VALU	SUSTAIN % CHANGE	TOT LCC. NEW VALU	TOT LCC. % CHANGE
FIRST UNIT LABOR $	-50.0			-100.0		-100.0		-100.0	0	-100.0
FIRST UNIT LABOR $	-25.0			-100.0		-100.0		-100.0	0	-100.0
FIRST UNIT LABOR $	0.0			0.0		0.0		0.0	0	0.0
FIRST UNIT LABOR $	25.0			-100.0		-100.0		-100.0	0	-100.0
FIRST UNIT LABOR $	50.0			-100.0		-100.0		-100.0	0	-100.0
LEARN CURVE	-50.0			-100.0		-100.0		-100.0	0	-100.0
LEARN CURVE	-25.0			-100.0		-100.0		-100.0	0	-100.0
LEARN CURVE	0.0			0.0		0.0		0.0	0	0.0
LEARN CURVE	25.0			-100.0		-100.0		-100.0	0	-100.0
LEARN CURVE	50.0			-100.0		-100.0		-100.0	0	-100.0
ANNUAL OP HRS	-50.0			-100.0		-100.0		-100.0	0	-100.0
ANNUAL OP HRS	-25.0			-100.0		-100.0		-100.0	0	-100.0
ANNUAL OP HRS	0.0			0.0		0.0		0.0	0	0.0
ANNUAL OP HRS	25.0			-100.0		-100.0		-100.0	0	-100.0
ANNUAL OP HRS	50.0			-100.0		-100.0		-100.0	0	-100.0

5. When finished, invoke the quit macro and return to the main menu.

PRINTING

Printing can be done from any worksheet with the print macro. Invoke the print macro by pressing {F9}, *P*, and return. A menu list of items that can be printed will appear at top of the screen. Within the input worksheets, individual Variable Input Sheets and the table of results may be printed. In the matrix worksheets, individual Cost Data Sheets and the three matrices may be printed. In the sensitivity worksheet, the sensitivity table may be printed. To print, make sure the printer is on, position the paper and select the item to be printed from the menu list.

The print macro in the main menu worksheet provides the capability to print in bulk. The items that will appear in the menu list are cost data sheets, variable input sheets, total matrices and sensitivity table. For example, selecting cost data sheets will print all the cost data sheets in all four input worksheets at one time. Selecting matrices will print the three total matrices at one time.

The Variable Input Sheets and the Cost Data Sheets can be printed on 8-1/2 by 11 inch paper. For improved readability, the matrices and sensitivity table should be printed on 11 by 14 inch paper.

CHANGING EQUATIONS

There may be times when the equation for a certain cost element does not fit the specific item being costed by the BCM. In these cases, the existing equation can be modified to meet the situation.

For example, if another method for estimating the Tooling cost element in the Development phase is desired, the variables and equation can be changed to reflect this. The following steps will demonstrate the procedure:

1. Go to DEVINP.WR1 and move to Variable Input Sheet for Tooling. The first section of this sheet contains the variables for the existing equation. Change the text of the variable names to the variables in the new equation and input the new data values. Note the cell addresses of the data for each of the new variables. These cell addresses will be used to make a cell reference equation for Tooling.

2. The text for the existing equation is right below the variables. Move down to the existing equation and change the text to the new equation.

3. Invoke the menu macro and select the Equations option. The cursor will move to the upper left hand corner of the equation table. All the cell reference equations for the cost elements are in this table. Move the cursor down to the Tooling equation under the subsystem 1 column.

4. Use the cell addresses of the data for the new equation variables to make a cell reference equation. A cell reference equation is the same as any other equation, except that cell references are used in place of variable names. Start the equation with a "+" (this lets SYMPHONY known that you are typing in an equation), type in the equation and press return. If you make a mistake, move the cursor back to to the cell, press (F2) for edit, and edit the equation. When you press return, SYMPHONY will calculate the equation and place the value of the equation in the cell.

5. The new equation must be changed for subsystem 2 and 3 also. The simplest way to do this is to copy the equation that was just entered to the next two columns. Press (F10) to display the SYMPHONY menu, and type s C for copy. SYMPHONY will ask for the range to copy from, in this case, the cell that the new equation is in, and the range to copy to, the two cells for subsystems 2 and 3. A range of more than one cell is signified by the first cell

reference in the range, two periods, and the last cell reference in the range.

6. Exit the worksheet with the quit macro and save the worksheet.

7. From MAINMENU.WR1, retrieve DEV.WR1. The equation in the Cost Data Sheet for Tooling must be updated also. This is done by invoking the NEWEQ macro. This macro will transfer the equation text from DEVINP.WR1 to DEV.WR1. The change of the Tooling equation is now complete.

CHANGING THE SENSITIVITY ANALYSES

If changes are made to the variables or equations used in the input worksheets, then the Sensitivity Analysis worksheets must be updated to reflect such changes. There are three worksheets corresponding to each subsystem. This procedure should only be attempted by someone who is familiar with SYMPHONY and understands how the software works. The equations used in the Sensitivity Analysis worksheets are stored beginning at cell U1.

When updating the equations there are several possibilities:

1. Variables in Research & Development or Military Construction have been changed. Provided that variables which undergo sensitivity analysis are not added to either of these phases, simply update the equations in the input worksheets and run the 'Init' option in each Sensitivity Analysis worksheet.

2. Equations in Research & Development or Military Construction have been changed. As long as the new equations do not contain variables that undergo sensitivity analysis, just change the equations in the input worksheets and run the 'Init' option in each Sensitivity Analysis worksheet.

3. Variables in Production, Fielding, or Sustainment that do not undergo sensitivity analysis have been changed. In this case, the appropriate equations must be updated in the Sensitivity Analysis worksheets. First, exercise the 'Init ' option in each Sensitivity Analysis worksheet. This will bring all the variables (new and old) into the worksheets. Second, go through the sensitivity worksheets and note the cell reference location of all variables that have just been brought in. Variables start in cell A146 and are in the same order as the cost elements in Production, Fielding and Sustainment. Third, go to the equations (starting in cell U1) and reconstruct the equations with the new variables and cell references. The equations are labelled by cost element to the left of the equations. The variables that have sensitivity analyses performed on them are listed starting in cell P1. Column Q contains the B column reference to the same variable as it was brought in from the input worksheets. Whenever this variable is used in an equation, reference the Q column, not the B column.

4. Variables in Production, Fielding or Sustainment that undergo sensitivity analysis have been changed. The sensitivity variable list in columns P and Q would have to be revised. The Q column would reference the B cell reference where the variable was brought in from the input worksheet. The equations in column U that use the sensitivity variable would have to be changed to reference the correct Q column and row for the variable. In addition, the resulting table would have to be modified to correspond exactly to the order of the sensitivity variables now listed in P and Q.

5. Always, if modifying the Sensitivity Analysis worksheets, remember to make the same changes in <u>all three</u> worksheets and double-check your equations afterwards for accuracy.

ADDITIONAL NOTES

In some cases in the worksheet, a calculated value cell will display all asterisks. This means that the width of the number of characters in the numerical value is larger than the width of the cell. If the cursor is moved to the cell, the value of the cell is displayed at the top of the screen. The cell width for the column can be increased so that all characters in the value are displayed. To increase a column width, press {F10} for the SYMPHONY menu, select Width, press return and select Set. Type in the value for the new column width and press return. The entire column will be expanded. If the column is now wide enough to hold all the characters, the asterisks will be erased and the numerical value displayed.

There may be times when 'ERR' shows up in a cell in the worksheets or matrix. If this happens, there is an error in calculation, usually an attempted divide by zero. If this should occur, double check all the data]nput and make sure that all variable values are correct.

APPENDIX B

BCM MENU TREE STRUCTURE

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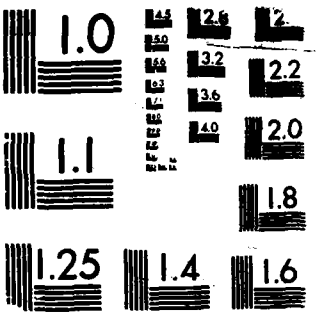

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BCM MENU TREE

The BCM Menu Tree, described in this appendix, consists of 13 major sections. Each section contains a diagram and description that explains what the specific menu is used for and which other menus can be accessed from it. The Menu Tree provides a good overall picture of the BCM Menus and shows how they are tied together. Table B-1 below lists the 13 major sections of the BCM Menu Tree and the corresponding figure number.

TABLE B-1. BCM MENU TREE BREAKDOWN

MENU SECTION	FIGURE No.
Main Menu	B-1
Menu for Data Input	B-2
Data Input Development Phase	B-3
Data Input Production Phase	B-4
Data Input Military Construction & Fielding Phases	B-5
Data Input Sustainment Phase	B-6
Menu for Matrix Worksheets	B-7
Matrix Menu Development Phase	B-8
Matrix Menu Production Phase	B-9
Matrix Menu Military Construction & Fielding Phases	B-10
Matrix Menu Sustainment Phase	B-11
Sensitivity Analysis	B-12
Total Matrix	B-13

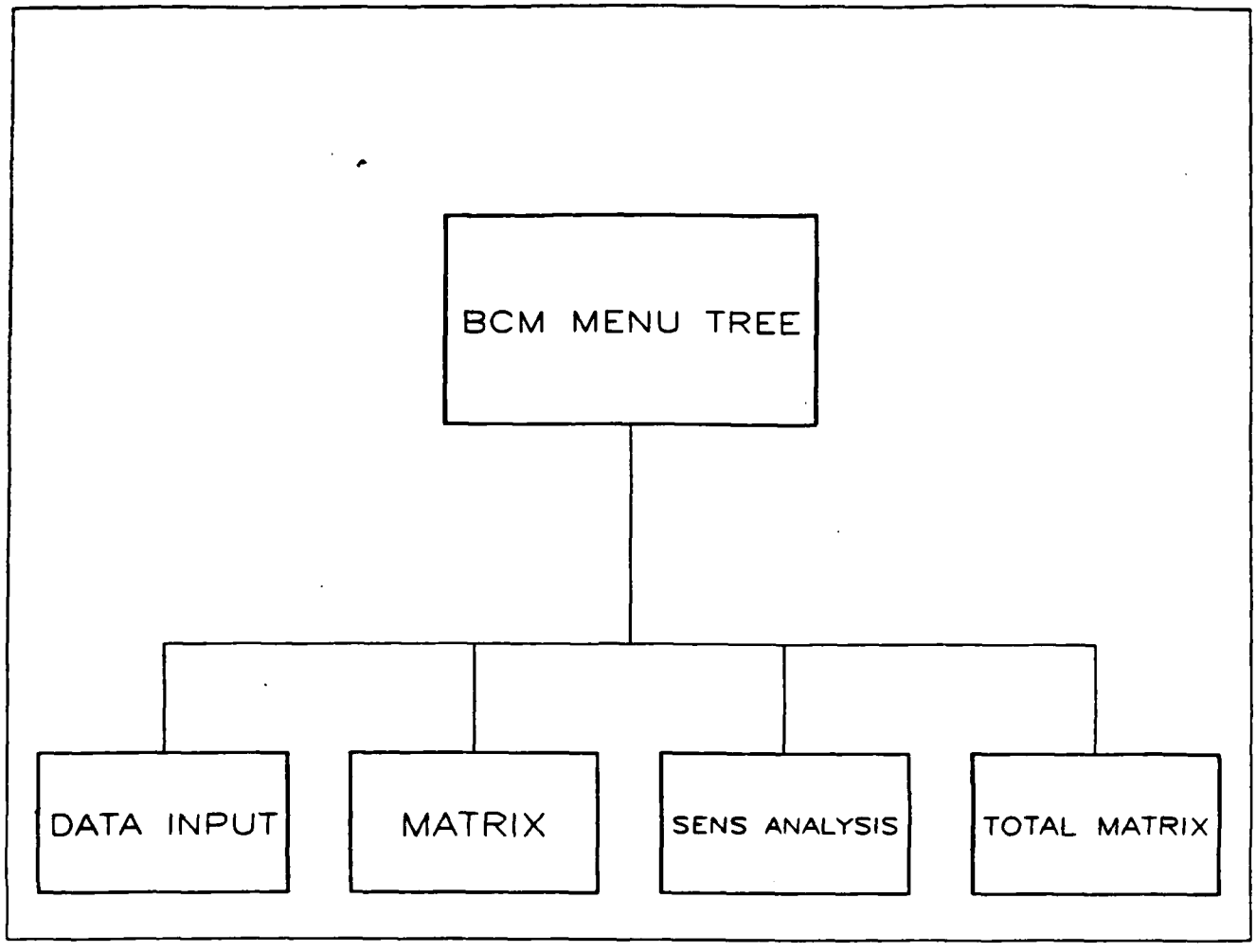


Figure B-1 MAIN MENU

MAIN MENU. The Main menu exists in the Main Menu Worksheet. It represents the 'root' of the menu tree. All menus in the BCM can be accessed from the Main Menu. The Main Menu has four options; 'Data Input', 'Matrix', 'Sens Analysis', and 'Total Matrix'. The 'Data Input' option will retrieve any of the 4 data input worksheets. The 'Matrix' option will retrieve any of the 4 matrix worksheets. The 'Sens Analysis' option retrieves the sensitivity analysis worksheet and the 'Total Matrix' option retrieves the total matrix worksheet.

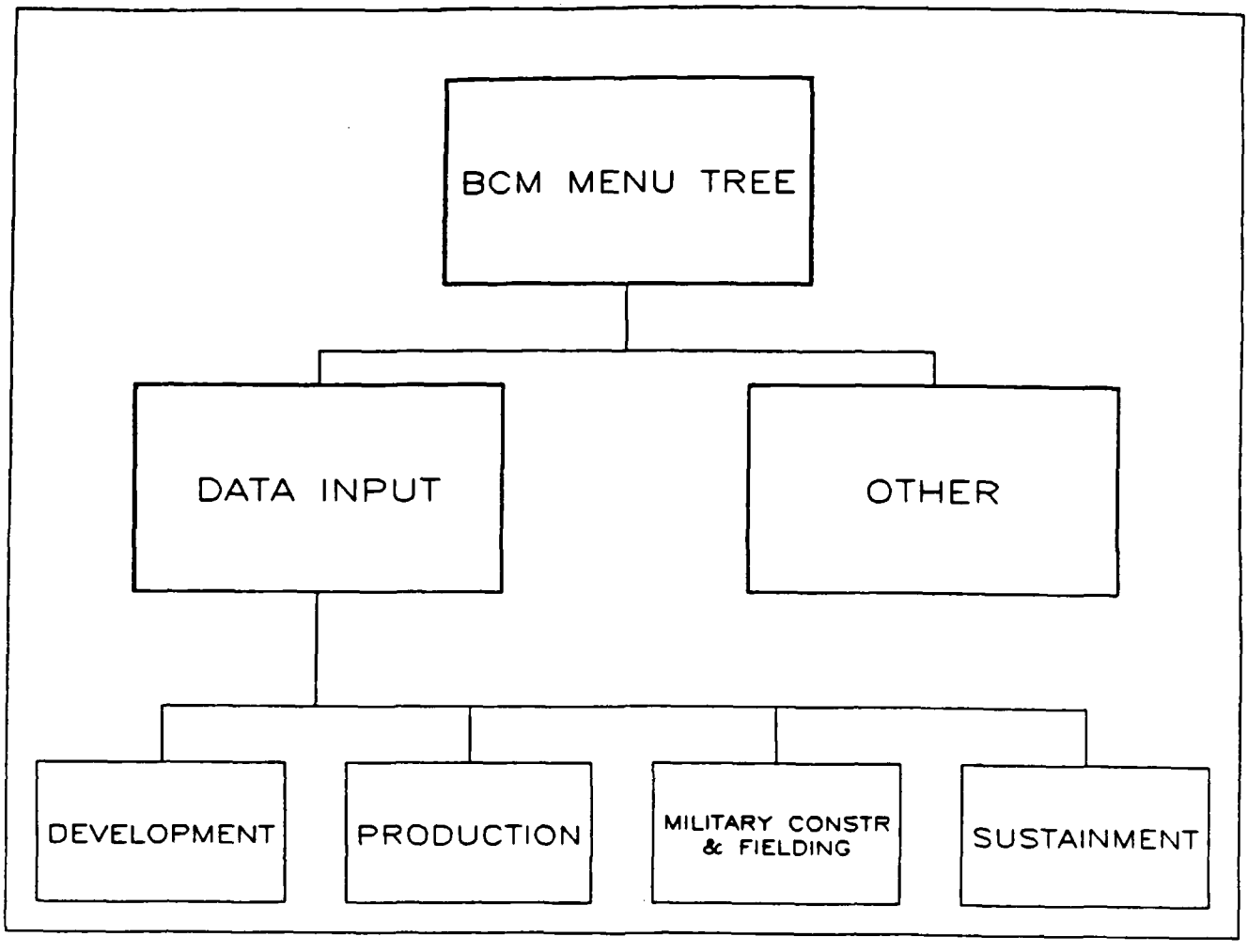


Figure B-2 MENU FOR DATA INPUT

DATA INPUT. The initial Menu for Data Input exists in the Main Menu worksheet. The Data Input Menu has four options; 'Development', 'Production', 'Mil Constr & Fielding' and 'Sustainment'. These options correspond to the different phases of the Army Cost Model. Each of these options will retrieve the Data Input worksheet for the corresponding phase. For example, the 'Development' option will retrieve the Data Input worksheet for the Development phase, the 'Production' option will retrieve the Data Input worksheet for the Production phase and so on.

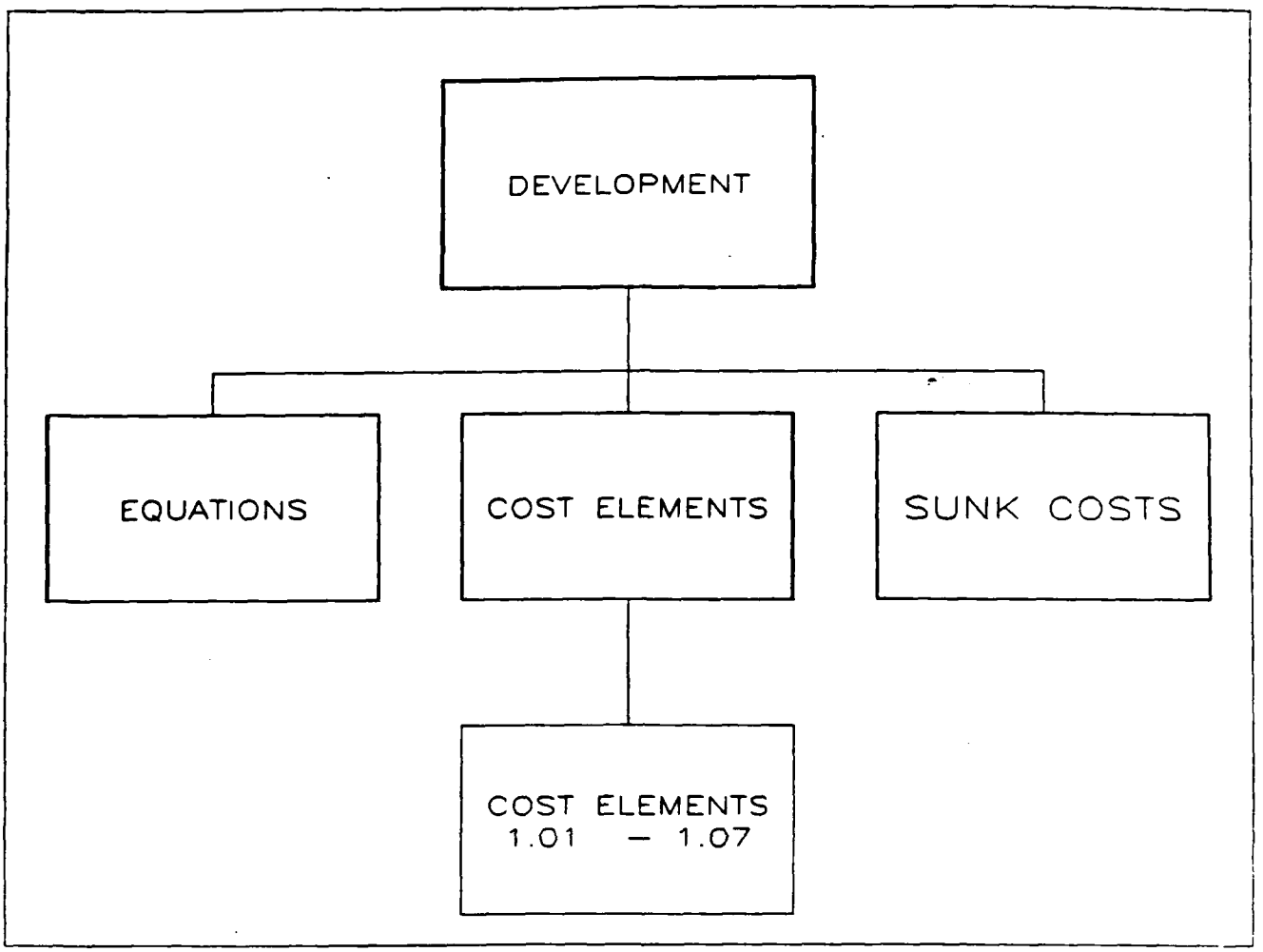


Figure B-3 DATA INPUT DEVELOPMENT PHASE

DATA INPUT DEVELOPMENT. The Data Input Menu for Development exists in the Development Input worksheet. This menu has three options; 'Equations', 'Cost Elements' and 'Sunk Costs'. The 'Equations' option moves to the section of the worksheet that contains the table of equations used in the Development phase. The 'Cost Element' option moves to the Variable Input Sheet of the selected cost element within the Development phase. The 'Sunk Cost' option moves to the beginning of the Sunk Cost Input Sheet. These are the only menu options in the Development Input Worksheet. The Main Menu worksheet must be retrieved to gain access to Data Input menus for the other phases.

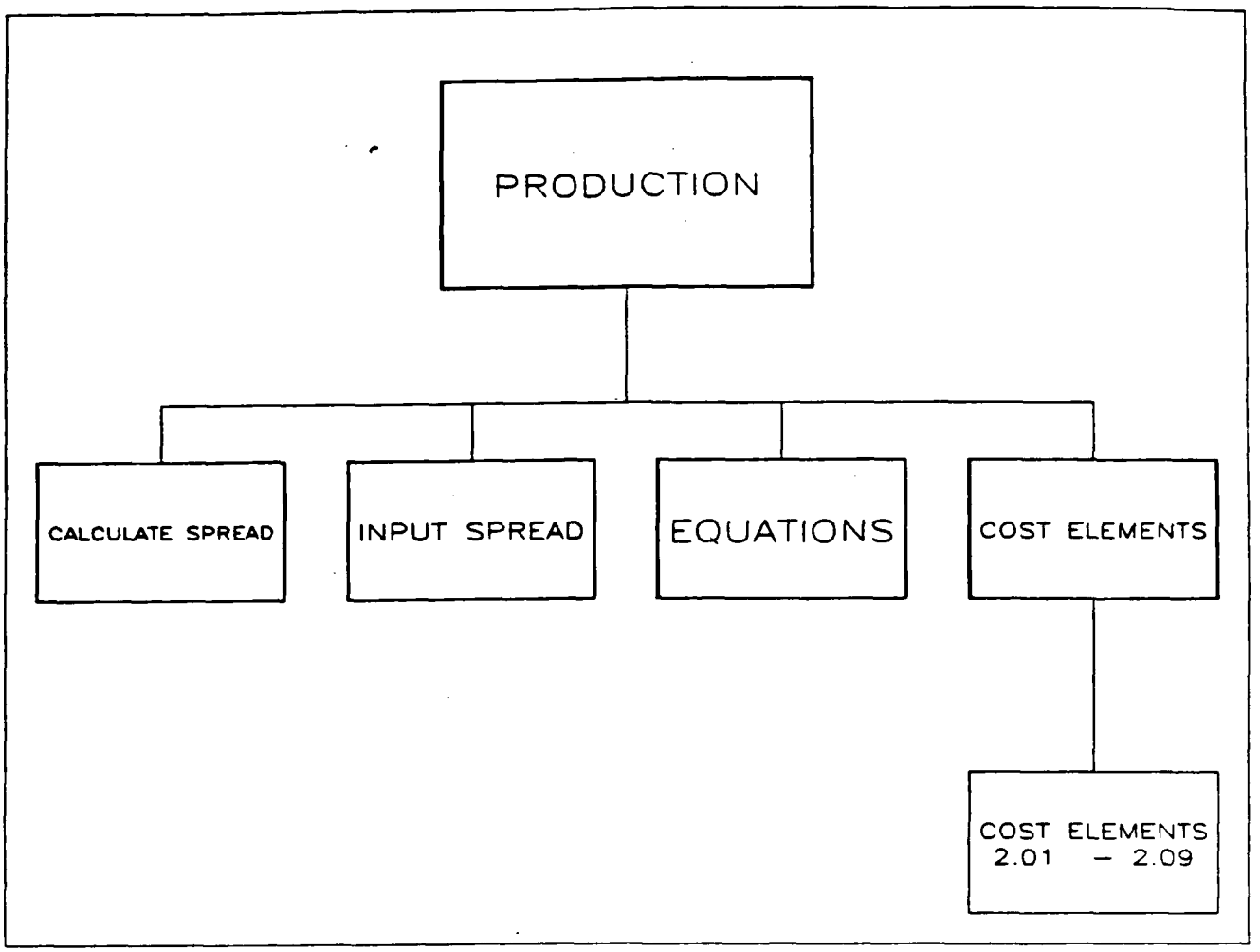


Figure B-4 DATA INPUT FOR PRODUCTION PHASE

DATA INPUT PRODUCTION. The Data Input Menu for Production exists in the Production Input worksheet. The menu options for Production are 'Calculate Spread', 'Input Spread', 'Equations' and 'Cost Elements'. The 'Calculate Spread' option moves to an area where production quantity and schedule can be calculated based upon the life cycle requirement and production parameters. The 'Input Spread' option moves to an area where the percentage spread of production costs across production years is input. The 'Equations' option and 'Cost Elements' option in Production are identical to those in Development Figure B-3.

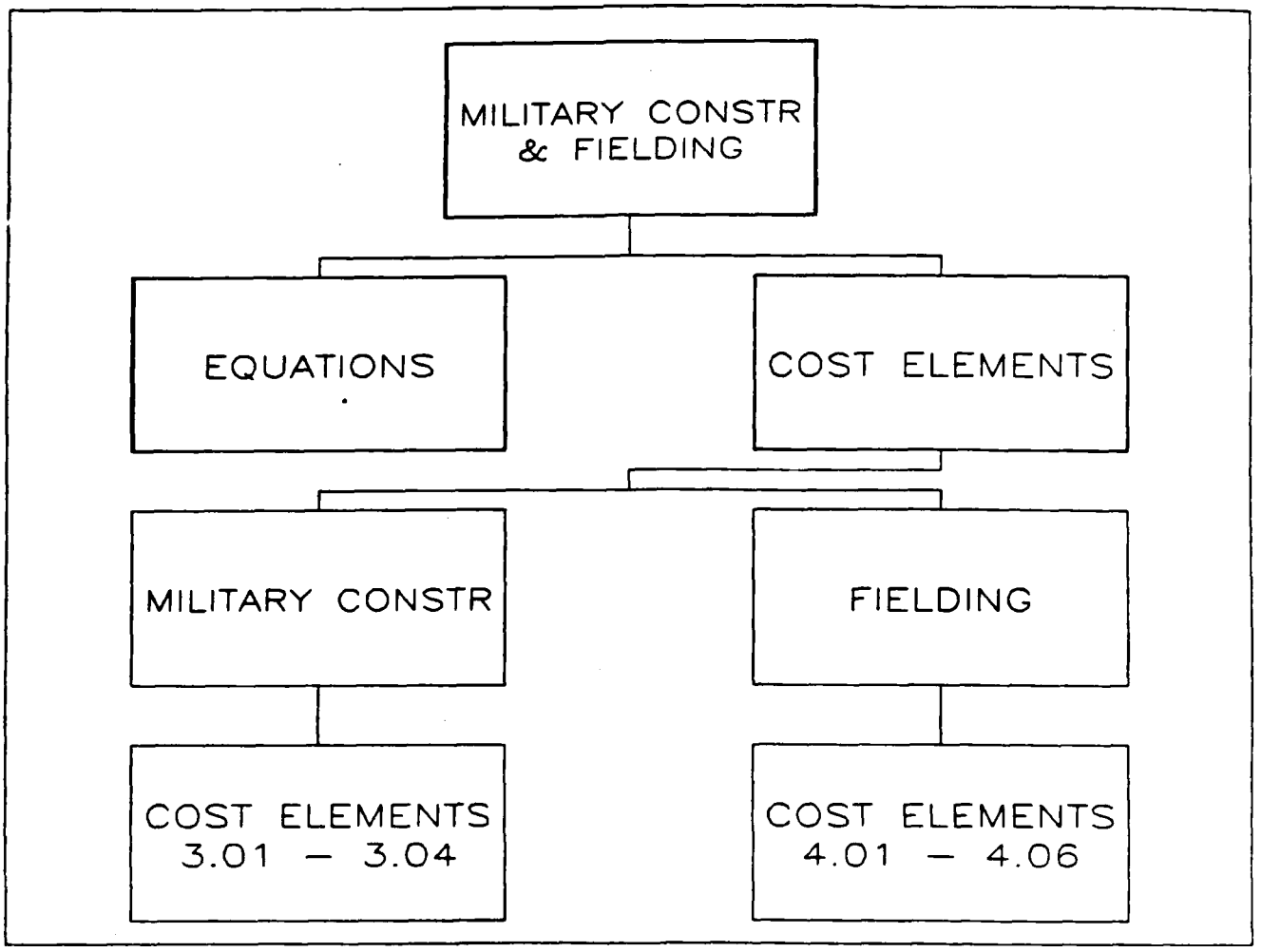


Figure B-5 DATA INPUT MILITARY CONSTRUCTION & FIELDING PHASE

DATA INPUT MILITARY CONSTRUCTION & FIELDING. The Data Input Menu for Military Construction & Fielding exists in the Military Construction & Fielding input worksheet. The menu options for Military Construction & Fielding are 'Equations' and 'Cost Elements'. The Cost Elements option has two sub-options, 'Military Constr' and 'Fielding. The 'Military Constr' option moves to the Variable Input Sheet of the selected cost element within the Military Construction phase. The 'Fielding' option moves to the Variable Input Sheet of the selected cost element within the Fielding phase. The 'Equations' option is identical to the Equations option in Development Figure B-3.

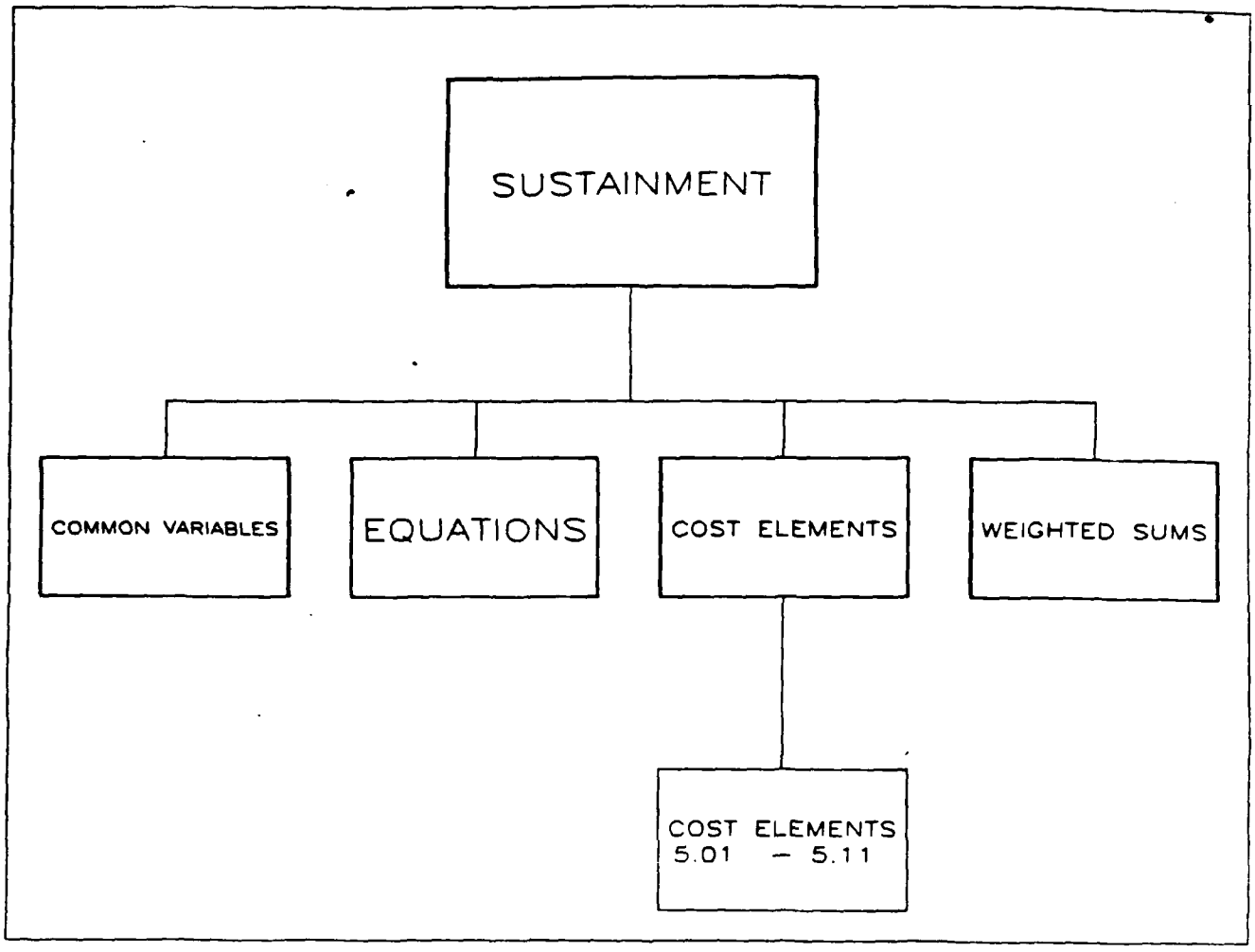


Figure B-6 DATA INPUT SUSTAINMENT PHASE

DATA INPUT SUSTAINMENT. The Data Input menu for Sustainment exists in the Sustainment Input worksheet. The menu options for Sustainment are 'Common Variables', 'Equations', 'Cost Elements' and 'Weighted Sums'. The 'Common Variables' option moves to a table of variables that are common to one or more equations in the Sustainment phase. These variables are filled in one time in the common table to avoid the repetition of filling them in every time they appear in an equation. The 'Weighted Sums' option moves to a table that will be filled in with various data that are used to calculate weighted sums of military personnel costs and operational quantities. 'Common Variables' and 'Weighted Sums' must be completed prior to entering any data in any of the Sustainment cost elements. The 'Equations' and 'Cost Element' options in Sustainment are identical to those in Development Figure B-3.

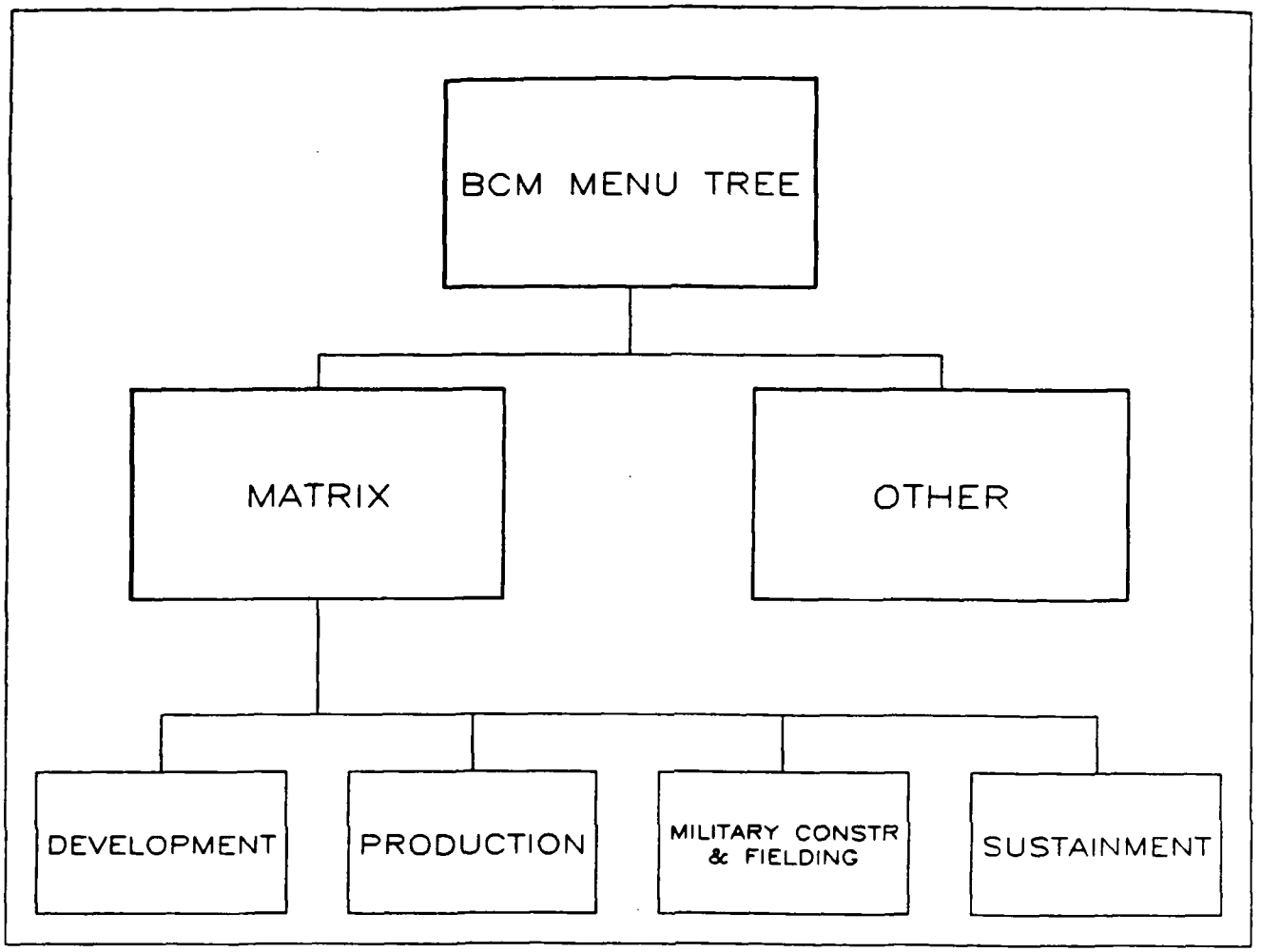


Figure B-7 MENU FOR MATRIX WORKSHEETS

MATRIX MENU. The initial Menu for Matrix worksheets exists in the Main Menu worksheet. The Matrix Menu has four options; 'Development', 'Production', 'Mil Constr & Fielding' and 'Sustainment'. These Matrix options are very similar to the options under Data Input. They correspond to the different phases of the Army Cost Model. Each of these options will retrieve the Matrix worksheet for the corresponding phase. For example, the 'Development' option will retrieve the Matrix worksheet for the Development phase, the 'Production' option will retrieve the Matrix worksheet for the Production phase and so on.

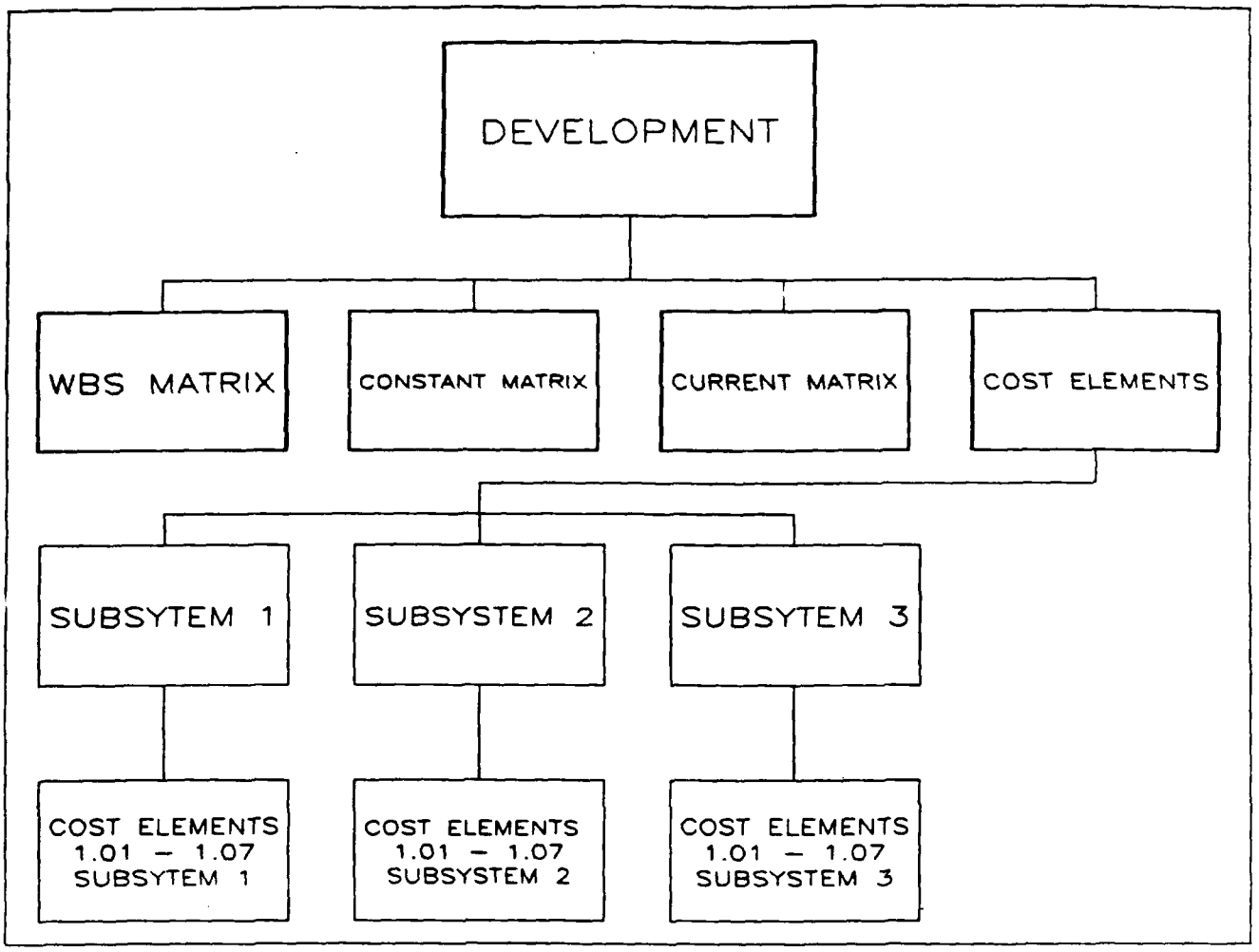


Figure B-8 MATRIX MENU DEVELOPMENT PHASE

MATRIX MENU FOR DEVELOPMENT. The Matrix Menu for Development exists in the Development Matrix worksheet. The menu options for Development are 'WBS', 'Constant', 'Current' and 'Cost Elements'. The 'WBS' option moves to the WBS matrix. The 'Constant' option moves to the Constant Dollar Matrix. The 'Current' option moves to the Current Dollar Matrix. The 'Cost Elements' option moves to the Cost Data Sheet of any cost element for any subsystem within the Development phase. The 'Cost Elements' option has 3 sub-options, 'Subsystem 1', 'Subsystem 2', 'Subsystem 3'. These options will move to the Cost Data Sheets of the subsystem that is selected. The Main Menu worksheet must be retrieved in order to gain access to the Matrix Menus for the other phases.

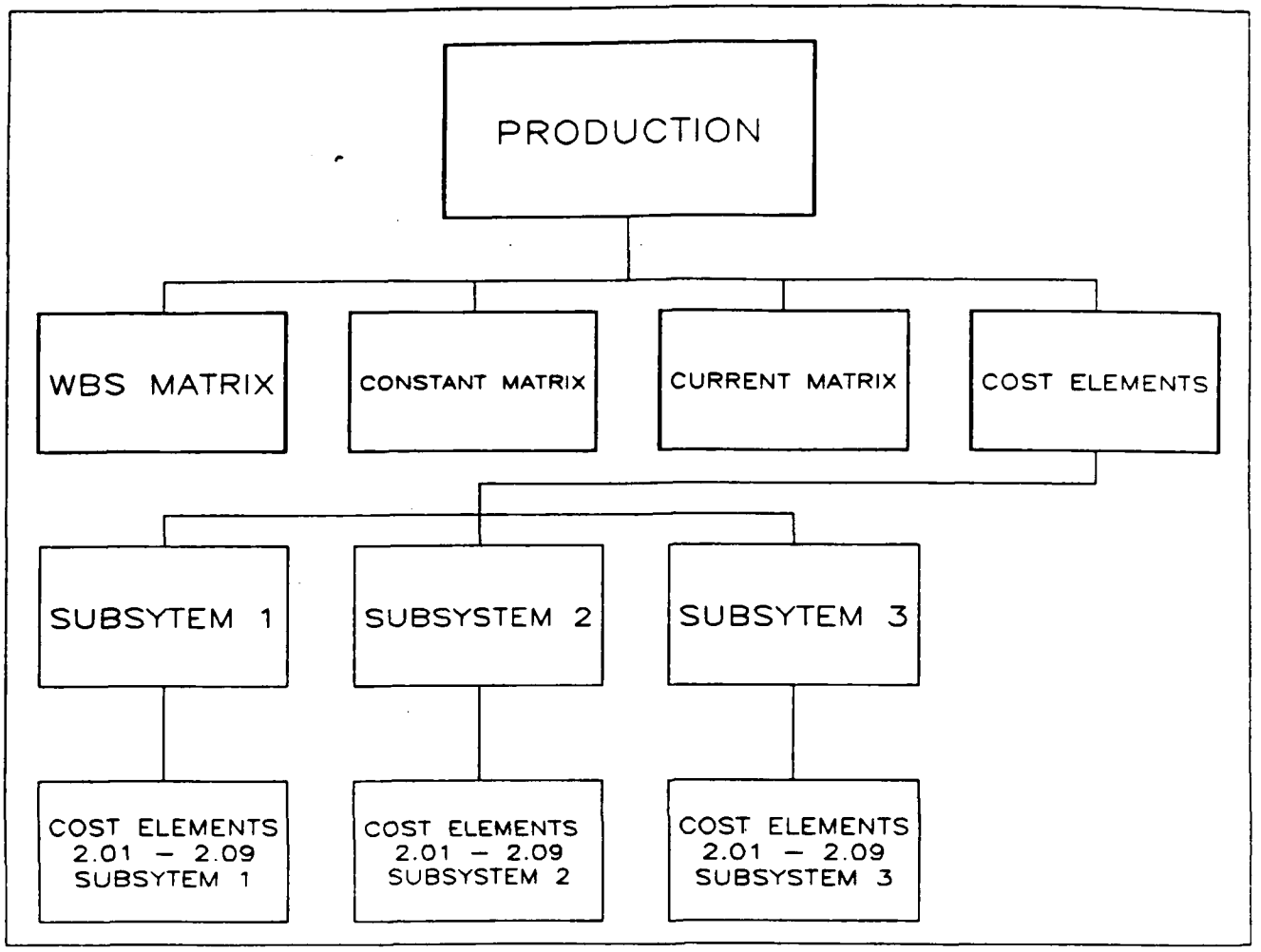


Figure B-9 MATRIX MENU PRODUCTION PHASE

MATRIX MENU FOR PRODUCTION. The Matrix Menu for Production exists in the Production Matrix worksheet. The menu options for Production are 'WBS', 'Constant', 'Current' and 'Cost Elements'. These options are identical to the options in the Development Matrix Menu in Figure B-8.

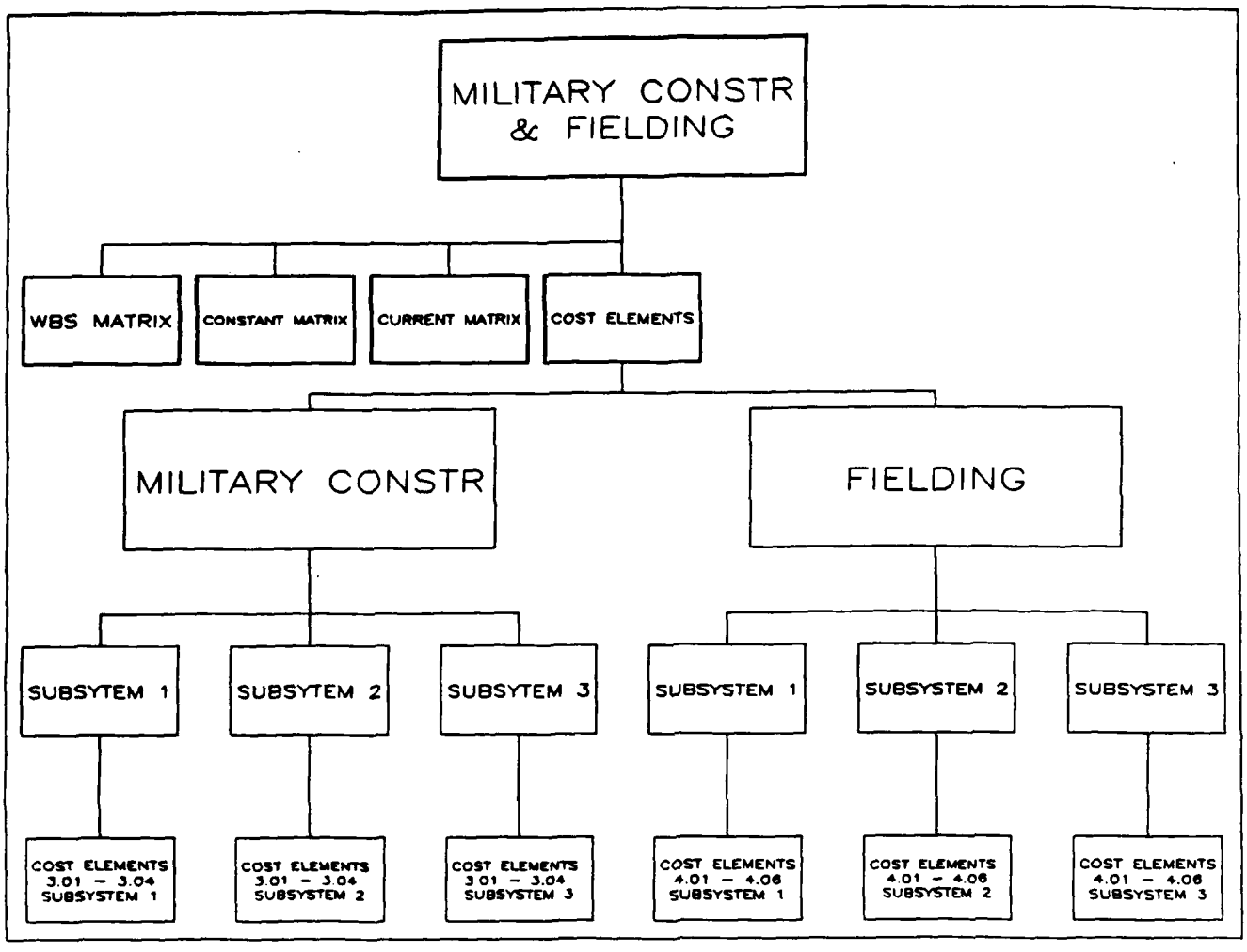


Figure B-10 MATRIX MENU MILITARY CONSTRUCTION & FIELDING PHASE

MATRIX MENU FOR MILITARY CONSTRUCTION & FIELDING. The Matrix Menu for Military Construction & Fielding exists in the Military Construction & Fielding Matrix worksheet. The menu options are 'WBS', 'Constant', 'Current' and 'Cost Elements'. The Cost Elements option has two sub-options, 'Military Constr' and 'Fielding. The 'Military Constr' option moves to the Cost Data Sheet of any cost element for any subsystem within the Military Construction phase The 'Fielding' option moves to the Cost Data Sheet of any cost element for any subsystem within the Fielding phase. The 'WBS', 'Constant' and 'Current' options in Military Construction & Fielding are identical to those options in the Development Matrix Menu Figure B-8.

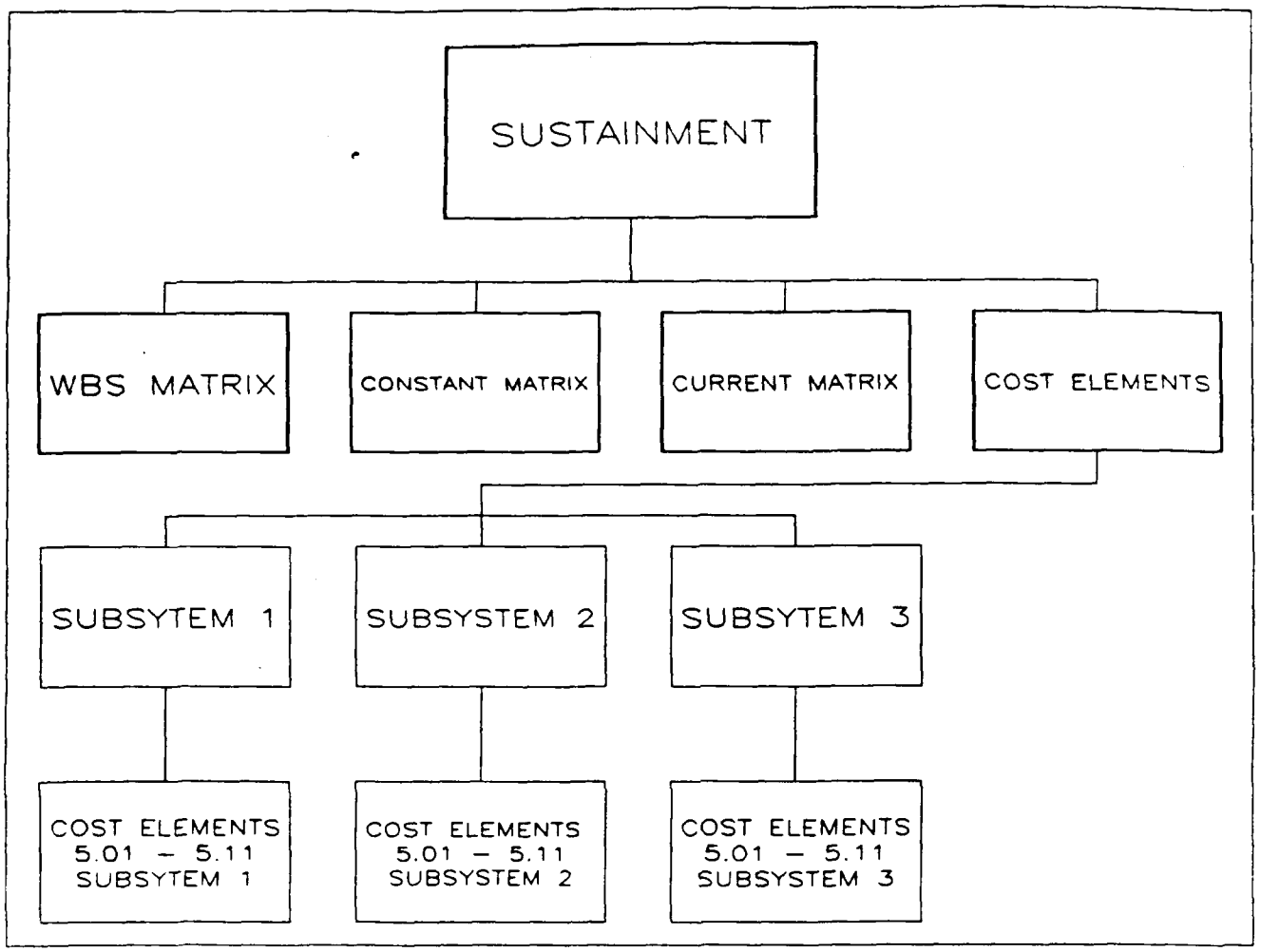


Figure B-11 MATRIX MENU SUSTAINMENT PHASE

MATRIX MENU FOR SUSTAINMENT. The Matrix Menu for Sustainment exists in the Sustainment Matrix worksheet. The menu options for Sustainment are 'WBS', 'Constant', 'Current' and 'Cost Elements'. These options are identical to the options in the Development Matrix Menu in Figure B-8.

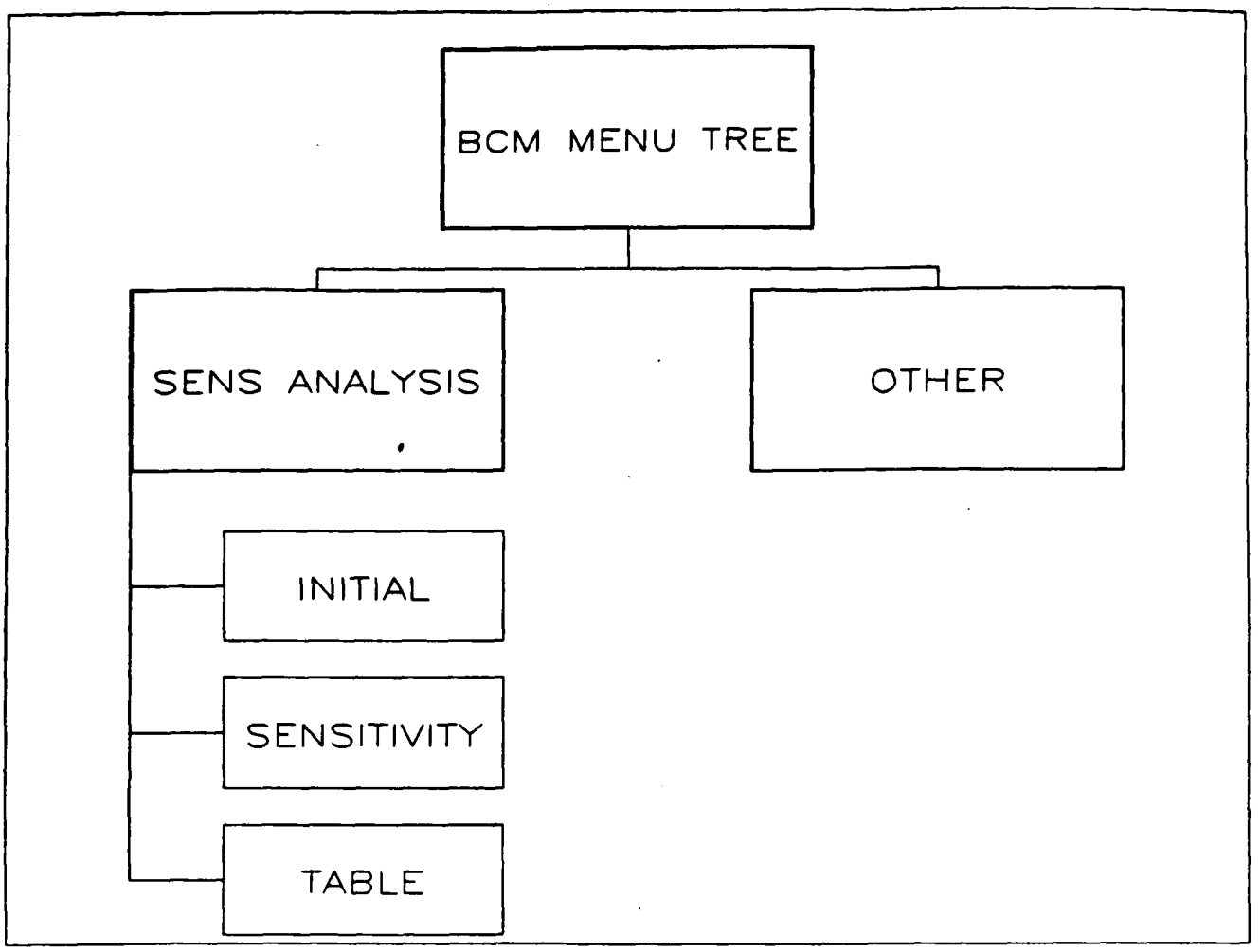


Figure B-12 SENSITIVITY ANALYSIS

SENSITIVITY ANALYSIS. The Sensitivity Analysis menu is in the Sensitivity worksheet and can only be accessed from the Main Menu. The options under Sensitivity Analysis are 'Initialize', 'Sensitivity', and 'Table'. The 'Initialize' option is used to retrieve all the data from the different Input worksheets that are needed for the sensitivity analysis. The 'Sensitivity' option performs the actual sensitivity analysis and inputs the results in the sensitivity table. The 'Table' options moves to the sensitivity analysis results table.

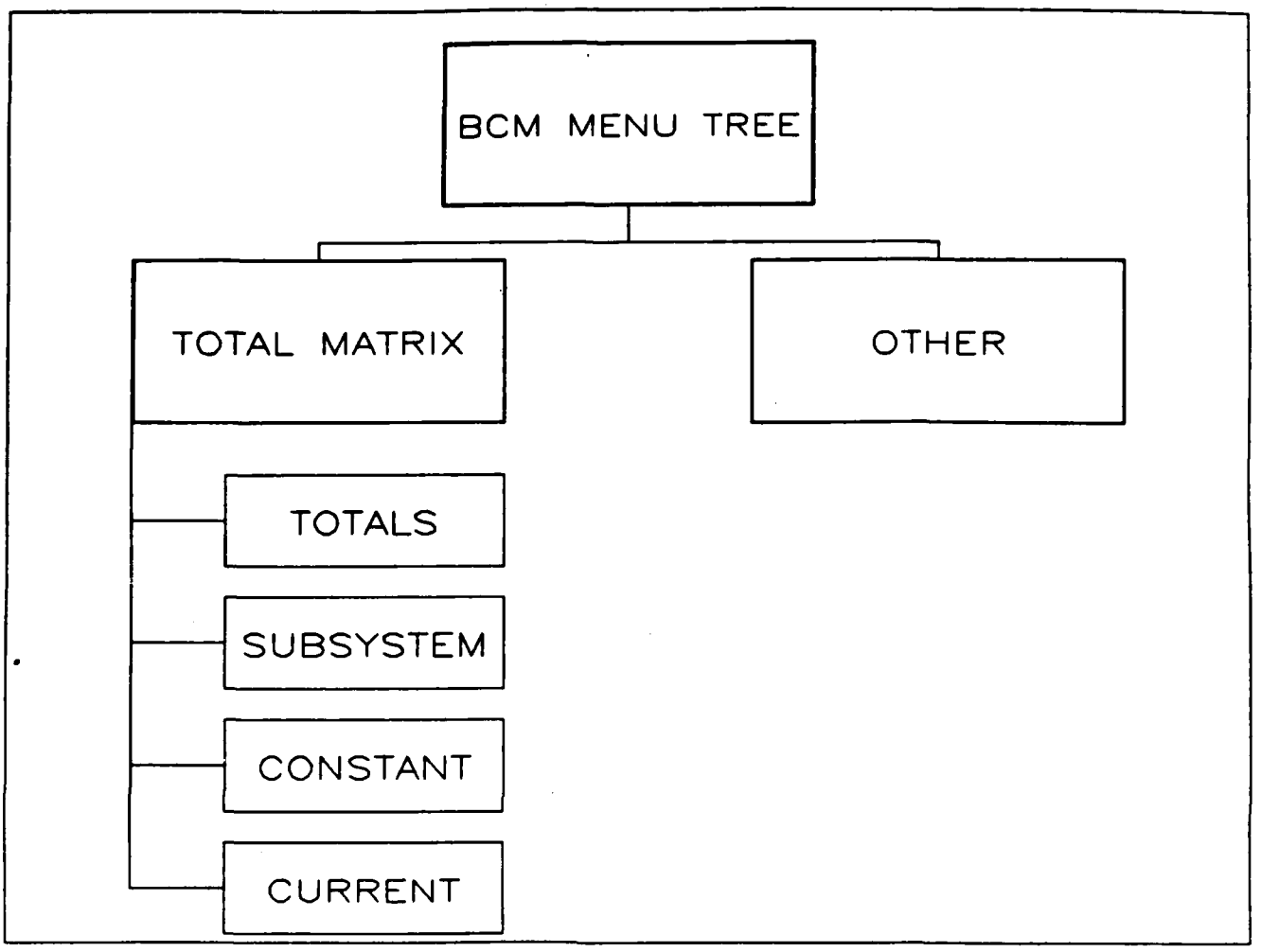
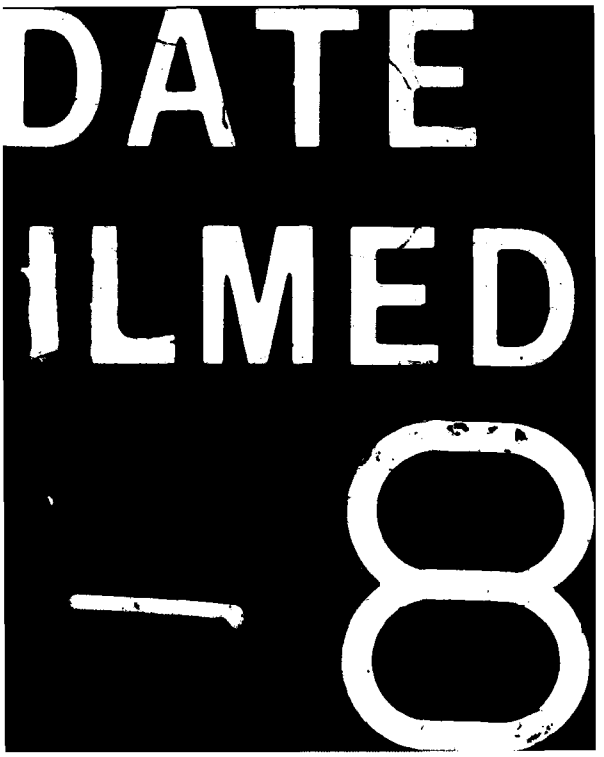


Figure B-13 TOTAL MATRIX

TOTAL MATRIX. The Total Matrix is in the Total Matrix worksheet and can only be accessed from the Main Menu. The options under Total Matrix are 'Totals', 'Subsystem', 'Constant' and 'Current'. The 'Totals' option retrieves the cost data from the five phases and inputs it in three matrices. The 'Subsystem' option moves to the WBS matrix. The 'Constant' option moves to the Constant matrix and the 'Current' option moves to the Current matrix.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