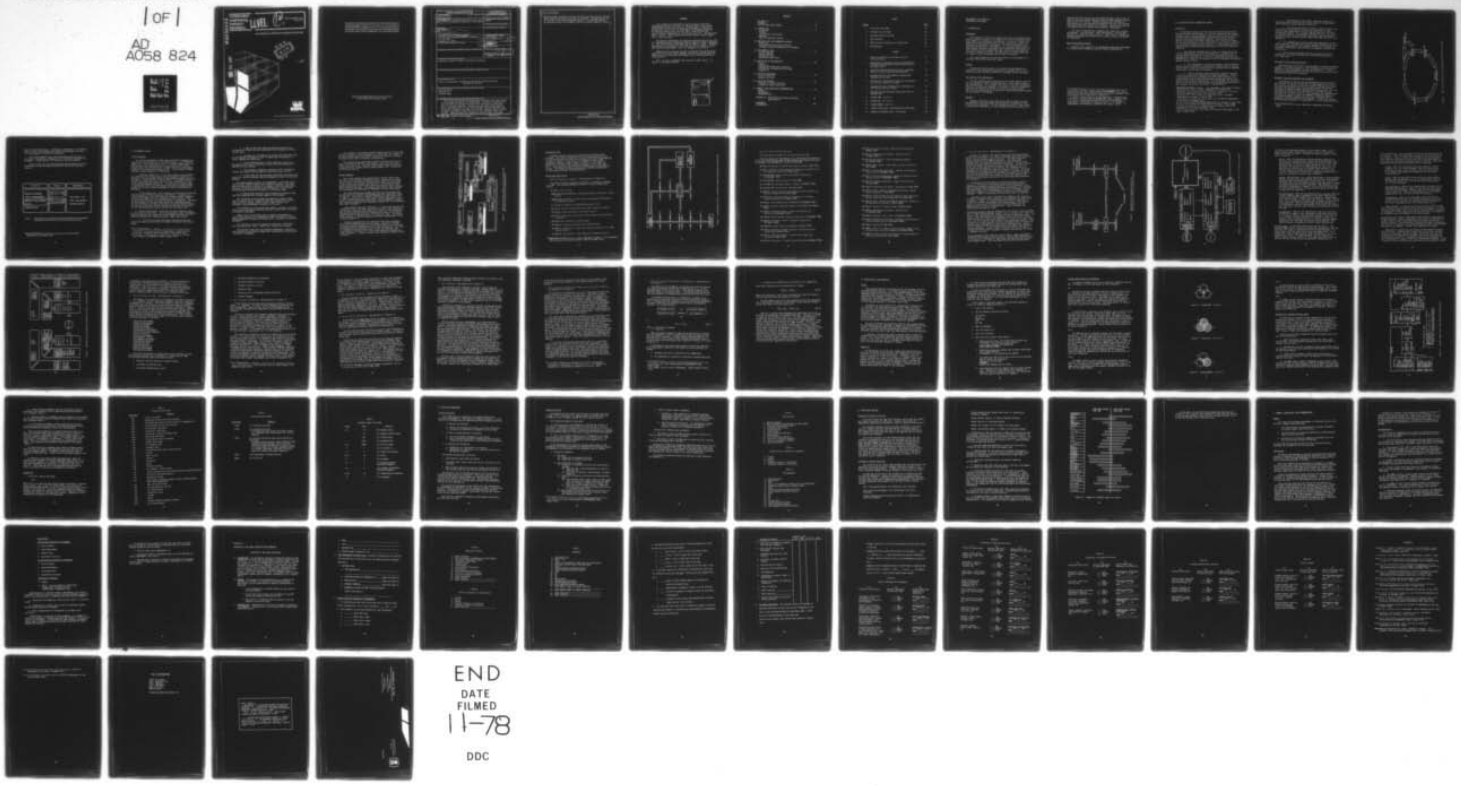
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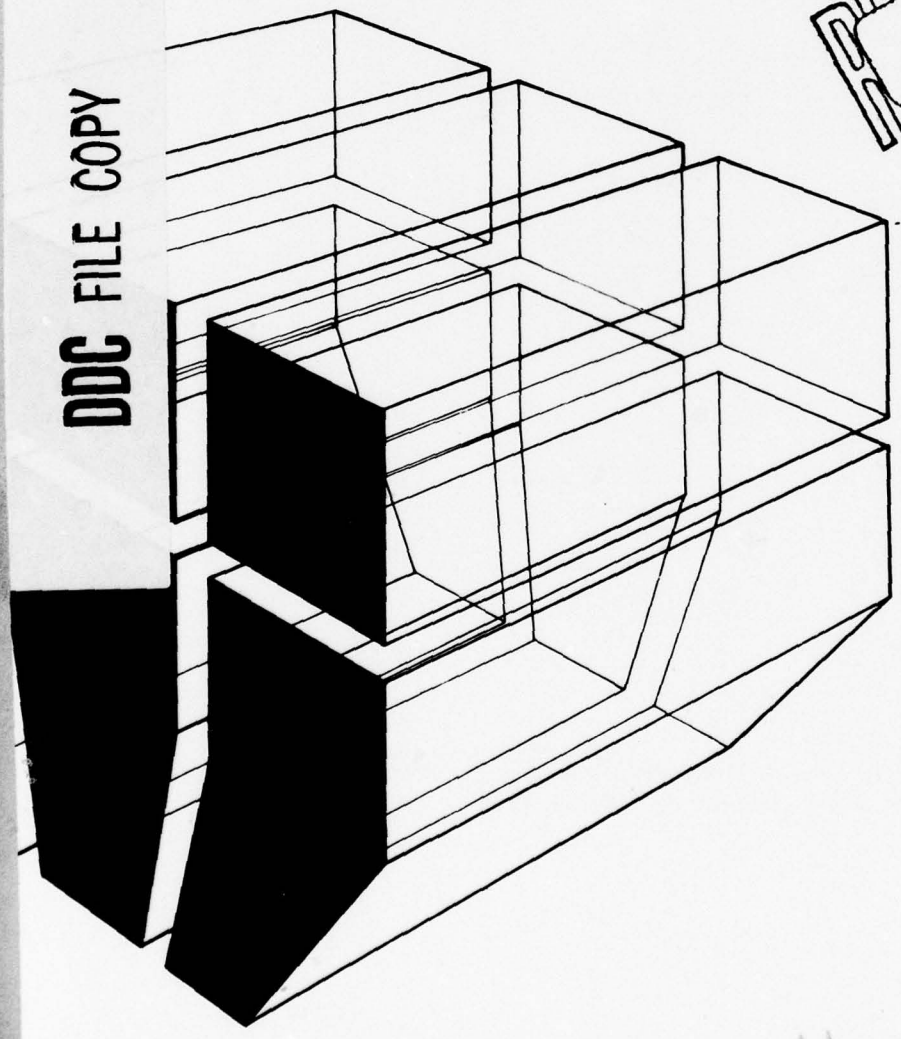
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1. REPORT NUMBER: CERL-SR-E-134	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: Special rept.	
4. TITLE (and Subtitle): DEVELOPMENT OF A PROTOTYPE HABITABILITY DATA BASE	5. TYPE OF REPORT & PERIOD COVERED: SPECIAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): A. Thomas Davis	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: CONSTRUCTION ENGINEERING RESEARCH LABORATORY, P.O. Box 4005, Champaign, IL 61820	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 4A762719AT03-01-001 / 01
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: August 1978
	13. NUMBER OF PAGES: 69
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service
Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

facility design
habitability
occupant needs

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report discusses the development, operation, and field testing of a prototype Habitability Data Base (HDB). The HDB is designed to be used for technical guidance in the Military Construction, Army (MCA) facility delivery processes. Occupant activity needs, space requirements, and habitability criteria are excerpted from Army documents and the general literature and coded into the HDB. Research data in support of needs, requirements, and criteria are also excerpted, coded, and entered. Retrieval codes are included to classify types of occupant, →

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occupant needs, occupant activities, facility settings, facility environments, Army facility type, and kinds of statement. Information can also be retrieved using natural language requests. The prototype HDB can be accessed on-line via telephone using any low-speed computer terminal.

FOREWORD

This research was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A762719AT03 "Architectural Research and Development in Support of Military Facilities"; Task 01, "Development of Automated Procedures for Military Construction"; Work Unit 001, "Identification and Classification of Human Needs in the Military Facility." The applicable QCR is 1.01.012. The OCE technical monitors were Mr. Richard Cramer and Mr. Robert Shibley.

The work was performed by the Energy and Habitability Division (EP), U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, IL. The CERL principal investigator was Dr. Roger L. Brauer. The major contributor to the progress of this work unit was Mr. Thomas A. Davis, CERL associate investigator. Mr. R. G. Donaghy is Chief of EP.

Appreciation is expressed to those individuals from installations, Corps District offices, major commands, and OCE who provided input and feedback during the prototype development and to those who made that input possible.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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DEVELOPMENT OF A PROTOTYPE
HABITABILITY DATA BASE

1 INTRODUCTION

Background

This research is part of an overall study that will develop procedures to generate, evaluate, and communicate criteria relating personnel requirements to architectural requirements. The overall research program will develop procedures which (1) identify physical, social, and psychological (personnel) requirements, (2) identify functional and technical (architectural) requirements, (3) accurately define relationships between personnel requirements and architectural requirements so that criteria can be developed from them, and (4) provide a means for collecting, analyzing, storing, and retrieving such relationship data to support criteria development and habitability research.

This report addresses the fourth procedure--the development of a prototype "Habitability Data Base" (HDB).

Purpose

The purpose of this report is to describe the development and evaluation of an information processing tool (the HDB) that is an information system from which habitability statements can be retrieved.

Description of the HDB System

The HDB system provides information on low-speed computer terminals that are operable through telephone receivers. It has been designed for three purposes: (1) to support the Office of the Chief of Engineers (OCE) facility delivery processes, (2) to build a store of information from which to formulate an objective definition of occupant/built facility interaction, and (3) to define the relationship between occupant and architectural requirements.

Approach

Research literature to be stored in the HDB was coded, analyzed, and compared to the requirements for habitability information as outlined by three objectives: (1) the information must be a single source of habitability information; (2) the information must be usable by all

types of Military Construction, Army (MCA) personnel; and (3) the information must be oriented toward provision of Army personnel requirements in built facilities. Problems concerned with information, information users, and information storage and retrieval were defined, with appropriate modifications to the system. Finally the system was field-tested twice to identify and incorporate improvements.

Four kinds of habitability statements were identified, studied, and reported: activity needs[1], space requirements[2], research data expressions[3], and habitability criteria.[4] Each kind of statement was analyzed intensively to ascertain its structure, content, and method of formulation.

Mode of Technology Transfer

Results of this study will be implemented through the development of an operational information analysis center on habitability.

[1]T. A. Davis, *Conceptualization of Habitability Expressions for the Habitability Data Base*, Interim Report D-68/ADA029661 (U.S. Army Construction Engineering Research Laboratory [CERL], September 1976).
[2]*Conceptualization of Habitability Expressions.*
[3]T. A. Davis, *Conceptualization for the Generation of Habitability Requirements*, Interim Report D-69/ADA030091 (CERL, September 1976).
[4]T. A. Davis, "Formulating Habitability Criteria from Research Information," *Programming for Habitability*, W. F. E. Preiser, ed. (Department of Architecture, University of Illinois, 1974).

2 HDB OBJECTIVES AND INFORMATION SOURCES

Objectives

The technical objective of the work unit under which the Habitability Data Base was developed is to collect information about human physical, social, and psychological needs and values, and to objectively define the relationship between Army personnel and the design of physical spaces and environmental features. Using the word "habitability" to represent the phrase "human physical, social, and psychological needs and values in built facilities," three specific objectives for collecting information were identified. It was hypothesized that completing these objectives would substantially fulfill the technical objective.

1. The collected information must serve as a single source for official Department of the Army (DA) habitability statements and for research data on habitability to assist OCE and field activities in performing four functions as set forth by a memorandum of record from DAEN-MCE-A (R. Cramer) on the subject of the 12-13 September Architectural Research Review at CERL:[5]

a. The development of planning and design criteria related to specific building categories and repetitive building types as defined in AR 415-28[6]; as well as military facility complexes such as community centers which are defined in TM 5-803-6.[7]

b. Corps of Engineers design procedures should be improved to relate to accumulated information on human requirements. This includes procedures used to develop and specify design criteria, and the procedures used to make design analyses and design reviews as discussed in the following publications: ER 1110-345-100[8], ER 1110-345-700[9], ER 1110-345-710[10], the TM 5-800 series (Engineering and Design for Real Property Facilities), AR 415-15[11], and AR 415-20.[12]

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[5]Memorandum of Record, Subject: 12-13 September, Architectural Research Review at CERL, from R. Cramer, DAEN-MCE-A, 15 October 1973.

[6]*Department of the Army Facility Classes and Construction Categories,* AR 415-28 (Department of the Army, 10 August 1973).

[7]*Installations: Site Planning of Community Centers,* TM 5-803-6 (Department of the Army, 11 April 1973).

[8]*Design Policy for Military Construction,* ER 1110-345-100 (Department of the Army, 14 December 1973).

[9]*Design Analysis,* ER-1110-345-700 (Department of the Army, 15 July 1975).

[10]*Drawings,* ER 1110-345-710 (Department of the Army, 18 April 1969).

[11]*Military Construction, Army (MCA) Program Development,* AR 415-15 (Department of the Army, 4 December 1975).

[12]*Project Development and Design Approval,* AR 415-20 (Department of the Army, 28 March 1974).

c. The demonstration of effects resulting from decisions made about design criteria at the various levels of the MCA review and the approval process defined in AR 415-15.

d. The further definition of specific research problems and priorities to improve design criteria for the various military facility types referenced in the Five-Year Defense Plan - Military Construction Program. This includes problems related to such issues as personnel retention, professional performance, personal growth, physical security, personal health, safety, and other quality-of-life indicators.

2. To accommodate the various professional backgrounds of the people involved in the MCA cycle, the collected information must serve as a generic paradigm for the systematic handling of information by interested professionals from all fields of endeavor concerned with habitability.

3. The collected information must be structured toward the formulation of an objective definition of Army personnel needs in built facilities.

The Corps Facility Delivery Process

When delivering facilities for DA occupancy, the Corps of Engineers engages in five major activities: master planning, construction programming, project development, design, and construction. Figure 1 depicts the interrelationships of these activities as a cycle of events beginning and ending with "occupancy."

Documents Containing Habitability Statements

Documentation of the policies and procedures which structure the facility delivery process for MCA and the requirements and criteria which specify the facility to be built, contain sentences which state the known, the believed-to-be, the desirable, and/or the expected relationships between occupants and the proposed facilities. All such statements are descriptive of "habitability." Although the word "habitability" may never occur in a given document, all documents which were found to contain a significant number of statements about the relationships between occupants and facilities have been labeled "documents containing habitability statements." Three kinds of documents have been identified: (1) DOD 4270.1,[13] (2) the DA Design Guides,

[13] *Construction Criteria Manual*, DOD 4270.1 (Department of Defense, 1968).

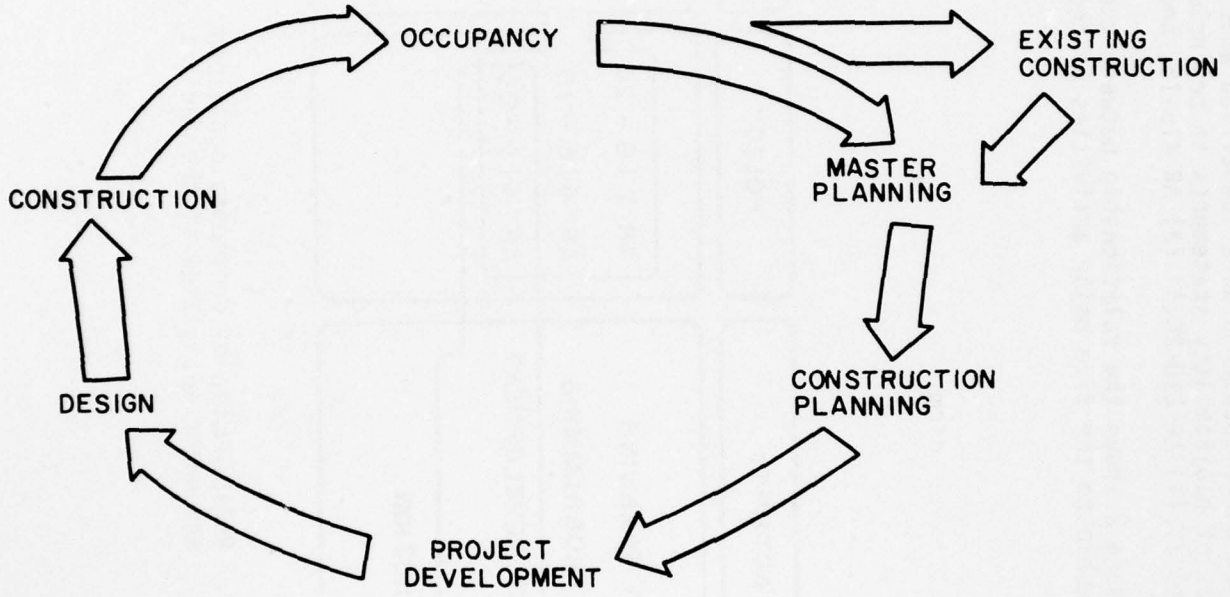


Figure 1. Cycle of activities in the Corps facility delivery process.

and (3) the TM 5-800 series. Habitability information is occasionally found in other policy guidance, but these three documents are specifically designed to include such information.

Three other documents were identified which establish policy on the types of habitability statements to be included in "habitability documents": (1) AR 210-20,[14] (2) AR 415-15, and (3) AR 415-20.

Figure 2 shows the relationship between these documents and their relationship to the five major activities of the facility delivery process.

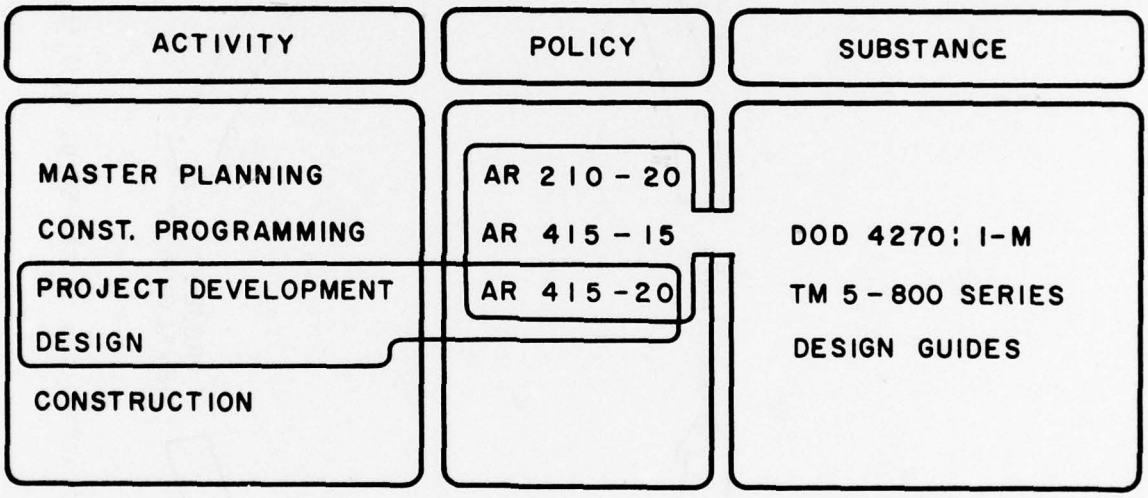


Figure 2. Relationship of documents containing habitability statements and major activities of the facility delivery process.

[14] *Master Planning for Permanent Army Installations*, AR 210-20 (Department of the Army, 1972).

3 DEVELOPMENT OF HDB

Initial Approach

The initial development of HDB, begun during FY73, produced four outputs which were helpful to the on-going research: (1) Preliminary Report D-4,[15] (2) Interim Report D-41,[16] (3) Second Summary Report of Work by the Library Research Center of the University of Illinois (unpublished), and (4) comments of reviewers during the Second Annual Review of the architectural program at CERL. The principal findings reported in each document are listed below.

1. Preliminary Report D-4. This report suggests using relationship sentences for storing research data valuable to researchers or designers. The relationship would be shown between occupant activities and physical characteristics of the facilities. Contextual information also describes user group, facility type, functional area, and social and governmental constraints. The concept of occupant "needs" is abandoned as unrealistic both because they cannot be measured and because of the lack of general agreement on their classification or definition.

2. Interim Report D-41. This discusses current means of assessing, organizing, and storing architectural information. The report provides alternatives to the "CERL Relational Sentence System" suggested in Preliminary Report D-4, and recommends two pilot studies of the sentence using CERL data first and then general research data. Questions are raised about (1) the cost-effectiveness of an automated system, (2) the contribution the CERL system would make toward standardization, (3) the use of available external services by CERL, and (4) the need for more detailed design criteria and specific performance data.

3. Second Summary Report of Work by the Library Research Center of the University of Illinois. The Library Research Center investigated questions posed by CERL concerning the development and operation of a proposed architectural information system. Major results were:

a. A list of 24 journals and seven indexing services was compiled to keep architects aware of research on behavior and physical design.

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[15] D. L. Dressel and R. L. Brauer, *Initial Report on Systematizing Information to Identify and Relate Behavioral and Physical Design Parameters*, Preliminary Report D-4/757627 (CERL, March 1973).

[16] N. D. Lane, *An Evaluation of Architectural Information Systems*, Interim Report D-41/ADA001616 (CERL, October 1974).

b. A need for more data about the potential users of the information was identified and a questionnaire was designed for obtaining user data.

c. The need for a preliminary set of key words about the field of environmental psychology in order to demonstrate the key-word-in-context approach was identified.

d. It was determined that a useful thesaurus could not be developed in the form of a hierarchy of terms for either behavioral or behavior-facility concepts.

e. The conceptual categories contained in the "relationship sentence" was found to be too vague for untrained persons to code.

f. It was found that the procedure of matching relationship sentences for retrieval purposes should be abandoned in favor of a key word approach.

The Library Research Center also recommended a system that would contain actual research results plus citation of sources. The system would be structured as a matrix of 10 columns of data and would have a thesaurus of key words developed from information as it was entered. The system would be based on ultimate user information needs.

4. The Second Annual Review of the architectural program at CERL, June 1973, generated the following comments from reviewers.

The information to be collected must generate a theory, rather than vice versa, and the information should be categorically specific about particular persons, groups, places, times, missions, etc. (Professor Claude Winkelhake, University of Illinois).

The information to be collected must contain a vocabulary of human needs and must be updated regularly (William M. Smith, Ph.D., University of Wisconsin, Green Bay).

"Needs" must be considered either as several physiological or psycho-social groups or as a compensatory model of clusters of environmental parameters (Professor Dan Carson, Ph.D., University of Wisconsin, Milwaukee).

The construct of "activity" might be sub-set into "constituent" and "non-constituent" (Paul V. Gump, Ph.D., University of Kansas).

The question of who uses the collected information is central to the problem of classification schemes (Mr. Guy Weinzapfel, Massachusetts Institute of Technology).

The syncretic relationships between occupant and facility were the essential elements of the information to be collected; user "needs" can be inferred from these relationships using factor analysis techniques (Professor Philip Thiel, University of Washington).

The information system should be based on building types or programs of concern to the Corps, then coded to items such as privacy, noise, odors, and so on. Citations and abstracts should be collected instead of actual research results (Robert Sommer, Ph.D., University of California, Davis).

Present Approach

The initial approach had concentrated on research data as the substance of the proposed information system. Based on the findings and criticisms of the initial approach and the objectives explicated in the review, a new approach was structured. New objectives added planning and design criteria that should be required, space requirements, and activity needs. The research data would be used to support the development and improvement of statements of these requirements.

The interrelationships between the three work units supporting the MCA cycle of activities and documentation were redefined as shown in Figure 3. This project, labeled "information system project 001," is shown to contain military construction criteria (generated in part by the "criteria formatting project 003"), man-environment statements from in-house research by the "measurement project 002," and information from other literature."

Three problem areas were identified: (1) those concerned with the information itself, (2) those concerned with users of the information, and (3) those concerned with storage and retrieval of the information. Information storage and retrieval problems were given to the Library Research Center of the University of Illinois for study. The Center's final design of a computer hardware and software configuration is described in Chapter 4.

Problems concerned with the information users were assigned to the Criteria Formatting work unit for study. Analysis of the MCA activities identified three kinds of locations where 12 functions are performed involving information from 17 kinds of documents. The kinds of information accessed during each of these functions were then ascertained by this work unit in the second evaluation procedure outlined in Chapter 5. Chapter 6 reports the information findings of this evaluation.

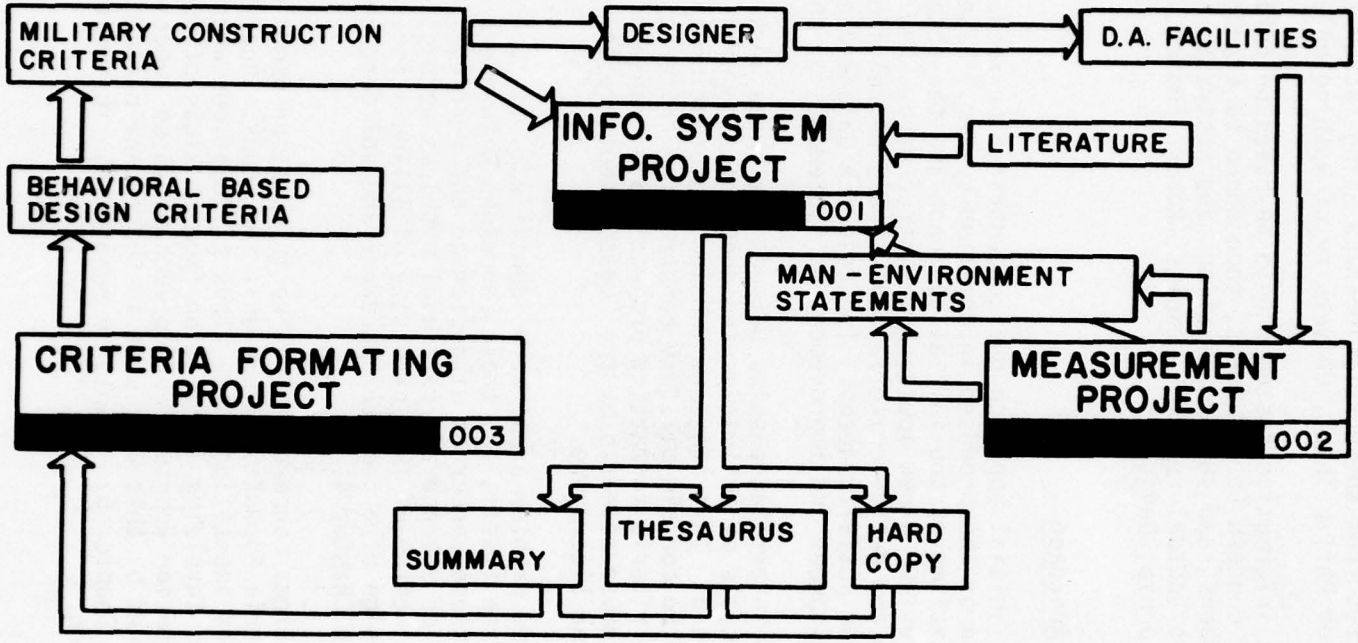


Figure 3. Interrelationships between work units supporting MCA cycle of activities and documentation.

Information Flow

Problems concerned with the information were studied by CERL personnel. The flow of information into the proposed data base from existing MCA documentation and from literature articles was hypothesized as shown in Figure 4. From there, the information flows to MCA operational documents (such as 1391's or PDB's), to the "objective definition," and back to MCA reference documents (such as AR's and TM's). Eight questions were defined as indicated by the interrogative phrases. The answers to these questions were assumed, hypothesized, or operationally defined as described below.

Operational Definitions

1. *Which MCA Reference Documents?* (See Question A in Figure 4.)

The topic of service schools was selected[17] to develop a prototype of an HDB. The following documents relevant to service schools were chosen:

AR 350-1, *Army Training*

TRADOC Requisition 350-100-1, *Systems Engineering of Training (Course Design)*

TRADOC Requisition 351-3, *TRADOC Schools Curriculum Administration and Training Policies*

MOS Technical Training of Equipment-Maintenance Clerk

AR 415-15, *Military Construction, Army (MCA) Program Development*

AR 415-20, *Project Development and Design Approval*

AR 415-28, *Department of the Army Facility Classes and Construction Categories*

DOD 4270.1-M, *Construction Criteria Manual*

TM 5-800-1, *Construction Criteria for Army Facilities*

TM 5-843-1, *Construction: Space and Planning Criteria for U.S. Army Service Schools*

TM 5-803-6, *Installations: Site Planning of Community Centers*

[17]Memorandum for Record from R. Cramer, DAEN-MCE-A, subject: 12-13 September 1973 Architectural Research Review at CERL (15 October 1973).

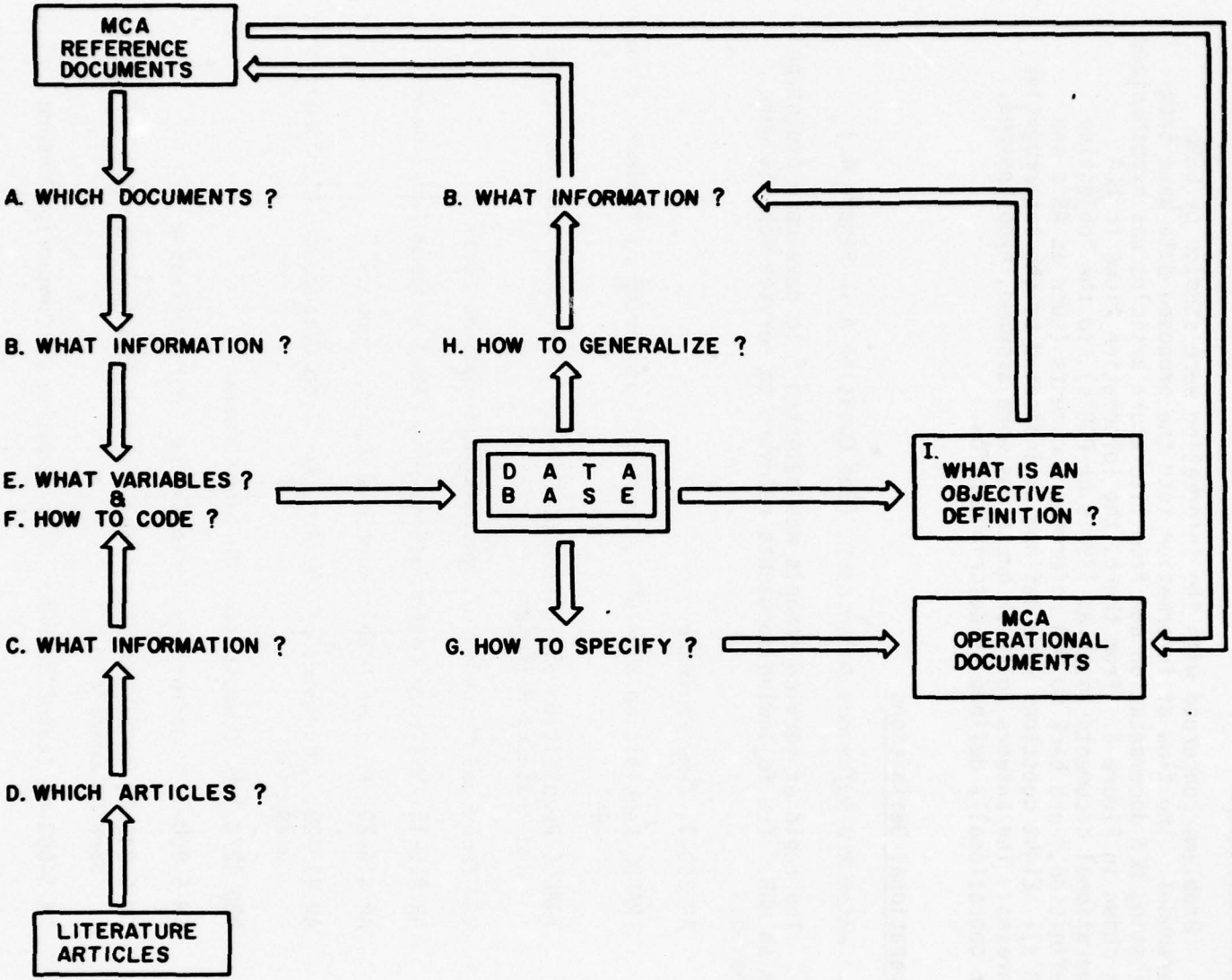


Figure 4. Hypothesized flow of information between MCA documents and the HDB.

Guide for Space Planning and Layout

The Army's Master Program for the Modern Volunteer Army

After the concept of "habitability" was formalized (see question 3, p 27), the following additional 35 MCA documents published by the Corps of Engineers were reviewed for inclusion in the HDB:

AR 415-2, *Department of Defense Construction Criteria* (June 1973).

AR 415-17, *Empirical Cost Estimates for Military Construction and Cost Adjustment Factors* (6 August 1973).

ER 1110-345-100, *Design Policy for Military Construction* (14 December 1973).

ER 1110-345-700, *Design Analyses* (1 June 1966).

ER 1110-345-710, *Drawings Changes 1 through 2* (18 April 1969).

ER 1110-345-720, *Specifications* (25 June 1973).

TM 5-800-2, *General Criteria: Preparation of Cost Estimates for Military Construction* (2 March 1959).

TM 5-805-10, *Building Construction Materials and Practices: Acoustical Treatment* (31 August 1965).

TM 5-809-1, *Load Assumption for Buildings* (27 September 1966).

TM 5-809-2, *Concrete Structural Design for Buildings* (25 January 1967).

TM 5-809-3, *Structural Design: Masonry Construction for Buildings* (30 September 1963).

TM 5-809-5, *Wood Structural Design for Buildings* (15 December 1966).

TM 5-809-9, *Structural Design: Thin-Shell Construction* (31 August 1965).

TM 5-809-10, *Seismic Design for Building* (17 April 1973).

TM 5-810-1, *Mechanical Design: Heating, Ventilating and Air Conditioning* (January 1956).

TM 5-811-1, *Electrical Design: Electric Power Supply and Distribution* (May 1953).

TM 5-811-2, *Electrical: Interior Electrical System* (December 1946).

TM 5-811-3, *Electrical Design, Lighting Protection System* (August 1954).

TM 5-811-4, *Engineering and Design: Corrosion Control* (1 August 1962).

TM 5-813-5, *Water Supply: Water Distribution Systems* (31 January 1963).

TM 5-813-6, *Water Supply: Water Supply for Fire Protection* (July 1958).

TM 5-814-1, *Engineering and Design: Sanitary and Industrial Waste Sewers* (1 September 1958).

TM 5-812-2, *Sanitary Engineering: Sewage and Industrial-Waste Pumping Stations* (1 September 1958).

TM 5-814-3, *Sanitary Engineering: Sewage Treatment Plants* (15 June 1959).

TM 5-814-4, *Engineering and Design: Incineration* (7 May 1959).

TM 5-822-1, *Roads, Streets, and Pavements Generally, Traffic Study Requirements* (1 May 1961).

TM 5-822-2, *General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas* (21 July 1961).

TM 5-822-3, *Roads, Streets and Pavements Generally, Parking for Nonorganizational Vehicles* (1 April 1963).

TM 5-830-1, *Planting: Planting Design* (20 March 1959).

TM 5-830-2, *Engineering and Design: Planting Turf* (31 October 1961).

TM 5-830-3, *Planting: Dust Control* (15 February 1960).

TM 5-830-4, *Engineering and Design: Planting and Maintenance of Trees and Shrubs and Vines* (20 March 1959).

TM 5-830-5, *Plumbing* (31 May 1972).

TM 5-809-4, *Structural Design, Structural Steel, Openweb Joists, and Light Gage Steel for Buildings* (15 October 1963).

TM 5-809-11, *Design Criteria for Facilities in Areas Subject to Typhoons and Hurricanes* (3 May 1966).

2. *What MCA Information?* (See Question B in Figure 4.)

Guidance in answering this question was taken from the technical objective of this report: "To collect information about human physical, social, and psychological needs and values....(as they relate to)..... physical spaces and environmental features." The single word "habitability" was selected to represent that phrase, and the total proposed system was named the Habitability Data Base. The word "habitability" was technically defined to refer to the degree of fit (i.e., the direction and strength of correlations, etc.) between built environments and the needs and values of occupant activities. Using the relationship to represent the word "habitability," habitability could then also be used meaningfully to describe the properties of occupants and built facilities which are related to the entire statement containing the relationship, and even to the entire data base containing the statements.

The definition of habitability excludes psychological, physiological, or sociological information about man-man relationships, engineering information about equipment-facility relationships, ergonomic information about equipment-occupant relationships, and locational information about facility-geography or facility-environments, except when such information can be considered contextual to a habitability statement. Figure 5 illustrates how these disciplines are separated.

Guidance on four types of habitability statements that should be included in the HDB was also included in the memorandum of record cited in question 1 above: (1) planning and design criteria (habitability criteria), (2) human requirements (space requirements (space requirements), (3) quality of life indicators (activity needs), and (4) demonstrations of effects (research data). These statements were operationally defined as follows.

Habitability Criteria describe properties of facilities (a room, building, etc.) or facility environments (spatial, sonic, luminous, etc.) that will fulfill space requirements for occupant stations in functional areas. For example, they could describe the equipment to be used plus the length, width, and height of space, the temperature of the air, the light levels, and so on, for a typist's work station in the room he/she occupies. Thus, habitability criteria describe facility environments that will house the combined space requirements of a particular functional area. Habitability criteria are the links between space requirements and design and contract documents. Figure 6 shows the typical flow of this kind of information from potential occupants to designs and contracts for a new or remodeled facility.

Space Requirements are stated for activity needs. Space requirements include a list of names of desired spaces, the desirable characteristics of the physical environments of each space, and the desirable relationships between spaces. Each requirement should answer two questions:

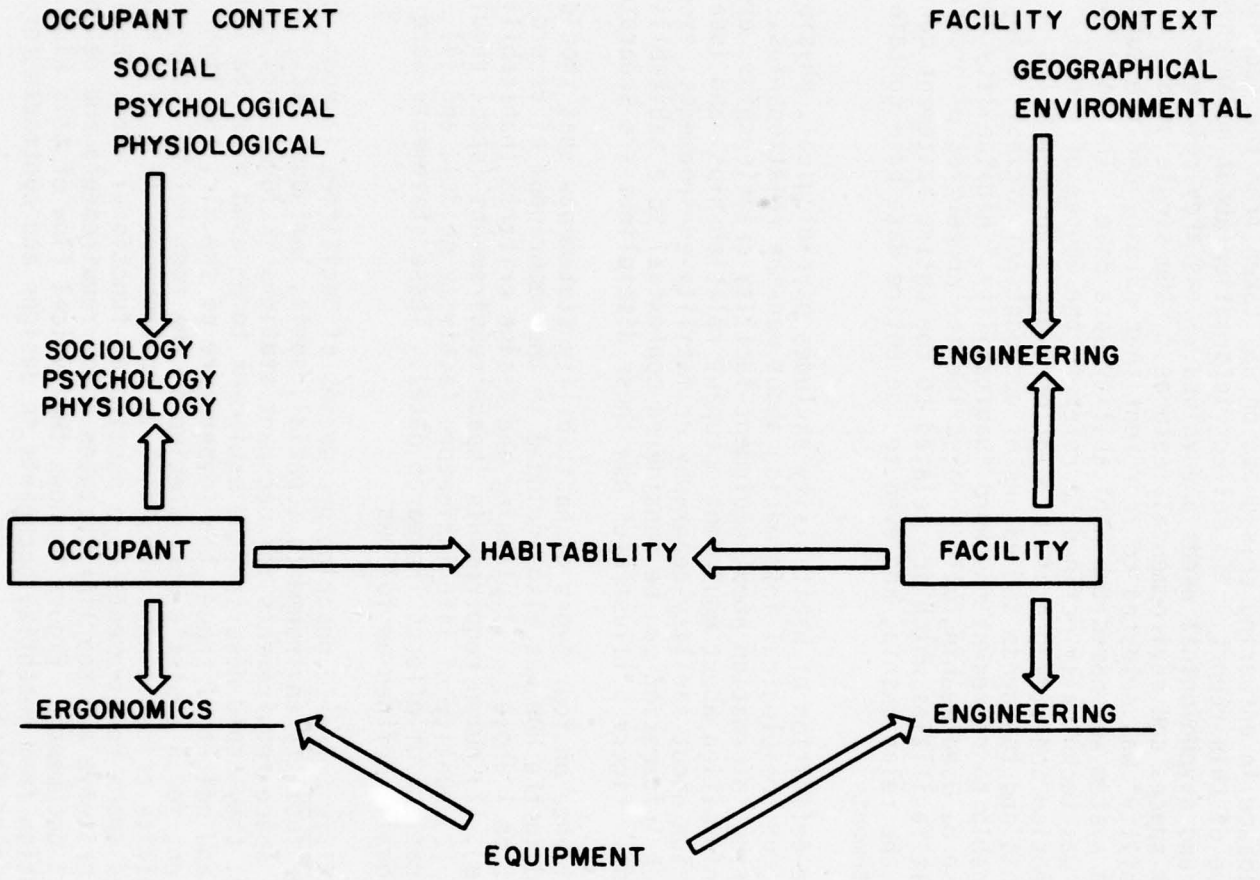


Figure 5. Habitability distinguished from other disciplines as a field of study for the HDB.

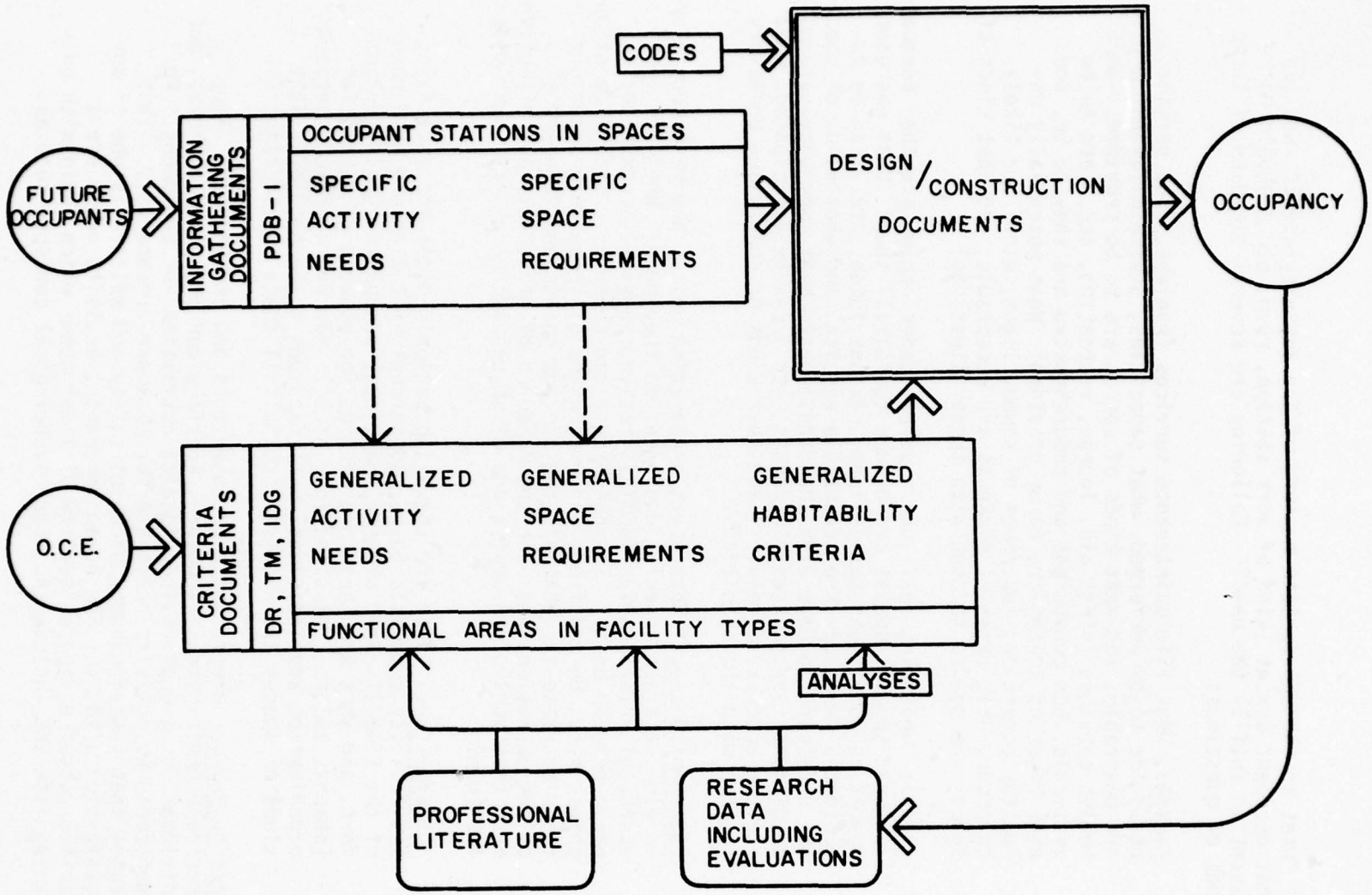


Figure 6. Hypothesized flow of habitability information in the facility delivery process.

(1) "what is the appropriate measure of the activity need?" and (2) "what occupant spaces (kind of work station, room, etc.) should be present to fulfill the need?" Following are several examples of these kinds of questions:

Health: What life maintenance services (hygiene, food service, etc.) are to be performed, what capacities, accessibilities, etc., are desirable, and what kinds of spaces are to be provided. What health services (first aid, lounge, recreation, etc.) are to be available, how convenient and comprehensive are they to be, and what kinds of spaces are to be provided? What potentially unhealthy conditions (extremes of sound, light, etc.) are likely to occur, what rates of sickness are acceptable, and what kinds of spaces are needed to cope with these situations?

Safety: What municipal, etc., safety codes apply, are they adequate, and what special spaces are needed to fulfill them? What emergency operating conditions (explosions, noxious fumes, etc.) can be anticipated, what are the acceptable results, and what kinds of spaces are necessary to cope with the conditions? What emergency natural conditions (earthquakes, tornadoes, etc.) can be anticipated, what are the acceptable results, and what kinds of spaces are necessary to cope with the conditions?

Task Performance: What are the operating units, how many people are in each, and what special equipment do they need? What are the essential relationships (administrative, physical, communication, etc.) between units? To what extent can these unit sizes, relationships, etc., be modified, and what kinds of spaces are necessary for their operations? What are the storage points and volumes, etc., of the operation, what are the measures of efficiency and effectiveness that apply, and what kinds of spaces are necessary to provide for them?

Satisfactions: What are the organization's goals for satisfying its facility occupants (e.g., 80 percent of the people 80 percent of the time.)? What are the individual occupants' goals for comfort, and what are their preferences for aspects of facilities (shapes, colors, relationships, etc.)? How are conflicts between organization and individual satisfactions to be handled? What kinds of spaces are necessary to fulfill these satisfactions?

Activity Needs: are for both organizations and individuals. They describe organizational structure, workflow and occupancy policies, and individual (or groups of individuals) activities and equipment. For organizations, activity needs are for task performance only. This assumes that insuring human occupant safety and welfare is one of any organization's tasks. For human occupants, activity needs are a specific subset of those "quality of life" needs which begin with sustaining life and include the more psychological concepts such as

self-actualization. Activity needs in facilities result from the act of occupancy. Thus, four categories of needs can be used to classify all such acts: health, safety, task performance, and satisfactions. These needs are expressed as mental, physical, and/or physiological activities that an occupant must and/or wants to perform. They can be ascertained by answering the following kinds of questions:

Health: What life maintenance activities (hygienic, dining, sleeping, etc.) are to be performed? What life preservation activities (injury, repair, recreation, social, etc.) are to be performed? What potentially unhealthful activities are to be performed?

Safety: What are the normal safety activities (use of safety devices, good housekeeping, etc.) to be anticipated? What are the emergency safety activities (quick exiting, taking cover, etc.) to be anticipated?

Task Performance: What are the organizational structural units, functions and procedures? What are the roles and activities of the individual and group occupants? What are the input-output flows of materials? What are the administrative, circulation, communication, etc., activities within the facility?

Satisfactions: What are the anticipated overt satisfaction activities (modes of dress for comfort, attendance rate at work station, etc.)? What are the anticipated covert satisfaction activities (high motivations, self-actualization, etc.)?

Taken together, all these occupant activities that fulfill tasks, safety, health, and satisfactions are called activity needs. All other so-called higher needs, such as the need of an organization to motivate its employees, or for an employee to be fulfilled, etc., are assumed to be subsumable under the category of satisfaction needs.

Research Data are records of what happens when people or organizations occupy facilities. Needs, requirements, and criteria are prescriptions of what should be done, and research data are records of what has actually occurred. The formulation of habitability needs, requirements, and criteria is beginning to be influenced more and more by practitioners educated in the sciences. The HDB is an example of this impact.

Habitability research data are records of how occupants interact with facilities. Occupants act to modify their facilities, and react to facility conditions. Records of these interactions can be used to formulate specific habitability statements for an existing situation (see Question 3 below), or to generalize habitability statements for entire populations or types of facilities (see Question 8 below). Figure 7 shows the kinds of variables for which data must be available in order

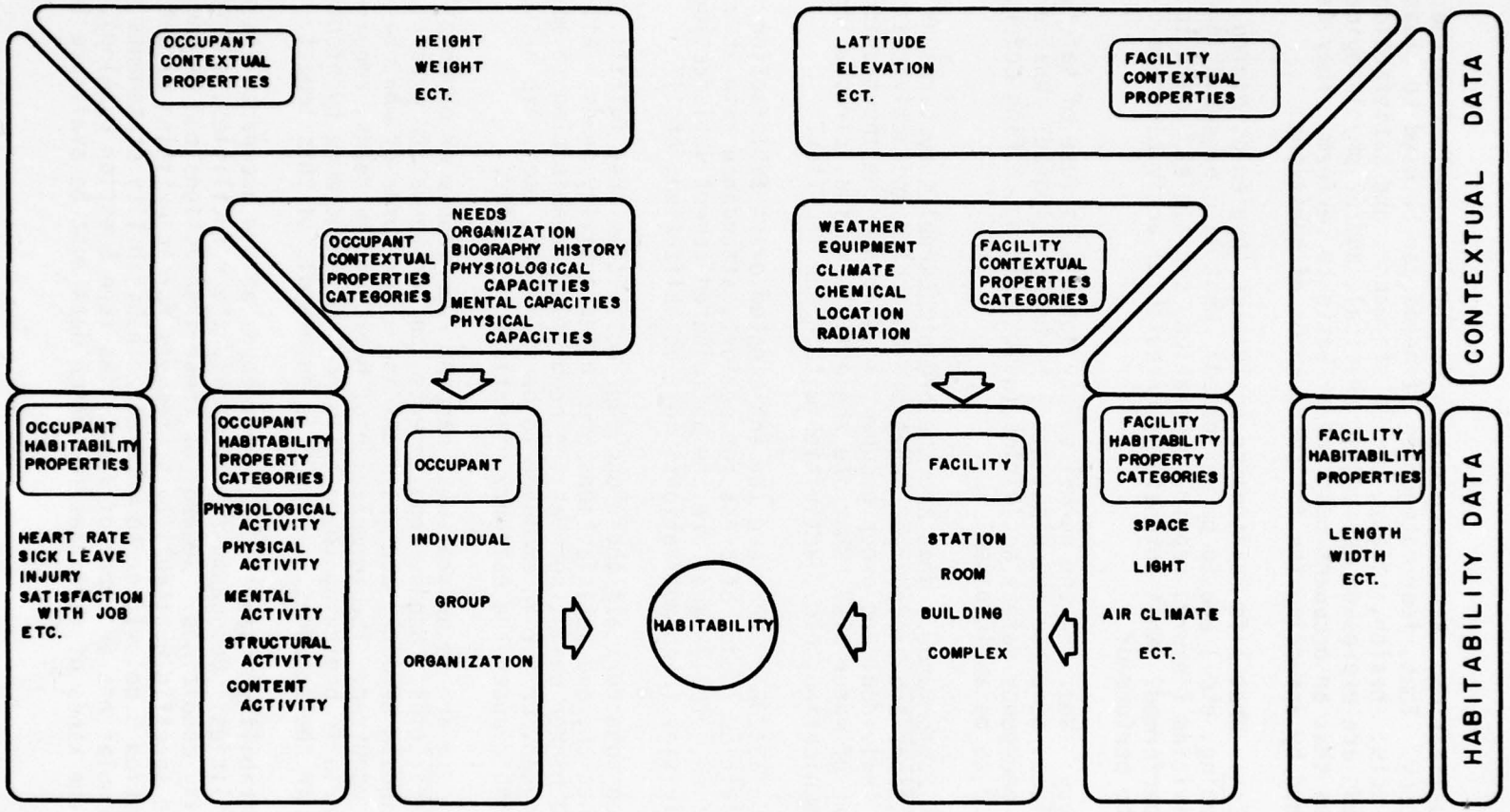


Figure 7. Habitability and contextual properties found in research data.

to formulate these habitability statements. The basic habitability relationship is between properties of occupant activities (e.g., comfort votes, etc.) and properties of physical facilities (e.g., temperature, light level, etc.). All other variables and categories of variables, both relational and contextual, are used either to be specific about an occupant and a space or to generalize over a group of occupants and/or a facility type or variety of facilities.

3. *Which Literature Articles?* (See Question C in Figure 4.)

The answer to this question is an analogue to the answer to Question 1: all literature articles containing statements implying a condition of habitability in schools. The Library Research Center had recommended 24 journals and seven indexing services which would keep an architect aware of research on the area of inquiry previously defined as "habitability." Articles could have been selected from these sources. However, since "service schools" were selected as a co-topic to habitability, the indexing service called the Education Research Information Center (ERIC) became an economical and efficient alternative. After several iterations with selected phrases, 1868 article abstracts were retrieved using the following 17 "key words":

Acoustical Environment
Controlled Environment
Thermal Environment
Visual Environment
Architectural Research
Psychological Design Needs
Facility Utilization Research
Space Utilization
Simulated Environment
Environmental Criteria
Environmental Influences
Environmental Research
Flexible Facilities
Human Engineering
Planning (Facilities)
Physical Design Needs
Classroom Environment.

The titles and abstracts of these articles were reviewed, and 745 were selected as pertaining to habitability. Hard copies of these articles were obtained, read, and coded as follows:

a. Relevant (contains habitability subject matter)

b. Irrelevant (no habitability)

c. Irrelevant (methodological topic)

d. Research methodology not explained

e. Not about academic facilities

f. Abnormal condition as topic

g. Vehicular topic

h. Review and (or) bibliography (state-of-the-art)

i. Foreign language.

4. What Literature Information? (See Question D in Figure 4.)

Of the 745 articles for which hard copies were obtained, 148 were coded: "1. Relevant." Of these, 84 were summarized and entered into the prototype HDB. These articles, plus the 14 MCA documents from which relevant information was summarized, totaled 10,000 lines of information.

The kinds of habitability statements summarized from each literature article included activity needs, space requirements, habitability criteria, and research data, as defined under Question 3 above. In addition, a "one-sentence objectives" statement was written for each article which contained an occupant activity property related to a facility physical property; i.e., the objective states the basic habitability relationship addressed by the article. Finally, if the article is a research report, two other kinds of information are summarized in the HDB: (1) the method used in conducting the research, and (2) the definitions, assumptions, etc., of the researcher.

The question of information validity (or credibility) was approached two ways. For research data, any results with real probability of not occurring by chance (and this is a judgment of the validity of the data) were considered for inclusion. For the three other kinds of habitability statements (needs, requirements, and criteria) a separate credibility standard was established. (More recently, other kinds of statements have been identified.[18] These are commentary and guidance.) These statements are all "ought-to-be's." None of these statements contained in the MCA documents are supported by research data, and few statements contained in the research literature, with the exception of studies of climate and lighting, are directly formulated from research data. Knowing this, and keeping in mind that one objective for the HDB was that it should help identify research problems for future study, it was decided to include certain needs, requirements, and criteria statements from

[18] R. L. Brauer and D. L. Dressel, *Concepts for the Generation, Communication, and Evaluation of Habitability Criteria,* Special Report D-78/ ADA041187 (CERL, 1977).

the literature to serve as analogue information to those same statements in MCA documents. In effect, they would serve as a "state of the art" of contemporary beliefs about needs, requirements, and criteria statements. The test for credibility is that the statements originate from a panel of "experts" in the field of habitability, or that they be officially published as policy by an organization for itself or its own people.

5. *What Information Variables?* (Question E of Figure 4.)

The basic habitability relationship has been defined to refer to the degree of fit (e.g., the direction and strength of a correlation, etc.) of built facilities to occupant activities. Thus, built facility variables are physical properties of a facility: length, width, light level, ambient sound level, temperature, and so on. Occupant activity variables are measurable properties of occupant activities: physical motions--arm, leg, etc.; physiological changes--eye (iris), blood pressure, respiration rate, etc.; or mental opinion, attitude and/or belief statements.

6. *How to Code the Information?* (See Question F of Figure 4.)

As outlined in the Objectives section of Chapter 2, the HDB was to (1) collect all official MCA habitability statements into a single source; (2) provide a generic paradigm for interested professionals from all fields of endeavor interested in habitability; and (3) provide a structure for formulating an objective definition of habitability.

The first objective was fulfilled by coding all MCA information to official facility class and construction category numbers. In addition, the functional areas (training facilities only) were assigned a three-number code.

Fulfilling the second and third objectives was begun by grouping the variables into relevant categories and assigning commonly known words as labels for each category. The categories were chosen to be relevant to the formulation of an objective definition of habitability (scale, needs, setting, etc.--see Question 7 below). The words used to label each category were chosen for their most common meaning (individual, health, room, air climate, etc.). The procedure used to arrive at these categories and labels was to first hypothesize[19] a preliminary version of the relationship (similar to the diagram in Figure 7), and then to compare this version to the information as it was prepared for the HDB. Many coding changes were made during the preparation of the 10,000 lines of information in the HDB, and all information had to be entirely recoded when the prototype was completed.

[19]T. A. Davis, "Systematizing Man-Environment Information," *Man Environment System*, Vol 4, No. 3 (May 1974).

Thus, the final coding and labeling scheme represents an induction from the information contained in the HDB.

7. How to Specify? (See Question G of Figure 4.)

This question can be rephrased as follows: How to formulate habitability guidance for a specific facility? One HDB objective is to assist in the programming of planning and design guidance for a specific facility. To the extent that habitability as it has been operationally defined herein is relevant to such guidance, the constructs of needs, requirements, and criteria can be used to formulate a logical sequence of habitability information from occupant activities to facility design and contract documents. The HDB stores information that is in the MCA documents reviewed for the prototype.

Habitability guidance for a specific facility and engineering and other architectural information from MCA documents such as the Project Description Brochure (PDB) are collected. Activity needs and space requirement statements answer the kinds of questions posed in the definitions under Question 2 above: (1) "what are the occupant health, safety, task performance and satisfaction activities?" and (2) "what is an appropriate measure of the activities, and what kinds of spaces are required for them?"

Activity needs and space requirements can be formulated for a specific facility by gathering information from samples of the future occupants, and making operational assumptions and probability inductions. The following procedure for specifying needs and requirements has been suggested by CERL personnel. The typical situation might be the preparation of a PDB for a new facility. Within the context of the MCA criteria information about occupant stations and functional areas for that facility type, a set of questions is prepared to gather information about activity needs and space requirements. The answers to these questions are obtained through interviews, observations, or questionnaires of sample populations. For human preferences, the sample should match the populations which are expected to occupy the facilities. For human activities and comforts, the sample should also be taken in the same type of facilities as those being programmed so that environmental properties can be measured for correlation to the occupant activity description. When gathering this type of information, it is important to ascertain the degree of choice the occupants will have for fulfilling their comforts and preferences.

The last step is stating probability inductions which express the percentage of future occupants who will probably be satisfied by the provision of specific environments (such as temperature ranges, light levels, etc.) or specific facilities (such as carports, fireplaces, etc.). For example, based on the finding that 80 percent of a random sample

of the future occupant population group prefer to have carports, then 80 percent of all such occupants of the planned housing will prefer carports.

8. *How to Generalize Habitability Guidance for MCA Criteria Documents:* (See Question H in Figure 4.)

One objective for the HDB was to assist in developing planning and design criteria for repetitive facility types. The extent to which guidance for specific projects (see Question 7 above) is relevant to habitability is important. The constructs of needs, requirements, and criteria can be used to formulate a logical sequence of information from occupant activities to facility design and construction documents. The process of formulating habitability criteria from space requirements and research data has been reported[20] by CERL personnel. The process quantifies a space requirement, selects research articles that address these requirements, summarizes the data in the articles, generalizes the facility setting, and generalizes the occupant groups. Thus, generalizing is only one step in the formulation process.

All three types of habitability statements can be generalized, and all three generalizations can be based on research data. A typical case would be the generalization of the needs and requirements gathered for specific facility projects, such as the family housing discussed under Question 7 above. If the same (or similar) questions were used to gather data from future occupants wherever family housing is programmed by the MCA, then the data could be generalized for MCA criteria documents. To be generalized over the military occupant population, the data must be shown to comprise a sample; i.e., they must be representative of the entire population, be proportionate to the important subgroups (age, sex, rank, activity, etc.), be each taken independently of the others, and be sufficiently numerous. These are standard operational rules for sampling.

If a facility type contains known space types (i.e., functional areas), and if the on-going activity of facility programming is continuous, it is possible, in a vast system such as MCA, to be working toward valid habitability needs, requirements, and criteria generalizations by planning research activities. One application for this plan would be a PDB containing a set of reliable questionnaire items that all programmers would use. The findings would be reported to the PDB originators for generalization and future modifications of habitability statements in the criteria reference documents.

[20] T. A. Davis, "Formulating Habitability Criteria from Research Information," *Programming for Habitability*, W. F. E. Preiser, ed. (Department of Architecture, University of Illinois, 1974).

9. *What is an Objective Definition of Habitability?* (See Question I in Figure 4.)

One objective for the HDB was to structure the collected information toward an objective definition of habitability (e.g., of Army personnel needs in built facilities). This objective definition has been the subject of a separate study.[21] The following definition and the three equations for habitability expressions are from this study.

A habitability expression is a statement of a property of an occupant activity (OH) as a function of a facility physical property (FP). Assuming that both properties can be quantified and represented as counts or measures, the function can be cast as a mathematical function. For a given context:

A PROPERTY OF AN OCCUPANT ACTIVITY	IS A FUNCTION OF	A PHYSICAL PROPERTY OF A FACILITY

or

$$OH = f(FP_i) \qquad \text{[Eq 1]}$$

where i = one facility property
f = function.

When an occupant property is shown to be the function of several facility properties, i can be replaced with a table of values of more than one facility property. The most sophisticated habitability expressions occur in air climate, where occupant satisfaction votes in a given context have been shown to be a function of several air climate properties.[22]

A more general case occurs when occupant and facility properties can be expressed as functions of each other in a given context; for example:

a. Occupants are cold as a function of air temperature.

b. Air temperature is raised as a function of occupant body heat.

[21] T. A. Davis, *Conceptualization of Habitability Expressions for the Habitability Data Base*, Interim Report D-68/ADA029661 (CERL, August 1976).

[22] P. O. Fanger, *Thermal Comfort* (Copenhagen: Danish Technical Press, 1970).

c. Occupants are comfortable as a function of air temperature.

These three interactions can be expressed as follows:

$$f(OH_i) = f(FP_j) \qquad \text{[Eq 2]}$$

Again, the subscripts i and j can be replaced by a table of values to indicate that more than one property is involved.

The most general case occurs when occupant and facility properties can be expressed as functions of each other in more than one occupant context (OC) and/or facility context (FC):

$$f(OH_i, OC_k) = f(FP_j, FC_i) \qquad \text{[Eq 3]}$$

When one is working toward mathematical expressions such as Eq 3, data must be categorized into manageable packages. The data in the HDB is coded for this purpose as follows. First, only research data is eligible and so has its own code. Next, activity-needs of health, safety, task performance, and satisfactions are coded separately. Then physical properties of facilities are coded two ways: (1) by occupant setting of station, room, building, outdoor constructed or outdoor natural setting, and (2) by physical environments of space, structure and surfaces, furniture and equipment, air climate, air chemicals, light, sound, other radiation, and motion. Finally, activity properties of occupants are coded by occupant activities of motor task performance, motor reactions, mental performance, mental opinions, attitudes, and beliefs, physiological performance, physiological reactions, organizational structural change, or organizational content change. These codes structure the data for retrieval and entry into the objective habitability definitions (habitability expressions).

4 DESCRIPTION OF HDB PROTOTYPE

Access

The prototype HDB can be accessed on-line via telephone using any low-speed computer terminal. The system is operational through the DECsystem10 time-sharing facility of the IBM/360 computer at the Urbana-Champaign campus of the University of Illinois. The HDB contains Army regulations and statements from general literature relating to the habitability requirements of Army service schools. No easily obtained information, such as recommendations in the Illuminating Engineers Society Lighting Handbook, is included at this time.

Information can be accessed in six substantively different ways: (1) functional area codes and training facility codes (including facility class and construction category codes), (2) generic codes describing properties of facilities and occupants, (3) statement content categories (activity needs, space requirements, habitability criteria, research data, and research contextual information), (4) document accession number for summary information, (5) natural language queries, and (6) document accession number for retrieval of bibliographic citations and all content information for a particular document.

All access programs are interactive with the user; program design has assumed minimal user knowledge of computers or information retrieval systems. Each program prompts the user when information is needed. Thus, user attention can be directed toward efficient extraction of information from the system, rather than the mechanics of system operation.

In addition, care has been taken to develop generic programs to safeguard both the programs themselves and their execution from user errors. In *all* cases, if input is not what the program requires at a particular time, the user will be informed of the nature of his/her error, and the execution sequence will restart.

Logging In

The DECsystem10 is an efficient, simple time-sharing facility. There are at present 80 dial-up ports, which means that 80 different terminals can use the system concurrently. Therefore, if no one answers the phone or if the line is busy, it is because there is not room for another user; however, such times are unusual. Peak usage periods are from 1 to 5 p.m., Monday through Friday. Evening-hour demands are generally much lower; accordingly, turnaround time (the time it takes a program from start to finish) is faster during the evening and morning, and slower in the afternoons.

All the interactive programs used take less than 7 minutes of elapsed time, and the Documentation Access and Bibliographic Access programs require much less (see p 36).

If there are problems with the system, it will be taken down for maintenance, even during the day; however, maintenance is usually done during the evening and on Sundays, so the computer may not always be available. At these times, if a user tries to log in, he/she will get a message such as "DEC-10 Off," or "DEC-10 Being Reloaded," or the phone will not be answered.

If the system is operating properly, the following sequence of steps will establish communication with it.

1. Plug in the terminal

2. Set the terminal switches as follows:

   full duplex
   30 cps
   upper case
   int
   on-line

3. Hook in telephone

4. Turn the terminal on

5. Dial (217) 333-4000

6. When the carrier detect light comes on:

   a. Press Control-C once. The system should respond with information lines similar to the following:
   U of I 6,01 11:35:34 TTY33 SYSTEM 691
   Please LOGIN or ATTACH

   b. Communication with the computer has now been established: type .LOGIN 15765/4474
   ("15765/4474" is the system account number)

   c. The system will now print a line similar to the following and will prompt for a password:
   JOB 22 U OF I 6.01 TTY33
   PASSWORD:
   Type in the password and hit return.

   d. The system will print out three lines of account information. Logging in is now complete, and a period will appear in the first column of the next line, which means that the system is waiting for a command.

Programs Which Retrieve Information

Six computer programs can be used to retrieve information from the HDB. Following is a brief description of their potentials.

AND

Inputting a string of variables and their values (limited to one per variable) in the AND program will return a statement only if *all* variable values match with their counterparts in the statement code number (in the data base itself). Any number of variables can be entered in any order. As more variables are entered, the demand for output becomes more specific, thus decreasing the chance that this information will be in the data base. The shaded portion in Figure 8 shows this selectivity of retrieved information.

OR

In the OR option, from one to ten variables, each having one value, can be given to the program. Output will appear when *any* of the variable values are satisfied in the data base. The amount of output that the user receives tends to increase as more variables are entered (the opposite of the AND option), because the number of possible matches is increased. The user should make sure that the request is specific enough (i.e., limiting the number of variables entered) to insure the relevancy of output information. Figure 9 shows this proliferation of retrieved information.

ANDOR

The ANDOR program is designed to satisfy all user needs in generic code access. The user may specify multiple values for each variable, so that if any of the submitted values for the variable are satisfied, the requirements for that variable are also satisfied. The major feature of this program is implied in the program's name. In addition to simple AND and OR variable strings, ANDOR accepts combinations of AND and OR. For example, one could ask that either of two variables be satisfied *and* a third variable be satisfied *and* at least one of three other variables be satisfied before a statement is printed out. The program provides many possible combinations of information. Figure 10 shows this combination of selectivity and proliferation of retrieved information.

BIBAX

The BIBAX program is used to obtain bibliographic information (author, title, etc.) about any document which has been listed in the HDB. This information is retrieved via the HDB document accession number which is provided with each summary statement retrieved by the AND, OR, and ANDOR programs

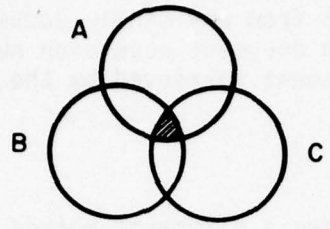


Figure 8. Program AND: A & B & C.

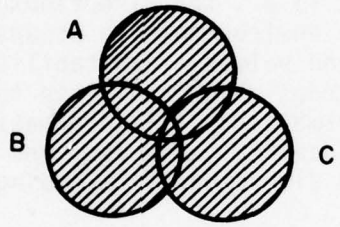


Figure 9. Program OR: A or B or C.

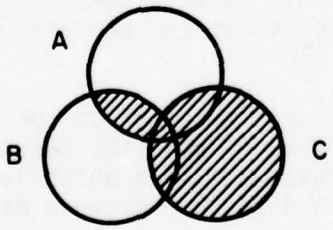


Figure 10. Program ANDOR: A & B or C.

DOCAX

The DOCAX program is used to obtain a complete printout of all information listed in the HDB from any single document. This information is retrieved via the HDB document accession number which is provided with each summary statement retrieved by the AND, OR, and ANDOR programs.

SMART

The SMART program provides a different method of retrieving information from the HDB. With this program, a question is input using English words, and sentences, phrases, or paragraphs are used to express information needs. These words are matched by the computer to words in the summary habitability statements in the HDB. The best matches are printed out.

Habitability Information Access Codes

The HDB contains information about habitability, which has been defined as the degree of fit (i.e., the direction and strength of correlations, etc.) of built environments to occupant activities in fulfillment of their needs and values. Habitability information is structured by 19 colmns of codes which delineate three separate dimensions of the summarized information: (1) information function, (2) categories of occupant and facility variables, and (3) Army facility type. Figure 11 shows three dimensions in a coding diagram.

There are seven coded information function categories which contain the following data:

1. Space requirement statements contain space names, space relationships, and environmental characteristics to be provided for occupant activity needs.

2. Habitability criterion statements contain quantitative counts and measures of the facilities and physical environments to be provided for space requirements.

3. Research data statements contain counts and measures of occupant activities related to counts and measures of an environment's physical facilities.

4. Statements about research information context contain counts and measures that are descriptive of both the occupants and facilities reported in research datum statements, and which lead to an understanding of the information contained in the research data statements coded 3.

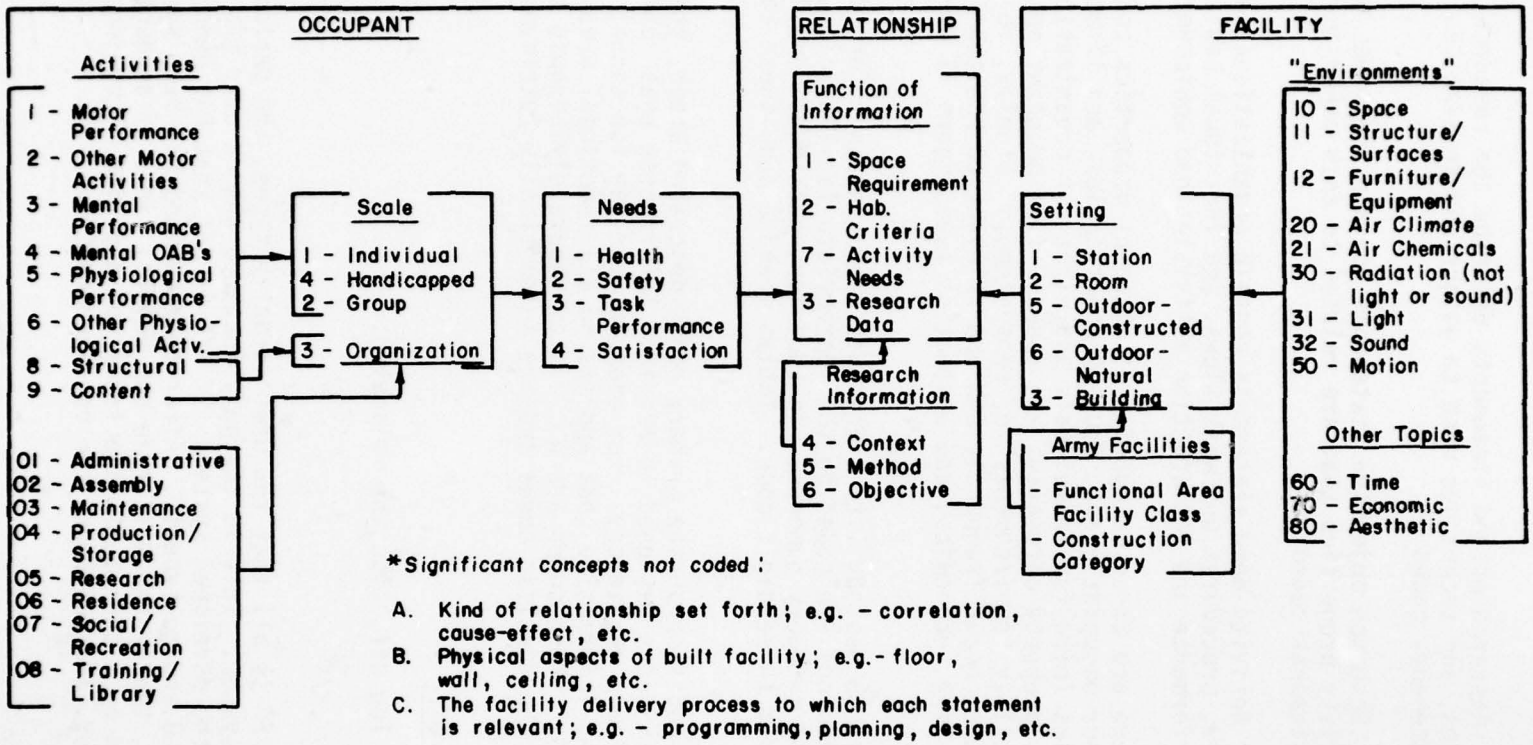


Figure 11. Primary codes* used in the Habitability Data Base.

5. Research method statements describe the research approach, procedures, and techniques used to gather and analyze the research data statements coded 3.

6. Research objective statements contain the names of the occupant and facility properties that are related to each other in the research data statements coded 3.

7. Activity-need statements contain organizational occupant structure, procedures and work flows, and individual health, safety, task performance and satisfaction activities and equipment.

There are three categories of occupant properties coded in the HDB: four occupant needs, four occupant scales, and 17 occupant activities (nine for individuals and eight for organizations). Two facility property categories are coded: five occupant settings, and nine facility "environments" or subsystems." Finally, three other topics that occur frequently and are relevant to habitability are coded: time, economics, and aesthetics (see Figure 11 for coding scheme).

All HDB habitability statements that contain information about Army buildings are coded to the appropriate facility class and construction category numbers. In addition, each functional area is assigned a three-digit code. Tables 1 and 2 show these categories and codes.

In addition to the primary codes described above, there are secondary codes designed to retrieve information that applies to all cases within a category. For example, the 999 functional area code retrieves information that applies to all functional areas (see Table 3). These codes are not listed separately because they are tied to the specific codes and are automatically retrieved.

Logging Off

To log off, type the following:

.K/F

When "K/F" is all that the user actually types, the period is supplied by the system. This is the only instance when a user mistake can damage the developed system. If K/F is *not* what has been typed, strike control-U and re-type it. After this command has been successfully entered, the system will type out several lines of account information, followed by a series of line feeds and a period. Logging off is now completed, and the phone can be disconnected.

Table 1

Functional Area Codes

Value Code	Meaning
010	Lecture classrooms
020	Combination lecture room and laboratory
030	Individualized study hall with carrels or language lab
040	Ceiling height for 010, 020, and 030
050	Instructional laboratory
060	Instructor's work space
070	Instructor's lounge or faculty room
080	Rear projection room
090	Visual and training aid storage
100	Student break areas
101	All academic areas
110	Custodial room
120	Circulation areas, walls, service areas
130	Toilets
131	Water closets
132	Urinals
133	Lavatories
134	Couch
140	Drinking fountains
141	All academic - service areas
151	Library reading area and circulation desk (including traffic)
152	Stack area (including traffic)
153	Reading and stacks
154	Staff areas, including lounges, toilets, administrative work, and reproductions
155	Wall and service areas
160	Ceiling height for 151-154
162	All library areas
170	School/site ratio
180	Parking
190	Walks
200	Distance between academic buildings
999	All occupied areas

Table 2

Training Facility Codes

Value Code	Meaning
17000	All training facilities
17100	All training facilities Classrooms and other special buildings in which use is generally for instructional and training purposes.
17900	All training facilities other than buildings and structures Includes training courses, ranges, maneuver areas, including training mockups, and similar type facilities either provided for or limited in use to training (does not include expendable targets, or airfield, waterfront, and other facilities which fall readily into other categories).
93210	Site improvement, including parking
99999	All facilities

Table 3

Secondary Codes of the HDB

Column	Code	Meaning
1-3	10	All academic areas
	14	All academic service areas
	162	All library areas
	999	All occupied areas
4-8	99999	All facility types
9	4	All of columns 1-3
9	7	All column 1-8 settings
10-13	90	All topics
14	9	All occupants
15	9	All occupant postures (obsolete category)
16	9	All occupant involvements (obsolete category)
17-18	99	All organizational functions
19	9	All statements

5 EVALUATION PROCEDURES

Initial Field Test

The 10,000 lines of information in the HDB prototype were originally programmed in a batch mode for computer retrieval. A field test of this configuration was made which had the following objectives:

1. To operate the prototype

    a. Ability of selected user groups to retrieve information
    b. Usefulness of habitability statements to user groups

2. To test cost-effectiveness of prototype

    a. Cost of providing information to user groups
    b. Cost of extracting pertinent information from published literature and converting it into habitability statements

3. To develop new information

    a. Suggestions for improvements to prototype
    b. Suggestions for additions: e.g., code to retrieve data for specific purposes.

The planned procedure was as follows:

1. Have potential users query the system

2. Calculate recall ratios, precision ratios, and cost per unit of output

3. Obtain expert reports on structure, content, and operation of both the data base and the accessing procedures and devices.

The potential users of the HDB selected for this field test included both Army and civilian personnel. Army users were OCE staff, installation personnel, MCA personnel, and research personnel. Civilian users were A/E contracting firms. The potential functions examined in the field test included master planning, PDB programming, design, and value engineering.

One exhibit was prepared for this field trial ("An Introduction to the Habitability Data Base") and was used as a handout in preliminary contacts. Instructions for the use of the HDB were also available, including an introduction, general instructions, and specific instructions for each retrieval option.

Each user was requested to complete a questionnaire both before and after the field test.

Second Field Test

The objective of the second field test was to evaluate the effectiveness of the information (its subject matter and access codes) in the HDB as a tool to support the MCA facility delivery process.

The following assumptions were made:

1. The *structure* of the information in the HDB was relevant to the theory of habitability expressions set forth by Davis in *Conceptualization of Habitability Expressions for the Habitability Data Base.*[23] This theory operationally defines a habitability expression as an occupant activity property stated as a function of a physical facilities property.

2. The *content* (subject matter) of this information in the HDB was relevant to the concept of habitability set forth by Davis. This concept operationally defines habitability as the degree of fit of built facilities to occupant needs.

It was hypothesized that both the structure and content of the information in the HDB are relevant to the MCA facility delivery process. The components to be evaluated in this hypothesis were as follows:

1. Structural components

    a. Variables
        (1) Properties of occupant activities
        (2) Properties of physical facilities

    b. Classifications of variables
        (1) Properties of occupant activities are classified in two ways:
            (a) They describe a task performance or a reactive behavior, and
            (b) They refer to physical, physiological, or mental dimension.
        (2) Properties of physical facilities are classified two ways:
            (a) They describe space, light, sound, or other radiation; structure or surfaces; furniture or equipment; air climate or chemicals; or motion; and
            (b) They refer to an occupant station, a room, an entire building, an outdoor constructed facility, or an outdoor natural site.
        (3) Both occupant activities and physical facilities are represented as DA functional area, facility class, and construction category codes.

[23] T. A. Davis, *Conceptualization of Habitability Expressions for the Habitability Data Base,* Interim Report D-68/ADA029661 (CERL, August 1976).

2. Content (subject matter) components

   a. Constructs: Four categories of statements have been operationally defined as inclusive of all habitability information relevant to the OCE facility delivery process: habitability needs, requirements, criteria, and data.

   b. Classifications of constructs: All habitability information is represented by English words synonymized in a thesaurus integral to the computer programming.

Two tests for relevancy were conducted:

1. The extent to which the HDB variables and/or constructs are used as inputs or outputs to each procedure.

2. The extent to which the HDB names for constructs and variables convey meaning appropriate to the MCA.

An analysis of MCA cycle procedures identified functions, activities, and documents being processed at OCE, OCE District Offices, major commands, and installations. The relevancy of the HDB coding and information was evaluated for the latter three. The MCA functions, activities, and documents are listed in Tables 4, 5, and 6, respectively.

Five tables of questions tested the relevancy of HDB information (see Appendix A).

Table 4

MCA Functions

1. Master Planning
2. MCA Programming (Intermediate or Short Range)
3. Functional Requirements (PDB-1)
4. Preconcept Control Data
5. Concept Design
6. Final Design
7. Construction Bid and Award
8. Construction
9. Post-Completion Inspection
10. Criteria or Technical Guidance
11. Policy or Procedural Guidance
12. Value Engineering

Table 5

MCA Activities (supervise or perform)

1. Prepare
2. Review
3. Execute
4. Technical Support or Consulting
5. Procedural Support or Consulting

Table 6

MCA Documents

1. Stationing Plan
2. Master Plan
3. 1391
4. Short or Intermediate Program (for an installation)
5. Preconcept Control Data, Including 3086
6. PDB-1
7. Concept Drawings and Specifications
8. Final Drawings and Specifications
9. 1390
10. AR
11. TM
12. ER
13. Design Guide
14. Engineering Instructions
15. Value Engineering Report
16. Post-Completion Inspection Report

6 EVALUATION FINDINGS

Findings of Initial Field Test

The initial field test (May 1975) failed to affirm that the computer batch mode of operation was effective. However, the concept of a habitability data base was affirmed as a tool in support of MCA processes.

An architect-researcher with no previous experience in the operation of a computer terminal conducted the test. The batch mode of operation proved to be above the level of the instructions provided to him, offered no prompting for his errors, and took too long to respond for demonstration purposes.

Two actions resulted: (1) the Library Research Center was contracted to re-program the HDB into an on-line mode, and (2) the only objective implemented was to develop the following new information. Major commands (TRADOC, FORSCOM) were interested in knowing activity needs and space requirements that were not currently supported by habitability criteria, and in obtaining a checklist of citations to select and communicate the needed criteria. The Corps District Office at Norfolk was interested in habitability criteria in Army documents that could be used to evaluate plans and specifications. OCE was the only potential user outside of CERL to express an interest in using the HDB as a tool in research.

Findings of Second Field Test

The second field test (June 1976) revealed that all HDB variables and constructs and the words used to represent them were relevant to the MCA facility delivery processes. A sample of District offices, installations, and major command offices was included in the second field test.

The HDB uses 48 constructs from 10,000 lines of habitability data to classify information. Twenty-five constructs are unique enough to warrant field testing. Seventeen of these were overwhelmingly endorsed, and eight were consistently recommended for modification. The consensus of these suggestions would appear to be fulfilled by the following changes:

Split "Structure/Surfaces" into "Materials" and "Finishes"

Split "Furniture/Equipment" into "Furnishings" and "Fixed Equipment"

Change "Organizational Structural Activities" to "Organization Functional Changes"

Change "Organizational Content Activities" to "Organization Procedural Changes"

Change "Outdoor Natural" to "Natural Outdoor Settings"

Change "Motion" to "Structural Motion"

Change "Air Climate" to "Air Climate, Including Odors"

Change "Satisfaction Needs" to "Comfort and Preference Needs."

The relevancy of the 25 constructs to MCA cycle functions was also investigated. Figure 12 shows the overall relevancy of constructs for 11 evaluated MCA functions of the 12 previously listed in Table 4. The number of functions which had a low use for a construct is compared to the number of functions which had a high use for it. Several observations can be made from the data.

1. Activity needs and habitability criteria are the kinds of information most used, with space requirements next.

2. Research data are used mostly for the Master Planning and Construction functions. It can be inferred that the respondents were thinking of construction engineering research data rather than of habitability research data.

3. Space and structure/surfaces are the most important "environments."

4. Radiation other than light and sound is the only "environment" not considered for a majority of the functions.

5. Individual occupant activities at the level of occupant properties are hardly ever considered (2 of 33 occurrences). Organizational activities, on the other hand, are considered at a majority of the functions (12 of 22 occurrences). It can be inferred that the task performance habitability of organizational units (as compared to any individual occupant needs) is now being considered for the first time. In the future, the Army must develop procedures to generate, evaluate, and communicate criteria relating personnel and architectural requirements.

6. Of the four occupant needs, only safety needs are considered for a majority (9 of 11) of the functions. Occupant health needs are considered for only three of eleven functions.

7. Although personnel at both major commands and District Offices were responsible for post-occupancy evaluations, they are not conducted systematically. This accounts for the lack of responses to this function.

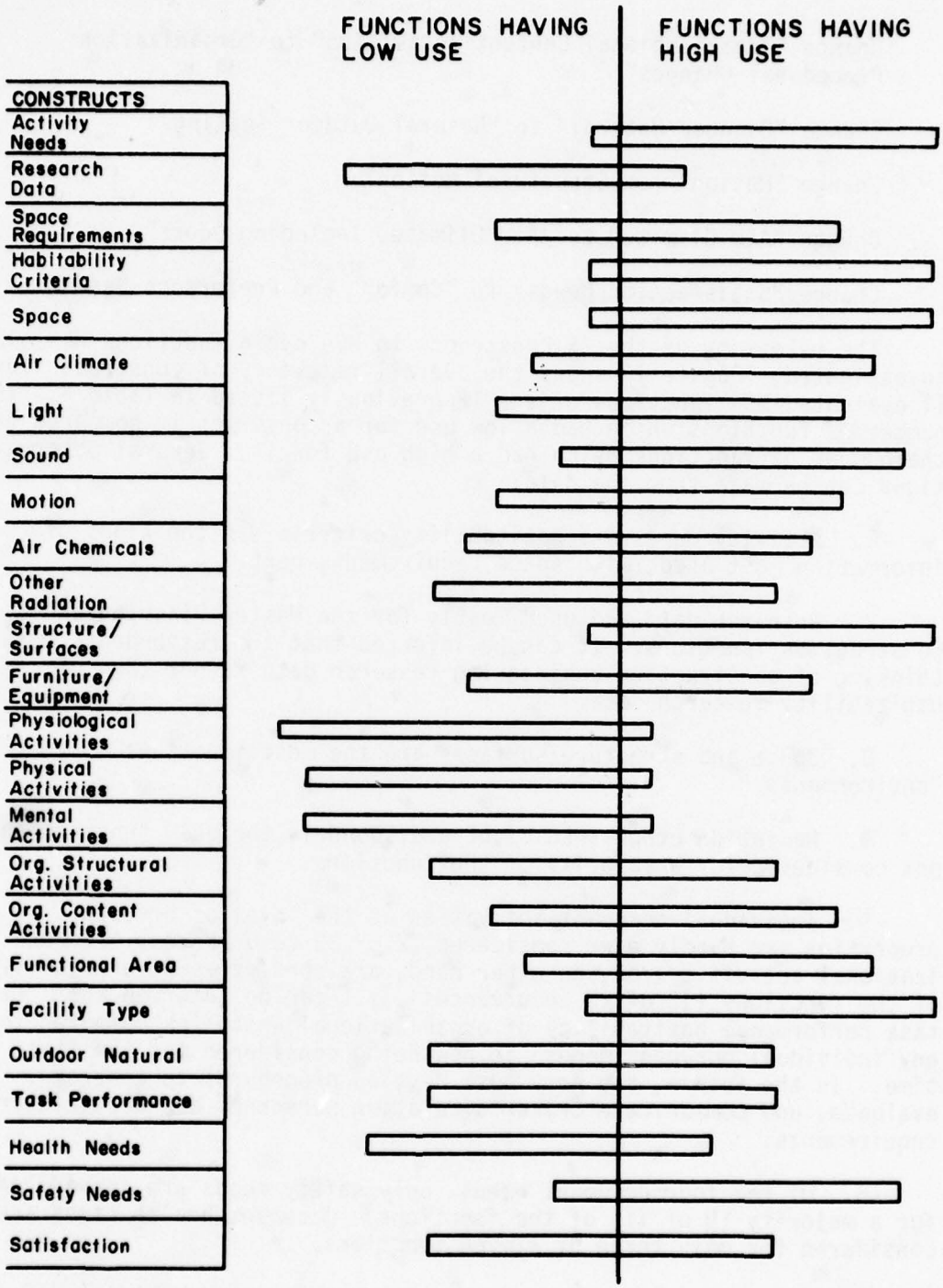


Figure 12. Summary of relevancy data--all returns.

On the whole, the two field tests showed that there was much interest in using specific HDB information for MCA functions and that if the HDB were available, there might be increased interest in improving the habitability of Army facilities.

7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This report has discussed development of a habitability data base which will support three activities:

1. The classification and codification of recorded information on occupant needs in built facilities

2. The formulation of an objective definition of Army personnel needs in built facilities

3. The provision of technical guidance on habitability to the facility delivery processes of the MCA.

The data base was designed for the first two activities and then evaluated for relevancy to the third activity.

Conclusions

The HDB has been designed to support the classification and codification of habitability information, the formulation of an objective definition of Army personnel habitability, and the substance of the facility delivery processes of the MCA.

More than 10,000 lines of habitability information on academic facilities have been classified and coded to 48 constructs in the HDB. The 48 constructs have been shown to be relevant to a hypothesized objective definition of occupant needs in built facilities. Army personnel needs would be a specific case of the objective definition.

Twenty-five potentially unique constructs have been tested for relevancy to the MCA facility delivery processes. Except for the construct of "occupant physiological activities," all were relevant to at least one event in 11 of the 12 MCA cycle of functions tested.

One surprising result was that the use of the construct of "individual occupant activities" was reported in only 2 of 33 events. This suggests that habitability for the individual occupant is not now given much consideration in the delivery of Army facilities and that much work remains to be done in accomplishing the goals for this research--developing procedures and tools to generate, evaluate, and communicate criteria which relate personnel requirements to architectural requirements. Making the HDB into an operational system would provide one tool for increasing the degree to which "individual occupant activities" are dealt with in facility delivery.

Habitability constructs were shown to be relevant to 12 out of 22 organizational activities, and the 11 MCA cycle of functions. In addition, considerable interest was shown in the use of specific kinds of HDB information for MCA functions during both field tests. It can be concluded that the availability of the HDB could stimulate an increased interest in the habitability of facilities provided through the MCA.

Recommendations

The following recommendations are limited to improving the structure and content of information in the HDB to fulfill the activities for which it was designed.

1. Since the activity needs considered were not identified until the prototype was completed, each document in the HDB should be reviewed and activity needs identified, excerpted, coded, and entered into the HDB.

2. The procedural "all" codes in the coding sheets should be re-listed, but their program ties to each code number in each category removed. This makes information coded to the "all" codes separately retrievable. It is currently retrieved automatically for each code of each category and often confuses the user because it is intermixed with specific information.

3. An MCA cycle-function code for information should be developed and implemented. This may be done by further analyzing the relevancy of information developed in the second field test.

4. To more closely match user terms, the information category names should be changed as recommended in the responses to the second field test.

5. The SMART retrieval program output requires two procedural and two substantive improvements: remove the two-hit limit, remove the 40-line statement length limit, add the document number as further information, and change the word "document" to "statement."

6. A "number of hits" routine should be added to precede printouts of information. This would allow HDB users to know in advance the potential volume of information that a request will retrieve.

7. Both the unsearched "state of the art" beliefs, and researched and valid concepts are important to the understanding of an evolving field of study such as habitability. In order to accommodate both, the "Function of Statement" category should be recoded to the following sub-categories:

Code Content

Substantiated Habitability Statements

1. Activity Needs

2. Space Requirements

3. Research Data

4. Habitability Criteria

Unsubstantiated Habitability Statements

5. Activity Needs

6. Space Requirements

7. Descriptive Data

8. Habitability Criteria

Contextual Information

9. Method

0. Other: research objective, definitions, *assumptions, literature reviews,* "expert panel" credentials, etc.

"Substantiated," as applied to needs, requirements, and criteria statements, means that *within* the article that the statement summarizes, there is one of three kinds of evidence which justifies the statement:

a. Quotations (or paraphrases) from articles cited in a literature review

b. Credentials of a group (two or more) of substantive experts who unanimously approve the statement

c. Data on observations of interactions of occupants with facilities.

"Substantiated," as applied to data statements, is a judgment of validity or accuracy or relevance and means that evidence in the article supports the statement. In the absence of such evidence, a statement may be coded as "unsubstantiated" and included in the HDB for future reference or research.

To accomplish this re-coding, all function code 4 and 5 articles must be re-read for the following concepts which were not considered relevant during the initial coding:

a. Activity needs (see recommendation 1)

b. Background contextual information used to justify habitability needs, requirements, and criteria

c. Methodological contextual information describing the procedures used to induce or deduce habitability needs, requirements, or criteria from evidence.

APPENDIX A:

HABITABILITY DATA BASE EVALUATION QUESTIONNAIRE

HABITABILITY DATA BASE EVALUATION

A. INTRODUCTION: An experimental prototype information system has been established to contain data pertaining to occupant interactions with facilities. It is titled the Habitability Data Base (HDB). The HDB was conceived as a way to systematically classify, code, and store information on habitability. Habitability is defined as the impact of built facilities on occupant health, safety, task performance, and satisfaction, and vice versa. Habitability information, therefore, is information dealing with building components such as windows, paint color, ventilation, etc. as related to human occupant requirements (rather than for economic, engineering, etc., requirements).

B. PURPOSE: The purpose of this questionnaire is to ascertain the relevancy of the HDB to the MCA facility delivery processes. Specifically, you are being asked to respond to three kinds of questions:

1. Is the information in the HDB relevant to your specific task performance?

2. Do the words used to label the information in the HDB convey the appropriate meanings to you?

3. What kinds of information would be helpful in the performance of your main task?

C. PERSONAL DATA: Required only if follow-up is needed to understand your comments. Individuals will not be identified in tabulating or reporting results.

1. NAME: _____

2. TITLE: _____

3. ORGANIZATION: _____

4. BUSINESS PHONE (commercial no.): _____

D. YOUR INVOLVEMENT WITH MCA CYCLE: We need to know how you are involved with the MCA cycle in your task so we can understand your subsequent evaluation.

1. YOUR MAIN TASK:

a. YOUR DESCRIPTION _____

_____

b. FUNCTION OF MCA CYCLE INVOLVED IN: _____ (Code from Table A)

c. MAIN ACTIVITY: _____ (Code from Table B)

d. DOCUMENT PRODUCED: _____ (Code from Table C)

e. DOCUMENTS UTILIZED THE MOST IN THIS ACTIVITY:

(Codes from Table C)

_____, _____, _____, _____, _____, _____.

E. GENERAL NEED FOR HABITABILITY INFORMATION:

1. In executing your main task, do you ever have a need for habitability information? If no, skip to Section F. _____ YES _____ NO

2. How frequently do you need habitability type information?

a. _____ About every day.

b. _____ About once a week.

c. _____ About once a month.

d. _____ About once a year.

Table A

MCA Cycle Function

1. Master Planning
2. MCA Programming (Intermediate or Short Range)
3. Functional Requirements (PDB-1)
4. Preconcept Control Data
5. Concept Design
6. Final Design
7. Construction Bid and Award
8. Construction
9. Post-Completion Inspection
10. Criteria or Technical Guidance
11. Policy or Procedural Guidance
12. Value Engineering
13. Other (specify) _____
14. Other (specify) _____

Table B

Activity (supervise or actually do)

1. Prepare
2. Review
3. Execute
4. Technical Support or Consulting
5. Procedural Support or Consulting
6. Other (specify) _____

Table C

Documents

1. Stationing Plan
2. Master Plan
3. 1391
4. Short or Intermediate Program (for an installation)
5. Preconcept Control Data, Including 3086
6. PDB-1
7. Concept Drawings and Specifications
8. Final Drawings and Specifications
9. 1390
10. AR
11. TM
12. ER
13. Design Guide
14. Engineering Instructions
15. Value Engineering Report
16. Post-Completion Inspection Report
17. Other Report, Memo or Letter (specify)

    _____

18. Other Report, Memo or Letter (specify)

    _____

19. Other (specify) _____
20. Other (specify) _____

3. How much difficulty do you have in locating habitability information which you need to know about?

a. _____ Very little; I find it 70% of the time or more.

b. _____ Little; I find it about 70% of the time.

c. _____ Some; I find it about 50% of the time.

d. _____ A lot; I find it about 30% of the time.

e. _____ A whole lot; I find it about 10% of the time or less.

4. If you were looking for information on habitability, what type of information would you need most? (Please rank most needed first, etc.)

a. _____ Data or tables showing impacts of buildings on people and organizations.

b. _____ Requirements (statements of what is to be achieved)

c. _____ Criteria (standards or movable limits for satisfying requirements)

d. _____ Occupant activity needs and organizational functions (what they do in facilities)

5. For your main task, what kind of information resource or service would be most helpful in providing you with habitability information? Please rate each item below.

RESOURCE OR SERVICE	POTENTIAL HELP: A Lot	Some	A Little	None
a. Data book or handbook as guidance (with periodic updates)				
b. New research findings type newsletter				
c. Automated data base with local terminal				
d. Consultant or expert referral service				
e. State-of-the-art reports				
f. Abstracts of new publications				
g. Bibliographies				
h. Conferences on special topics in habitability				
i. Answers to requests for technical information				
j. Loans or reprints				
k. Other (specify)_____				
l. Other (specify)_____				
m. Analysis and reports on specific design solutions				

F. DATA BASE EVALUATION: The following tables are designed to determine the extent to which the kind of information we now have in the prototype Habitability Date Base (HDB) is used by you in the performance of your main task.

There are five tables, each having three columns of information.

Column 1 contains a listing of the habitability words which occur in the HDB.

Column 2 contains a blank line on which you can check _____ Low, _____ Medium, or _____ High indicating the relative importance of these listings of words to you in the performance of your main task.

Column 3 contains suggested word(s) (underlined) to represent the group of words in Column 1. Check _____ Yes or _____ No whether they do or not. If no, please suggest other word(s).

Table A1

Kinds of Habitability Statements

(1) Properties being rated	(2) Relative importance to your main task.	(3) Word(s) which best represent the properties.
Individual's activities and behavior plus organization's functions and procedures.	_____ Low _____ Medium _____ High	Activity needs? _____ Yes _____ No Other _____
Properties of occupant mental, physical, and/or physiological activities related to properties of physical facilities.	_____ Low _____ Medium _____ High	Research data? _____ Yes _____ No Other _____
Space names, desirable characteristics of spaces and environments, and relationships within and between spaces.	_____ Low _____ Medium _____ High	Space requirements? _____ Yes _____ No Other _____
Properties of facilities (a room, building, etc.) or environments (air, light, sound, etc.) that will fulfill space requirements.	_____ Low _____ Medium _____ High	Habitability criteria? _____ Yes _____ No Other _____

Table A2

Properties of Physical Facilities

(1) Properties being rated	(2) Relative importance to your main task.	(3) Word(s) which best represent the properties.
Length, width, height, directions, shape, area, cubage, etc.	_____ Low _____ Medium _____ High	Space? _____ Yes _____ No Other _____
Temperature, humidity, air velocity, heat transfer, etc.	_____ Low _____ Medium _____ High	Air Climate? _____ Yes _____ No Other _____
Light level, color, glare, reflectance, transparency, etc.	_____ Low _____ Medium _____ High	Light? _____ Yes _____ No Other _____
Sound intensity and duration, material transmissivity and absorption, etc.	_____ Low _____ Medium _____ High	Sound? _____ Yes _____ No Other _____
Floor vibrations, flexure, direction, and velocity, etc.	_____ Low _____ Medium _____ High	Motion? _____ Yes _____ No Other _____
Odor source and strength, air gases and particles, etc.	_____ Low _____ Medium _____ High	Air chemicals? _____ Yes _____ No Other _____
Radiation source and direction, infrared, radio, TV, etc.	_____ Low _____ Medium _____ High	Other radiation? _____ Yes _____ No Other _____
Concrete, steel, beams, columns, surface finishes, etc.	_____ Low _____ Medium _____ High	Structure and surfaces? _____ Yes _____ No Other _____
Fixtures, benches, chairs, desks, tables, etc.	_____ Low _____ Medium _____ High	Furniture and equipment? _____ Yes _____ No Other _____

Table A3

Properties of Occupant Activities

(1) Properties being rated	(2) Relative importance to your main task.	(3) Word(s) which best represent the properties.
Metabolism, blood pressure, respiration, etc.	_____ Low _____ Medium _____ High	Physiological activities? _____ Yes _____ No Other _____
Sit, walk, bend, turn, pick up, etc.	_____ Low _____ Medium _____ High	Physical activities? _____ Yes _____ No Other _____
Opinions, values, attitudes, preferences, beliefs, deductions, synthesis, etc.	_____ Low _____ Medium _____ High	Mental activities? _____ Yes _____ No Other _____
Functions, procedures, divisions, branches, operations, operational groups, etc.	_____ Low _____ Medium _____ High	Organizational structural activities? _____ Yes _____ No Other _____
Inputs, outputs, workflows, populations of groups, etc.	_____ Low _____ Medium _____ High	Organizational content activities? _____ Yes _____ No Other _____

Table A4

Occupant and Facility Settings

(1) Concepts being rated	(2) Relative importance to your main task.	(3) Words which best represent the concepts.
Station, room, functional area, behavior setting, activity setting, etc.	_____ Low _____ Medium _____ High	Functional area? _____ Yes _____ No Other _____
Office, training, etc., *building; warehouse*, hangar, facility, etc.	_____ Low _____ Medium _____ High	Facility type? _____ Yes _____ No Other _____
Land contours, acres, vegetation, waterways, drainage, etc.	_____ Low _____ Medium _____ High	Outdoor natural? _____ Yes _____ No Other _____

Table A5

Activity Needs

(1) Concepts being rated	(2) Relative importance to your main task.	(3) Word(s) which best represent the concepts.
Occupant mental, physical, and/or physiological *activities* in performing their main job.	_____ Low _____ Medium _____ High	Task performance needs? _____ Yes _____ No Other _____ _____
Occupant mental, physical, and/or physiological *activities* for life maintenance and preservation.	_____ Low _____ Medium _____ High	Health needs? _____ Yes _____ No Other _____ _____
Occupant mental, physical, and/or physiological *activities* to avoid accidents.	_____ Low _____ Medium _____ High	Safety needs? _____ Yes _____ No Other _____ _____
Occupant mental, physical, and/or physiological *activities* to express comfort and preferences.	_____ Low _____ Medium _____ High	Satisfaction needs? _____ Yes _____ No Other _____ _____

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