185

Subcontractor Report

**Development of a Methodology
for Defining Whole-Building Energy
Design Targets for Commercial
Buildings**

**Phase 2, Development
Concept Stage Report**

**Volume 4: Software Concept
Development Task Reports**

September 1990

**Prepared by the American Society of Heating,
Refrigerating, and Air-Conditioning Engineers, Inc.,
for Pacific Northwest Laboratory
under Contract DE-AC06-76RLO 1830
with the U.S. Department of Energy**

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PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401. FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

NTIS Price Codes, Microfiche A01

Printed Copy

Price Code	Page Range	Price Code	Page Range
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A03	11- 50	A16	351-375
A04	51- 75	A17	376-400
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**Development of a Methodology for
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**Volume 4: Software Concept Development
Task Reports**

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Project Perspective

The potential advantages of performance-based commercial building design guidelines have been recognized for some time. However, buildings industry acceptance of such performance guidelines has been slow, largely because of concern over the equity of the proposed procedures and the difficulty of applying them to design practice. The buildings industry currently needs a well-defined, easy-to-use methodology for setting target guidelines and for determining compliance with those guidelines.

To hasten industry acceptance and, ultimately, realization of the energy conservation benefits, the U.S. Department of Energy (DOE) Office of Building Technologies (formerly the Office of Buildings and Community Systems) asked the Pacific Northwest Laboratory (PNL) to develop performance-based guidelines for assessing energy efficiency in commercial building design. These guidelines, termed whole-building energy targets, would be indices or yardsticks with which to measure the annual energy performance of an entire building rather than of individual building components or subsystems.

In 1985, the Whole-Building Energy Design Targets project began as part of the Building System Integration Program (BSIP) managed by PNL for DOE. The BSIP comprises a number of research projects dealing with issues of whole-building energy use and systems integration.

The primary focus of the Targets project is to develop a flexible methodology for setting target guidelines and for determining compliance with them, rather than to determine numerical target values. Because the problem is so complex, computer software will be developed to implement the methodology. The software is referred to as the Targets model.

The Targets project is a two-phase effort. In Phase 1, Planning, the project team--design professionals from various segments of the industry--was assembled to conduct the research necessary for targets development.

In the concept stage of Phase 2, Development, the project team sought to define the technical and software development concepts upon which the overall Targets methodology will be based. The concept stage work is documented in four volumes, of which this is the fourth. The other three volumes are

- Volume 1: Summary Report
- Volume 2: Technical Concept Development Task Reports
- Volume 3: Workshop Summaries.

Work on the user interface and the data and system integration tasks described in this volume was performed for PNL during the period from late 1987 through early 1989 by project team members representing the American Institute of Architects, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., and the Illuminating Engineering Society of North America. A draft of the final report on their subcontracted activities was submitted to PNL and DOE in February 1989. The software engineering task was conducted at PNL. In this volume, the authors describe the objectives, results, and conclusions derived from the tasks they completed.

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1.0 Introduction

The primary focus of the Whole-Building Energy Design Targets project is to develop a flexible methodology for setting target guidelines with which to assess energy efficiency in commercial building design. The proposed methodology has several innovative features (Crawley et al. 1987a,b):

- Targets are based upon certain attributes of the spaces within a building and the functions those spaces support or house. These are referred to as space functions. Commercial buildings are viewed as collections of spaces designed for specific functions, such as private office space, storage space, or lobby space. The methodology will be based upon space functions that are common to a wide variety of buildings. For example, a kitchen is a space function that could occur in a restaurant, hotel, or office building. Whole-building targets can then be developed for specific building projects through combinations of the targets for individual space functions.
- Economics is integral to the targets process. Project-specific costs for energy and for initial construction are used as input to the methodology for establishing targets, so that the targets reflect an appropriate balance of energy and economic considerations.
- The methodology will make feasible the generation of custom, building-specific targets. In addition to target values based on average conditions, the Targets model is structured so that building designers can generate targets appropriate to a specific building design. These custom targets reflect building internal load levels and occupancy patterns, as well as site and other design constraints.
- Multiple levels of targets are planned. The concept of target levels was introduced to avoid setting a single target that, in some cases, may be too low or too high. The levels of targets proposed include a typical design level, a good design level, and a level representing the technical and cost-effective limit for what is achievable. Multiple levels should provide designers with the flexibility to address the different energy conservation priorities and economic perspectives of various building owners.

Because the problem is so complex, computer software will be developed to implement the methodology. The software is referred to as the Targets model.

In this report, the authors document their work to define the software development concepts upon which the overall Targets methodology will be based. Three task reports are included here. Development of the user interface--that critical connection through which the human end-user (architect, engineer, planner, owner) will apply the methodology--is described in Section 2. In Section 3, the use of the software engineering process in Targets model development efforts is described. Section 4 provides details on the data and system integration task, in which interactions between and among all the major components, termed modules, of the Targets model were examined to determine how to put them together to create a methodology that is effective and easy to use.

2.0 User Interface

The Targets model is intended to provide building designers with a flexible, easy-to-use means of determining custom targets for specific building designs using a desktop computer. An effective user interface is critical to the success of the model. The primary objective of the user interface is to make the Targets model as simple to use as possible. The user interface is also an important tool for demonstrating how the completed Targets model will work. The location of the user interface module within the overall Targets model is shown in Figure 2.1.

The user interface must provide a consistent, obvious, connection between the user and the analysis modules of the Targets model. It must allow the user to select options and to direct the flow of activities of the entire Targets model. It also must be structured so the user can generate or modify inputs to the various modules: energy, energy cost, building cost, characteristics development, and economic analysis.^(a) The user must also be able to interactively review outputs from all of the above modules. These represent a formidable set of task requirements.

2.1 Objectives

Several desirable attributes guided the conceptual development of the user interface during this stage of the Targets project. The overriding attribute is that the user interface be easy to use. In addition, it should

- have a clearly defined structure
- have a highly graphical interface
- accommodate different user skill levels
- have extensive context-sensitive defaults
- offer default values and use options that may be modified (customized) by the user.

These attributes formed the basis for the approach taken to conceptualize the user interface.

2.2 Tasks Completed

In this section, the tasks performed to develop the conceptual design for the user interface module are described.

The primary concern in developing the structure was to provide the user with flexibility. One way to do this is to provide multiple access to menus at different points in the structure. For example, the user can access "building systems" input information from several different levels within the overall structure

(a) The software implementation of the Targets model comprises several modules. These are described in detail in Volume 2 of this report.

Figure 2.1. User Interface Module Location Within the Targets Model

(e.g., building level, floor level, space function level). Possible software and hardware development environments for further refinement of the user interface, including an examination of currently available software, were assessed as well.

Two sample buildings were used in the development process. First, a small office building example was used to explore how the user interface would work with a relatively simple project. This office building has two floors, a T shape, and only one type of space function--open office areas with low partitions. Second, a large, multifunction conference hotel--termed the Optima Building--was selected to test the user interface concepts in a more complex setting. The hypothetical Optima Building has 18 stories in two configurations, as well as many different space functions, including those for conference and hotel, retail and dining, parking and offices. Using such a complex building forced the development process to grapple with a number of difficult input and output problems that would have been missed if only the simple building example had been used.

The user interface task resulted in several products:

- a taxonomy structure for the user interface that reflects many aspects of the logical structure of the Targets model
- detailed computer screen displays demonstrating user interface solutions - The screens indicate user options and show inputs to and outputs from the Targets model. More than 100 microcomputer display screens were created to demonstrate specific conceptual solutions to design problems.
- one screen presentation format selected for current demonstration purposes.

The structure of the user interface and the demonstration screens of user interface concepts were developed in parallel, with each activity reinforcing the other. The conceptual structures for the input, output, and user options portions of the user interface were completed. Some portions of this structure are more complete than others. These products are each described in the following sections.

2.2.1 Taxonomy Structure

A primary desirable attribute for the user interface is that it have a clearly understandable structure. Consequently, considerable effort went into developing consistent structures for data and for user options controlling the sequence of operations.

The result of this effort is a taxonomic classification that provides a logical structure for sequencing the operations and elements of the user interface. The user interface taxonomy structure is consistent with those of two other taxonomies being developed within two major analysis modules of the Targets model. The other two taxonomies are for building physical characteristics (used for energy simulations) and building costs.

Draft materials from other work elements were used to coordinate the development of a single, integrated logical data structure for the user interface and the characteristics development and building cost modules.

The taxonomy is in the form of a hierarchical, "object-oriented" tree structure. One advantage of the hierarchical tree structure is that it allows a user to quickly grasp the overall structure of the Targets model and the user's current location within that structure. This is important because of the underlying complexity of the subject domain and of the module that describes it.

The combination of the tree structure and the object-orientation of the logical structure has distinct advantages for developing, modifying, and enhancing the user interface. Portions can be developed independently without the entire structure being worked out in detail first. One portion can be changed with reasonable assurance that the change will not cause ripple effects throughout the entire logical structure. In fact, during the iterative development that occurred during the concept stage, many such modifications were made to the taxonomy structure.

In its current form, the taxonomy structure lacks elegance in certain areas (e.g., some obviously awkward sequences of user action are required). However, the power of this approach is that such problems can indeed be identified and addressed very early in the development process. Also, the structure by no means covers a full range of detail or options. For example, the proposed hierarchies for various outputs from the Targets model could be developed in considerably more detail. The sample concepts developed to date provide sufficient consistency and detail to convey the user interface structures, concepts, and approaches being explored.

The taxonomy addresses only the logical structure of the user interface. It does not address how this logical structure would be physically embedded within computer software. The physical structure of the data for the user interface (and other Targets model elements) will be defined during the development stage of the Targets project.

The taxonomy structure was used to provide the framework for the user interface menus for all of the sample microcomputer screen displays. The remaining desired attributes of the user interface will be examined using the screen displays as examples.

2.2.2 Computer Screen Display Sequences

Computer screen display sequences demonstrating how the user interface could be used were developed. The sequences address the voluntary building design application of the Targets model and are

- Target Setting Mode for a Small Office Building - This sequence demonstrates how the Targets model can be used to set a target for a building design with very little designer input through the extensive use of default options, systems, and data values. It also provides an example of a fairly complete use sequence of proposed user interface features.
- Target Setting Mode for the Optima Building - The Optima building--a hypothetical 18-story structure with multiple functions--provides the vehicle in this sequence for demonstrating some of the features that can be used to customize input data and to address subtleties that can be involved in setting targets for a large, complex, multifunction building.
- Design Analysis/Evaluation Mode (partial) for the Optima Building - This sequence emphasizes some of the options available for specifying building design features during design analysis for a large, complex, multifunction building. Two separate sequences are shown: one for the specification of a fenestration system, another for the specification of a lighting system. This is not considered a complete design analysis sequence, but it does demonstrate a number of important proposed capabilities.

Hardcopy versions of the three sequences are presented in Appendixes A, B, and C. Three 3.5-in. diskettes inside the back cover of this report contain the actual demonstrations. They may be run on any MS-DOS-compatible computer with EGA or VGA color monitor. No special software is needed.

2.2.3 Computer Screen Displays

In this section, several sample screens are shown. The screen displays quickly illustrate a number of important user interface concepts and desired attributes:

- graphical interface
- extensive defaults
- customized defaults
- user skill levels
- ease of use.

Because they contain detailed graphics and follow a logical sequence, the screen displays appear real, as if software to use them exists. However, the screen displays presented here are artificial. No input can be entered, no options selected, no calculations made, no output attained. There is no software behind the facade of the screen displays. The screens are simply graphical concepts of how the user interface might work, once it is developed.

Although they are not real, the screens are powerful tools. A reader can quickly see what will be involved in using the methodology, the level of inputs required, the options available, and the possible outputs. The screens also present a series of very complex ideas in ways that are easy to grasp. Further, they present such concepts before the software coding is begun. Thus, user interface issues can drive the software development process.

Developing such conceptual demonstration screens had another very useful function. The process of developing the screen displays forced the project team to think through, in detail, a number of issues about how the entire Targets model will be structured and will function, and how its various elements will be integrated.^(a)

Graphical Interface

The user interface is intended to be graphically based for both input and output. The graphical emphasis will not be at the expense of the standard text entry mode, which is intended to be available as an optional input mode. The emphasis on a graphical interface has a strong advantage--the concepts and information are easier to understand than would be long presentations of text and numbers.

Types of graphical displays proposed for the user interface include menus, icons, and geometry-handling modes. Each is discussed below; sample display screens are used to illustrate the discussions. Further, it is both recommended and anticipated that the user interface for the Targets model will link with one or more computer-assisted design and drafting (CADD) systems in the future. Such links will greatly increase the graphics capabilities of the Targets model.

Figure 2.2 shows a display screen containing the proposed summary output from the Targets model. The figure indicates the types of summary-level output that can be available in determining an energy target early in a building design process and explains how the various parts of the screen are used. This screen is also a good example of how concisely data can be presented graphically.

(a) To date, there has been no emphasis on hardcopy output from the model. In attempting to achieve a rigorous structure and sequence of user interactions with the entire operation of the Targets model, developing consistent screen displays has been considered a more complicated and direct means for approaching and understanding integration issues than hardcopy output.

Figure 2.2. Summary Results from the Target Setting Mode

Typical Format Elements of Display Screens. As Figure 2.2 indicates, the typical user interface screen is divided into four major areas:

- **TREE menu** - The TREE menu in the upper half of the menu bar on the left of the screen indicates the user's current position within the Targets model. The number of line items in the menu indicates the number of layers down in the hierarchy. The label on each line records the option chosen at each higher level to get to this point in the model; the EXECUTIVE level is the highest level.

As the screen indicates, the user is already six levels down in the hierarchy (EXECUTIVE, TARGET APPLICATION (not shown), TARGET MODE, TARGET SETTING, RESULTS, and TARGET) and has just selected the SUMMARY results option at the seventh level down. The SUMMARY results for a TARGET SETTING use have just appeared on the screen.

- **OPTIONS menu** - This menu section lists the options available to the user at that level of the TREE menu.

There are two ways of selecting an option: 1) by typing the underlined letter in each of the option choices; or 2) by moving a pointing device (e.g., a mouse) so that one of the options is highlighted (when the pointing device is moved close to a word) and by selecting the highlighted option.

Once an option is selected, it is moved up to become the last (lowest) item within the TREE menu, and a new set of options appears. This is the technique for moving lower into the tree hierarchy of the user interface.

- **FILES menu** - This menu will display current files in use by the model (e.g., project data files, cost files). This part of the screen has not yet been detailed in any of the demonstration screens.
- **active window area** - This area of the screen presents current graphics, input options, or output displays, depending upon the current location within the model. If the screen is blank, the user must make a selection from the current OPTIONS menu. The user can interact with the window area of the screen in several ways, depending upon what is shown; the user can
 - enter data in specified data areas, or edit data already present
 - select from a series of options presented, by moving the cursor to the area desired and selecting the desired option
 - change dimensions of graphic images
 - choose output display items to retrieve the next level of detail of output.

Typically, the available actions are obvious from the presentation within the active window area. Sometimes, actions taken will create subwindows within the active area, in which additional actions may be taken or data reviewed. Also, context-sensitive help screens will appear when requested, as indicated by a number of examples in the demonstration screens.

Sample Output Screen Display. In Figure 2.2, the output shown describes an energy target as a result of using the target setting mode of the model. This can be done very early in a building design process, for example, at the beginning of the conceptual or schematic design stage. The data shown represents a target for a specific building design, based primarily on location, space function mix, and building geometry. The target results do not reflect the specific materials and energy systems of the actual design under consideration.

From left to right, the seven bars of the display shown in Figure 2.2 indicate

- annual loads, by component (LOAD bar)
- annual energy consumption, by end-use component (ENERGY bar)
- annual energy costs, without demand charges, by end-use component (ENERGY \$ bar)
- annual demand charges, if any (DEMAND \$ bar)
- total annual energy costs, including demand charges (TOTAL \$ COSTS bar)
- building construction costs (BLDG COSTS bar)
- economic objective function (ECONOMIC OBJECTIVE FUNCTION bar).

This sample screen of target results is for presenting concepts only. For example, the screen shows only a single solution to representing a target. However, a target might also be defined by a set of solutions. In this case, the screen might show multiple solutions for each bar, where the set of solutions forms a target range for the building design situation. The precise formulation of the target output will be determined later in the Targets project.

The screen display contains considerable information about the intended products and formats of the overall outputs of the Targets model. For this reason, the general content of the display is discussed in some detail in the following bulleted items:

- loads, energy, and energy costs (bars 1-5) - The first five bars on the left indicate how perceptions of relative importance of various building energy end uses can change, depending upon whether one is looking at loads, energy, or energy costs. In the example, for discussion purposes it is assumed that heating is done by gas or oil, and that all other end uses are served by electricity.

Starting at the left, from a *loads* perspective (bar 1), heating, cooling, and lighting appear to be of equal importance. However, from an *energy* perspective (bar 2), because of the lower on-site conversion efficiency of typical heating equipment compared with cooling, heating appears to be more important.

Then, from an *energy cost* perspective (bar 3), the relative importance of heating and cooling appear to reverse, with cooling now appearing more important than heating, due to the higher cost of electricity compared with gas or oil. This last trend becomes even more pronounced from a *total energy cost* perspective (bar 5) that includes demand charges on electricity.

- building costs (bar 6) - This bar displays the magnitude of construction cost for the building. A breakdown of costs into energy-related systems is not shown, but this can be done much like the energy end-use breakdown (bar 2) or the total energy cost breakdown (bar 5).
- economic objective function (bar 7) - This bar displays the magnitude of the result of the economic analysis, using one of several different economic objectives that a user may choose. The value for this bar is developed in the characteristics development module of the Targets model. The results from the total energy costs and from the building costs are inputs to the economic analysis.

Only annual energy costs are displayed. However, monthly energy costs (related to monthly demand charges) or even diurnal energy cost patterns (related to time-of-day rates) may be required as inputs to properly assess the economic function.

From a cost-effectiveness perspective, the value of this bar defines the energy cost target for the proposed building design.

A user could also choose to display these data as a table of numbers instead of bar graphs. Because all data shown on this and subsequent output displays are hypothetical, no units have been indicated for the vertical dimension of the graph.

Comparative Results Capabilities. Figure 2.3 shows comparative results for two buildings. Output results for the target of a specific building (established during the target setting mode of operation) are compared with results for an actual design solution for that same building (established in the design analysis/evaluation mode). The capability to provide such comparative data is an important proposed feature of the Targets model.

With this feature, a user can compare various output results of a building design solution with results for the customized target for the building. Several different types of comparative analyses may be made in the design analysis/evaluation mode. For example, a designer may compare two different building design solutions.

In a voluntary application of the Targets model, all seven bars shown in Figures 2.2 and 2.3 constitute significant output about a target for a building design--useful information about design features. However, in a standards application of the Targets model, a single bar can take on a special significance. It is anticipated that a single metric will provide the direct comparison between an energy target and a proposed building design. Thus, a single bar, representing energy consumption, energy costs, or an economic objective function, would form the sole basis to determine if the proposed building design meets the energy target. In this standards application context, the other comparative bars are for information purposes in understanding how the results were obtained for the target metric.

Figure 2.4 shows another type of comparison possible in the design analysis/evaluation mode. A user may want to do parametric analyses of several features of the building design (e.g., window area versus shading coefficient) and to compare loads, energy, energy cost results, and so on. This is a potentially powerful feature of the Targets model, functioning as a design aid. Figure 2.4 shows a hypothetical set of results from such parametrics, in which the sets of results from analyses of multiple options (simulation runs) are displayed as points on surfaces.

Hierarchical Structure of Output Detail. The displays shown in Figures 2.2 through 2.4 are proposed as default level results from the Targets model. A user can, if desired, request progressively more detailed output data about specific parts of the results, down to the limits of the data stored for the

Figure 2.3. Summary Results from the Design Analysis Mode

Figure 2.4. Parametric Results from the Design Analysis/Evaluation Mode

analysis.^(a) This important feature permits default output to be simple, yet allows a user to interactively explore details. Such exploration of details is often necessary for troubleshooting, for research purposes, or simply for determining the basis of the summary results, especially if they are at all surprising. This is an example of "hiding" data until it is desired.

Figures 2.5 and 2.6 show two different examples of how such detail might be accessed in layers. The examples are for the energy simulation outputs, but the same concepts apply to other elements of the output (e.g., building cost, energy cost). Figure 2.5 shows monthly energy use, by end use, for a hypothetical building design. The menu structure on the left of the figure indicates the user-selected path of options to get from a summary output display to the monthly energy level of detail. Figure 2.6 shows monthly cumulative loads data for various building loads. Versions of Figure 2.6 might also be generated by zone of the building.

Use of Menus. The use of TREE and OPTION menus was discussed in reference to Figure 2.2. In addition, the entire display screen can be devoted to additional menus, a compact means of providing many options to a user. An example of such a feature is provided in Figure 2.7, which shows a SUMMARY screen.

(a) This assumes that defaults for levels of data to be stored from various Targets analysis modules would also be preset, but that the user could change those defaults and/or directly specify levels of results to be stored or presented.

Figure 2.5. Monthly Energy Use Results

Figure 2.6. Monthly Cumulative Loads Data for Various Building Loads

A summary screen provides a status report of currently active options and default values within each portion of the Targets model. This feature is considered important because the Targets model will have many defaults in terms of typical values for building features and costs, for analysis modules selected, and for the level of detail of analysis and outputs.

Figure 2.7 shows currently active choices for

- the four analysis modules that are used within the target setting mode
- the level of detail selected for the use of each module
- selected databases to be used with relevant modules.

Such summary screens are intended to enable a user to quickly review which options and defaults are active and to quickly modify the options and defaults. Summary screens are proposed to be used many places within the user interface.

Geometry. These demonstration screens include example geometric displays primarily of building floor plans. The handling of building geometry is one of the most challenging parts of the user interface development. In this section, several examples of addressing geometry within the user interface are provided. Figures 2.8 through 2.10 show three important geometry-handling concepts, from a user-convenience viewpoint.

Building Shape. Figure 2.8 provides a user with a menu of typical building shapes from which to choose. In the figure, the T-shape has been selected from the computer screen displays for the small T-shaped office building. In later screens in the same sequence (Appendix A), the user can "drag" each

TARGETS MODEL		ANALYSE SUMMARY	
<div> <div> EXECUTIVE TARGET MODE TARGET SETTING ANALYSES </div> <div> OPTIONS SUMMARY ENERGY ENERGY COST BUILDING COST ECONOMICS HELP </div> </div>			
ENERGY	MODEL:	DOE 2.1 D	
	TIME PERIOD:	FULL 8760 HOURS COMPACTED - MEDIUM COMPACTED - SHORT	
	FORMAT:	TRY	
	LOCATION:	WASHINGTON, DC	
ENERGY COST	MODEL:	DOE 2.1 D	
	DATABASE:	STANDARD DEMAND - DC	
BUILDING COST	MODEL:	SUMMARY DETAILED	
	DATA BASES:	MEANS DODGE SUPPLEMENTARY	
ECONOMICS	OBJECTIVE :	EROOC	
	MODEL :	ANSI STANDARD	
FILES:			

Figure 2.7. Summary Screen

Figure 2.8. Building Shape Options

Figure 2.9. Thermal Zoning Arrangement Alternatives

Figure 2.10. Space Function Assignment Options

edge of the shape chosen to alter the dimensions of the T, specify number of floors of this shape, or rotate the entire building or selected floors to a new orientation.

From a user-convenience viewpoint, the importance of this type of concept is that many typical building geometries can be modified (which is easy) rather than generated from scratch by user input (which is more difficult and time-consuming). Figure 2.8 shows several different building configurations without regard to space functions, but it is anticipated that the options available for selection will change. Thus, the typical building configurations that can be chosen will be context-sensitive. That is, different menus of building shapes could be presented depending upon the type of building functions being considered.

Thermal Zoning. Figure 2.9 shows another important user convenience that can be chosen from among several alternative thermal zone arrangements for a floor of the T-shaped building. Then, the user can alter the dimensions of the zone by "dragging" lines on the screen, similar to our concept for altering floor plan dimensions in Figure 2.8.

This thermal zoning feature is considered highly desirable for use early in the design process for developing an estimate of a target that is close but not necessarily precise. This feature is not so much a data default as a decision default, even though considerable geometric information is generated from a choice. Further, the user may not even need to decide among the zoning options, because one of the options would already be a "default" zoning choice.

Assigning Space Functions. Figure 2.10 is a key figure relative to the underlying philosophy of the Targets methodology, which focuses primarily on space functions for analysis. In Figure 2.10, the user is

able to assign a space function name to each thermal zone on the floor plan. Upon designation of a space function type, an extensive set of defaults becomes associated with the zone. The default data may include comfort criteria, schedules, system selections, and system parameters (e.g., envelope, lighting, HVAC). The process for selecting space functions is straightforward: a list of space functions is provided, as in the OPTIONS menu in Figure 2.10.

The user can select a space function from the list. The list of space functions in the menu is context-sensitive, in that the list differs depending upon previous selections made by the user, including the building type.^(a)

Summary. The series of choices just illustrated in Figures 2.8 through 2.10 has permitted the implicit selection of large amounts of default data available to the analysis modules of the Targets model. The user can use the program with virtually no direct entry or manipulation of numerical data. The user defines analysis parameters by making choices among available options; the data come along with the choices. The success of this proposed approach will depend primarily upon two features: 1) the robustness and appropriateness of the choices available at each step of the process; and 2) the quality of the defaults assigned to the choices made. It is intended that both of these features will be created from an in-depth consensus-based development process in collaboration with knowledgeable people throughout the building's community.

Use of Icons. In desktop computing environments, icons are widely used to represent objects and classes of objects. Icons are very useful identifying user decision options. Icons are also excellent options for referencing building elements, since buildings are conveniently described via nested sets and subsets of objects (e.g., envelope, wall, fenestration, glazing, framing, shading devices). Object-oriented structures that make extensive use of icons to reference objects are frequently used in CADD programs.

Figures 2.11 and 2.12 show two steps in a process of selecting a lighting system and for choosing its specific characteristics. These two screens are extracted from a complete sequence in Appendix C that selects and defines the characteristics for a lighting system. The sequence is shown occurring during a design analysis/evaluation use of the Targets model using the Optima Building.

Figure 2.11 shows icons (and names) for 10 general fluorescent lighting fixture categories. The wallslot or wallwash option has been selected by moving the arrow cursor to the icon and by clicking a mouse button. This is indicated both by the shaded highlight over this icon and by the cursor arrow pointing at the icon. If a different option were desired, the user could simply move the cursor to another icon and click a mouse button.

These icons are not just pictures; they are pointers either to other sets of objects or to sets of data that describe the physical features of the selected item. Thus, in choosing an icon, the user also chooses data that will be automatically assigned for use by the various analysis modules of the Targets model (e.g., an energy simulation model or a building cost model). Figure 2.11 exemplifies the context of an analysis of

(a) A building's targets will be based upon space function characteristics not upon building types. Users will be asked to designate the building category, type, and subtype. This is not so that a target generated will be related to the building type selected. Rather, the building type choice simply provides an efficient means for presenting the user the options and defaults that are most likely to be appropriate. The user, of course, will retain the option of selecting configurations and features more commonly associated with other building types.

Figure 2.11. Lighting System Options

Figure 2.12. Lighting Control Options

a building being designed, and the user is specifying the characteristics of a desired lighting system. In the example, the selection of the wallslot or wallwash fixture provides a pointer to three different types of such fixtures.

During the target setting mode, the user will not need to specify systems to be used. Default systems and parameters will be defined for typical space function choices. Thus, when a user defines a particular floor area to be a space function of "open office with low partitions," the Targets model automatically chooses a set of building systems and/or system physical and cost parameters. In a voluntary mode of using the Targets model, a user may be able to examine and reselect or modify some, or all, of the defaults selected.

Figure 2.12, occurring later in the sequence, is one of several screens allowing the user to select among optional parameters for the fixture type selected. In this case, a three-level time clock switching control has been selected from among the control options indicated by the icons. The OPTIONS menu at the left is not intended to be complete, but indicates that different types of lighting fixtures could be selected. If another type were selected, then a different array of icons would appear, indicating a different set of options.

Extensive Defaults

Default availability is critical to ease of use. As mentioned earlier, the intent of the user interface approach is to provide defaults for virtually all inputs. This includes defaults for most user inputs, for module configuration, for analysis specifications, and for output formats. The sequence of Figures 2.8 through 2.10 exemplifies features that provide access to large amounts of default data. Another example was shown in Figures 2.11 and 2.12, which accesses considerable default data about lighting fixtures via the selection of a few icons.

Customized Defaults

The original consensus-based default data for the Targets model are expected to reside in read-only files. However, a user can copy and edit the data to generate a new set of customized default files to reflect the specifics of the user's building ownership and/or design practice. The user can then save the data and configure the Targets model system to automatically use the customized default files instead of the original defaults.^(a) This is considered a powerful feature of the proposed user interface method.

The concept of customized defaults can be extended from data and options to also include the criteria that establish energy targets within the proposed Targets model. The criteria that will establish targets levels will consist of sets of available input data defaults and sets of constraints on the operation of the targets optimization routines in the target setting and the design analysis/evaluation modes. A set of defaults and constraints will define a target version X that can then be customized to a specific building by its application to the building's data; customized defaults and constraints can be generated and stored in user-specified files much like other default data. These files then become the source of custom target versions that are then available for use with the methodology.

(a) It will be necessary to set limits on modifications to certain defaults that are to be used in the target setting mode. Such limits are especially necessary within codes and standards applications of the Targets model.

To provide an example of how this might work, assume that when the Targets model is completed, it is well received, and a number of organizations develop custom target levels for use with it. Consider the following scenario:

- The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), the Illuminating Engineering Society of North America (IES), and the American Institute of Architects (AIA) collaborate to develop a new version, A, of a whole-building energy performance path as part of a consensus energy standard (say, a future revised version of ASHRAE/IES Standard 90.1-1989). The procedures would be as follows:
 - The specifications of this "standard path" would be described via sets of data defaults and constraints on the operation of the Targets model in the target setting mode.
 - These defaults and constraints would be contained in computer-stored files available to the Targets model.
 - Then, if a user wanted to generate a custom target for the building that reflected the ASHRAE/IES/AIA criteria, the user would access the ASHRAE/IES/AIA Version A target files when using the Targets model.
- Several federal agencies (e.g., the U.S. Department of Energy, Corps of Engineers, U.S. Postal Service, or General Services Administration) define target versions (B, C, D) by specifying sets of defaults and constraints that apply to the design of their buildings. These could also be installed as files in the Targets model. Then, for example, a future user designing a post office would access the postal service version target files when using the Targets model.
- Likewise, large corporations with an active building design program might define target objectives for buildings to be designed for them by developing their own versions of target files for use with the Targets model. A user could then access versions of target files for, say, General Computers, or United Insurance.
- Building design firms could also create, store, and use their own versions of target files of defaults and constraints that together define the objective of energy practice for each firm.

In a sense, all of the above organizations are "users" of the Targets model. Each organization uses the methodology to establish general versions of default and constraint files that define targets. These general target-defining files can then be applied to specific building design situations within the organization to provide custom targets reflecting the specific economic and design criteria and constraints. Some organizations may wish to further tailor the behavior of the Targets model by specifying certain specific building types and characteristics. For example, the postal service might define about six building types that describe its typical building stock and, consequently, have six versions of customized target files.

User Skill Level Accommodation

The graphical interface is especially good for learning to use the methodology. However, text modes of data entry are often faster for very experienced users. For example, an experienced Lotus 1-2-3™ user will often execute a series of well-known command keystrokes without ever looking at the program's menu

™ 1986, Lotus Development Corporation, Cambridge, Massachusetts.

structure on the screen. Likewise, an experienced energy simulation tool user may be much more comfortable with tables of numbers than with bar charts. Development of the user interface will permit rapid toggling among various use options to provide for such differences in skill level and preference.

Ease of Use

The overall objective of the user interface is to make the Targets model easy to use. All of the above concepts have addressed this objective in one way or another. In summary, a few key concepts are repeated for emphasis.

- Allow the Targets model to be as data-free as possible. This will permit it to be used with very little effort related to input. One way to do this is to keep required inputs to an absolute minimum through the extensive use of context-sensitive defaults.
- Hide input data. Data can be hidden until a user wishes to view or change it. The intent here is to make each part of the model appear simple, yet provide access, when a user wishes, to very detailed data input options, design options, and output data.
- Simplify complexity. The proposed Targets model will be sophisticated and complex. The user interface concepts presented above are intended to present many ideas to the user in a simple, straightforward way and to hide as much complexity as possible until the user actually wishes to address it. Actually achieving ease of use of the user interface will be a major challenge in the next stages of development.

2.2.4 Alternative Display Formats

In this report, a consistent display format for computer screens has been used. However, this format is but one of several potential alternatives. A number of different formats are being used today for computer interfaces, and refinements and new approaches are being developed almost daily. This is an area of rapid change and evolution.

Three generic types of interfaces seem likely candidates for a format for the needs of the Targets model. These are 1) menu system; 2) windows for option menus only (tiled options); and 3) full windows (tiled windows).

For this report, the menu system option was used to provide a consistent presentation format. The menu technique has some apparent advantages and disadvantages. One advantage is that it is graphically simpler than the others, making it easy to change as the development concepts get more sophisticated. This reduces development time and cost, which is important, given the time involved in generating nonprogrammable screen displays using available software packages. It is also a very usable technique in practice and offers many advantages to an experienced user.

One disadvantage of this technique is that the structure of the concepts is not as clear to a first-time user. The tiled options and tiled windows techniques provide more visual clues about program structure and about current user location within the structure. However, this is done at the cost of increased graphic complexity. As a result, these other techniques may become more attractive in later stages of Targets model development. Also, they become increasingly attractive as display resolution increases. Because all three options listed above are essentially identical in terms of structural logic, there is no reason that the format cannot be changed in the future.

2.3 Issues, Conclusions, and Recommendations

Because the user interface presents, in some form, all aspects of the Targets model, it could become the focus for virtually all issues faced by the elements of the model. However, the focus here is on only the interface-related issues. Several issues appear especially important for further deliberation, and are discussed below. The conclusions and recommendations expressed here for these issues are those of the ASHRAE/AIA/IES team.

2.3.1 Audiences and Screen Display Features

Issue 1: *Who are major anticipated audiences of the Targets methodology, and how will anticipated audience characteristics impact the user interface?*

The Targets methodology is intended for voluntary use to assist building designers and owners in addressing whole-building energy issues during the design of commercial buildings. It is also intended as a methodology to be used to establish future whole-building energy standards. In a standards mode, it is likely to generate one of several paths for complying with such standards. In either situation, a widespread potential audience exists.

Because of the complexity of whole-building energy considerations, the proposed Targets methodology is complex and sophisticated. In this context, likely early users of the methodology will be

- the more innovative building designers (irrespective of size of firm or of project)
- designers of larger, more complex projects
- managers and decision makers within public and private sector organizations responsible for the design and construction of multiple buildings.

It is likely that these potential users will have a substantial need for the type of assistance provided by the Targets methodology, and the ready experience and expertise to use the methodology effectively with little training or learning effort.

Issue 2: *What user interface features should be used as "standards" for development of the user interface?*

One example of such features is screen display resolution. A PC-based standard of VGA (640+ x 480+ pixels) was agreed upon as a standard for the concept stage. Yet, all easily available development software for the PC was only in EGA resolution (640 x 350 pixels). Therefore, the demonstrations contained in this report are in EGA resolution.^(a) It is recently reported that IBM and Compaq are now manufacturing VGA boards but not EGA boards, and higher resolutions are expected soon as new standards. The rate of change is quite rapid; for example, EGA resolution has effectively lasted only 2 years. On the other hand, the installed computer display base lags behind this trend. For example, many reviewers (and developers) of the Targets methodology still have systems that address only the lower resolution of CGA (640 x 200 pixels).

Selecting a low level of screen resolution will not permit the use of many desirable graphic features (many limitations have been encountered during this concept stage within the EGA mode of resolution,

(a) VGA resolution is now available for all of these packages, but became available too late to convert the considerable graphics already developed for this report.

e.g., very limited amount of text that can be placed on the screen, because of resolution limits). On the other hand, selecting higher resolutions of displays will exclude potential users who have not yet acquired the higher resolution hardware.

Other examples of such features are processor speed, available RAM, and on-line disk storage capacity and access speed.

Conclusions: Screen display features chosen will probably depend upon the nature of the primary expected users of the Targets model and the type of computer hardware they might be expected to have. It is likely that all of the users defined in Issue 1 would also tend to be "early adopters" of the more advanced desktop environment screen display features discussed in Issue 2. Likewise, given the complexity of the proposed Targets methodology, the user interface will function better using the more advanced technologies available for processor speed, RAM, and disk storage. Market penetration of the Targets model itself is likely to parallel the market penetration of continual advancement of computer screen display capabilities.

Recommendation: The development process of the user interface should continue to focus on the more advanced levels of hardware and software reasonably available on the market.

2.3.2 Possible Development Environments

Issue: *From a number of options available as hardware and software vehicles for further development of the Targets model user interface, which should be used?*

Technology and capabilities in both hardware and software areas are advancing rapidly. Relative to hardware, all development has been based within the PC-compatible desktop environment, for this is where virtually all of the available desk top analysis models now reside. For developing the user interface graphic examples, a number of PC-based graphics packages were used: Showpartner/FX™ for script preparation and much graphics editing; Pizzazz™ for printing; and Freelance Plus™, Dr. Halo™, Scan Gallery™, and Graphics Gallery™ for graphics preparation.

The Apple Macintosh™ represents an alternative hardware environment with desirable graphics capabilities and a reasonably large user base within the architecture community (more than the engineering community). All user interface graphic examples could have also been developed within a Macintosh environment using Hypertext™ software capabilities.

Graphical user interfaces is a software area in which rapid advances are being made. Use of proprietary environments will likely make development faster and cheaper. But this approach appears to conflict with the need that software supporting the Targets model be in the public domain.

Recommendation: Throughout the user interface development process, surveys should be done to monitor the rapidly changing software/hardware technologies available. This will enable the team to identify and obtain the best hardware and software development environments to enhance the capabilities of the user interface, to lower development costs and time, and to satisfy the public domain constraints.

2.3.3 User Interface Complexity and Development Resources

Issue 1: *Can a really easy-to-use interface be developed for such a complex methodology?*

To achieve this goal will take creativity, a high level of talent, experience and expertise, and sheer hard work. However, this goal is a necessity if the methodology is to have widespread adoption and use.

Issue 2: *How much priority should the user interface receive in terms of overall project resources?*

The proposed user interface approach developed during the concept stage has many exciting features. The authors think that such an interface, or something like it, would be a valuable asset to an effective Targets methodology. The experts present at the energy simulation workshop also placed considerable stress on the importance of the user interface to the success of the overall project.

Considerable project resources will likely be required to develop a satisfactory user interface. Experience with other software development projects indicates that as much as 50% of project resources are required for user interface development. The use of new interface software environments being developed may reduce the level of resources required. Some of the elements of the proposed interface could be especially expensive to develop. The two areas that are likely to be the most expensive are

- the considerable levels of detail involve in any sophisticated "custom target" capability within the Targets methodology (this has been defined as a major objective of the project)
- including a comprehensive geometry-handling capability as part of the user interface.

The difficulty is that, while these two elements are likely to be very expensive to develop, they are both also very important to the success of the Targets methodology as an effective aid to designers.

Conclusion: Efforts have been made during the concept stage to develop a conceptually robust user interface model. At the same time, in recognition of projected limited development resources, the user interface is structured so that it can be developed incrementally.

Recommendations: The following recommendations of the authors recognize that an incremental development may be necessary for some Targets methodology elements:

- that continued high priority be given to developing the user interface within the overall Targets methodology development, in recognition of its importance to achieving a successful product
- that the best possible software system design and programming talent be identified and engaged to work on the user interface, especially during the development stage, when detailed system features will be delineated
- that every attempt be made to develop the user interface as completely as possible
- if full levels of detail cannot be initially developed, that at least a few areas of the user interface be developed in great detail, to indicate the potential, and to ensure that the future complete detailed development is possible
- that text-based, menu-based, and icon-based user interface features be developed in parallel
- that some means be found to include substantial geometry-handling capabilities within the user interface - This recommendation and issues surrounding it are discussed more fully below.

2.3.4 Building Geometry

Issue 1: *How important is a comprehensive geometry-handling capability to the acceptance of the User Interface by intended audiences?*

It is considered a very important user interface objective that a designer be able to easily define a building's geometry reasonably closely within the Targets model. If an architect cannot reasonably represent a building's geometry, the Targets methodology will be strongly discounted in value no matter how good the other features. This aspect will become increasingly important as design-oriented software that permits "sketching" of a building becomes more prevalent (as opposed to CADD systems, which are currently more production than design tools).

Issue 2: *How important is a comprehensive geometry-handling capability to ease-of-use?*

Two elements of the Targets model--building physical characteristics and building costs--require data about building areas, volumes, and quantities. This can involve considerable input data. Requiring a user to directly supply this data to the Targets model violates a basic user interface objective--that the Targets model be very easy to use. The data will need to be either generated by the Targets model or "read in" by it from other software programs.

Conclusion: Several options appear available in response to the issues above, with each option carrying its own set of mixed blessings.

Option 1: *To not attempt to develop comprehensive geometry-handling capabilities for the user interface, but concentrate on text, menu, and icon modes.*

Some geometry-handling capabilities can be developed. The advantage to this approach is a relatively low cost. The disadvantage is a limiting of the scope of building configurations that can be handled. A quick look at the abundance of building shapes in an urban area indicates the confirming nature of such a constraint. This will also constrain the extent of customization that can be done by the Targets model relative to building configuration.

Option 2: *Develop comprehensive geometry-handling capabilities from scratch as part of the user interface.*

The advantage of this option is that the capabilities would be present and in the public domain. Two disadvantages exist for this option. First, properly addressing the complexity involved in both these issues by brute force programming from scratch could involve a formidable software development effort. To graphically match the sophistication of, say, DOE-2's Building Design Language (Simulation Research Group 1989) could easily take 5 to 10 person-years of programming time using such an approach. Second, the effort would require significant resources to duplicate software that already exists within the private sector.

Option 3: *Develop "hooks" into proprietary software packages that already address this geometric complexity.*

Such hooks could be developed both for sketching packages and for CADD packages.

This approach has two advantages: 1) a relatively low development cost, for the extensive geometric capabilities obtained; and 2) the Targets model might be "callable" from software packages already being used by intended audiences. However, this approach would greatly simplify the geometry-related data handling tasks for the energy simulation portion of the Targets model, and even more so for the building cost portion. Two disadvantages are 1) the geometry-handling software would not be in the public domain; and 2) the development of such hooks is not within the scope defined for Targets methodology development.

Regardless of which approach is taken, the issue of addressing geometry (including areas of materials for costing) is important for the user interface.

Recommendation: The possibility of developing hooks into proprietary software packages that already handle the complexities of building geometry should be explored as soon as possible. This exploration should include examination of cost-sharing possibilities and also examination of ways to limit the negative impacts of using proprietary software.

3.0 Software Engineering

Software engineering is an application of an engineering approach and a systematic engineering method to the development of software. An engineer designing a bridge does not have the construction workers start building the bridge until the design has been thoroughly refined and tested. An engineer must make sure that the design is very accurate and foolproof. The concept of taking an engineering approach to the design of software is to increase the probability that a system will achieve all of the requirements requested by the designers and users. A software engineer designs a system relying on computer science engineering techniques to produce a reliable, cost-effective, understandable, maintainable, modifiable, transportable, and well-documented piece of software that meets the users' needs.

The size and the complexity of the proposed Targets model indicated the need for a structured design procedure to achieve a complete and correct system the first time around. Many Targets system design issues needed resolution. Most issues could not be resolved until more analysis was done and the system began to evolve. The software engineering process is a design technique that allows the system to evolve while issues are being resolved without having to go back and start over.

This section briefly explains what software engineering is and how it works in the design of software. Software engineering accomplishments on the Targets project to date, as well as the remaining challenges, are also described. Section 3.1 describes the software engineering process in detail. The justification for why the software engineering design process was chosen for the Targets model is presented in Section 3.2. The work completed on the software engineering task is described in Section 3.3.

3.1 Software Engineering Process

The traditional software development life cycle consists of the four major phases shown in Figure 3.1: analysis, design, implementation, and testing. The traditional software development life cycle would usually plan for 20% of time for analysis, 15% for design, 20% for coding, and 45% for testing. The problem with the traditional software development process is that most of the time is spent on testing and maintaining the system because not enough time was spent on analysis and design. The problems that occur include unmet users' needs, difficult system maintainability, longer-than-planned development, and overrun cost estimates. Usually, at least 50% of the time ends up being spent on maintenance alone (Figure 3.2).

The software engineering methodology stresses spending more time on analysis and design, which, in return, will minimize the amount of time spent on implementing and maintaining the system (Figure 3.3). Software engineering methodology requires using structured analysis and design methods. Several different methods are available; the choice depends on the problem to be solved.

The Yourdan/DeMarco structured analysis method (Fairley 1985) was chosen for the Targets project. It consists of data flow diagrams, data dictionaries, and minispecs, which are described in Section 3.1.1. The structured design method chosen was the Yourdan-Constantine structure chart, which is exemplified by the illustration shown in Figure 2.1, Section 2.

Five steps in the software development life cycle will be used for the Targets project:

- Step 1 - logical analysis
 - logical data flow diagrams

Figure 3.1. Traditional Software Development Process

Figure 3.2. Percentage of Temporal Resources Expended in Life Cycle Phases

Figure 3.3. Structured Software Life Cycle

- Step 2 - physical analysis
 - user interface screens
 - file definitions
 - physical data flow diagrams
 - prototype
- Step 3 - detailed design
- Step 4 - implementation (coding)
- Step 5 - testing.

3.1.1 Logical Analysis

The logical analysis step involves creating data flow diagrams with data dictionaries and minispecs. Data flow diagrams indicate data flow between the functions of the system. Data dictionaries are descriptions of the data being used on the data flow diagrams. Minispecs are descriptions of each of the major functions within the system. They appear as either some form of structured English or a chart showing the flow of data throughout that particular function.

3.1.2 Physical Analysis

The second step of the software engineering process is the physical analysis. This step includes all the physical features of the system like the user interface screens, demos, prototypes, and data files for input and output. The first two steps usually involve substantial iteration to resolve most of the major issues.

3.1.3 Detailed Design

The detailed design step is where all the planning and decision making from the first two steps (laid out in structured charts, data flow diagrams, data dictionaries, and minispecs) are iteratively refined until

they reach a level detailed enough for the next step, implementation. At the implementation step, there is absolutely nothing left to break down and everything has been described to the fullest extent.

3.1.4 Implementation

The implementation step should be fairly straightforward if enough time and effort were spent on the previous three steps. During implementation, the refined detailed design is coded into a working program. If a problem is discovered with the design during coding, it may be necessary to return to the first step, logical analysis, and reanalyze, redesign, and re-implement a particular part of the system. This is called stepwise refinement and is not an uncommon occurrence. Problems are often discovered while trying to implement a design that looks good on paper but does not seem to work well on a machine.

3.1.5 Testing

The fifth step, testing, is usually done in parallel with the implementation step as well as after it. A test plan should be created before any testing is done. The test plan should include test cases, expected results, completion criteria, a tentative test schedule, and some standards for documenting the results of the tests. This will allow for some sort of quantitative or qualitative measurement of how accurate the system is or how satisfied the users are with the product.

3.1.6 Structured Walkthroughs

The stepwise refinement often required during the first three steps in the software engineering process can become tedious if management, programmers, and users are giving input throughout the entire process. Structured walkthroughs are helpful in minimizing the amount of iteration during the different steps. Walkthroughs can pinpoint what is not correct in the eyes of all project members or what features were misinterpreted or left out during the different steps. A structured walkthrough is a constructive way to critique a technical process; it will help the entire team better understand the detail within the project, along with making sure the system is implemented the way it was designed. Starting at the top and working one's way down through a system usually requires much refinement.

3.2 Software Engineering as a Basis for Targets Methodology Development

To develop a system that would meet all the requirements specified by the designers and users, and was easy to modify, maintain, and understand, the software engineering methodology was chosen for the Targets model. An organized process was needed to make the complex Targets methodology a working application. Software engineering seemed to be the most consistent process for generating a system that meets its stated requirements and all the needs of its users.

A key objective of this software development effort is to design a system that is cleaner and more maintainable by system developers. A software engineering approach can provide easier maintainability because a systematic approach is used. The approach uses a simple tree-like format that begins with a basic concept and gradually branches out to finer and finer levels of detail. At each level of detail, relevant issues are resolved and documentation is provided. Good documentation allows other programmers and users to quickly trace through the system to locate specific areas for modification, which, in return, provides better maintainability.

3.3 Results

Work has progressed simultaneously on the logical and physical steps in the software engineering process. The team created a structure diagram, a way to document the basic flow of a system. The diagram shows the main idea and components of the Targets model. From the structure diagram, the team created a simple data flow diagram to show the basic flow of the data throughout the system (Figure 3.4). The team started the iteration process on the analysis phase by breaking down the main data flow diagram to show the Targets model in greater detail (Figure 3.5). Again repeating the process, another level of detail was created by showing data flow for two of the modules within the Targets model (Figures 3.6 and 3.7).

The team also dealt with many user interface issues and Targets taxonomy issues (discussed in Section 4). It created a prototype of a Targets model user interface (Appendix A). The detailed design step will be approached next, in the development stage of the project.

Figure 3.4. Logical Context Diagram for the Targets Model

Figure 3.5. Logical Data Flow Diagram for the Targets Model

Figure 3.6. Logical Data Flow Diagram for the Analysis Control Module

Figure 3.7. Logical Data Flow Diagram for the Energy, Building Cost, and Economic Analysis Modules

4.0 Data and System Integration

The data and system integration task addressed the interactions among all of the modules comprising the Targets model. Consequently, the task encompassed integration issues throughout the entire model, as indicated by the shaded portions of Figure 4.1.

4.1 Objectives and Approach

Careful planning is necessary to develop a system that is fast, flexible, easy to use, and easily modified. The work described in Section 3 addressed the process of developing the system, but did not specifically address the details of accomplishing the task.

The data and system integration task had two objectives:

- to develop a strategy for the effective integration of the various modules being developed
- to generate a work plan for integrating the various modules of the Targets model for the next stages of the project.

4.1.1 Large System Design

The Targets project involves the design of a large system for a personal workstation computing environment. A decision was made during the concept stage to embed the DOE-2.1D energy simulation program (Simulation Research Group 1989) within the model. See Volumes 2 and 3 for complete discussions of the decision process and rationale. The decision included making provisions for eventual use of other simulation programs of similar complexity as well.

Characteristics that will make the Targets model a large system include the following:

- It will use several sophisticated analysis modules.
- It will require the availability of many default values for both data and user options, probably contained in many files.
- It will generate (and need to keep track of) large quantities of information, also probably contained in many files.
- The Targets model may interface with one or more proprietary software packages. Possible types of proprietary packages include energy analyses, building cost estimating, and CADD.

4.1.2 User Interface Operation Sequence

The development of user interface concepts, described in Section 2, has been a major tool for exploring integration issues. Especially important has been the development of proposed sequences of user interactions with the Targets model. Such sequences are best seen by reviewing the scripts of computer display screens in Appendixes A, B, and C. The sequences are by no means complete, but they do provide a convincing framework for understanding major steps involved in using the Targets model from a user's point of view.

Figure 4.1. Data and System Integration Within the Targets Model

4.2 Tasks Accomplished and Results

The data and system integration task focused on three activities in the concept stage. Their completion resulted in the development of three major elements of a Targets taxonomy.

The three taxonomy elements developed are

- user interface taxonomy
- building characteristics set taxonomy
- building cost taxonomy.

The logical structures for these three major portions of the overall Targets taxonomy were developed in some detail.

The taxonomies emphasize the logical categorizing and structuring of data within the specific subject areas addressed. Each of the three taxonomies was developed independently by different working groups as part of separate tasks during the concept stage. However, considerable coordination occurred among these groups to ensure that the taxonomies would be consistent with each other. As a result of this successful collaboration, there is substantial overlap among the three taxonomies developed. Therefore, the three taxonomies are presented here together to show how they interrelate. The user interface taxonomy is also imbedded in the screen displays within the text of Section 2 and in the appendixes to this volume. The building characteristics set taxonomy is described in appendixes to Volume 2.

Each of these taxonomies has been developed in some detail, but none is considered complete. The intent during the concept stage was to develop concepts in detail, not to develop final system descriptions. Further work is needed on each taxonomy element to develop complete descriptions of building features. For example, the user interface taxonomy will need to be expanded to include the logical structure for all Targets input and output options; only conceptual examples of a proposed structure have been developed to date. Likewise, the building characteristics set and building cost taxonomies eventually need to be expanded so that they describe the logical structures for all building elements that will constitute inputs to the Targets model about building physical and cost descriptors.

In this context, the work done to date on integration of the various pieces of the methodology has concentrated on developing logical structures for data. While considerable detail has been addressed, the analysis has not yet addressed the precise details of input and output formats for each analysis module of the Targets model. For example, details of DOE-2 input and output structure and format have been addressed to date only at a conceptual level.

Many integration concepts and issues, especially of sequences of operations, were addressed through the development of a conceptual structure for the user interface, discussed in Section 2 of this report. Concepts relating to the logical structure of data in three related areas were addressed via development of a combined taxonomy structure, presented below. The current targets taxonomy is a combination that includes taxonomies for the user interface, the building characteristics set, and the building costs modules. This combined taxonomy addresses major elements of data flowing among several key analysis modules of the overall Targets model. However, the taxonomies do not address how the logical structure of the data might be physically imbedded into computer software. The relationship of the logical structure of the data to the physical structure imbedded in software will be fully defined in the development stage of the project.

During the concept stage, the generation of a set of data flow diagrams was explored by the project team, using a top-down approach. Such data flow diagrams are one of a number of valuable tools used in software development. They show the logic of the flow of data from one program element to another.

Because of the top-down approach used, the data flow diagram development has not progressed far to date. For example, the diagrams produced have addressed only the upper-most levels of detail contained in the separate taxonomies, which have emerged from the bottom up. The use of data flow diagrams in the context of a systematic approach to software development will be presented in future products of the Targets project.

The taxonomies developed to date are in the form of hierarchical tree structures. This type of structure has several advantages:

- During development, it is easy to change the structure of a branch on the tree without affecting the rest of the tree.
- The structure can be developed incrementally.
- A user can move from branch to branch easily if desired; often, multiple paths are provided.
- A number of software packages are available that use this structure for organizing information. Thus, these packages might be used to reduce development time and cost for prototypes.
- The tree structure is amenable to the way building data tends to be organized and used.
- Detailed structures from one branch of the tree can be reused on other branches, and at different levels (e.g., the same complete hierarchy of data for lighting, HVAC, or envelope systems can be used at any one of several levels of generality: for a whole building; for a floor of the building; or for a space function within a floor.)
- For output, the hierarchical approach allows access to increasingly detailed output information, down to the limits of detail in which output data has been stored.

4.2.1 User Interface Taxonomy

Figure 4.2 shows the higher levels of the user interface taxonomy. Each indentation in the taxonomy indicates one level down into the hierarchical tree structure. Thus, Figure 4.2 shows the hierarchy to a depth of six levels, where EXECUTIVE is at the first level and THERMAL FUNCTIONS and LIGHTING FUNCTIONS are at the sixth level. This is not the total number of layers developed for the user interface hierarchy. However, because lower levels include the building characteristics set taxonomy, these will be shown in the next section.

The structure of the data in the hierarchy is identical for all Targets applications and modes of use. For this reason, the applications and modes of use are listed together in Figure 4.2, and all lower levels in the hierarchy refer equally to all of them. The level of detail to be accessed within the hierarchy structure is expected to vary with mode of use (and building complexity as well). However, there are no major differences in structure associated with the various modes of use. Identical structures for data for all modes of use is an important result of the concept stage that was not obvious at the beginning.

The user interface taxonomy shows one way to structure these data; others are possible. Feedback from intended users is expected to generate many different possible ways to address these elements.

```
EXECUTIVE (MAIN MENU)
FILE
APPLICATION
  VOLUNTARY TARGETS
  STANDARDS AND CODES
MODE (Targets Mode)
  TARGET SETTING
  DESIGN ANALYSIS
  COMPREHENSIVE EVALUATION
  RESEARCH AND DEVELOPMENT
    SUMMARY
    PROJECT
    LOCATION
    OWNER
    BUILDING DESCRIPTION
      SUMMARY
      FUNCTIONAL PROGRAM
      SPACE FUNCTIONS
      THERMAL FUNCTIONS
      LIGHTING FUNCTIONS
    STORIES
    FLOOR
    CONFIGURATION
    ORIENTATION
    ZONING
    BUILDING TYPES
    SYSTEMS
    BUILDING COST
    DESIGN STRATEGIES
    HELP
    EXIT
  BUILDING COST DATA
  ANALYSIS
  CALC
  RESULTS
  HELP
  EXIT
  HELP
  EXIT
CONFIGURATION
  SUMMARY
  HARDWARE
  SOFTWARE
  HELP
  EXIT
DISPLAY
  TEXT
  MENU
  GRAPHIC
  HELP
  EXIT
  CALC
  SEARCH (Tree Structure)
  HELP
  EXIT
QUIT
```

Figure 4.2. User Interface Taxonomy Overview

One of the advantages of hierarchical tree structures is that they allow a user to quickly grasp the overall structure of the Targets model and where the user is within that structure. This is important because of the underlying complexity of the subject domain and, hence, of the module that describes it.

The combination of the tree structure and the object-orientation of the logical structure of the user interface have distinct advantages for developing, modifying, and enhancing the user interface. Portions can be developed independently, without the entire structure being worked out in detail first. Changes can be made to one portion with reasonable assurance that the changes will not cause ripple effects throughout the entire logical structure. In fact, during the iterative development that has occurred during the Concept Stage, many such modifications have been made to the user interface taxonomy structure. The taxonomy structure has been used to provide the structure for the user interface menus for the computer screen displays shown in this report.

4.2.2 Building Characteristics Set Taxonomy

A detailed taxonomy for building characteristics sets was developed. In terms of data integration, this entire taxonomy can be related to the user interface taxonomy shown in Figure 4.2. In fact, the user interface has incorporated major portions of the building characteristics set taxonomy.

Figure 4.3 shows the summary two levels of the building characteristics set taxonomy, and how the summary levels would be accessed from a number of points within the user interface taxonomy. In Figure 4.3, a number of line items in the user interface taxonomy on the left can access the complete building characteristics set taxonomy on the right. Each line item with a line to its right can access the building characteristics set taxonomy. This capability provides considerable user flexibility in moving through the system. Also, this capability makes the two taxonomies in effect a single, combined taxonomy.

Figures 4.4, 4.5, and 4.6 show how the summary levels of the building characteristics set taxonomy contain further detailed levels. The building characteristics set taxonomy contains detailed data structures that describe features of entire buildings, as well as features of parts of buildings: whole building; an entire floor; and orientation on one or more floors; a space function. The taxonomy has been developed so that the structure of the data is identical irrespective of the level addressed. This has strong advantages. The entire taxonomy can be treated as an object that always has the same structure. Its contents can vary according to the subject at hand.

Take a subset of a building system, fenestration, for example. One can define the characteristics of a fenestration system for all 18 floors of the Optima Building (see Appendixes B and C). The fenestration for a single floor can then be specified as different from the building norm (say the ground floor, with lobby). However, fenestration for the space functions on the ground floor providing delivery services can have no windows and be defined as an exception to the entire floor specification.

4.2.3 Building Cost Taxonomy

A third taxonomy was developed for building costs. This building cost taxonomy is discussed in detail in Volume 2. Figure 4.7 shows how different elements of the building cost taxonomy can be called from the overall user interface taxonomy in much the same way as the building characteristics set taxonomy can be called.

The building cost taxonomy has not been developed to the same level of detail as the building characteristics set taxonomy. The taxonomy structure details are discussed in Volume 2.

User Interface Taxonomy

EXECUTIVE (MAIN MENU)

FILE

APPLICATION

VOLUNTARY TARGETS

STANDARDS AND CODES

MODE (targets mode)

TARGET SETTING

DESIGN ANALYSIS/EVALUATION

SUMMARY

PROJECT

LOCATION

OWNER

BUILDING DESCRIPTION

SUMMARY

FUNCTIONAL PROGRAM

SPACE FUNCTIONS

THERMAL FUNCTIONS

LIGHTING FUNCTIONS

STORIES

FLOOR

CONFIGURATION

ORIENTATION

ZONING

BUILDING TYPES

SYSTEMS

BUILDING COST

DESIGN STRATEGIES

HELP

EXIT

BUILDING COST DATA

ANALYSIS

CALC

RESULTS

HELP

EXIT

HELP

EXIT

CONFIGURATION

SUMMARY

HARDWARE

SOFTWARE

HELP

EXIT

DISPLAY

TEXT

MENU

GRAPHIC

HELP

EXIT

CALC

SEARCH (of Tree Structure)

HELP

EXIT

QUIT

Summary Level: Building Characteristics Set Taxonomy

BASIC CHARACTERISTICS

Size

Configuration

Orientation

Site adjacencies

FUNCTIONAL PARAMETERS

Occupancy

Internal gains

Schedules: select/modify

COMFORT CRITERIA

Temperature

Humidity

Air movement

Fresh air

Visual

Acoustic (HVAC, ballast, etc...)

BUILDING SYSTEMS

Envelope

Lighting

HVAC

Service water heating

Power

Vertical transportation

->

Figure 4.3. Multiple Links Between Building Characteristics Set and User Interface Taxonomies

Summary Level	Detailed Levels
Basic Characteristics	Basic Characteristics
Size	Size
Configuration	Configuration <ul style="list-style-type: none"> Building shape Number of floors Height changes of 1 story or more Internal adjacencies <ul style="list-style-type: none"> Percent of perimeter adjacent to other spaces with which a high temperature difference exists Percent of perimeter that is at exterior wall Partitioning (open/closed offices, partition height,...)
Orientation	Orientation
Site adjacencies	Site adjacencies
Functional Parameters	Functional Parameters
Occupancy	Occupancy <ul style="list-style-type: none"> Occupant density Load (per person) <ul style="list-style-type: none"> sensible latent Special requirements <ul style="list-style-type: none"> age distribution (lighting, thermal,...) handicap requirements
Internal gains	Internal gains <ul style="list-style-type: none"> Receptacles Priority (process and other) <ul style="list-style-type: none"> sensible latent Miscellaneous <ul style="list-style-type: none"> sensible latent Vertical transportation
Schedules: select/modify	Schedules: select/modify <ul style="list-style-type: none"> Occupancy HVAC Lighting Equipment DHW Vertical transportation Miscellaneous

Figure 4.4. Building Characteristics Set Taxonomy Details: Basic Characteristics and Functional Parameters

Summary Level	Detailed Levels
Temperature	Temperature Cooling Sensible Mean radiant temperature (MRT) Heating Sensible Mean radiant temperature (MRT)
Humidity	Humidity Cooling Heating Special Requirements
Air movement	Air movement Cooling Heating Special requirements
Fresh air	Fresh air Cooling Heating Special requirements (labs, kitchens...)
Visual	Visual Desired footcandles Quality factors Special requirements
Acoustic (HVAC, ballast)	Acoustic (HVAC, ballast, etc...)

Figure 4.5. Building Characteristics Set Taxonomy Details: Comfort Criteria

Summary Level	Detailed Levels
Envelope	<ul style="list-style-type: none"> Envelope <ul style="list-style-type: none"> Exterior Elements <ul style="list-style-type: none"> Roof/Ceiling <ul style="list-style-type: none"> Basic information Area Slope & slope orientation Selection criteria Input library Input form Walls (opaque) <ul style="list-style-type: none"> Basic information Area Orientation Tilt Selection criteria Input library Input form Floor <ul style="list-style-type: none"> Basic information Area Selection criteria Input library Input form Doors (exterior) <ul style="list-style-type: none"> Basic information Area Orientation Selection criteria Input library Input form Fenestration <ul style="list-style-type: none"> Basic information Area Selection criteria Input library Input form Infiltration <ul style="list-style-type: none"> Occupied air change rate Unoccupied air change rate Interior sub-divisions <ul style="list-style-type: none"> Floor/Ceiling <ul style="list-style-type: none"> Basic information

Figure 4.6. Building Characteristics Set Taxonomy Details: Building Systems

Summary Level	Detailed Levels
Envelope	Area Selection criteria Input library Input form Partitions Basic information Selection criteria Input library Input form
Lighting	Lighting Selection rules Criteria Typical systems library Input forms Daylighting Daylighting parameters Daylighting controls
HVAC	HVAC Selection rules Criteria Typical systems library Input forms Systems Plants
Service water heating	Service water heating Selection rules Criteria Typical systems library Input forms
Power	Power Selection rules Criteria Typical systems library Input forms
Vertical transportation	Vertical transportation Selection rules Criteria Typical systems library Input forms

Figure 4.6. (contd)

User Interface Taxonomy

EXECUTIVE (MAIN MENU)

FILE

APPLICATION

VOLUNTARY TARGETS

STANDARDS AND CODES

MODE (targets mode)

TARGET SETTING

DESIGN ANALYSIS/EVALUATION

SUMMARY

PROJECT

LOCATION

OWNER

BUILDING DESCRIPTION

SUMMARY

FUNCTIONAL PROGRAM

SPACE FUNCTIONS

THERMAL FUNCTIONS

LIGHTING FUNCTIONS

STORIES

FLOOR

CONFIGURATION

ORIENTATION

ZONING

BUILDING TYPES

SYSTEMS

BUILDING COST

DESIGN STRATEGIES

HELP

EXIT

BUILDING COST DATA

ANALYSIS

CALC

RESULTS

HELP

EXIT

HELP

EXIT

CONFIGURATION

SUMMARY

HARDWARE

SOFTWARE

HELP

EXIT

DISPLAY

TEXT

MENU

GRAPHIC

HELP

EXIT

CALC

SEARCH (of Tree Structure)

HELP

EXIT

QUIT

Summary Level: Building Cost Taxonomy

DATABASES

REGIONAL/ADJUSTMENTS

SUMMARY

WAGE RATES (UNION/NON-UNION)

(ELECT, PLUMB, SHEET

METAL, CARP. ETC.)

INDICES (MEANS, TCCO, ENR, ETC.)

MARK-UP (GENERAL CONTR., SUB-

CONTR., OWNER)

SIZE-FACTOR (DESIGN CONTINGENCY,

RENOVATION,

SMALL JOB)

DESIGN STAGE (SCHEMATIC, DEVELOP-

MENT, FINAL)

INTEREST

BUILDING

DESIGN STRATEGIES

SPACE DETAIL LEVEL

BUILDING

SPACE

FLOOR

THERMAL LIGHTING

UPDATE

Figure 4.7. Multiple Links Between Building Cost and User Interface Taxonomies

4.3 Issues, Conclusions, and Recommendations

The authors of this task report raised two primary issues; each is discussed below.

Issue 1: *What is the best modular structure to ensure both ease of incremental development and ease of modification?*

The final data structure for the Targets model will be both very detailed and complex. Thus, it will need to be designed to be developed in increments of increasing detail. It will also need to be structured for ease of modification. Further studies will need to be done to assess the best logical and software data structures for accomplishing these tasks.

Issue 2: *Which portions of the taxonomy should be developed in detail first, and in how much detail?*

A strategy must be developed to address this issue.

5.0 References

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- Crawley, D. B., R. S. Briggs, J. W. Jones, W. W. Seaton, J. E. Kaufman, J. J. Deringer, and E. W. Kennett. 1987b. *Development of Whole-Building Energy Design Targets for Commercial Buildings - Phase I Planning, Volume 2: Technical Report*. PNL-5854 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.
- Fairley, R. E. 1985. *Software Engineering Concepts*. McGraw-Hill, New York.
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6.0 Acknowledgments

The task reports presented in this document represent the results of a team effort. The primary participants and their roles are identified below.

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Appendix A

Target Setting Sequence for a Small Office Building

Appendix A

Target Setting Sequence for a Small Office Building

The computer screen display sequence presented here demonstrates how the Targets model can be used to set a target for a building design with very little input from the designer. The extensive use of default options, systems, and data values is illustrated. The sequence also exemplifies how most of the proposed user interface features might be used in target setting.

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING OPTIONS: SUMMARY PROJECT LOCATION OWNER BUILDING ANALYSES CALCULATIONS RESULTS HELP EXIT	<div> <div> DIRECTORV: A:\ FILENAME: </div> <div> PROJECT NAME: BUILDING NAME: LOCATION: </div> <div> CHOICES: <div></div> </div> </div>
FILES:	

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING PROJECT	<div> <div> DIRECTORV: C:\TOOL\TAR FILENAME: DEMO-OFC.TAR </div> <div> PROJECT NAME: DEMO BUILDING NAME: SMALL OFFICE LOCATION: WASH., D.C. </div> <div> CHOICES: OFFICE . BARANCO . RMEC-HQ . 33 MONROE . DEMO-OFC . GSA-BLDG . USPSKOP2 . ATRIUM-1 . </div> </div>
OPTIONS: SUMMARY NEW EXISTING DELETE RENAME HELP EXIT	
FILES:	

TARGETS MODEL		
TREE		
EXECUTIVE
TARGET MODE		
TARGET SETTING		
OPTIONS:		
SUMMARY
PROJECT		
LOCATION		
OWNER		
BUILDING		
ANALYSIS		
CALCULATIONS		
RESULTS		
HELP		
EXIT		
FILES:		

TARGETS MODEL		
TREE		
EXECUTIVE
TARGET MODE		
TARGET SETTING		
LOCATION		
OPTIONS:		
WEATHER
BUILDING COST		
FUEL COST		
UTILITY RATE		
HELP		
EXIT		
FILES:		

TARGETS MODEL	
<div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div>LOCATION</div> <div>WEATHER</div>	
<div>OPTIONS:</div> <div>DOE-2.1D</div> <div>WYEC</div> <div>TRY</div> <div>THY</div> <div>BLAST</div> <div>WYEC</div> <div>TRY</div> <div>THY</div> <div>ASEAM-2.1</div> <div>DOD</div> <div>AWD</div> <div>BWD-WYEC</div>	
<div>FILES:</div>

SELECTION:

TARGETS MODEL	
<div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div>LOCATION</div> <div>WEATHER</div>	
<div>OPTIONS:</div> <div>DOE-2.1D</div> <div>WYEC</div> <div>TRY</div> <div>THY</div> <div>BLAST</div> <div>WYEC</div> <div>TRY</div> <div>THY</div> <div>ASEAM-2.1</div> <div>DOD</div> <div>AWD</div> <div>BWD-WYEC</div>	
<div>FILES:</div>

SELECTION: **WASHINGTON, D.C.**

TARGETS MODEL	
<div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div></div>	
<div>OPTIONS</div> <div>SUMMARY</div> <div>PROJECT</div> <div>LOCATION</div> <div>OWNER</div> <div>BUILDING</div> <div>ANALYSES</div> <div>CALCULATIONS</div> <div>RESULTS</div> <div>HELP</div> <div>EXIT</div>	
FILES:	

TARGETS MODEL																
<div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div>BUILDING</div>	<table border="1"> <thead> <tr> <th><u>BUILDING CATEGORY</u></th> <th><u>BUILDING TYPE</u></th> <th><u>BUILDING SUBTYPE</u></th> </tr> </thead> <tbody> <tr> <td>COMMERCIAL</td> <td></td> <td></td> </tr> <tr> <td>OFFICES</td> <td>HIGH RISE MID RISE LOW RISE</td> <td>HIGH QUALITY NORMAL QUALITY COMPETITIVE LEVEL GOVERNMENT OFFICES MEDICAL OFFICES DENTAL OFFICES LAW OFFICES</td> </tr> <tr> <td>HOTELS MOTELS</td> <td>HIGH RISE MID RISE LOW RISE</td> <td>MULTIFUNCTION CONFERENCE STRIP</td> </tr> <tr> <td>RETAIL</td> <td>REGIONAL SHOPPING CENTERS RETAIL SHOPS</td> <td>RETAIL SHOPS WOMEN'S WEAR MEN'S WEAR BOOKSHOPS GIFT SHOPS JEWELRY SHOPS BARBER SHOPS</td> </tr> </tbody> </table>	<u>BUILDING CATEGORY</u>	<u>BUILDING TYPE</u>	<u>BUILDING SUBTYPE</u>	COMMERCIAL			OFFICES	HIGH RISE MID RISE LOW RISE	HIGH QUALITY NORMAL QUALITY COMPETITIVE LEVEL GOVERNMENT OFFICES MEDICAL OFFICES DENTAL OFFICES LAW OFFICES	HOTELS MOTELS	HIGH RISE MID RISE LOW RISE	MULTIFUNCTION CONFERENCE STRIP	RETAIL	REGIONAL SHOPPING CENTERS RETAIL SHOPS	RETAIL SHOPS WOMEN'S WEAR MEN'S WEAR BOOKSHOPS GIFT SHOPS JEWELRY SHOPS BARBER SHOPS
<u>BUILDING CATEGORY</u>	<u>BUILDING TYPE</u>	<u>BUILDING SUBTYPE</u>														
COMMERCIAL																
OFFICES	HIGH RISE MID RISE LOW RISE	HIGH QUALITY NORMAL QUALITY COMPETITIVE LEVEL GOVERNMENT OFFICES MEDICAL OFFICES DENTAL OFFICES LAW OFFICES														
HOTELS MOTELS	HIGH RISE MID RISE LOW RISE	MULTIFUNCTION CONFERENCE STRIP														
RETAIL	REGIONAL SHOPPING CENTERS RETAIL SHOPS	RETAIL SHOPS WOMEN'S WEAR MEN'S WEAR BOOKSHOPS GIFT SHOPS JEWELRY SHOPS BARBER SHOPS														
<div>OPTIONS</div> <div>SUMMARY</div> <div>TYPE</div> <div>STORIES</div> <div>FLOOR</div> <div>CONFIGURATION</div> <div>ORIENTATION</div> <div>FUNCTIONS</div> <div>SYSTEMS</div>																
FILES:																

TARGETS MODEL

TREE

EXECUTIVE

TARGET MODE

TARGET SETTING

BUILDING

TARGET BUILDING

OPTIONS:

SUMMARY

TARGET/DESIGN

PROGRAM

TYPE

STORIES

FLOOR

CONFIGURATION

ORIENTATION

ZONING

FUNCTIONS

SYSTEMS

DESIGN STRAT

HELP

EXIT

FILES:

Diagram showing a floor plan with dimensions D1 through D8. D1 is highlighted with a value of 50 ft 6 in.

TARGETS MODEL

TREE

EXECUTIVE

TARGET MODE

TARGET SETTING

BUILDING

TARGET BUILDING

OPTIONS:

SUMMARY

TARGET/DESIGN

PROGRAM

TYPE

STORIES

FLOOR

CONFIGURATION

ORIENTATION

ZONING

FUNCTIONS

SYSTEMS

DESIGN STRAT

HELP

EXIT

FILES:

Diagram showing a floor plan with a north arrow and a text box indicating 2 floors.

TARGETS MODEL	
<div style="border: 1px solid black; padding: 2px;">TREE</div> <div style="border: 1px solid black; padding: 2px;">EXECUTIVE</div> <div style="border: 1px solid black; padding: 2px;">TARGET MODE</div> <div style="border: 1px solid black; padding: 2px;">TARGET SETTING</div> <div style="border: 1px solid black; padding: 2px;">BUILDING</div> <div style="border: 1px solid black; padding: 2px;">TARGET BUILDING</div>	<div style="border: 1px solid black; padding: 10px; text-align: center;"> <p>DEFAULT ARRANGEMENT OF THERMAL ZONES :</p> <p>ARRANGEMENT A ARRANGEMENT B ARRANGEMENT C</p> <p>FOR FLOORS 1 THROUGH 2</p> </div>
<div style="border: 1px solid black; padding: 2px;">OPTIONS: ↓ ↑</div> <div style="border: 1px solid black; padding: 2px;">SUMMARY</div> <div style="border: 1px solid black; padding: 2px;">TARGET/DESIGN</div> <div style="border: 1px solid black; padding: 2px;">PROGRAM</div> <div style="border: 1px solid black; padding: 2px;">TYPE</div> <div style="border: 1px solid black; padding: 2px;">STORIES</div> <div style="border: 1px solid black; padding: 2px;">FLOOR</div> <div style="border: 1px solid black; padding: 2px;">CONFIGURATION</div> <div style="border: 1px solid black; padding: 2px;">ORIENTATION</div> <div style="border: 1px solid black; padding: 2px;">ZONING</div> <div style="border: 1px solid black; padding: 2px;">FUNCTIONS</div> <div style="border: 1px solid black; padding: 2px;">SYSTEMS</div> <div style="border: 1px solid black; padding: 2px;">DESIGN STRAT</div> <div style="border: 1px solid black; padding: 2px;">HELP</div> <div style="border: 1px solid black; padding: 2px;">EXIT</div>	
FILES:	

TARGETS MODEL											
<div style="border: 1px solid black; padding: 2px;">TREE</div> <div style="border: 1px solid black; padding: 2px;">EXECUTIVE</div> <div style="border: 1px solid black; padding: 2px;">TARGET MODE</div> <div style="border: 1px solid black; padding: 2px;">TARGET SETTING</div> <div style="border: 1px solid black; padding: 2px;">BUILDING</div> <div style="border: 1px solid black; padding: 2px;">TARGET BUILDING</div> <div style="border: 1px solid black; padding: 2px;">FUNCTIONS</div>	<div style="border: 1px solid black; padding: 10px; text-align: center;"> <p>ASSIGNMENT OF FUNCTIONS TO THERMAL ZONES</p> <p>FOR FLOORS 1 THROUGH 2</p> </div>										
<div style="border: 1px solid black; padding: 2px;">OPTIONS: ↓ ↑</div> <div style="border: 1px solid black; padding: 2px;">OFFICE GENERAL</div> <div style="border: 1px solid black; padding: 2px;">OPEN OFFICE</div> <div style="border: 1px solid black; padding: 2px;">NO PART</div> <div style="border: 1px solid black; padding: 2px;">OPEN OFFICE</div> <div style="border: 1px solid black; padding: 2px;">LOW PART</div> <div style="border: 1px solid black; padding: 2px;">ENCLOSED OFC</div> <div style="border: 1px solid black; padding: 2px;">CONFERENCE</div> <div style="border: 1px solid black; padding: 2px;">DRAFTING</div> <div style="border: 1px solid black; padding: 2px;">ACCOUNTING</div> <div style="border: 1px solid black; padding: 2px;">HELP</div> <div style="border: 1px solid black; padding: 2px;">EXIT</div>	<table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center; padding: 2px;">ZONE</th> <th style="text-align: center; padding: 2px;">TYPE</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 2px;">1</td> <td style="text-align: center; padding: 2px;">OPEN/LOW PART</td> </tr> <tr> <td style="text-align: center; padding: 2px;">2</td> <td></td> </tr> <tr> <td style="text-align: center; padding: 2px;">3</td> <td></td> </tr> <tr> <td style="text-align: center; padding: 2px;">4</td> <td></td> </tr> </tbody> </table>	ZONE	TYPE	1	OPEN/LOW PART	2		3		4	
ZONE	TYPE										
1	OPEN/LOW PART										
2											
3											
4											
FILES:											

TARGETS MODEL		ANALYSES SUMMARY	
TREE EXECUTIVE TARGET MODE TARGET SETTING ANALYSES		ENERGY MODEL: DOE 2.1 D TIME PERIOD: FULL 8760 HOURS COMPACTED - MEDIUM COMPACTED - SHORT	
OPTIONS SUMMARY ENERGY ENERGY COST BUILDING COST ECONOMICS HELP		ENERGY COST MODEL: DOE 2.1 D DATABASE: STANDARD DEMAND - DC	
		BUILDING COST MODEL: SUMMARY DETAILED	
		DATA BASES: MEANS DODGE SUPPLEMENTARY	
		ECONOMICS OBJECTIVE : EROOC MODEL : ANSI STANDAFID	
FILES:			

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING	
OPTIONS SUMMARY PROJECT LOCATION OWNER BUILDING ANALYSIS CALCULATIONS RESULTS HELP EXIT	
FILES:

TARGETS MODEL

TREE

OPTIONS:

FILES:

CAUTION

This is a draft demonstration of User Interface CONCEPTS. These are screen displays only, to show how a future system might work. At present, there are not any working programs behind these screens. Also, future versions of the screens themselves may change substantially.

TARGETS MODEL																	
TREE																	
	<p style="text-align: center;">USER INTERFACE CREDITS</p> <p>This demonstration disk was developed by the following participants:</p> <p>ASHRAE/AIA/IES TEAM PARTICIPANTS:</p> <table> <tr> <td>J.J. Deringer</td> <td>Technical Manager</td> </tr> <tr> <td>J.W. Jones</td> <td>Technical Support</td> </tr> <tr> <td>H. McKay</td> <td>Technical Support</td> </tr> <tr> <td>J.D. Hall</td> <td>Technical Support</td> </tr> <tr> <td>P. Dillingham</td> <td>Demonstration Graphics</td> </tr> <tr> <td>S.T. Hunt</td> <td>Demonstration Graphics</td> </tr> </table> <p>PNL STAFF PARTICIPANTS:</p> <table> <tr> <td>J. Evans</td> <td>Graphics Support</td> </tr> <tr> <td>R. Briggs</td> <td>Graphics Support</td> </tr> </table>	J.J. Deringer	Technical Manager	J.W. Jones	Technical Support	H. McKay	Technical Support	J.D. Hall	Technical Support	P. Dillingham	Demonstration Graphics	S.T. Hunt	Demonstration Graphics	J. Evans	Graphics Support	R. Briggs	Graphics Support
J.J. Deringer	Technical Manager																
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J. Evans	Graphics Support																
R. Briggs	Graphics Support																
OPTIONS:																	
FILES:																	

Appendix B

Target Setting Sequence for the Optima Building

Appendix B

Target Setting Sequence for the Optima Building

The computer screen display sequence presented in this appendix demonstrates some of the Targets model features that can be used to customize input data. It also illustrates how those features can be used to address some of the subtleties encountered when setting targets for a large, complex, multifunction structure such as our hypothetical Optima Building.

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING 	
OPTIONS: SUMMARY PROJECT LOCATION OWNER BUILDING ANALYSES CALCULATIONS RESULTS HELP EXIT FILES:	

DIRECTORY:	<input type="text" value="A:\"/>	CHOICES: <div style="border: 1px solid black; height: 100px; width: 100%;"></div>
FILENAME:	<input type="text"/>	
PROJECT NAME: <input type="text"/> BUILDING NAME: <input type="text"/> LOCATION: <input type="text"/>		

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING PROJECT	
OPTIONS: SUMMARY NEW EXISTING DELETE RENAME HELP EXIT FILES:	

DIRECTORY:	<input type="text" value="C:\TOOL\TAR"/>	CHOICES: <div style="border: 1px solid black; padding: 5px;"> OFFICE BARANCO . RMEC-HQ . 33 MONROE . BATESON . GSA-BLDG . USPSKOP2 . ATRIUM-1 . </div>
FILENAME:	<input type="text" value="OFFICE.WDC"/>	
PROJECT NAME: <input type="text" value="OPTIMA CENTER"/> BUILDING NAME: <input type="text" value="OFFICE TOWER"/> LOCATION: <input type="text" value="WASH., D.C."/>		

TARGETS MODEL	
TREE	
EXECUTIVE TARGET MODE TARGET SETTING	
<div> </div>	
OPTIONS:	
SUMMARY	
PROJECT	
LOCATION	
OWNER
BUILDING	
ANALYSIS	
CALCULATIONS	
RESULTS	
HELP	
EXIT	
FILES:	

TARGETS MODEL	
TREE	
EXECUTIVE TARGET MODE TARGET SETTING LOCATION	
<div> </div>	
OPTIONS:	
WEATHER	
BUILDING C
FUEL COST	
UTILITY RATE	
HELP	
EXIT	
FILES:	

TARGETS MODEL	
<div> <div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div>LOCATION</div> <div>WEATHER</div> </div>	
<div> <div>OPTIONS:</div> <div>DOE-2.ID</div> <div>WYEC</div> <div>TRY</div> <div>TMY</div> <div>BLAST</div> <div>WYEC</div> <div>TRY</div> <div>TMY</div> <div>ASEAM-2.1</div> <div>DOD</div> <div>AWD</div> <div>BWD-WYEC</div> </div>	
<div> <div>FILES:</div> <div> </div> </div>	
<div>SELECTION: <input type="text"/></div>	

TARGETS MODEL	
<div> <div>TREE</div> <div>EXECUTIVE</div> <div>TARGET MODE</div> <div>TARGET SETTING</div> <div>LOCATION</div> <div>WEATHER</div> </div>	
<div> <div>OPTIONS:</div> <div>DOE-2.ID</div> <div>WYEC</div> <div>TRY</div> <div>TMY</div> <div>BLAST</div> <div>WYEC</div> <div>TRY</div> <div>TMY</div> <div>ASEAM-2.1</div> <div>DOD</div> <div>AWD</div> <div>BWD-WYEC</div> </div>	
<div> <div>FILES:</div> <div> </div> </div>	
<div>SELECTION: WASHINGTON, D.C.</div>	

TARGETS MODEL			
TREE EXECUTIVE TARGET MODE TARGET SETTING BUILDING OPTIONS: SUMMARY TYPE STORIES FLOOR CONFIGURATION ORIENTATION FUNCTIONS SYSTEMS			
BUILDING CATEGORY COMMERCIAL OFFICES HOTELS MOTELS RETAIL	BUILDING TYPE HIGH RISE MID RISE LOW RISE HIGH RISE MID RISE LOW RISE REGIONAL SHOPPING CENTERS RETAIL SHOPS	BUILDING SUBTYPE HIGH QUALITY NORMAL QUALITY COMPETITIVE LEVEL GOVERNMENT OFFICES MEDICAL OFFICES DENTAL OFFICES LAW OFFICES MULTIFUNCTION CONFERENCE STRIP RETAIL SHOPS WOMEN'S WEAR MEN'S WEAR BOOKSHOPS GIFT SHOPS JEWELRY SHOPS BARBER SHOPS
FILES:			

TARGETS MODEL	
TREE EXECUTIVE TARGET MODE TARGET SETTING BUILDING OPTIONS: SUMMARY TARGET/DESIGN PROGRAM TYPE STORIES FLOOR CONFIGURATION ORIENTATION ZONING FUNCTIONS SYSTEMS DESIGN STRAT HELP EXIT
SELECT NUMBER OF STORIES: <input type="text" value="18"/>	
FILES:

TARGETS MODEL										
EXECUTIVE TARGET MODE BUILDING FLOOR 2 FUNCTIONS EDIT	<p>SPACE USE? ☒ "MULTI-USE CONFERENCE"</p> <p>SQUARE FOOTAGE? <input type="text" value="3600"/></p> <p>or % OF TOTAL FLOOR? <input type="text"/></p> <p>SPACE LOCATION? <input type="text" value="INTERIOR"/> or <input type="text" value="EXTERIOR"/></p> <p>SPACE ORIENTATION? <input type="text" value="N"/> <input type="text" value="S"/> <input type="text" value="E"/> <input type="text" value="W"/> <input type="text" value="UNKNOWN"/></p> <p>AVERAGE CEILING HEIGHT? <input type="text" value="9'6\"/></p> <p>NUMBER OF IDENTICAL ROOMS? <input type="text" value="3"/></p> <p>or AVERAGE SQ FT PER ROOM? <input type="text"/></p>									
<p>OPTIONS</p> <p>A OFFICE B OPEN PLAN C CONFERENCE D CORRIDOR E ELEV/LOBBY F FILING G STORAGE H MECHANICAL I GUEST ROOM J RECEPTION K MULTI-CONF</p>	<table border="1"> <thead> <tr> <th colspan="3">FLOOR AREA (SQUARE FEET)</th> </tr> </thead> <tbody> <tr> <td><input type="text" value="30,000"/></td> <td><input type="text" value="65"/></td> <td><input type="text" value="10,500"/></td> </tr> <tr> <td colspan="3">TOTAL % DEFINED REMAINING</td> </tr> </tbody> </table>	FLOOR AREA (SQUARE FEET)			<input type="text" value="30,000"/>	<input type="text" value="65"/>	<input type="text" value="10,500"/>	TOTAL % DEFINED REMAINING		
FLOOR AREA (SQUARE FEET)										
<input type="text" value="30,000"/>	<input type="text" value="65"/>	<input type="text" value="10,500"/>								
TOTAL % DEFINED REMAINING										
FILES										

TARGETS MODEL							
EXECUTIVE TARGET MODE TARGET SETTING BUILDING FLOOR 2 FUNCTIONS EDIT K MULTI-CONF	<p>SPACE FUNCTION - CHARACTERISTICS</p> <p>SPACE USE? ☒ "MULTI-USE CONFERENCE"</p> <p>AVERAGE CEILING HEIGHT? <input type="text" value="9'6\"/></p> <p>INTERIOR PARTITIONS? ☒</p>						
<p>OPTIONS</p> <p>SUMMARY OCCUPANCY INTERNAL GAINS SCHEDULES COMFORT CRIT CONFIGURATION LOCATION HELP EXIT</p>	<p>FLOOR 2: CONFERENCE ; HEALTH CLUB</p> <p>FLOOR AREA (SQUARE FEET)</p> <table border="1"> <tbody> <tr> <td><input type="text" value="30,000"/></td> <td><input type="text" value="65"/></td> <td><input type="text" value="10,500"/></td> </tr> <tr> <td colspan="3">TOTAL % DEFINED REMAINING</td> </tr> </tbody> </table>	<input type="text" value="30,000"/>	<input type="text" value="65"/>	<input type="text" value="10,500"/>	TOTAL % DEFINED REMAINING		
<input type="text" value="30,000"/>	<input type="text" value="65"/>	<input type="text" value="10,500"/>					
TOTAL % DEFINED REMAINING							
FILES

FILES: 100-443887-1000

J. Evans	Graphics Support
R. Briggs	Graphics Support

STUDY SHEETWORK CREDITS

The following table shows the number of credits earned by each student.

Student Name Credits

John Smith	10
Jane Smith	10
Robert Smith	10
Patricia Smith	10
William Smith	10
Elizabeth Smith	10

Total Credits

10	10
10	10

Appendix C

Design Analysis/Evaluation Sequence for the Optima Building

Appendix C

Design Analysis/Evaluation Sequence for the Optima Building

The partial design analysis/evaluation sequence shown in this appendix demonstrates a number of important capabilities proposed for the Targets model. It emphasizes some of the options available for specifying building design features during the design analysis of a large, complex, multifunction building. Two scenarios are presented. One shows the specification of a fenestration system; the other illustrates the specification of a lighting system.

TARGETS MODEL

FILE

EXECUTIVE

TARGET MODE

DESIGN

ANALYSIS

BUILDING

SYSTEMS

ENVELOPE

FENESTRATION

OPTIONS

SUMMARY

SYSTEMS

GLAZING

SHADING

PHYSICAL

COST DATA

HELP

EXIT

FILES:

CURRENT FENESTRATION SYSTEM

	GLA	SHA	PHY	COST DATA	
	INITIAL COST (\$/SF)	O&M (\$)	REPL. (\$)		
Glazing	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Framing	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Shading	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Materials Sub-Total	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Labor Sub-Total	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total Costs	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00

TARGETS MODEL

FILE

EXECUTIVE

TARGET MODE

DESIGN

ANALYSIS

BUILDING

FLOOR 12

OPTIONS

SUMMARY

FUNCTIONS

SYSTEMS

ZONING

HELP

EXIT

FILES:

TARGETS MODEL	
TREE	WALLSLOT/WALLWASH - FLUORESCENT
EXECUTIVE	PARABOLIC WALLWASH
TARGET MODE
DESIGN ANALYSIS	
BUILDING	
FLOOR 12	
SYSTEMS	
LIGHTING	
FIXTURES	
FLUORESCENT	
PARA WALLWASH	
OPTIONS	
SUMMARY	
LAMP/BALLAST	
LUMINAIRE	
CONTROLS	
SCHEDULES	
PHYSICAL DATA	
COST DATA	
HELP	
EXIT	
FILES	

SELECT LAMPS:			
1	40W	3200 LUMENS	80 LUMENS/WATT
1	34W	2900 LUMENS	85 LUMENS/WATT
2	40W	6400 LUMENS	80 LUMENS/WATT
2	34W	5800 LUMENS	85 LUMENS/WATT

SELECT BALLAST:	
TYPE	# LAMPS
STANDARD	1 LAMP
ENERGY SAVING	2 LAMPS
ELECTRONIC	4 LAMPS
ELECTRONIC DIMMING	
BALLAST FACTOR	

TARGETS MODEL	
TREE	CURRENT SYSTEM
EXECUTIVE	PARABOLIC WALLWASH
TARGET MODE
DESIGN ANALYSIS	
BUILDING	
FLOOR 12	
SYSTEMS	
LIGHTING	
FIXTURES	
FLUORESCENT	
PARA WALLWASH	
OPTIONS	
SUMMARY	
LAMP/BALLAST	
LUMINAIRE CTRL	
CONTROLS	
SCHEDULES	
PHYSICAL DATA	
COST DATA	
HELP	
EXIT	
FILES	

SELECT LUMINAIRE CONTROL OPTIONS:			
NONE	ACRYLIC DIFFUSER	PRISMATIC LENS	EGG CRATE
PARALLEL BLADES (SM)	PARALLEL BLADES (LGE)	PARABOLIC BLADES	
SMALL PARA CELLS	LGE PARA CELL	LGE PARA CELL DEEP	

TARGETS MODEL

TREE

EXECUTIVE

TARGET MODE

DESIGN ANALYSIS

BUILDING

FLOOR 12

SYSTEMS

LIGHTING

FIXTURES

FLUORESCENT

PARA WALLWASH

OPTIONS

SUMMARY

LAMP/BALLAST

LUMINAIRE CTRL

CONTROLS

SCHEDULES

PHYSICAL DATA

COST DATA

HELP

EXIT

CURRENT SYSTEM

PARABOLIC WALLWASH

E.S.B.

PARABOLIC BLADES

SWITCHING CONTROLS:

TIMECLOCKS

2 LEVEL

3 LEVEL

PHOTOCELLS

2 LEVEL

3 LEVEL

DIMMING CONTROLS:

LOCAL CONTROL

AUTO TIMER

PRESET DIMMING

FILES:

TARGETS MODEL		CURRENT SYSTEM	
TREE EXECUTIVE TARGET MODE DESIGN ANALYSIS BUILDING FLOOR 12 SYSTEMS LIGHTING FIXTURES FLUORESCENT PARA WALLWASH		PARABOLIC WALLWASH ☐ E.S.B. ☐ PARABOLIC BLADES	
OPTIONS: SUMMARY LAMP/BALLAST LUMINAIRE CTRL CONTROLS SCHEDULES PHYSICAL DATA COST DATA HELP EXIT		PHYSICAL DATA CU @ RCR 1 INPUT WATT LUMENS/WATT EFFICIENCY SPACING/M	COST DATA LUMINAIRE \$X/SF FIXTURE \$A LAMP \$B BALLAST \$C OPERATING \$Y MAINTENANCE \$Z REPLACEMENT \$W
FILES:			

TARGETS MODEL		ANALYSES SUMMARY	
TREE EXECUTIVE TARGET MODE TARGET SETTING ANALYSES		ENERGY MODEL: DOE 2.1D TIME PERIOD: FULL 8760 HOURS COMPACTED - MEDIUM COMPACTED - SHORT FORMAT: TRY LOCATION: WASHINGTON, DC ENERGY COST MODEL: DOE 2.1D DATABASE: STANDARD DEMAND - DC BUILDING COST MODEL: SUMMARY DETAILED DATA BASES: MEANS DODGE SUPPLEMENTARY ECONOMICS OBJECTIVE: ERODC MODEL: ANSI STANDARD	
OPTIONS: SUMMARY ENERGY ENERGY COST BUILDING COST ECONOMICS HELP			
FILES:

TARGETS MODEL

TREE

OPTIONS:

FILES:

CAUTION

This is a draft demonstration of User Interface CONCEPTS. These are screen displays only, to show how a future system might work. At present, there are not any working programs behind these screens. Also, future versions of the screens themselves may change substantially.

TARGETS MODEL	
TREE	
OPTIONS:	
FILES:	

USER INTERFACE CREDITS

This demonstration disk was developed by the following participants:

ASHRAE/AIA/IES TEAM PARTICIPANTS:

J.J. Deringer	Technical Manager
J.W. Jones	Technical Support
H. McKay	Technical Support
J.D. Hall	Technical Support
P. Dillingham	Demonstration Graphics
S.T. Hunt	Demonstration Graphics

PNL STAFF PARTICIPANTS:

J. Evans	Graphics Support
R. Briggs	Graphics Support

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