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AEOSS Runtime Manual for System Analysis on Advanced Earth-Orbital Spacecraft Systems

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PREFACE

AEOSS is a specially tailored software coded within the framework of the relational database program of the Acius' **4th Dimension** with an Apple Macintosh version. It enables users to predict the required power, weight, and cost for a generic Earth-orbital spacecraft system. These variables are calculated on the component and subsystem levels, and then the system level. Selected performance analyses for essential components and subsystems are provided. The costs are assessed using statistically determined cost models of the flown spacecraft that were categorized into classes in accordance with their functions and structural complexity. This software has the feature permitting a user to enter totally or partially known values of these parameters at all levels. Such capabilities warrant the results to be realistic and reliable. All information is of vital importance to project managers of the spacecraft subsystems or a spacecraft system.

Prompted by the licensing agreement with the Acius, Inc., two versions of the software associated documents have been prepared. They are:

(1) AEOSS Runtime Manual - A finite number copies of the restrictive **4D Runtime** version are permitted, through a licensing agreement, to be distributed with the developed AEOSS database sofeware. This version does not allow a user to make any changes of the program structures nor to alter any program procedures; it is fully capable of running all contents of the applications.

(2) AEOSS Design Guide - This version is for users to exploit the full capability of the **4th Dimension**. It is for an advanced user or a programmer who wants to alter or expand the program structures, the program statements, and the program procedures. However, the user has to possess a **4th Dimension** first.

Thanks are due to the staffs of the ATR, Inc. who provided the coding efforts. Specifically, to Peter Hui who assisted in searching an appropriate relational database software suitable for the intended applications, and in mapping the conceptual architecture of the program; to Livia Zien who brought this program into being and furnished the document related to the preliminary version; to Ronald Yurow who made final corrections and revisions to assure this accomplishment to be a viable and valuable tool.

AEOSS Runtime Manual

for operating in the Custom Environment

I. INTRODUCTION

The **Advanced Earth-Orbital Spacecraft Systems** (**AEOSS**) database is a specially tailored software coded from the relational database of **4th Dimension** (Ref. 1). It permits the user to determine the power consumption, weight, and cost for a spacecraft system. The interested parameters are common to all spacecraft and can be calculated on the component or subsystem level and then the system level. The flexibility of permitting the user to enter known values, total or partial, of these parameters at different levels adds another dimension to this software capability. Performance analyses for a number of essential components and subsystems are also provided. These capabilities, that were implemented on the basis of the mathematical models or expressions and the collected data given in Reference 2, enable this software to yield realistic and reliable results for a spacecraft system. All this information is of vital importance to project managers of a spacecraft system.

This **AEOSS** Runtime is a restrictive version. It uses the **4D Runtime** version that is permitted to have a finite number copies for free distributions with this **AEOSS** database software through a licensing agreement with the Acius, Inc. Although the Runtime version is fully capable of performing all included applications, its companion version, whose manual being the **AEOSS** Design Guide (Ref. 3), should be consulted if the user wishes to gain insight to the program structures, wants to make any alterations of the program statements or the program procedures, or has the need for supplementing any enhancements.

II. STARTING UP

To start, the user enters the **AEOSS** database by clicking on the **AEOSS** folder icon twice. This will bring up a list of all files associated with the database. Double clicking on any of the "**start.xxx**" file icons will start the program.

A password hierarchy has been built in so that a user has limited access to the three specified environments: (1) **Design**, (2) **User**, and (3) **Custom**. A user who has access to the **Design environment**, the highest hierarchy access, is accessible to all three environments, including both the **User** and the **Custom environments** automatically. A user who has access to the **User environment**, is inaccessible to the **Design environment** but is accessible to the **User** and the **Custom environments**. The **Custom environment** access does not allow the user to enter any other environments in higher hierarchy but to itself. The **Custom environment** lets the user gain access to all menus that allow the user to input or modify data and to view or delete the data already entered, but does not allow any changes of stored database nor of the design codes except in a few special cases.

For simplicity, the **Runtime** version is specially provided for users who will only apply this database without any program changes. Its access is limited to the **Custom environment.** A password is to be entered by typing in at the outset. A menubar, Menubar #1, will appear on the screen with seven menus. It has the following form:

File **Edit** **System Info** **Subsystem Data** **Subsystems** **Formats** **Tables**

The **System Info** menu allows the user to input, modify, and delete data for a spacecraft at the system level. Under the **Subsystem Data** menu, the user again has options to input, modify, and delete data on parameters pertaining to any subsystems of a spacecraft. In addition, the user can view the entered data that can also be printed if so desired. Under the **Subsystems** menu, there are six defined subsystems: ***Electric Power, Thermal Control, Structure, Auxiliary Propulsion, Attitude Control, and CC&DH (Communication, Command and Data Handling)***. Each subsystem selected under this menu calls up a new menubar that will be discussed later in detail.

The **Subsystems** menu differs from the **Subsystem Data** menu in that the former includes many performance analyses of individual components as well as the defined subsystems that require the user input for various parameters unique to the cases, and the latter, on the other hand, requires direct user entries of summarized data, whether calculated or specified known values, of the listed parameters for all subsystems and their components as well. These parameters include ***weight, size, power consumption, temperature***, and ***Cost.***

The user first enters the system information via the **System Info** menu, then enters data into the subsystem of concern under the **Subsystems** menu for detailed performance analyses and, finally, enters the calculated or specified values through the **Subsystem Data** menu to input data for calculating the unknown parameters. The results are entered automatically into the ***Summary of S/C System*** that can be selected under the **Formats** menu.

The **Formats** and **Tables** menus generally require no input from the user. The **Formats** menu allows the user to select different layouts to be viewed or printed. The contents are ***Summary of S/C system, Cost models,*** and the Spacecraft ***System totals.*** The **Tables** menu contains: ***Cost Constants***, the NASA ***Inflation Index***, ***Physical Constants***, ***Weight Limits***, and ***Modify Table.*** The last one is a special provision permitting the user to expand or modify the data in several tables.

III. FUNCTION AND OPERATION

Detailed instructions of operation for various menus are described in the following:

A. System Info Menu

The user shall first select the ***Input System Info*** from the **System Info** menu to enter information relevant to the entire spacecraft system. The layout is entitled **Spacecraft Classification.** The number **100** has been coded to identify the spacecraft system under the **Spacecraft ID Number**. The user is to enter a name following the title of the **Spacecraft Name** and to identify the **Spacecraft Type -- Explorer** or **Nonexplorer** and the **Structure Class -- Simple** or **Complex** for a spacecraft. The corresponding values for the two constants **a** and **b** of the cost models will be linked and displayed automatically unless the weight falls out of the ranges, then the user will be asked to supply new data. Having entered all input data, the user clicks on the **OK** button to save the record and to exit from the layout, or he can click on the **Cancel** button to abort the attempt and to exit from the layout.

When modifications of the entered data are needed, the user can select the ***Modify System Info*** under the **System Info** menu to input new values.

B. Subsystems Menu

The **Subsystems** menu lists all six defined subsystems of a spacecraft. Each selection of these subsystems will lead to a new set of menus allowing the user to enter values for various parameters through different layouts unique to the particular components or subsystems.

For convenience, the database features an option to store frequently used constants in some layouts to avoid repeated typing inputs. The user can click a field displaying the title of ***Constant Needed*** to select such a constant with its proper units, and the value will enter into the field automatically. For those layouts containing such a field, the user can enter this field and select the values many times, depending on the number of constants involved. A window displaying the available constants will appear on the right-hand side of the screen for selections.

A typical example for entering these constants in the layout of the Space Radiator Design is to enter the values of the Stefan-Boltzmann constant and the solar constant. The user clicks on the field of ***Constants Needed***, a name list of constants will appear in a window at the upper right corner of the layout. A selection on the name *Stefan-Boltzmann* will call up another table displaying several units. When the one having the desired units is selected, its value will enter into the proper field automatically. Similar procedure applies to select another value for the *Solar constant*.

In the performance calculations for all subsystems, some procedures are common to all cases, and they need only be described once herein.

Under each individual subsystem menu, the user will find four selections: the ***Input Data***, ***Modify Data***, ***View Data***, and ***Delete Data***. Any selection will call up a dialog box that lists the available layouts that can perform specific calculations.

When data are first entered into a layout through a selection of the ***Input Data***, only the **OK** and **Cancel** buttons are available. The **OK** button will save all data shown on the screen and exit from the layout. The **Cancel** button will exit from the layout without saving any information. If data are modified through the ***Modify Data***, there are four buttons available at the bottom of the layout. The two additional buttons are **Save** and **Retrieve.** The **Save** button will save all data appearing on the screen but will not exit from the layout. The **Retrieve** button will retrieve the saved old data before the new data have been saved. The currently saved data will replace the old ones that are retrievable as long as the user does not exit from the layout and continues to experiment with different values. Once the **Save** button is clicked, the old data are gone forever. The data entered through the preceding five layouts will constitute one record. The execution of the ***Delete Data*** will delete all information entered in this record. The user will have to enter data all over again through the individual ***Input Data*** layouts.

It is not a procedural necessity but is advisable to complete data entries to all layouts of a subsystem before proceeding to the next one.

The ***Quit*** selection under the **File** menu will lead the user to exit from the Menubar #2 and to return to Menubar #1, the main menu.

1. Electric Power

When the ***Electric Power*** is selected under the **Subsystems** menu of the Menubar #1, a new set of menus, Menubar #2, will appear on the screen:

File Edit Electric Power Formulas Tables

In the Electric Power subsystem, there are five listed layouts: ***Sunlight and Eclipse Durations***, ***Solar Array Sizing***, ***Weight*** (***Solar Panel Weight Calculation***), ***Solar Array Temperatures***, and ***Battery Design***.

The **Formulas** menu contains selections corresponding to the listed layouts, allowing the user to view or print the underlying formulas used in computations for the individual layouts.

The **Tables** menu contains a table on solar cells.

2. Thermal Control

The selection of ***Thermal Control*** under the **Subsystems** menu from the Menubar #1 will show the Menubar #3 as follows:

File Edit Thermal Formulas Tables

The layouts under the **Thermal** menu include ***Simple Space Radiators Sizing***, ***Space Radiators Sizing***, and ***Thermal Louvers and Electric Heaters***. The formulas corresponding to the preceding layouts are included under the **Formulas** menu with the same titles. The **Tables** menu contains five tables of thermophysical properties of the absorptivity and emissivity of various coatings.

3. Structure

The selection of ***Structure*** under the **Subsystems** menu from the Menubar #1 will show the Menubar #4 as follows:

File Edit Structure Formulas Tables

Structural analyses on static performances and dynamic responses depend on large scale main-frame computer programs, such as the NASTRAN. Two important post analysis determinations are included: (1) The determination of the ***Direction of ith Mode***, *and* (2) ***Margin of Safety***. The former uses the NASTRAN results of the calculated SPC forces (Forces of single-point constraint); the latter makes use of the NASTRAN-generated stress results and the related material property data.

Nothing is currently stored under this **Formulas** menu. The **Tables** menu contains a table of yield stresses for some aerospace structural materials that will be used, for instance, in determining the margin of safety.

4. Auxiliary Propulsion

The selection of the **Auxiliary Propulsion** menu from the Menubar #1 will call up a set of menus in the Menubar #5 as follows:

File Edit Auxiliary Propulsion Formulas Tables

There is only one layout or performance analysis associated with this subsystem. It is a detailed analysis on the ***Velocity and Weight Requirements*** (*for the Propellant*). The working equations are summarized under the menu **Formulas** that can be viewed or can have a printed output.

5. Attitude Control

The selection of the **Attitude Control** menu from the Menubar #1 will call up a set of menus in the Menubar #6 as follows:

File Edit Attitude Control Formulas Tables

6. CC&DH

The selection of the **CC&DH** menu from the Menubar #1 will call up a set of menus in the Menubar #7 as follows:

File Edit CC&DH Formulas Tables

The preceding two menubars, Menubar #6 and Menubar #7 are skeletal only, and no contents have been implemented in either case. Depending on the mission and thus to employ selected components with specific characteristics, the designs of the last two subsystems may vary widely. No detailed functional performance analyses are attempted for a generic spacecraft system at this stage, because the scope is just too large to be covered. However, the ultimate cost for a specific design still can be analyzed using any known data, either calculated or specified, through the **Subsystem Data** that will be treated in detail in the next section.

C. Subsystem Data Menu

Having completed calculations on all components or subsystems (with the exception of the last two subsystems at this point of time), the user can now enter data for individual components through the **Subsystem Data** menu in the Menubar #1. Again, the user is given four options to input, modify, view, or delete data through the ***Input New Data***, ***Modify Data***, ***View Data***, ***and Delete Data*** selections, respectively.

When entering information into the **Subsystem Data** for the first time, the ***Input New Data*** is to be selected. This layout has two buttons: the **OK** and **Cancel**, and both buttons will be activated. When modifying data, all four buttons at the bottom of the layout will be functioning. The two additional buttons, the **Save** and **Retrieve** buttons, operate in exactly the same manner as previously described. The **Retrieve** button, however, will also retrieve the old data from the component subrecords previously entered through the ***Component Data*** layout.

The selections of a subsystem name and its coded ID number are mandatory. The ID numbers designated for the subsystems are as follows:

Subsystem ID Number	***Subsystem Name***
1	*Electric Power*
2	*Thermal control*
3	*Structure*
4	*Auxiliary Propulsion*
5	*Attitude Control*
6	*CC & DH*

The user fills in the ***Subsystem ID Number*** field first by typing in the ID number; the corresponding ***Subsystem Name*** will be entered automatically. If the user enters a nondefined ID number in the case of a special or expanded application, the user will be asked whether or not a new subsystem name will be created and entered into other records relevant to the weight and cost for the undefined subsystem.

To add a picture in the ***Picture*** field, the user has to copy the picture by any available means into the clipboard under the **Edit** menu before entering the **4th Dimension** database program. The user clicks on the ***Picture*** field where the region will become highlighted, then selects the ***Paste*** from the **Edit** menu to transfer the stored image. It will be automatically scaled to fit the size set out for the picture.

To enter data for each component of a subsystem, the user clicks twice at the **Component Data** area within the **Subsystem Data** layout. It will call up a dialog box having the title of the **Component Data** through which the data of the **Component Name, weight, size,** and **power** consumption can be entered. The three buttons on the left-hand margin labelled as **Enter, Delete,** and **Cancel** are self-explanatory. This layout is referred to as an included layout for its inclusion within the parent layout of the **Subsystem Data**. One merely repeats the process to enter data for more than one component. The **Required Power** and **Weight** fields in the **Subsystem Data** layout will use the calculated sums obtained from the component entries by clicking on the ***Calc Power*** and ***Calc Wt*** buttons, repeatedly. However, the user can also enter data directly at this stage.

The ***Known Cost*** field allows the user to input a specified value if the cost of a component or a subsystem in a year, labelled as the **Cost Year**, is known. The user enters the known cost and the year of that value becoming valid.

The cost estimates consist of two cost models for the protoflight and its follow-on unit(s). Cost will be calculated as a function of weight, using the deduced empirical expressions from flown satellites. All calculated costs are in millions of the 1980 dollars, and the NASA inflation factors will be used to convert to any year of interest.

The two constants ***a*** and ***b*** in the empirically determined cost expressions are displayed automatically (for verification purpose) if the weight of a subsystem does fall within its criteron.

The three fields in the middle of the lower space in the **Subsystem Data** layout are the **Sum of Weights, Sum of Power,** and **Size.** Their inputs are automatically recorded from the results previously computed in individual subsystems. These data are displayed for reference only; they may aid the user to compare the results of components calculated previously. Their values cannot be altered in this layout.

D. Formats

Under the **Formats** menu in Menubar #1, there are three functional selections: ***Summary of S/C System***, ***Cost Models***, and ***System Totals.***

The ***Summary of S/C System*** selection will display a summary of the interested parameters of a spacecraft system with all its subsystems and components data already entered through the **Subsystem Data** layout. The weights of individual subsystems are the ones used in the cost models. When the user clicks on the **Done** button at the bottom of this layout, an option of **Print** will appear on the screen for selection.

The ***Cost Models*** selection will call up a dialog box that lists two options: the **Protoflight** and the **follow-on unit** for cost estimates. The selected layout will show on the screen. The magnitures of weight of individual subsystems are automatically transferred from the table of the **Summary of Spacecraft System.** Their values, in turn, were originally entered via the layout of the **Subsystem Data.** The calculated costs of individual subsystems and the spacecraft system are in millions of the 1980 dollars. For any other years, the user needs to specify that year inside the parenthesis in the last line of the layout. The cost will be adjusted to that year, using the NASA inflation index. The **Print** button at the bottom of the screen, as an option, allows the user to print out the results with the entire layout.

The ***System Totals*** selection will show a layout displaying various fields for the interested parameters of the spacecraft system. They are listed clearly and are self-explanatory. The user also has an option to print out the results of this layout.

E. Tables

Nine items are listed in this menu: ***Cost Constants***, ***Inflation Factors***, ***Physical Constants***, ***Weight Limits***, and ***Modify Table*** with the options of **View** and **Print** given to the first four items. The ***Cost Constants*** table displays values of ***a*** and ***b*** for all subsystems in both the protoflight and the follow-on models. The NASA ***Inflation Factors*** table displays the year versus the inflation factor, adopting the 1980 value as the datum. The ***physical Constants*** table lists a number of conversions of units in addition to some frequently used physical constants in different units. The ***Weight Limits*** table displays the viable ranges of weight for the cost models for the individual subsystems and the system. The last one ***Modify Table*** is a special convenience capability permitting the user to enter several tables. It allows for expansion, modification, or deletion of their contents without altering the programming codes.

IV. REFERENCES

(1) Walden, J., "4th Dimension User's Guide", Acius, Inc. 1987.
(2) Lee, H. P., "System Analysis on Advanced Earth-Orbital Spacecraft Systems", in preparation.
(3) Lee, H. P., "AEOSS Design Guide for System Analysis on Advanced Earth-Orbital Spacecraft Systems", NASA TM-100772, 1990.

Menubar #1: After selecting the **Custom** environment, this menubar appears

File Edit System Info Subsystem Data Subsystems Formats Tables

File	Edit	System Info	Subsystem Data	Subsystems
Quit	Show Clipboard	Input System Info Modify System Info Delete System Info	Input New Data Modify Data View Data Delete Data	Electric Power Thermal Control Structure Auxiliary Propulsion Attitude Control CC & DH

Formats	Tables
Summary of S/C System	Cost Constants
Cost Models	Print Cost Constants
System Totals	Inflation Factors
	Print Inflation Factors
	Physical Constants
	Print Physical Constants
	Weight Limits
	Print Weight Limits
	Modify Table

Menubar #2: for the Electric Power subsystem

File Edit Electric Power Formulas Tables

File	Edit	Electric Power	Tables	Formulas
Quit	Show Clipboard	Input Data View Data Modify Data Delete Data	Solar cell Table	Sunlight and Eclipse Durations Array Sizing and Weight Temperatures Battery Size and Weight

Menubar #3: for the Thermal Control subsystem

File Edit Thermal Formulas Tables

File	Edit	Thermal	Formulas	Tables
Quit	Show Clipboard	Input Data View Data Modify Data Delete Data	Simple Space Radiator Sizing Space Radiator Sizing Thermal Louvers and Heaters	Conductive Paints Table Thermal Coatings Table Black Coatings Table White Coatings Table Miscellaneous Coatings

Menubar #4: for the Structure subsystem

File Edit Structure Formulas Tables

File	Edit	Structure	Formulas	Tables
Quit	Show Clipboard	Input Data Modify Data View Data Delete Data	Structure Variables*	Structural Material Table

* No contents being implemented.

Menubar #5: for the Auxiliary Propulsion subsystem

File Edit Auxiliary Propulsion Formulas Tables

File	Edit	Aux.Propulsion	Formulas	Tables
Quit	Show Clipboard	Input Data Modify Data View Data Delete Data	Vel. & Weight Requirements	Message*

* No contents being implemented.

Menubar #6: for the Attitude Control subsystem

File Edit Attitude Control Formulas Tables

File	Edit	Attitude Control	Formulas	Tables
Quit	Show Clipboard	Input Data Modify Data View Data Delete Data	Message*	Message*

* No contents being implemented.

Menubar #7: for the CC & DH subsystem

File Edit CC & DH Formulas Tables

File	Edit	CC & DH	Formulas	Tables
Quit	Show Clipboard	Input Data Modify Data View Data Delete Data	Message*	Message*

* No contents being implemented.

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15. Supplementary Notes

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16. Abstract

AEOSS enables users to project the required power, weight, and cost for a generic Earth-orbital spacecraft system. These variables are calculated on the component and subsystem levels, and then the system level. The included six subsystems are (1) electric power, (2) thermal control, (3) structure, (4) auxiliary propulsion, (5) attitude control, and (6) communication, command and data handling. The costs are computed using statistically determined models that were derived from the flown spacecraft in the past and were categorized into classes according to their functions and structural complexity. Selected design and performance analyses for essential components and subsystems are also provided. AEOSS has the feature permitting a user to enter known values of these parameters, totally and partially, at all levels. All information is of vital importance to project managers of subsystems or a spacecraft system.

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