CONCEPTUAL DESIGN
SUBDOMAIN
MODEL

prepared for
ADVANCED ENERGY DESIGN AND OPERATION TECHNOLOGIES
RESEARCH PROJECT

Pacific Northwest Laboratories

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prepared by
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF OREGON

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EXECUTIVE SUMMARY

As an outgrowth of the Commercial Building Systems Integration Program, the U.S. Department of Energy concluded that commercial buildings in the public and private sector consume more energy and cost more to operate than is necessary (Bramley, et al, p. vii). These findings led to the identification of building design and operation as the principal targets for improving energy performance in the overall building lifecycle. Specifically, impact on decision making which integrates improved knowledge of building subsystems and their interactions in design, construction, and operation is the focus of continuing work to significantly reduce energy consumption by the year 2010.

The Advanced Energy Design and Operation Technologies (AEDOT) Research Project was created to develop a scientific and technical basis for improved energy-related decision making early in the design process and in ways that impact operational efficiencies. AEDOT research will develop intelligent computer-based tools to provide the technological basis for presenting and testing energy options.

A multiyear plan has been developed by Pacific Northwest Laboratories with the Department of Energy to administer and coordinate research activities on the AEDOT project. Additionally, three research teams share responsibility for completing individual research tasks: California Polytechnic State University (Cal Poly), Lawrence Berkeley Laboratory (LBL), and the University of Oregon. At the University of Oregon, AEDOT will draw upon building design process experience and developmental work with conceptual energy design software tools. This report addresses work done on the modeling of the conceptual design subdomain.

In order to establish the boundaries for a model of decision making in conceptual design, our focus is centered on building form, organization, siting, and envelope solid-void relationships. A preliminary design proposal for a building design will have addressed most if not all of these issues. Each issue has significant energy-related implications for the building lifecycle. Therefore, improving early design decisions during conceptual design is a prime target for reducing energy consumption in buildings.

From our study of the design process, we have concluded that design consists of iterations of "generating"and "evaluating" proposals. Each of these activities is composed of many more subactivities. Although we can describe the "universe" of activities in design process, we cannot anticipate any single path taken for a given project. Design is a process where conflicting needs

and desires are gradually resolved through complex decision making. Designers skilled in this process are often unaware of their complex ability to reason multiple concerns simultaneously, unlike the significant effort required to automate the same process using inference techniques. This activity of conflict resolution-- of accepting, prioritizing, or rejecting criteria is the primary activity of design at any stage. In conceptual design, however, many design decisions are still flexible as many issues remain undiscovered and unfixed. Thus, it is still relatively easy to reintroduce concerns, such as energy, and positively influence a designer's thought process.

"Structured analysis" (De Marco, 1978) was adopted as a modeling framework. This approach proved effective in detailing requirement analysis: input, output, and process description as well as satisfying the need to express time sequence interrelationships between design activities.

Development of a prototype which demonstrates a design guidance tool for conceptual design using intelligent computer-based technology is an early objective of the AEDOT project. To meet this objective, our focus will be design decision making for building form, organization, siting and envelope solid-void relationships. In the development of the prototype, user interface design will be a critical aspect of implementation. The tool will be generative in nature, suggesting and evaluating alternative design proposals in a software environment responsive to a designer's need for fluidity and spontaneity. Our goal is to assist designers in generating energy-related design strategies that they would not have generated otherwise and to determine the level of automation appropriate to such an intelligent computer-based tool.

1.0   INTRODUCTION

As an outgrowth of the Commercial Building Systems Integration Program, the U.S. Department
of Energy concluded that commercial buildings in the public and private sector consume more
energy and cost more to operate than is necessary (Bramley, et al, p. vii). These findings led to the
identification of building design and operation as the principal targets for improving energy
performance in the overall building lifecycle. Specifically, impact on decision making which
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The Advanced Energy Design and Operation Technologies (AEDOT) Research Project was created
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design process and in ways that impact operational efficiencies. AEDOT research will develop
intelligent computer-based tools to provide the technological basis for presenting and testing energy
options.

A multiyear plan has been developed by Pacific Northwest Laboratories with the Department of
Energy to administer and coordinate research activities on the AEDOT project. Additionally, three
research teams share responsibility for completing individual research tasks: Lawrence Berkeley
Laboratory (LBL), California Polytechnic State University (Cal Poly), and the University of
Oregon. LBL offers expertise in building subsystem research in building envelope and
fenestration. Cal Poly offers experience developing knowledge based systems and has developed
an Intelligent Computer Aided Design System (ICADS) that will contribute a CAD drawing
package and expert system conflict resolver to AEDOT.

At the University of Oregon, AEDOT will draw upon building design process experience and
developmental work with conceptual energy design software tools. The general categorization of
tasks represents these two areas:

1) Activity Decomposition for the Building Design Process, and
2) Conceptual Design Subdomain Model.

The Conceptual Design Subdomain Model is discussed in detail in this report.

2.0   CONCEPTUAL DESIGN SUBDOMAIN

Conceptual design in architecture is the expression of a basic idea which underlies all further development. Its origin is often from within the building designer, noted as a preference for a particular strategy or theme throughout the development of a building design. It determines a building's basic form, organization, siting, and envelope solid-void relationships.

In developing a design concept for a building, a designer's values and experience combine with contextual information and user requirements to shape the design proposal. Relative importance is weighed between diverse (structural, aesthetic, functional, etc.) requirements. Conflicting needs and desires are gradually resolved through a complex decision making process. Designers skilled in this process are often unaware of their complex ability to reason multiple concerns simultaneously, unlike the significant effort required to automate the same process using inference techniques. This activity of conflict resolution-- of accepting, prioritizing, or rejecting criteria is the primary activity of design at any stage. In conceptual design, however, many design decisions are still flexible as many issues remain undiscovered and unfixed. Thus, it is still relatively facile to reintroduce concerns, such as energy, and positively influence a designer's thought process.

For some designers, the physical environment serves as the driving force behind their basic building concept. Louis Kahn, for example, used natural light as a form determinant pervading decisions at all scales with many of his buildings. Frank Lloyd Wright engaged features of the desert landscape in his response to Taliesin West in Phoenix, Arizona. For many designers, however, energy is not part of developing a design concept, and, therefore, energy does not serve as form generator. <u>Conceptual design decisions play a critical role for energy consumption over the building lifecycle and therefore energy strategies must be integrated at this early decision making stage</u>.

Preliminary design performance evaluations based on form, organization, siting, and solid-void relationships can be done early at the conceptual design phase. For evaluation tools to be used at this stage of design development, an expert system is one way of providing assistance to complete input requirements a designer may not be prepared to specify.

In the context of energy, evaluation of a conceptual design requires examination of building form as it relates to the skin to volume ratio, building organization as it relates to location of heat loss/gain program elements, siting as it relates to orientation and access to all natural energy resources, and envelope solid-void relationships as it corresponds to opaque versus non-opaque

area. The key issue, therefore, is to help the designer recognize energy as a potential form determinate or to couple energy with the designer's own basic building concept. Ways to fit these generation and evaluation tools into the modeling framework are demonstrated in the sections that follow.

3.0   METHODOLOGY

Conceptual design was modeled to establish relationships between activities, input requirements, and resulting output in the design process. A standard software process modeling approach called "structured analysis" (De Marco, 1978) was used. The model was based on the traditional, human building design process with the intent of informing the automated processes of an expert system design advisor.

As a precursor to this approach, a decomposition model of the overall building design process was constructed to establish the complete context of design process activities (Brown and McDonald, 1990). This earlier model produced the desired effect of externalizing a definitive and discrete list of design activities. It identified broad categories as well as subcategories of activities.

The activity decomposition model includes a description of activities that constitute conceptual design. The decomposition model however indicated *what* activities occur in design rather than *how* a designer accomplishes the activity or in *what sequence*. Comparison of the decomposition model and data flow diagram demonstrates the difference between the two approaches.

For example, in the decomposition model, DESIGN / BUILD divides into three components: INITIATE PROJECT, DESIGN PROJECT, and BUILD PROJECT. All we can ascertain from the model is that DESIGN / BUILD consists of three subactivities. We can assume nothing more about the activities themselves (i.e., what order they occur in, which is the most significant, etc.). In the data flow diagram, DESIGN / BUILD is also broken into three components. There is additional information about what these activities require as input and what they produce as output. They are also linked in a particular sequence.

For our purposes, conceptual design was modeled using a top down approach. As described above, at the highest level, three activities completely describe DESIGN / BUILD: INITIATE PROJECT, DESIGN PROJECT, and BUILD PROJECT (Figures 3.0-1 and 3.0-2). A collection of subactivities are given in a sequence that leads to development of a conceptual design proposal. Data definitions and process descriptions are provided to establish components of the activities. Data flow diagrams contain the interface between definitions and processes.

Two activities are identified as primary to all phases of design: generate and evaluate. During "generate", a designer produces a formal (i.e., physical) design proposal from an idea. Then, the designer can "evaluate" the proposal according to the criteria they have selected. Data flows,

definitions associated with the activities, and examples are given in Sections 4.0 and 5.0, respectively. The two examples, one non-energy-related and another energy-related, are given to demonstrate applicability of the model to specific conceptual design activities.

Manual design tools were also inventoried to study the range of designer activities undertaken in conceptual design. These tools depict how human designers process written and graphic information and how they use this information to generate building form. (See Appendix.)

```
                          BUILDING  LIFE  CYCLE


          DESIGN /                      OPERATE                      DEMOLISH
          BUILD (0.1)                    (0.2)                        (0.3)


   INITIATE        DESIGN        BUILD
   PROJECT        PROJECT       PROJECT
    (1.0)          (2.0)         (3.0)


              GENERATE        EVALUATE
               DESIGN          DESIGN
               (2.1)            (2.2)


UNDERSTANDING   FORMULATING    APPLY      ASSESS
    THE          SOLUTIONS     RULES     QUALITIES
  PROBLEM         (2.1.2)     (2.2.1)     (2.2.2)
  (2.1.1)
```
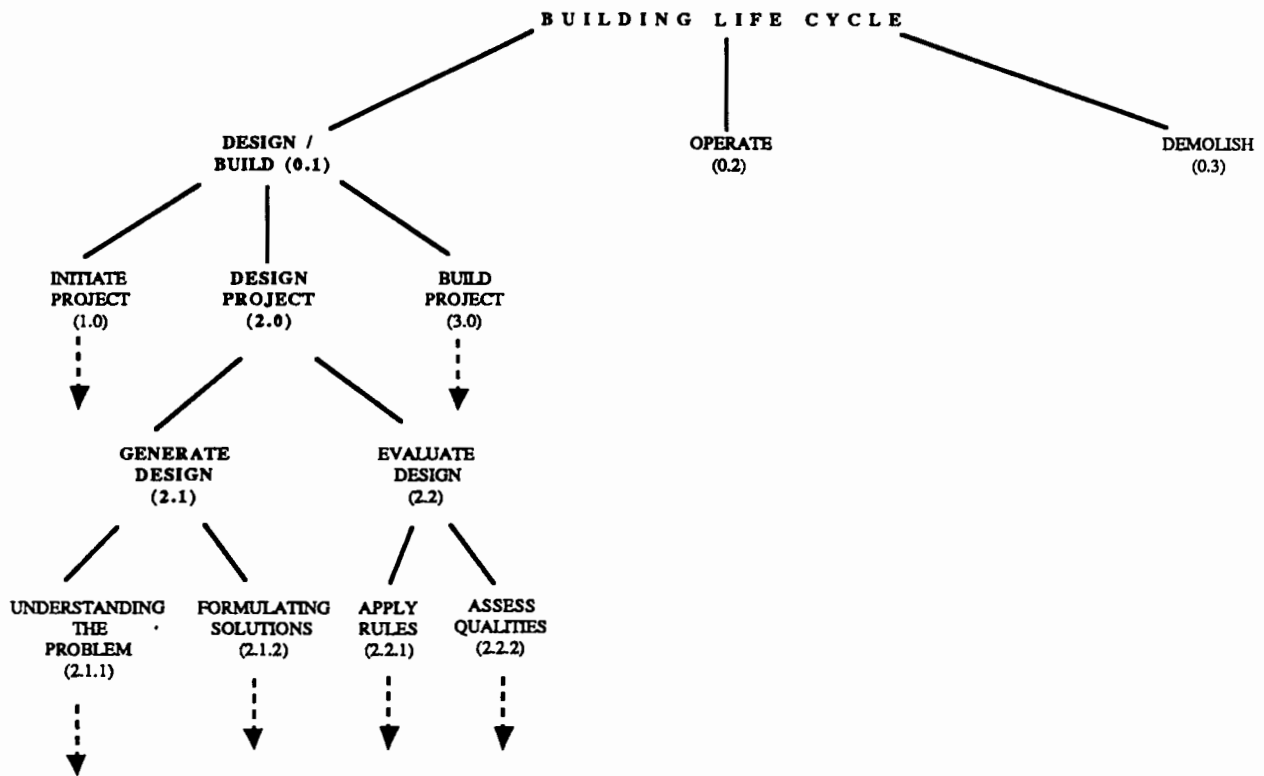
Figure 3.0-1

The activity decomposition diagram depicts hierarchical relationships between activities in the overall building lifecycle. Notice how this information is transformed in the structured analysis approach.
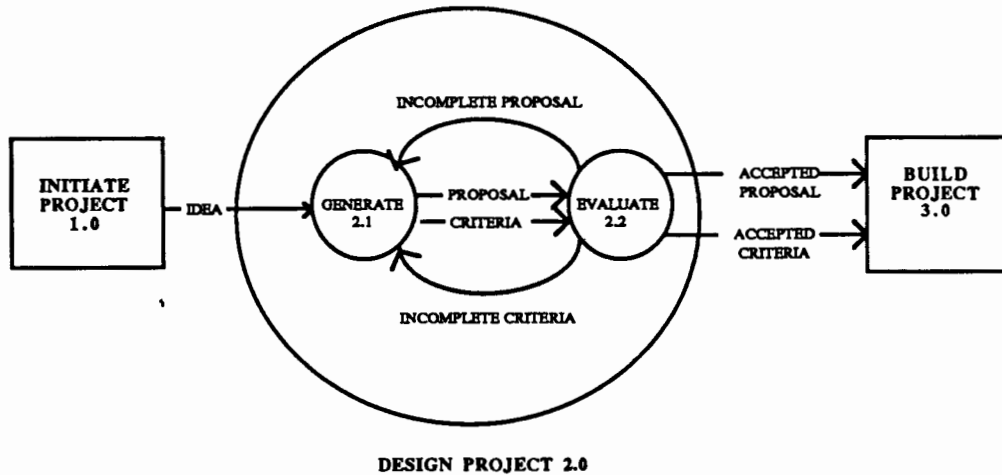
DESIGN PROJECT 2.0

Figure 3.0-2

The data flow diagram shows data and the processes acting on the data.
Activites from the decomposition model are the processes. Data flows, not
part of the decomposition model, are integral to the structured analysis model.

3.1   Data Flow Diagrams

Data flow diagrams serve as the language of the process model. Conventions give a consistent
meaning to and usage for the information contained in the diagram as shown in Figure 3.1-1.
Arrows represent data flows, circles represent processes that act on the data, and rectangles are
used for processes performed outside the immediate diagram. This modeling technique diagrams
the data exchange that occurs between processes. Information is linked sequentially and data is
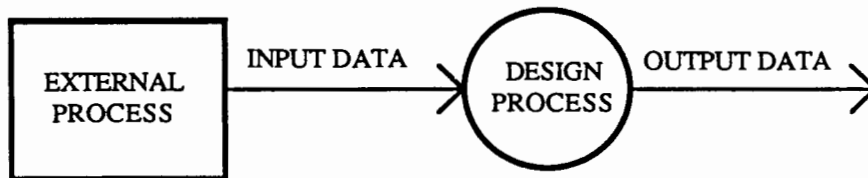uniquely specified.

Figure 3.1-1

A numbering convention is used which indicates a process location in the nesting sequence.
All processes occurring as part of the same procedure are numbered with iterations of the
same significant digit. In Figure 3.0-2 notice *GENERATE* and *EVALUATE* are numbered
2.1 and 2.2 respectively.

3.2 Data Dictionary

All data of the model are fully defined in the data dictionary. The data are specified in terms of subordinate definitions until they can be reduced no further. The most fundamental definition is called a "primitive" because it cannot be further refined.

Definitions express all components of data not the process that combines the components. Several conventions are used to describe the relationships of components in a definition. These are:

=	equivalent to
+	and
[x | y]	either x or y
x{ } y	iterations from x to y
{ }	iterations from 0 to infinity (i.e., from none to many)
( )	optional.

In the theory of structured analysis, all data can be expressed in terms of these relational operators. In addition, the convention of * * is used for explanatory comments added to the definition for clarification.

An example of a definition is as follows:

EXISTING CONDITIONS = {ENVIRONMENTAL CONTEXT} +
                    {LEGAL RESTRICTIONS} +
                    {PHYSICAL FEATURES} +
                    {FINANCIAL ISSUES} +
                    {DEVELOPMENT ISSUES}
        and
ENVIRONMENTAL CONTEXT = {SENSORY} +
                    {MICROCLIMATE} etc.

Figure 3.2-1

In each of the above cases, the operator { } without lower and upper limits expresses that there may be multiple entries or there may be none at all. More definitions follow in Sections 4.2 and 5.2 of this document.

3.3   Prototype

The conceptual design subdomain model will be used to develop an intelligent computer-based prototype for the AEDOT project. ICADS, an Intelligent Computer-Aided Design System developed at California Polytechnic State University, San Luis Obispo (Pohl, 1989), has been adopted as the expert system. ICADS Intelligent Design Tools (IDTs) allow for the integration of expert subdomains in a variety of disciplines.

Our task, at the University of Oregon, is to develop a computer-based conceptual design tool that brings energy issues to the forefront of a designer's decision making process. The tool will be generative in nature, suggesting and evaluating alternative design proposals in a software environment responsive to a designer's need for fluidity and spontaneity. In the development of the prototype, user interface design will be a critical aspect of implementation.

3.4   Evaluation

Information processing which involves data aggregation and decision making in the design process is a complicated task of sorting, prioritizing, and resolving conflicting design issues. In the manual process, designers are capable of intuitively storing and processing several variables at a time. Moreover, some decisions made by designers defy logic and unless the designer can articulate the reasoning behind a design decision, this information is inaccessible to the computer. Dealing with the ill-structured aspect of design decisions presents the greatest challenge in incorporating design advisors into the design process.

Several consultants reviewed the model and commented on these subjects: the structure of decision making in conceptual design and automation of the design process.

Ron Kellett, Assistant Professor of Architecture at the University of Oregon and design process specialist, supplied resources on design process research conducted over the past ten years. His references included automated attempts at modeling the design process as well as more traditional design process literature. These references are given in this document (Section 7.0).

Lance LaVine, Professor of Architecture at the University of Minnesota and specialist in energy education for students and professionals, also reviewed the model. Prof. LaVine concurred that the structured analysis model does capture "how designers design" and that it would be useful to

compare the contents of the model to design process as described by Broadbent and others. The data dictionary was viewed as essential to the process because "sometimes the things about design process... are shrouded in mystery simply because no one will put those things down to disagree with." Prof. LaVine also commented on the value of linking all phases of the building lifecycle in the diagram. Each phase can inform the other and have a significant influence at least where energy is concerned. In Prof. La Vine's words, this awareness of DESIGN/BUILD, OPERATE, and DEMOLISH makes the designer "responsible." Knowledge of operation performance, for example, can have positive influence on design decisions if we learn from that experience. Finally, he reiterated a statement by Donlyn Lyndon which is how design is "what a designer focuses on." Our goal is to influence that focus in the conceptual design phase so as to improve energy consideration and integration with other design criteria.

Beverly Jones, Associate Professor of Art Education, is a specialist in learning styles and is evaluating assumptions about learning styles implicit in the model and the representational structures used to interface stored knowledge of an expert system with the user. (Jones, 1990) With respect to learning styles, Prof. Jones comments highlighted the importance of "multiple interfaces for various audiences." These interfaces need to take into consideration interface structures such as "iconic, symbolic, representational, auditory, etc." and "individual and cultural similarities and differences."

Prof. Jones discussed several examples of representational structures used in processing and presentation of human knowledge in a computing environment. She first addressed the use of a hierarchial model for structuring design process information as presented in Activity Decomposition for the Building Design Process (Brown and McDonald, 1990). Her comments were concurrent with our understanding of the primary function of the model in that "hierarchial structures are excellent for organizing data for an outside observer and for designing easy access interfaces for nontechnical users." Her comments continue, "consequently for knowledge elicitation from designers that is 'hard data' definable and comprehensive in data elements, this structure is excellent." (Hard data being that which is well defined (e.g., building codes, microclimate), and, soft data, that which is intangible (e.g., memories and metaphors).)

An appropriate representational structure, in Prof. Jones consideration, is one that allows for "conceptual and structural variations in interface design" such as provided by a hypertext environment. "Hypertext knowledge base structure can facilitate use of information by a variety of users for a variety of purposes" including the use of hypermedia. This representational structure allows for hierarchial and non-hierarchial interfaces by users where the interface varies with the

type of information presented. Representational structures such as hypertext are introduced to manage the interface with human decision making processes. The applicability of any representational structure will depend on the direction of all subdomains and the principal domain (expert system) under AEDOT development.

In content, Prof. Jones inquired about the handling of "repurposing" of buildings. In creating the decomposition structure, we considered remodeling to be part of the DESIGN/BUILD process. There were more similarities than differences in activities of design for new construction and re-use of existing buildings.

Other reviews of the model were conducted with AEDOT team members. In October 1990, the University of Oregon met with Pacific Northwest Laboratories to discuss progress and approach on the conceptual design subdomain model. In November, all AEDOT team members joined to review individual team members work and to discuss the upcoming project tasks. At this meeting, the relationship of the conceptual design subdomain model to an automated design advisor was discussed.

It was concluded that manual tools inform but do not represent the full potential of automated design tools especially in the context of expert systems. A significant part of the prototype development will address how to present energy strategies and performance in a generative fashion, assisting the designer to reduce energy consumption through manipulation of building form and organization.

4.0   CONCEPTUAL DESIGN SUBDOMAIN MODEL: GENERATE

The diagrams and data dictionary that follow in this section describe the design process in terms of data flows, processes, and definitions. One process, GENERATE 2.1, is resolved further in this section. This process serves as one of the primary activities associated with conceptual design as described in our model. The diagrams step through the process of generating a formal (i.e., physical) design proposal from an initial idea.

Figures 4.1-1 through 4.1-7 represent a general design process model for generating physical design ideas. To demonstrate how the model is inclusive of particular generation process, an example based on bubble diagraming is given in the captions below each figure indicated by the word EXAMPLE. Relevant parts of the data dictionary follow the caption. The part of the definition pertinent to the bubble diagram example is indicated by **bold face**.

Bubble diagraming is a common design activity used to combine information about space: sizes, shapes, adjacencies, and organization. Information comes to the bubble diagram from numerous sources. For example, a user may give what they consider optimal dimensions for a room size. Or, if no information exists for the room size, the designer might consult the building code for minimum dimensions based on persons/square foot for that occupancy. Much of the input to this activity comes from multiple sources. The activity of combining this information, however, is the same independent of the source of the input.

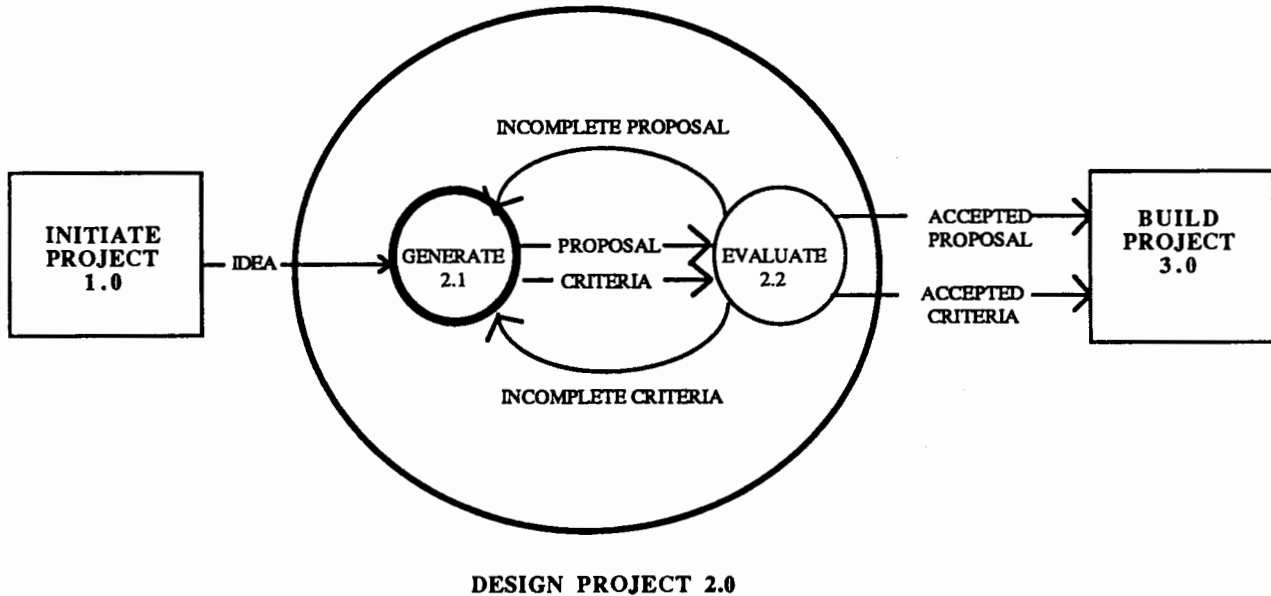## 4.1   Data Flow Diagrams: Generate

DESIGN PROJECT 2.0

Figure 4.1-1

Generate 2.1 is highlighted because this is the data flow we are following through the diagram in Section 4.0. This process receives an idea and returns a design proposal and criteria. The evaluation process is described in Section 5.0.

EXAMPLE: In the bubble diagram example, an idea is equivalent to a *building type description*. because information about building type is necessary before a designer can start an organizational diagram. For example, initiation of a project may start with an idea to build an office building. A site description or building occupant description, if known, would contribute to the building organization at this stage but is not essential.

DATA DICTIONARY:
IDEA=   {SITE DESCRIPTION} +
           {BUILDING TYPE DESCRIPTION} +
           {BUILDING OCCUPANT DESCRIPTION}

PROPOSAL= * physical representation of a design proposal *
PROPOSAL = {PLAN} +
        {SECTION} +
        {ELEVATION} +
        {CONSTRUCTION DETAILS} +
        {SPECIFICATIONS} +
        {3-D RENDERING} +
        {MODEL}

CRITERIA = * design goals statement for evaluation of a proposal *
CRITERIA = {EXISTING CONDITIONS} +
        {USER-DEFINED PARAMETERS} +
        {DESIGNER INTUITION}

INCOMPLETE PROPOSAL= * partially approved proposal *
INCOMPLETE PROPOSAL = {INCOMPLETE PLAN} +
        {INCOMPLETE SECTION} +
        {INCOMPLETE ELEVATION} +
        {INCOMPLETE CONSTRUCTION DETAILS} +
        {INCOMPLETE SPECIFICATIONS} +
        {INCOMPLETE 3-D RENDERING} +
        {INCOMPLETE MODEL}

INCOMPLETE CRITERIA= * design goals statement insufficient for evaluation of proposal *
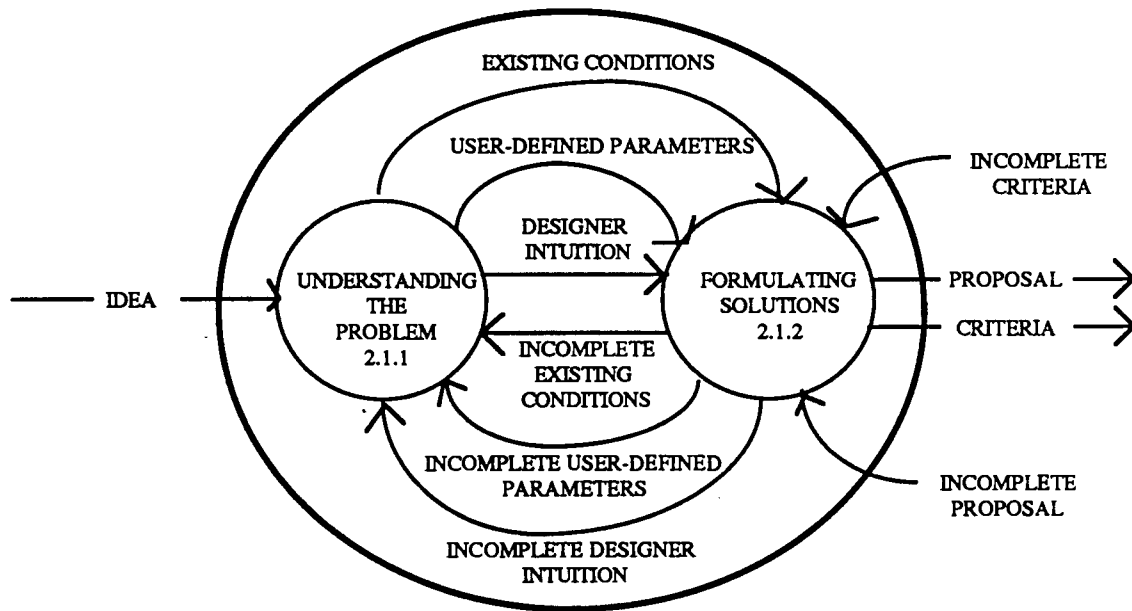INCOMPLETE CRITERIA = {INCOMPLETE EXISTING CONDITIONS} +
        {INCOMPLETE USER-DEFINED PARAMETERS} +
        {INCOMPLETE DESIGNER INTUITION}

ACCEPTED PROPOSAL= * temporarily approved proposal *
ACCEPTED PROPOSAL = {ACCEPTED PLAN} +
        {ACCEPTED SECTION} +
        {ACCEPTED ELEVATION} +
        {ACCEPTED CONSTRUCTION DETAILS} +
        {ACCEPTED SPECIFICATIONS} +
        {ACCEPTED 3-D RENDERING} +
        {ACCEPTED MODEL}

ACCEPTED CRITERIA= * temporarily achieved design goals *
ACCEPTED CRITERIA = {ACCEPTED EXISTING CONDITIONS} +
        {ACCEPTED USER-DEFINED PARAMETERS} +
        {ACCEPTED DESIGNER INTUITION}

GENERATE 2.1

Figure 4.1-2

Generate 2.1 is expanded into its two primary components: Understanding the Problem and Formulating Solutions. The first represents data collection from the context (existing conditions), the user (user-defined parameters), and the designer (designer intuition). These data are delivered to the second process where they are developed into a proposed solution to the original idea.

EXAMPLE: For a bubble diagram, data needed is a physical description of room sizes, shapes, adjacencies, and organization. This is further resolved in the next diagram.

DATA DICTIONARY:
IDEA (See Data Dictionary for Figure 4.1-1)
PROPOSAL (See Data Dictionary for Figure 4.1-1)
CRITERIA (See Data Dictionary for Figure 4.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 4.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 4.1-1)

EXISTING CONDITIONS= {EXISTING ENVIRONMENTAL CONTEXT} +
                     {EXISTING LEGAL RESTRICTIONS} +
                     {EXISTING PHYSICAL FEATURES} +
                     {EXISTING FINANCIAL ISSUES} +
   {EXISTING DEVELOPMENT ISSUES}

USER-DEFINED PARAMETERS= {USER-DEFINED FUNCTIONS} +
{USER-DEFINED PLACES} +
{USER-DEFINED IMAGE} +
{USER-DEFINED TECHNICAL} +
{USER-DEFINED CONCERNS} +
{USER-DEFINED FINANCIAL ISSUES} +
{USER-DEFINED PLANNING ISSUES}

DESIGNER INTUITION=   {PRECEDENTS} +
{DESIGNER BAGGAGE}

INCOMPLETE EXISTING CONDITIONS=
{INCOMPLETE EXISTING ENVIRONMENTAL CONTEXT} +
{INCOMPLETE EXISTING LEGAL RESTRICTIONS} +
{INCOMPLETE EXISTING PHYSICAL FEATURES} +
{INCOMPLETE EXISTING FINANCIAL ISSUES} +
{INCOMPLETE EXISTING DEVELOPMENT ISSUES}

INCOMPLETE USER-DEFINED PARAMETERS =
{INCOMPLETE USER-DEFINED FUNCTIONS} +
{INCOMPLETE USER-DEFINED PLACES} +
{INCOMPLETE USER-DEFINED IMAGE} +
{INCOMPLETE USER-DEFINED TECHNICAL} +
{INCOMPLETE USER-DEFINED CONCERNS} +
{INCOMPLETE USER-DEFINED FINANCIAL ISSUES} +
{INCOMPLETE USER-DEFINED PLANNING ISSUES}

INCOMPLETE DESIGNER INTUITION=   {INCOMPLETE PRECEDENTS} +
{INCOMPLETE DESIGNER BAGGAGE}

RECORD
EXISTING
CONDITIONS
2.1.1.1

DESCRIBE
USER-DEFINED
PARAMETERS
2.1.1.2

EXPLORE
DESIGNER
INTUITION
2.1.1.3

— IDEA

EXISTING
CONDITIONS

INCOMPLETE
EXISTING
CONDITIONS

USER-DEFINED
PARAMETERS

INCOMPLETE
USER-DEFINED
PARAMETERS

DESIGNER
INTUITION

INCOMPLETE
DESIGNER
INTUITION
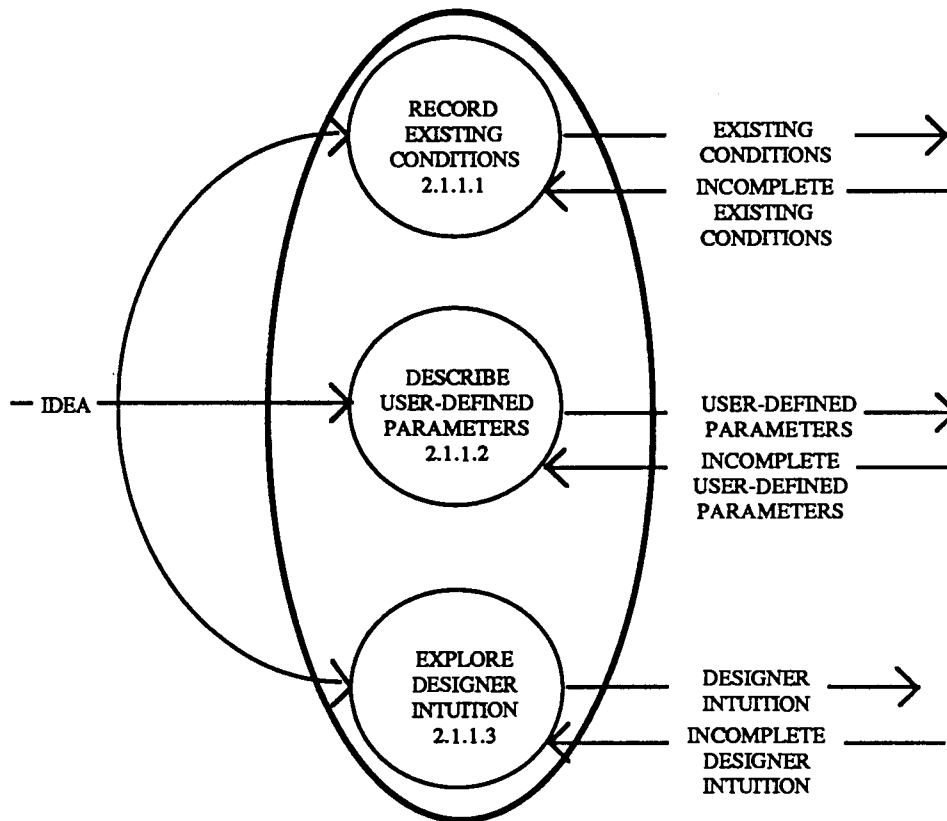
UNDERSTANDING THE PROBLEM   2.1.1

Figure 4.1-3

Understanding the Problem has three components: Recording Existing Conditions, User-Defined Parameters, and Designer Intuition. Recording Existing Conditions is the gathering of contextual information. Describe User-Defined Parameters is the collection of programmatic information as supplied by the user. Explore Designer Intuition is the assembling of a designer's thoughts on reference projects (precedents) and previous experience (baggage).

EXAMPLE: Data needed for bubble diagrams comes from the bold face categories in the dictionary below. Descriptions are given between the asterisks (*).

DATA DICTIONARY:
IDEA (See Data Dictionary for Figure 4.1-1)
EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2)
USER-DEFINED PARAMETERS (See Data Dictionary for Figure 4.1-2)
DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2)
INCOMPLETE EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2 and 4.1-3)

INCOMPLETE USER-DEFINED PARAMETERS (See Data Dictionary for Fig. 4.1-2 and 4.1-3)
INCOMPLETE DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2 and 4.1-3)

EXISTING CONDITIONS is defined in the Data Dictionary for Figure 4.1-2 as having the following five components. The components are given in terms of their subcomponents below. In the bubble diagraming example, room sizes could come from the contextual data component in bold face.

EXISTING ENVIRONMENTAL CONTEXT = {SENSORY FACTORS} +
{MICROCLIMATES FACTORS}

EXISTING LEGAL RESTRICTIONS = {**BUILDING CODES**} +
{OTHER CODES, COVENANTS & RESTRICTIONS} +
{PROPERTY DESCRIPTION} +
(ZONING}

EXISTING PHYSICAL FEATURES = {LAND FEATURES} +
{BUILT FEATURES} +
{SYSTEMS FEATURES}

EXISTING FINANCIAL ISSUES = {VALUATION/TAXATION} +
{REVENUE ANALYSIS} +
{GRANT FUNDING SOURCES} +
{FINANCING}

EXISTING DEVELOPMENT ISSUES = {LAND USE PLANNING} +
{SOCIAL IMPACT}

USER-DEFINED PARAMETERS is defined in the Data Dictionary for Figure 4.1-2 as having the following seven components. The components are given in terms of their subcomponents below. In the bubble diagraming example, room sizes, shapes, adjacencies, and organization could come from the user-defined data component in bold face.

USER-DEFINED FUNCTIONS =   {USERS} +
{ACTIVITIES}

USER-DEFINED PLACES = {EXPERIENTIAL QUALITIES} +
{**DIMENSIONAL QUALITIES**} +
{**ORGANIZATION**} +
{BUILDING PARTS}

USER-DEFINED IMAGE =   {IMAGE ATTRIBUTES} +
{APPROPRIATE MATERIALS}

USER-DEFINED TECHNICAL CONCERNS =   {TECHNIQUES} +
{MATERIALS} +
{SYSTEMS}

USER-DEFINED FINANCIAL ISSUES = {COSTS}

USER-DEFINED PROJECT PLANNING ISSUES =   {STAKEHOLDERS} +
                                              {TIME SCHEDULE} +
                                              {PROJECT DELIVERY}

DESIGNER INTUITION is defined in the Data Dictionary for Figure 4.1-2 as having the following two components. The components are given in terms of their subcomponents below. In the bubble diagraming example, room sizes, shapes, adjacencies, and organization could come from the designer data component in bold face.

DESIGNER PRECEDENTS =   {IMAGE CONCEPTS} +
                               {TECHNICAL CONCEPTS} +
                               {ORDERING CONCEPTS} +
                               {ORGANIZATION CONCEPTS} +
                               {TYPOLOGY}

DESIGNER BAGGAGE =   {MEMORIES} +
                     {METAPHORS}

FORMULATING SOLUTIONS   2.1.2
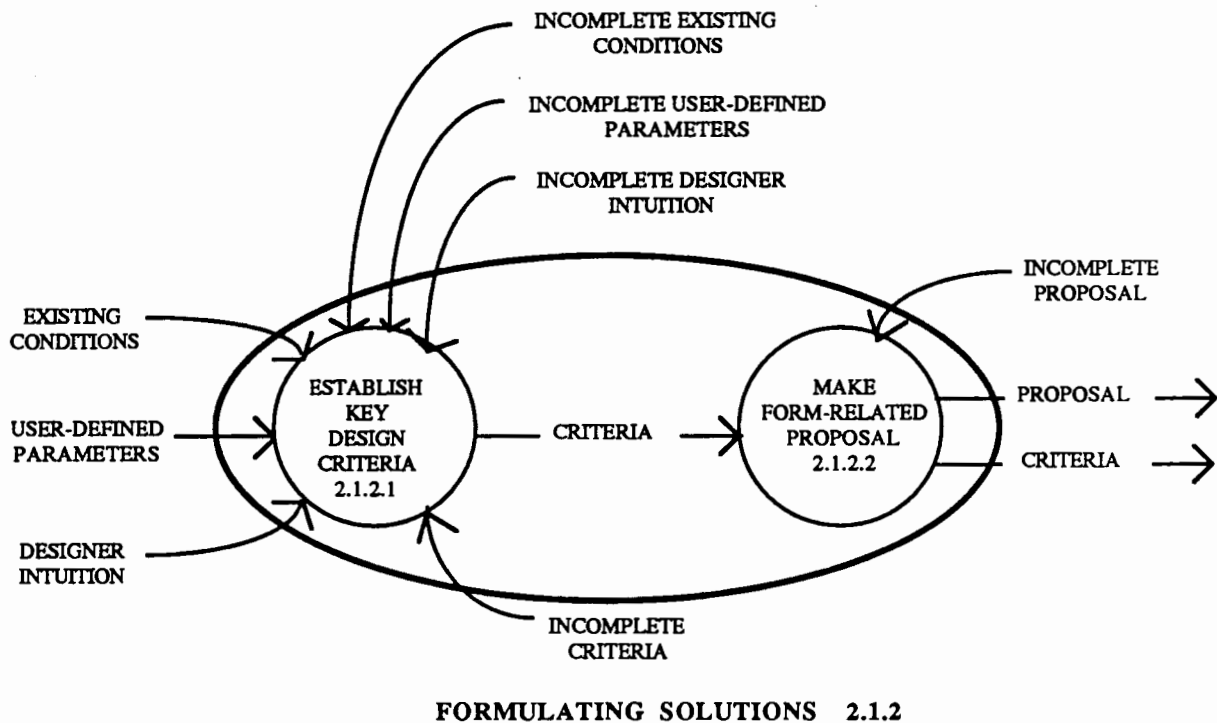
Figure   4.1-4

Information collected from the user is not entirely devoid of a particular bias towards a design solution. This is evident through our preferences for certain issues over others and our data collection proceeds accordingly. Therefore, the process Establish Key Design Criteria is a rearrangement of the data such that priorities and their complement are explicitly stated.

EXAMPLE: All data from Recording Existing Conditions, User-Defined Parameters, and Designer Intuition are gathered together so that the designer can establish priorities.

DATA DICTIONARY:
PROPOSAL (See Data Dictionary for Figure 4.1-1)
CRITERIA (See Data Dictionary for Figure 4.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 4.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 4.1-1)
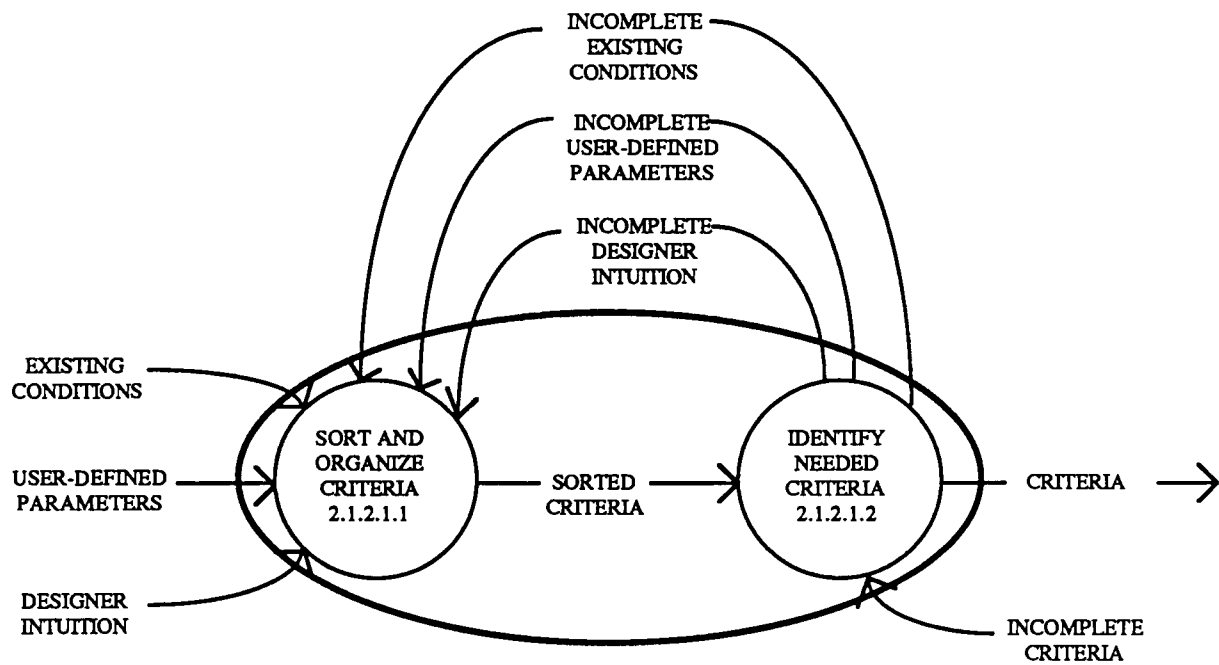EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
USER-DEFINED PARAMETERS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2 and 4.1-3)
INCOMPLETE EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
INCOMPLETE USER-DEFINED PARAMETERS (See Data Dictionary for Fig. 4.1-2 and 4.1-3)
INCOMPLETE DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2 and 4.1-3)

ESTABLISH KEY DESIGN CRITERIA 2.1.2.1

Figure 4.1-5

In establishing key criteria, a designer decides which criteria from their current understanding of the design problem will play a dominant role and which criteria is less important to shaping the proposal. This is a process of sorting and organizing criteria. Once arranged, additional criteria may be needed to reinforce a particular design solution. The results are returned as sorted criteria.

EXAMPLE: The designer sorts and organizes the code requirements with those of the user and designer. If additional criteria is needed either because it is missing or because it will reinforce a particular strategy it is collected now.

DATA DICTIONARY:
SORTED CRITERIA = {EXISTING CONDITIONS} +
         {USER-DEFINED PARAMETERS} +
         {DESIGNER INTUITION}
CRITERIA (See Data Dictionary for Figure 4.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 4.1-1)
EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
USER-DEFINED PARAMETERS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2 and 4.1-3)
INCOMPLETE EXISTING CONDITIONS (See Data Dictionary for Figure 4.1-2 and 4.1-3)
INCOMPLETE USER-DEFINED PARAMETERS (See Data Dictionary for Fig. 4.1-2 and 4.1-3)
INCOMPLETE DESIGNER INTUITION (See Data Dictionary for Figure 4.1-2 and 4.1-3)
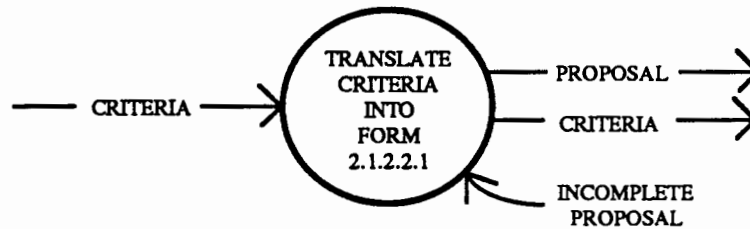
MAKE FORM-RELATED PROPOSAL   2.1.2.2

Figure   4.1-6

Criteria already identified and provided from the input sources are used in the physical solution to the design problem. However, the designer needs a means to make this translation. Making Form-Related Proposal is Translating an Idea into Form.

EXAMPLE: The sorted criteria determining room sizes, shapes, adjacencies and organization are changed into a physical solution in this case using a graphic technique called BUBBLE DIAGRAMING. Figures A-2 through A-4 in the appendix demonstrate this manual tool.

DATA DICTIONARY:
PROPOSAL (See Data Dictionary for Figure 4.1-1)
CRITERIA (See Data Dictionary for Figure 4.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 4.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 4.1-1)
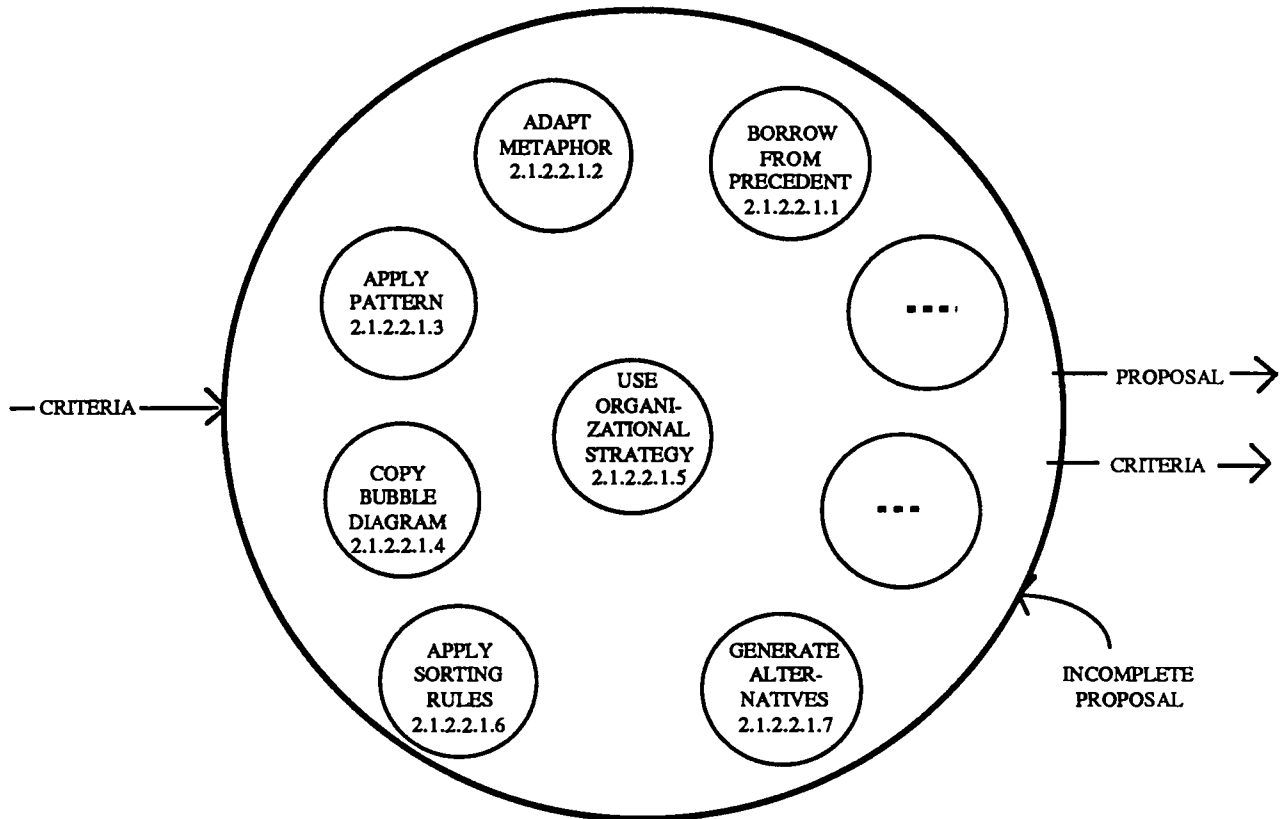
TRANSLATE CRITERIA INTO FORM 2.1.2.2.1

Figure 4.1-7

This data flow diagram shows criteria input to each of the processes that a designer might employ to make a physical solution to the design problem. The output in each case is a formal (i.e., physical) design proposal. Manual tools used in the above diagram are detailed in the appendix.

EXAMPLE: A bubble diagram resulting from the previous data flow diagram may be joined with any of the above translation techniques. For example, it could be directly copied if the relational diagram was a good starting point for an actual floor plan. (It is important to remind the reader that a bubble diagram is itself an expression of relationships not a floor plan. In some occasions, it can be used as a basis for a floor plan if spaces are close to a desired physical location.)

DATA DICTIONARY:
PROPOSAL (See Data Dictionary for Figure 4.1-1)
CRITERIA (See Data Dictionary for Figure 4.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 4.1-1)

5.0   CONCEPTUAL DESIGN SUBDOMAIN MODEL: EVALUATE

The diagrams and data dictionary that follow in this section describe the design process in terms of data flows, processes, and definitions. One process, EVALUATE 2.2, is resolved further in this section. This process serves as an evaluation tool that assesses the design proposal relative to design goal statements. The diagrams step through the process of evaluating a formal (i.e., physical) design proposal generated in the previous data flow diagrams from an initial idea.

Figures 5.1-1 through 5.1-7 represent a general design process model for evaluation procedures. To demonstrate how the model is inclusive of particular evaluation procedure, an example based on net building energy load is given in the captions below each figure indicated by the word EXAMPLE. Relevant parts of the data dictionary follow the caption. The part of the definition pertinent to the energy load example is indicated by **bold face**.

Because net building energy load calculations are fundamental to energy performance we have chosen this as our example evaluation procedure. This procedure has numerous input requirements and designers often do not consider details (such as U-value) in conceptual design. On the other hand, minimum requirements (such as building energy code in the U-value example) may be available and would serve as initial input. Thus, the implication for doing such an evaluation in conceptual design is that some input may need to be prompted for or automatically supplied by the procedure.

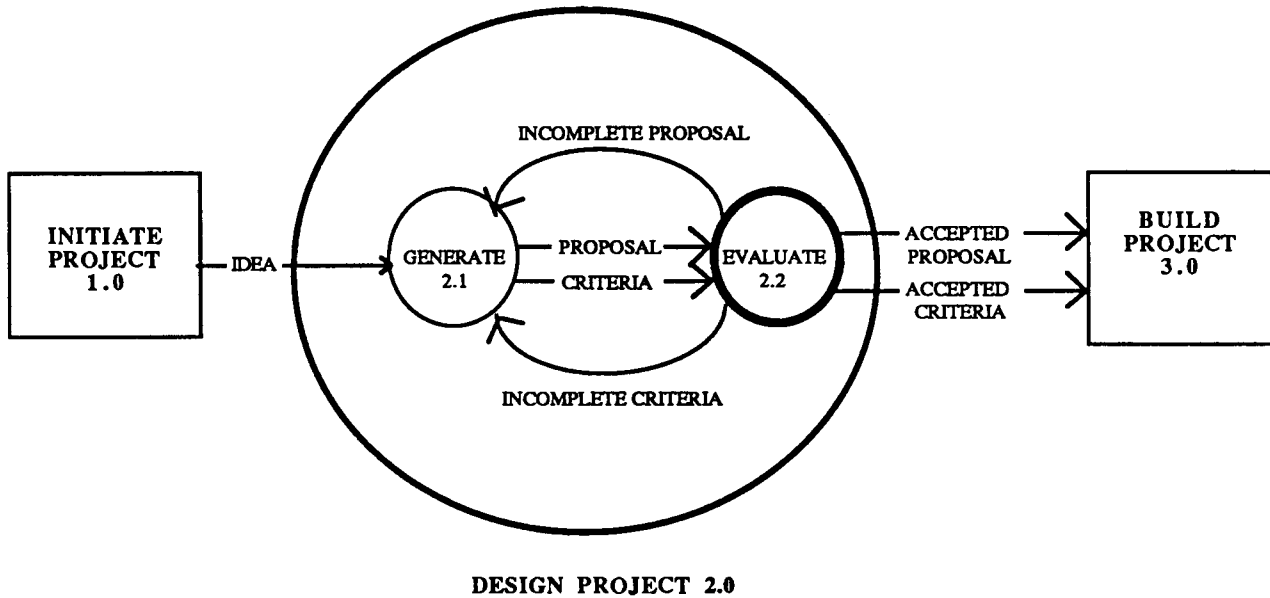## 5.1 Data Flow Diagrams: Evaluate

DESIGN PROJECT 2.0

Figure 5.1-1

Evaluate 2.2 is highlighted because this is the data flow we are following through the diagram in this section. This process receives a design proposal and criteria as input and returns either an accepted proposal and accepted criteria or a partially accepted proposal and partially accepted criteria.

EXAMPLE: For the purposes of an evaluation, a proposal is a *physical description* that provides the necessary inputs to do an evaluation. The criteria comes from one of several possible sources and is a goal statement regarding energy performance.

DATA DICTIONARY:
IDEA (See Data Dictionary for Figure 4.1-1)
PROPOSAL= * physical representation of a design proposal *
PROPOSAL = {PLAN} +
{SECTION} +
{ELEVATION} +
{CONSTRUCTION DETAILS} +
{SPECIFICATIONS} +
{3-D RENDERING} +
{MODEL}

CRITERIA = * design goals statement for evaluation of a proposal *
CRITERIA = {EXISTING CONDITIONS} +
            {USER-DEFINED PARAMETERS} +
            {DESIGNER INTUITION}

INCOMPLETE PROPOSAL= * partially approved proposal *
INCOMPLETE PROPOSAL = {INCOMPLETE PLAN} +
            {INCOMPLETE SECTION} +
            {INCOMPLETE ELEVATION} +
            {INCOMPLETE CONSTRUCTION DETAILS} +
            {INCOMPLETE SPECIFICATIONS} +
            {INCOMPLETE 3-D RENDERING} +
            {INCOMPLETE MODEL}

INCOMPLETE CRITERIA= * design goals statement insufficient for evaluation of proposal *
INCOMPLETE CRITERIA = {INCOMPLETE EXISTING CONDITIONS} +
            {INCOMPLETE USER-DEFINED PARAMETERS} +
            {INCOMPLETE DESIGNER INTUITION}

ACCEPTED PROPOSAL= * temporarily approved proposal *
ACCEPTED PROPOSAL = {ACCEPTED PLAN} +
            {ACCEPTED SECTION} +
            {ACCEPTED ELEVATION} +
            {ACCEPTED CONSTRUCTION DETAILS} +
            {ACCEPTED SPECIFICATIONS} +
            {ACCEPTED 3-D RENDERING} +
            {ACCEPTED MODEL}

ACCEPTED CRITERIA=   * temporarily achieved design goals *
ACCEPTED CRITERIA =   {ACCEPTED EXISTING CONDITIONS} +
            {ACCEPTED USER-DEFINED PARAMETERS} +
            {ACCEPTED DESIGNER INTUITION}

INCOMPLETE PROPOSAL

INTERMEDIATE
EVALUATION
RESULTS

IDEA → GENERATE 2.1

PROPOSAL
CRITERIA

APPLY RULES 2.2.1

PROPOSAL
CRITERIA

ASSESS QUALITIES 2.2.2

ACCEPTED PROPOSAL →
ACCEPTED CRITERIA →
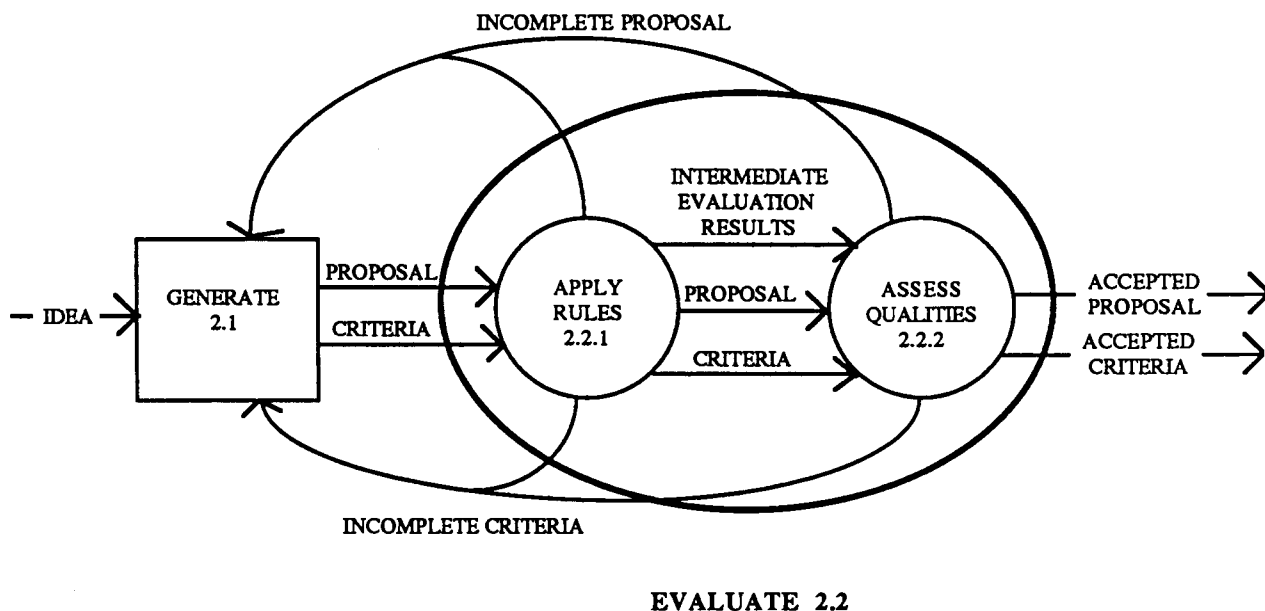
INCOMPLETE CRITERIA

EVALUATE 2.2

Figure 5.1-2

Evaluation procedures have two components: APPLY RULES and ASSESS QUALITIES. Each of these processes accept proposal and criteria as input for the evaluation process. APPLY RULES contains procedures to do the evaluation procedure. ASSESS QUALITIES contains procedures to interpret the results and determine a strategy.

EXAMPLE: In building energy load calculations, APPLY RULES contains the input requirements and formulas for the procedure. ASSESS QUALITIES compares results to energy standards or goals.

DATA DICTIONARY:
INTERMEDIATE EVALUATION RESULTS = * "raw" evaluation results *
IDEA (See Data Dictionary for Figure 4.1-1)
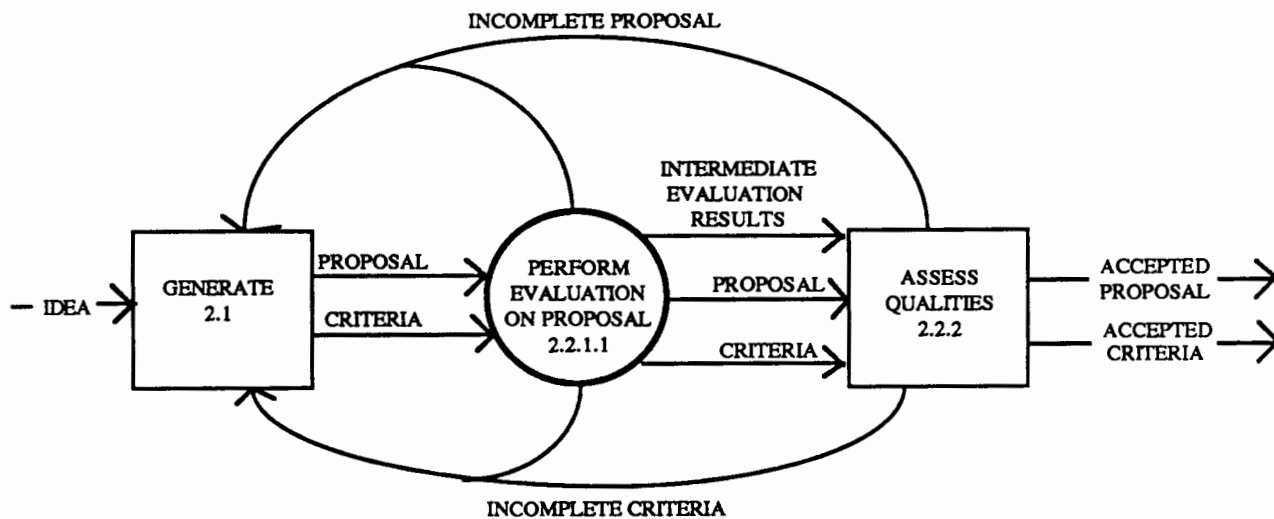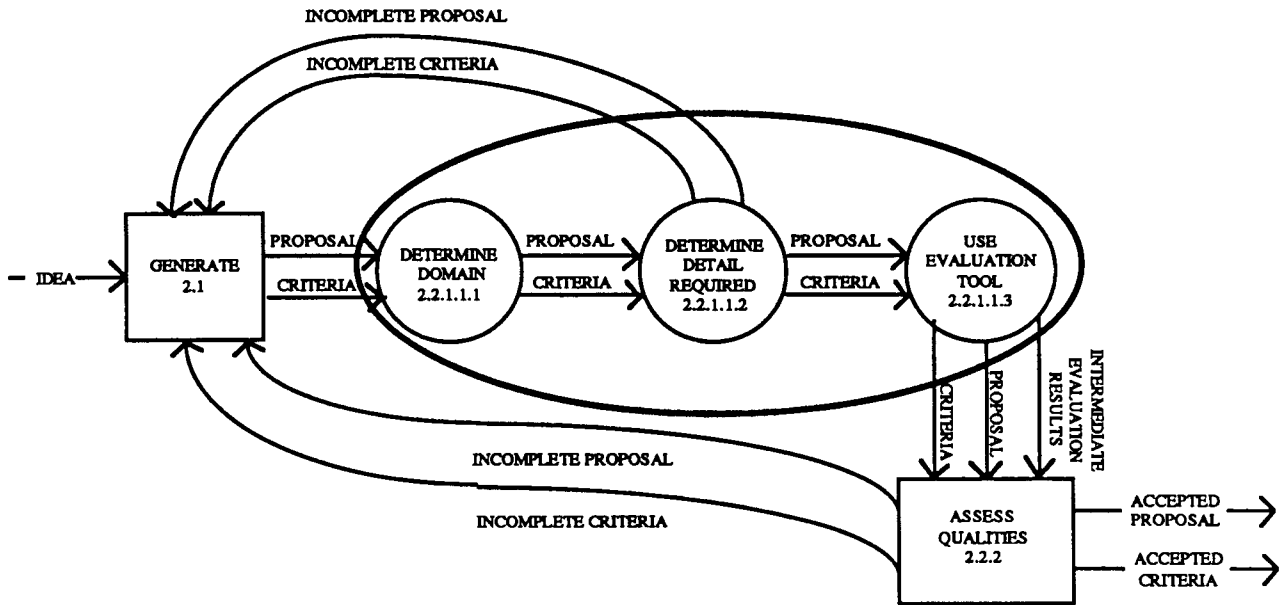PROPOSAL (See Data Dictionary for Figure 5.1-1)
CRITERIA (See Data Dictionary for Figure 5.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 5.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 5.1-1)
ACCEPTED PROPOSAL (See Data Dictionary for Figure 5.1-1)
ACCEPTED CRITERIA (See Data Dictionary for Figure 5.1-1)

APPLY RULES 2.2.1

Figure 5.1-3

Perform Evaluation on Proposal is the primary component of Apply Rules.

EXAMPLE: This is the step where an evaluation is actually done.

DATA DICTIONARY:

INTERMEDIATE EVALUATION RESULTS (See Data Dictionary for Figure 5.1-2)
IDEA (See Data Dictionary for Figure 4.1-1)
PROPOSAL (See Data Dictionary for Figure 5.1-1)
CRITERIA (See Data Dictionary for Figure 5.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 5.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 5.1-1)
ACCEPTED PROPOSAL (See Data Dictionary for Figure 5.1-1)
ACCEPTED CRITERIA (See Data Dictionary for Figure 5.1-1)

INCOMPLETE PROPOSAL

INCOMPLETE CRITERIA

IDEA

GENERATE
2.1

PROPOSAL

CRITERIA

DETERMINE
DOMAIN
2.2.1.1.1

PROPOSAL

CRITERIA

DETERMINE
DETAIL
REQUIRED
2.2.1.1.2

PROPOSAL

CRITERIA

USE
EVALUATION
TOOL
2.2.1.1.3

INCOMPLETE PROPOSAL

INCOMPLETE CRITERIA

CRITERIA

PROPOSAL

INTERMEDIATE
EVALUATION
RESULTS

ASSESS
QUALITIES
2.2.2

ACCEPTED
PROPOSAL

ACCEPTED
CRITERIA

PERFORM EVALUATION ON PROPOSAL 2.2.1.1

Figure 5.1-4

The three components of Perform Evaluation are shown here with their data flows. The criteria determines the evaluation domain. The evaluation domain together with the proposal and criteria determine the level of detail required. If insufficient detail is found, a return to generate occurs to gather the required input. Otherwise, the evaluation may proceed to doing the actual evaluation.

EXAMPLE: The domain for building energy load calculation is *energy*. This information would be contained in the criteria. The level of detail is checked by examining what the proposal contains compared to what is required to do the evaluation procedure. Therefore, incomplete input would be handled as an incomplete proposal or incomplete criteria.

DATA DICTIONARY:
INTERMEDIATE EVALUATION RESULTS (See Data Dictionary for Figure 5.1-2)
IDEA (See Data Dictionary for Figure 4.1-1)
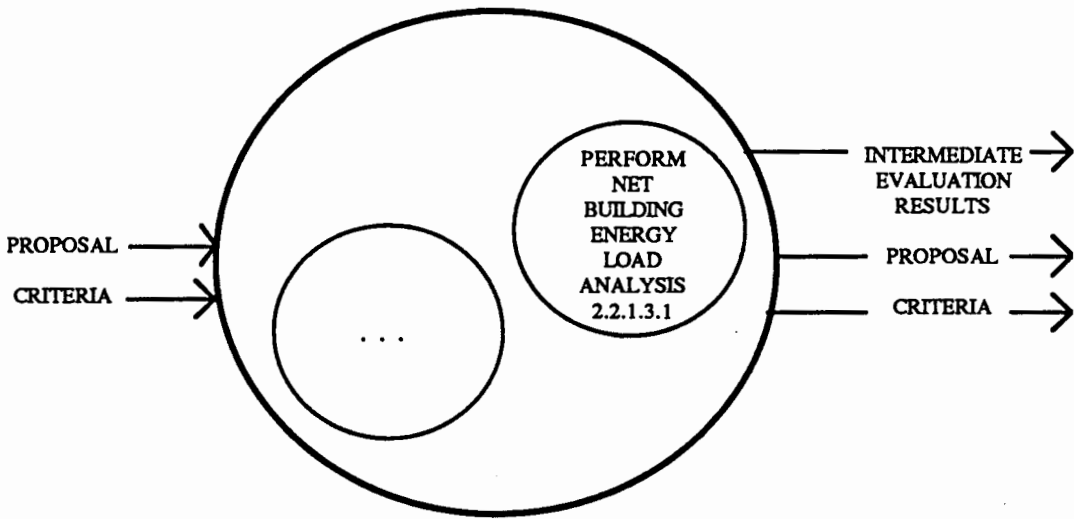PROPOSAL (See Data Dictionary for Figure 5.1-1)
CRITERIA (See Data Dictionary for Figure 5.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 5.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 5.1-1)
ACCEPTED PROPOSAL (See Data Dictionary for Figure 5.1-1)
ACCEPTED CRITERIA (See Data Dictionary for Figure 5.1-1)

USE EVALUATION TOOL 2.2.1.1.3

Figure 5.1-5

This is diagram is the generalization of a number of tools that may be used in an evaluation.

EXAMPLE: In our example, the evaluation tool is net building energy load calculation.

DATA DICTIONARY:

INTERMEDIATE EVALUATION RESULTS (See Data Dictionary for Figure 5.1-2)
IDEA (See Data Dictionary for Figure 4.1-1)
PROPOSAL (See Data Dictionary for Figure 5.1-1)
CRITERIA (See Data Dictionary for Figure 5.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 5.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 5.1-1)
ACCEPTED PROPOSAL (See Data Dictionary for Figure 5.1-1)
ACCEPTED CRITERIA (See Data Dictionary for Figure 5.1-1)

PERFORM NET BUILDING ENERGY
LOAD ANALYSIS
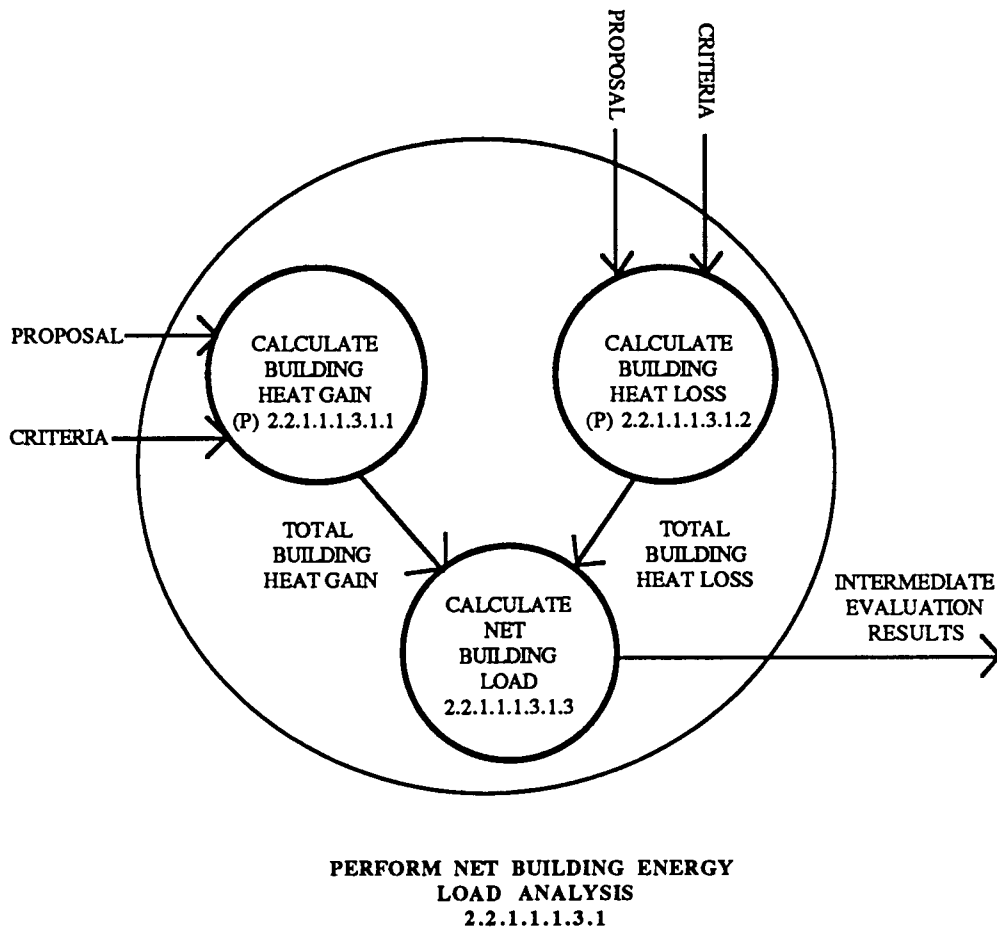**2.2.1.1.1.3.1**

Figure 5.1-6

This is the module that contains different evaluation procedures.

EXAMPLE: In our example, the evaluation procedure is energy load calculations. This calculation is a two step procedure consisting of calculating net gains and net losses.

DATA DICTIONARY:

INTERMEDIATE EVALUATION RESULTS (Complete definition, see Figure 5.1-2)
(EXAMPLE) INTERMEDIATE EVALUATION RESULTS = * net building energy load *
PROPOSAL (Complete definition, see Figure 5.1-1)

PROPOSAL for the net building energy loads example consists of a subset of the complete definition. The exact requirements to do this evaluation are listed below. This definition is used to determine if sufficient information is available to do the evaluation or if the proposal is incomplete. Similarly, a definition for CRITERIA follows for the net building energy loads example.

(EXAMPLE) PROPOSAL = TOTAL BUILDING FLOOR AREA +
                    BUILDING PERIMETER +
                    1{WINDOW AREA}+
                    1{WALL AREA} +
                    1 {ROOF AREA} +
                    1{SHADING DEVICES} +
                    1{SURFACE TILT} +
                    1{ELECTRIC LAMP} +
                    1{EQUIPMENT}

CRITERIA (Complete definition, see Figure 5.1-1)
(EXAMPLE) CRITERIA = 1{OCCUPANCY} +
                    1{ACTIVITY} +
                    1{PERSONS/SQ.FT OCCUPANCY} +
                    1{OCCUPANCY FLOOR AREA} +
                    1{U-WINDOW} +
                    1{U-WALLS} +
                    1{U-ROOF} +
                    CLIMATE CITY

The following definitions are of data that appears in the definitions for this process. This is a partial list.

WINDOW AREA = * non-opaque area in square feet *
WALL AREA = * opaque area in square feet *
WALL LENGTH = * perimeter in lineal feet *
OCCUPANCY FLOOR AREA = * space allocated to that occupancy *
OCCUPANCY = * primary building use *
TOTAL BUILDING FLOOR AREA = * sum of floor area all floors *
BUILDING PERIMETER = * lineal feet of building footprint *
SURFACE TILT = * angle from horizontal plane of surface *
CLIMATE CITY = * location used for climate database *
ACTIVITIES = * user activities for determining sensible/latent heat gains *
LAMPS = * electric lamps for lighting for determining heat gains *
EQUIPMENT = * equipment in use for determining heat gains *

NET BUILDING LOAD =	TOTAL HEAT GAIN + TOTAL HEAT LOSS
TOTAL HEAT GAIN =	1 {INTERNAL HEAT GAIN} + 1 {SOLAR GAIN GLAZING} + 1 {CONDUCTION GAIN} + 1 {VENT/INFILTRATION GAIN}
TOTAL HEAT LOSS =	1 {CONDUCTION LOSS} + 1 {VENT/INFILTRATION LOSS}

INTERNAL HEAT GAIN =   1 {HEAT GAIN FROM PEOPLE} +
                       1 {HEAT GAIN FROM LIGHTS} +
                       1 {HEAT GAIN FROM EQUIPMENT}

SOLAR GAIN GLAZING = 1 {GLAZING CHARACTERISTICS} +
                     1 {SHADING CHARACTERISTICS} +
                     1 {SOLAR RADIATION THRU GLAZING}

CONDUCTION GAIN =   1{CONDUCTION GAIN FLOOR} +
                      1{CONDUCTION GAIN WALLS} +
                      1{CONDUCTION GAIN ROOF} +
                      1{CONDUCTION GAIN GLAZING}+
                      1{CONDUCTION GAIN MASS}

VENT/INFILTRATION GAIN =   TOTAL BUILDING FLOOR AREA +
                             DELTA (T)+
                             V/I VALUE

CONDUCTION LOSS=   1{CONDUCTION LOSS FLOOR} +
                      1{CONDUCTION LOSS WALLS} +
                      1{CONDUCTION LOSS ROOF} +
                      1{CONDUCTION LOSS GLAZING}+   ′
                      1{CONDUCTION LOSS MASS}

VENT/INFILTRATION LOSS=   TOTAL BUILDING FLOOR AREA +
                             DELTA (T)+
                             V/I VALUE

HEAT GAIN FROM PEOPLE =   1 {OCCUPANCY FLOOR AREA} +
                             1 {PERSONS/SQ.FT FOR OCCUPANCY} +
                             1 {ACTIVITY SENSIBLE/LATENT GAINS}

HEAT GAIN FROM LIGHTS =   1{LAMP GAINS} +
                             1 {OCCUPANCY FLOOR AREA}
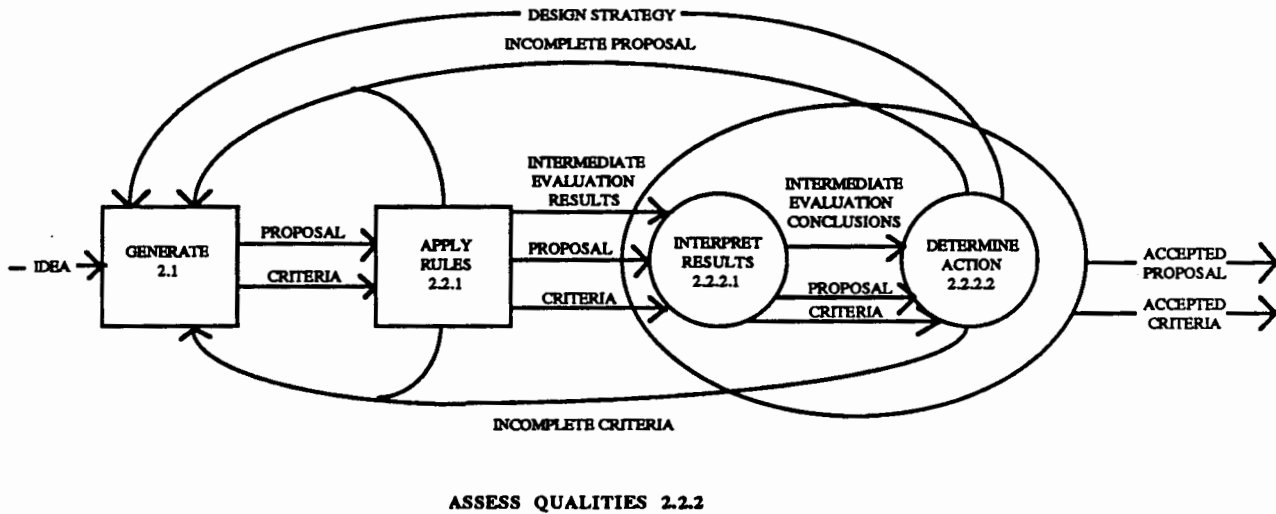
ASSESS QUALITIES 2.2.2

Figure 5.1-7

In the second half of the evaluation procedure, evaluation results are interpreted and the appropriate action determined. Either a design strategy (and the incomplete proposal) is returned to regenerating a design proposal or the proposal is accepted.

EXAMPLE: The result in this case is the net building energy load. The interpretation of this number is that if it is greater than zero we have a net gain. If it is less than zero we have a net loss. There are numerous predetermined design strategies that could be suggested at this point to assist the designer.

DATA DICTIONARY:
INTERMEDIATE EVALUATION CONCLUSIONS = * evaluation assessment *
DESIGN STRATEGY = * strategy that can be implemented to improve design proposal *
INTERMEDIATE EVALUATION RESULTS (See Data Dictionary for Figure 5.1-2)
IDEA (See Data Dictionary for Figure 4.1-1)
PROPOSAL (See Data Dictionary for Figure 5.1-1)
CRITERIA (See Data Dictionary for Figure 5.1-1)
INCOMPLETE PROPOSAL (See Data Dictionary for Figure 5.1-1)
INCOMPLETE CRITERIA (See Data Dictionary for Figure 5.1-1)
ACCEPTED PROPOSAL (See Data Dictionary for Figure 5.1-1)
ACCEPTED CRITERIA (See Data Dictionary for Figure 5.1-1)

6.0 ACKNOWLEDGEMENTS

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8.0   APPENDIX

MANUAL TOOLS FOR CONCEPTUAL DESIGN
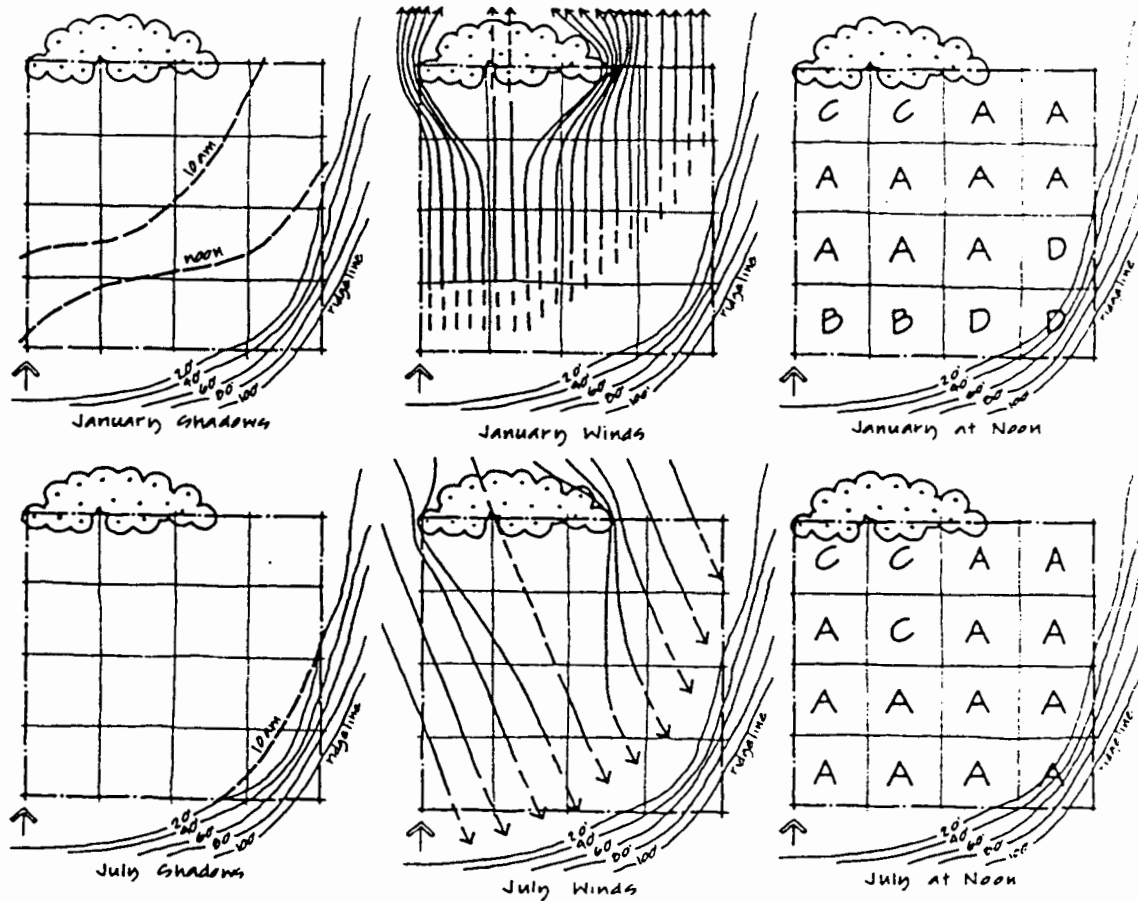
Figure A-1

Site Analysis

This tool combines information about the sun and wind conditions on the site. The designer plots shadows cast by the ridge in January and July and wind conditions imposed by the ridge and trees. Depending on the designer's criteria regarding whether to admit or block sun and wind the building location can be identified. (Brown, 1985, p. 29.)
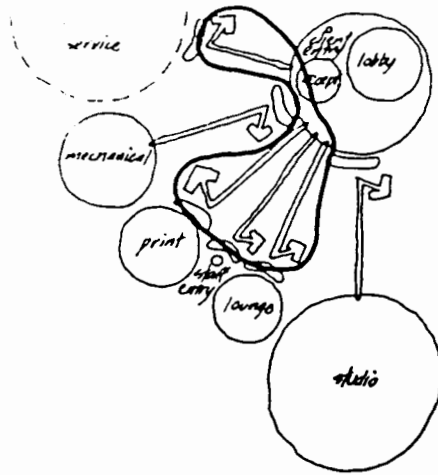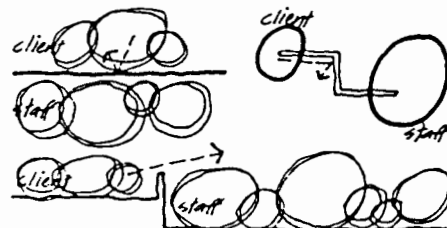
Figure A-2

Use Bubble Diagram to Generate Building Form

Bubble diagrams illustrate spatial relationships. For a given diagram, there are unlimited architectural expressions of the relationships contained within. In the above example, the designer is focusing on minimizing visual connections between staff and the client. Four alternative architectural solutions are shown below the bubble diagram which achieve the desired effect. (White, 1986, p.143.)
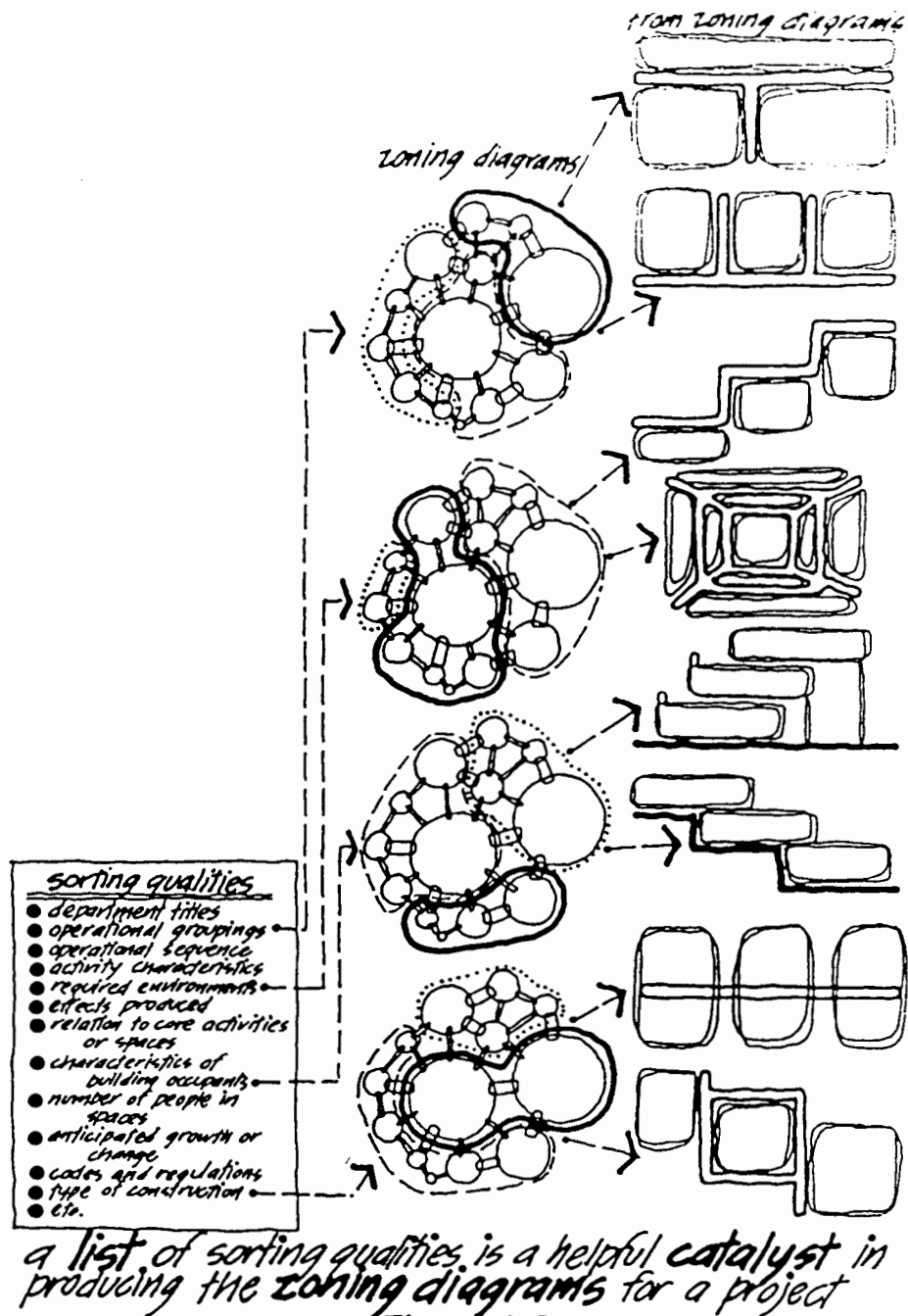
from zoning diagrams

zoning diagrams

sorting qualities
● department titles
● operational groupings
● operational sequence
● activity characteristics
● required environments
● effects produced
● relation to core activities
   or spaces
● characteristics of
   building occupants
● number of people in
   spaces
● anticipated growth or
   change
● codes and regulations
● type of construction
● etc.

a list of sorting qualities is a helpful catalyst in
producing the zoning diagrams for a project

Figure A-3

Apply Sorting Rules

Bubble diagrams illustrate spatial relationships. Bubble diagrams can be used as a basis for sorting
design criteria. In the above example, one diagram is sorted on several ways including on
operational groupings, required environments, characteristics of building occupants, and type
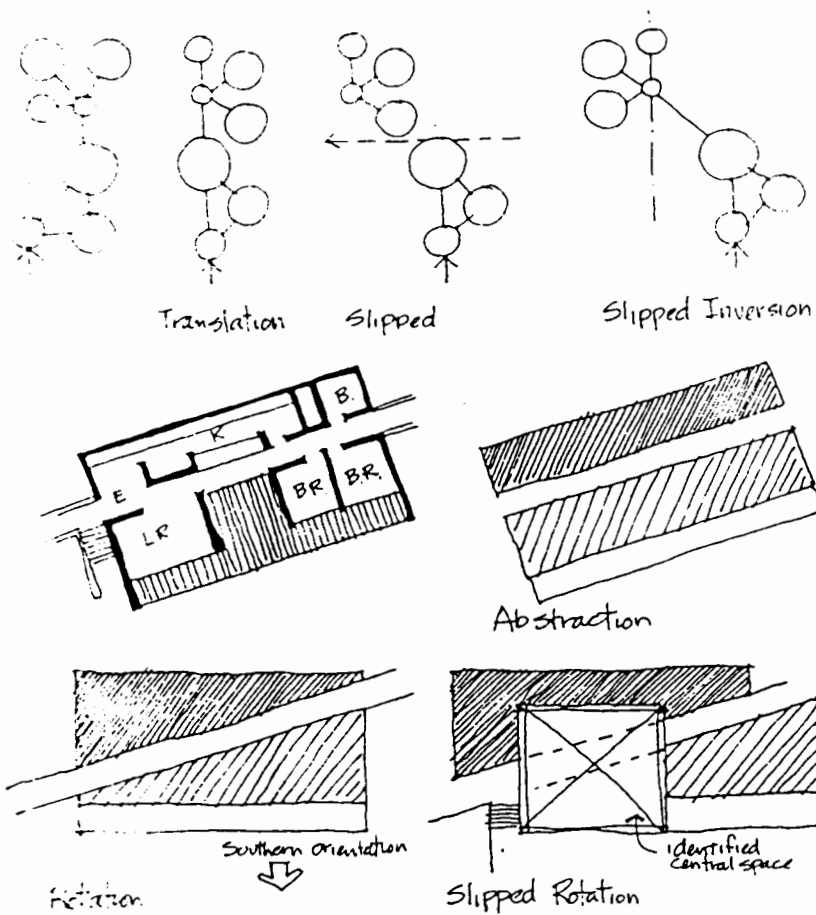construction. (White, 1986, p.106.)

Translation   Slipped   Slipped Inversion

Abstraction

Southern orientation

Rotation   Slipped Rotation   identified Central space

Figure A-4

Copy Bubble Diagram

Bubble diagrams are used to create a plan or section organization of generalized spaces. They lack specific information, such as wall thickness and interior partitions, in order to concentrate on bigger decisions such as room layout. A bubble diagram expresses relationships which may be translated literally into a floor plan or may be interpreted. (Laseau, 1980, p.100.)
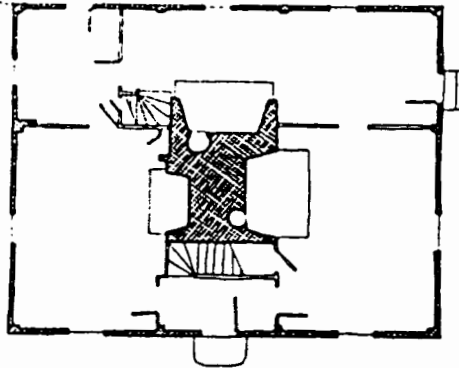
Old Ogden House   Fairfield, Conn.
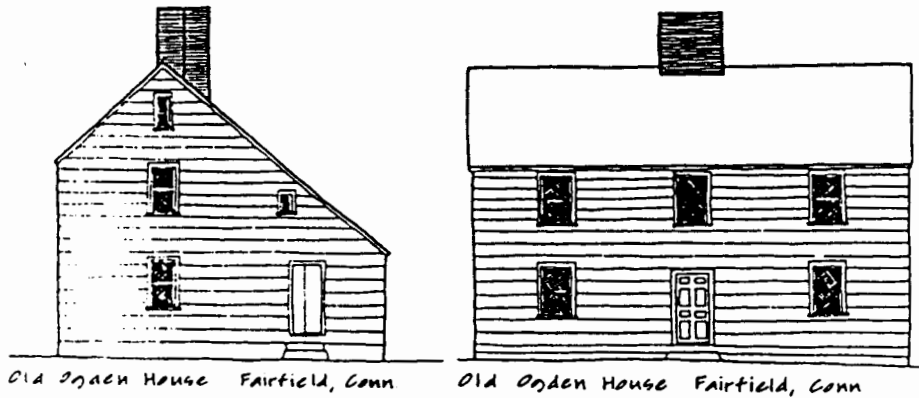
Old Ogden House   Fairfield, Conn   Old Ogden House   Fairfield, Conn

Figure A-5

Borrow from Precedent

A designer may draw from past examples in order to establish similar principles. The precedent
may be used in a literal way such that a physical aspect is "copied". Or, a principle may be
abstracted from a precedent and reinterpreted by the designer. In the above example, traditional
New England Salt Box houses provided minimal skin area (compact room organization) as a
strategy for reducing heat loss in a cold climate. Designers might borrow from this idea when
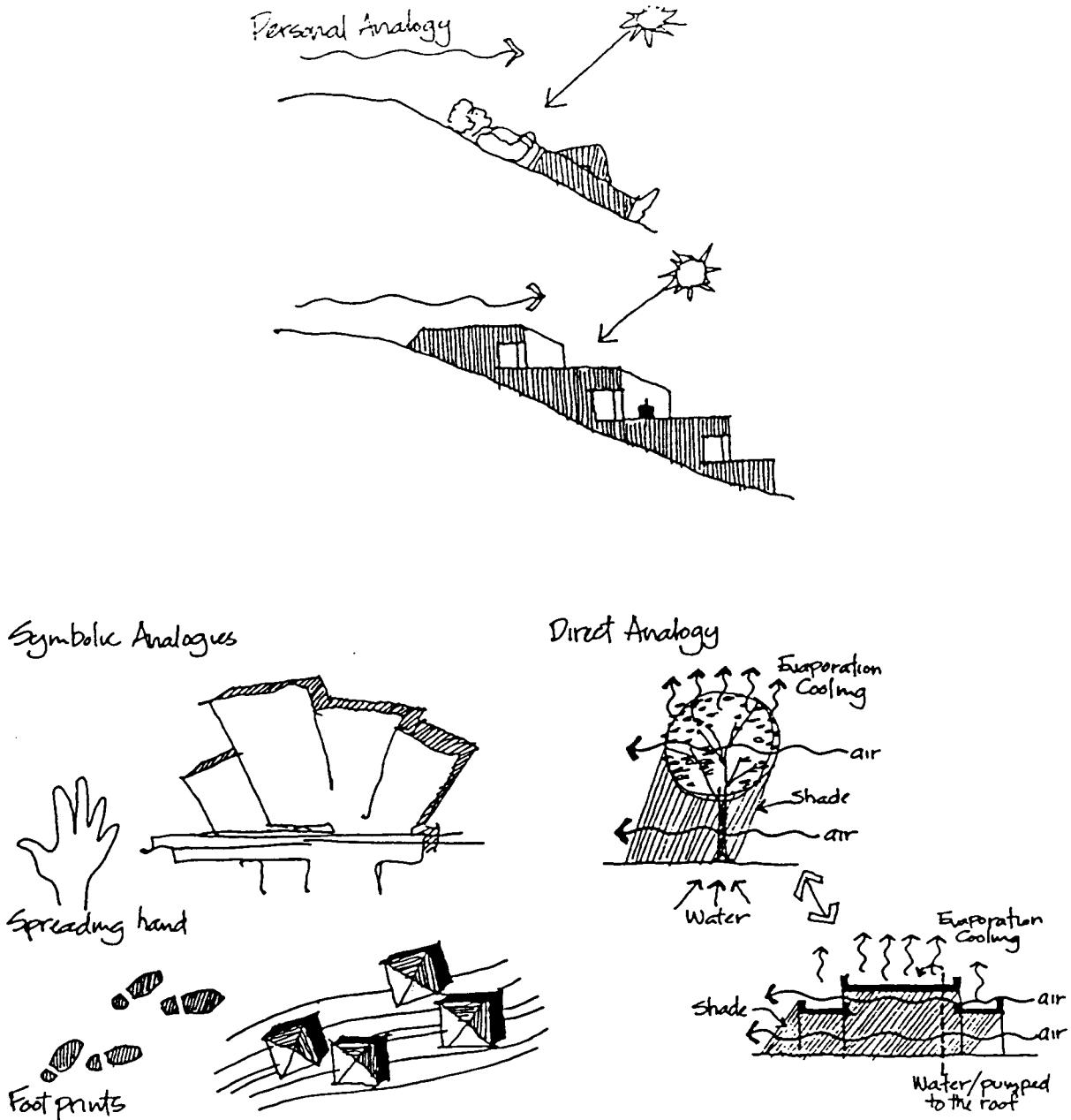designing in a similar climate. (Brown, 1985, p. 106.)

Personal Analogy

Symbolic Analogues

Spreading hand

Foot prints

Direct Analogy

Evaporation Cooling

air

Shade

air

Water

Evaporation Cooling

Shade

air

air

Water/pumped to the roof

Figure A-6

Adapt Metaphor

A designer may draw from past examples in order to establish similar principles. The precedent may be used in a literal way such that a physical aspect is "copied". Or, a principle may be abstracted from a precedent and reinterpreted by the designer. (Laseau, 1980, p. 119-120.)

But of course, no matter how clever we are with the plan, no matter how carefully we convolute the building edge, sometimes it is just impossible. In these cases, the rooms can get the effect of light on two sides under two conditions. They can get it, if the room is very shallow—not more than about eight feet deep—with at least two windows side by side. The light bounces off the back wall, and bounces sideways between the two windows, so that the light still has the glare-free character of light on two sides.

And finally, if a room simply has to be more than eight feet deep, but cannot have light from two sides—then the problem can be solved by making the ceiling very high, by painting the walls very white, and by putting great high windows in the wall, set into very deep reveals, deep enough to offset the glare. Elizabethan dining halls and living rooms in Georgian mansions were often built like this. Remember, though, that it is very hard to make it work.

Therefore:

Locate each room so that it has outdoor space outside it on at least two sides, and then place windows in these outdoor walls so that natural light falls into every room from more than one direction.
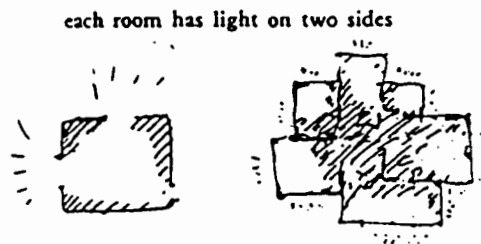
each room has light on two sides

Figure A-7

Apply Patterns

"Patterns" have been established as guidelines for "good" design. These patterns may have emerged from empirical observations (i.e., numbers of occurrences) or by human experience. A well noted example of patterns as a design process is the work of Chris Alexander, author of A Pattern Language. The example here demonstrates desirable lighting practice of light coming from two sides in every room. (Alexander, 1977, p. 750.)

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Figure A-8

Generate Alternatives

Investigation of a design problem may include generating alternatives based on permutations and combinations of a few program elements. This technique is a useful exploration device that may produce alternatives that a designer has not considered previously. In this example from Moore, Allen, and Lyndon's book Place of Houses, alternative organizations are given for the order of machines with "rooms around, within rooms, outside rooms, and between rooms". (Laseau, 1980, p. 128.)
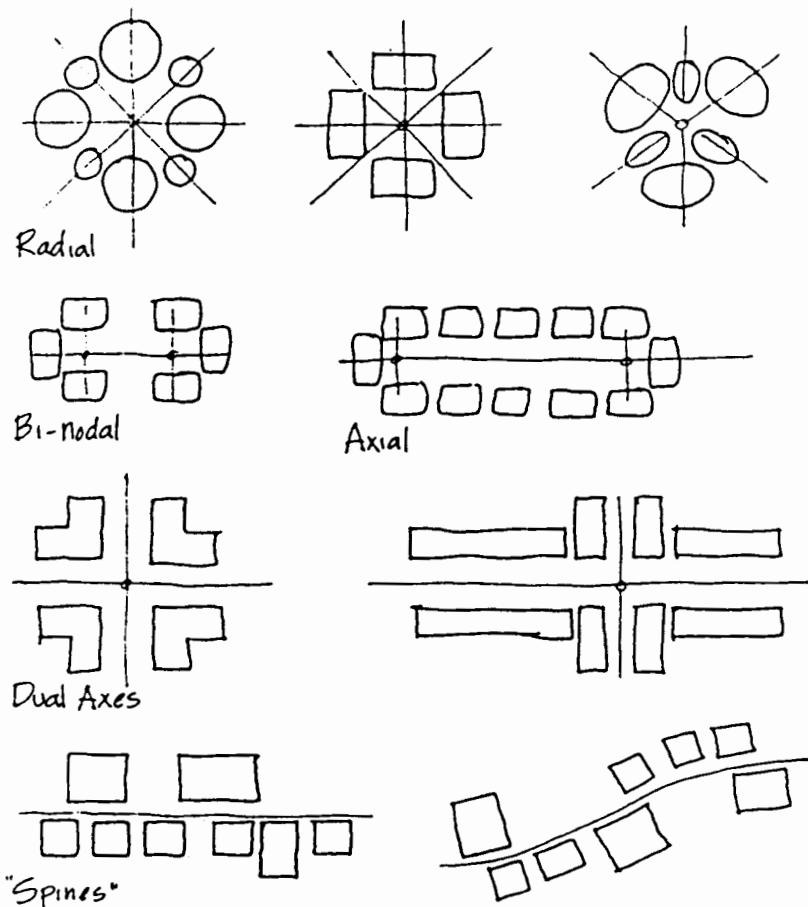
Radial

Bi-nodal   Axial

Dual Axes

"Spines"

Figure A-9

Use Organizational Strategy

Designers use geometric or organizational strategies for exploring spatial arrangements. These include transformations (reflections, rotations, inversions, etc.) and applications of clear organizational strategies (radial, axial, and linear schemes). (Laseau, 1980, p. 108)
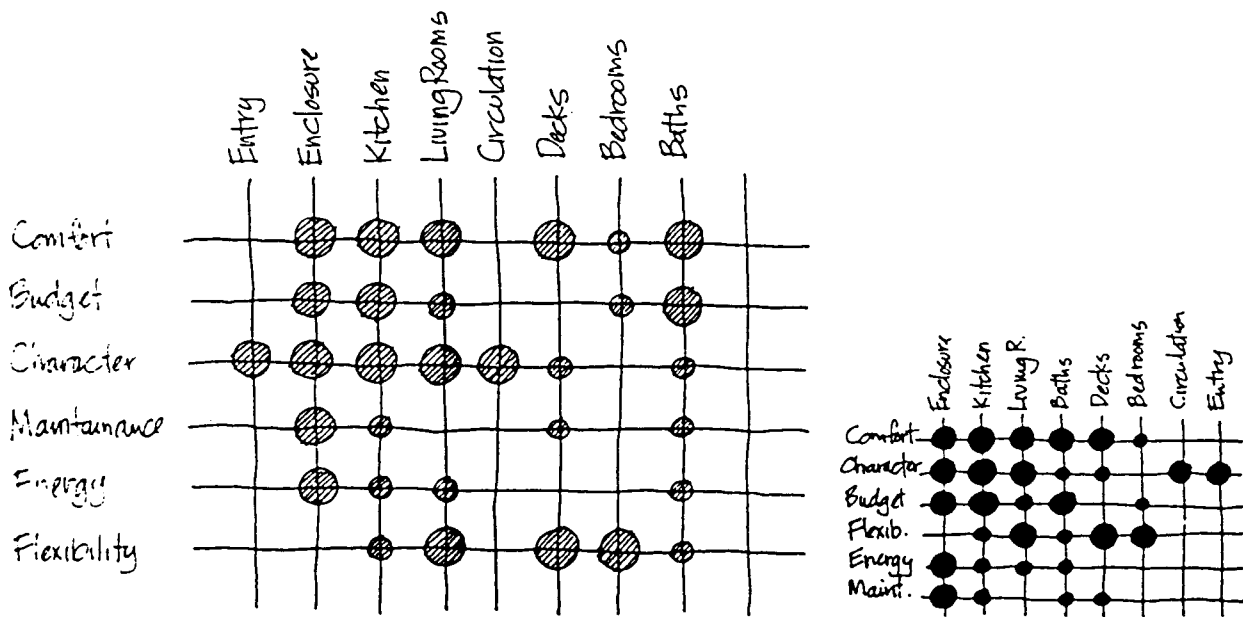
Figure A-10

Organize Priorities using Matrix

Designers sort, prioritize, and rearrange design criteria based on a number of different issues. The matrix above is used to present several categories of design issues (rows) relative to rooms. (Laseau, 1980, p. 72.)