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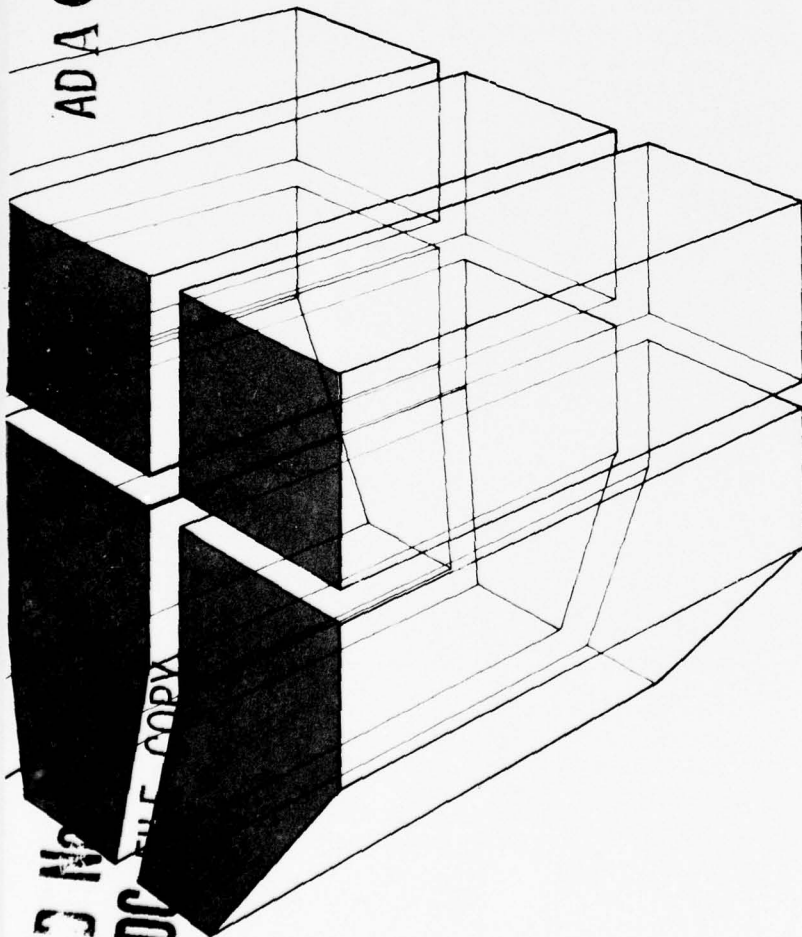
June 1977

Procedures for Generating and Communicating Criteria For Living,
Working and Training Environments and Testing for Conformance

CONCEPTS FOR THE GENERATION, COMMUNICATION,
AND EVALUATION OF HABITABILITY CRITERIA

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by
R. L. Brauer
D. L. Dressel

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents background information and concepts concern- ing the generation, evaluation, and communication of habitability criteria. Interactions between habitability criteria and facility delivery and use are discussed. The concepts presented form a basis for developing procedures relating personnel requirements to archi- tectural requirements in the Army facility delivery and use process.			

FOREWORD

This research was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A7-62719AT41, "Design, Construction, and Operations and Maintenance Technology for Military Facilities"; Task 03, "Architectural Research and Development in Support of Military Facilities"; Work Unit 006, "Procedures for Generating and Communicating Criteria for Living, Working and Training Environments and Testing for Conformance." The applicable QCR is 1.01.012. The OCE Technical Monitors for this study were Richard Cramer and Robert Shibley.

The work was performed by the Architecture Branch (HPA), Habitability and Planning Division (HP), U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, IL. The Principal Investigator was Dr. Roger L. Brauer, and Mr. David L. Dressel was Associate Investigator. Mr. Robert Porter is Chief of HPA and Dr. Robert Dinnat is Chief of HP.

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

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CONCEPTS FOR THE GENERATION, COMMUNICATION AND EVALUATION OF HABITABILITY CRITERIA

1 INTRODUCTION

Background

According to AR 415-20,¹ one of the responsibilities of the Office of the Chief of Engineers (OCE) is to develop, maintain, and promulgate architectural and engineering design criteria for use in providing the Department of the Army with constructed facilities.

Criteria must be responsible to user requirements in order for effective facilities to result from their application. Thus, developing, maintaining, and promulgating criteria are key factors in achieving buildings which effectively support the mission, functions, and operations of the using organizations as well as the health, safety, morale, and performance of the people who occupy them.

Because the responsiveness of facilities constructed by the Corps of Engineers to user requirements depends on the Army's design criteria and the procedures for their development and application in Military Construction-Army (MCA) cycle activities, OCE issued a Quality Construction Requirement (QCR 1.01.012, 19 November 1974) calling for the development of procedures to generate, evaluate, and communicate criteria so that responsiveness to user requirements is assured.

Objective

This report is part of a study designed to respond to QCR 1.01.012. The main objectives of this study are (1) to understand and list relationships between personnel requirements and architectural requirements (these relationships are referred to as habitability relationships) and (2) to develop procedures for implementing these relationships in criteria generation, evaluation, and communication as well as in related MCA-cycle activities.

The purpose of this report is to document work performed to date on habitability procedures. The products of this work are concepts about generating, evaluating, and communicating habitability criteria and about the place of these activities within the Army's ongoing facility delivery and use process. These concepts are expected to form the basis for future work in this area.

¹*Project Development and Design Approval*, AR 415-20 (Department of the Army, 1974).

Approach

The overall study approach involves three phases: (1) gaining a more thorough understanding of the problem and formulating concepts for meeting the study objectives, (2) developing and testing solutions based on the concepts, and (3) implementing those solutions which the tests show to be effective, efficient, and economical. The work presented in this report completes the first phase of this study.

2 DEFINITION OF TERMS

Several terms used in this report have been given specific operational meanings. To clarify their use, definitions are presented below:

Criteria: statements inferred from requirements which form the basis for determining whether a purported solution satisfies those requirements.

Habitability criteria are those criteria that state or imply relationships between facilities and people or organizations.

Criteria generation is the process by which criteria are established.

Criteria communication is the medium format for documenting and retrieving established criteria.

Commentary: statements that describe the rationale used in establishing a criterion. Such things as why a criterion was selected, why a particular limiting value of a measure was chosen, and why satisfying the criterion will also satisfy the requirement are included in these statements.

Effectiveness: the degree to which a desired effect is actually produced or achieved.

Evaluation: the process of judging or determining the quality of something.

Criteria evaluation is the systematic process of determining how effectively criteria yield built solutions which satisfy requirements.

Facility evaluation is the process of determining the quality of a facility based on conformance with the criteria established for it.

Evaluation procedures are the step-by-step methods used in evaluation.

Guidance: advice regarding the application of criteria in facility planning, design, or operation.

Habitability: the condition of being habitable expressed in terms of a collection of relationships that should exist between a constructed environment and its inhabitants.

Needs: basic or fundamental goals.

Human needs are goals sought by human beings, such as health, safety, security, task performance, and satisfaction.

Organizational needs are goals sought by organizations, such as mission performance (efficiency and effectiveness), and economy.

Objectives: qualitative or quantitative statements of the aims of organizations, groups, or individuals. Objectives are subsets of goals and are more specific than goals.

Relationship: any aspect or quality identifying how two or more things are connected, such as direction, similarity, causality, intensity, frequency, correlation.

Habitability relationships are relationships which identify how properties or attributes of built facilities are related to properties or attributes of organizations, groups, or individuals.

Requirements: qualitative statements of objectives for facilities. In performance language they are defined as statements of discrete technical need or expected results for a facility.

Habitability requirements are facility objectives which relate objectives of organizations, groups, or individuals to built facilities.

3 BACKGROUND CONSIDERATIONS

Before criteria generation, communication, and evaluation can be discussed in detail, three factors must be considered: (1) the interactions between the facility delivery and use process and the process of criteria generation, communication, and evaluation; (2) the dispersion of habitability criteria among existing criteria classifications; and (3) the role of habitability criteria in the facility delivery and use process. The concepts about habitability criteria generation, communication, and evaluation presented in subsequent chapters have been formulated based on these three considerations.

Interactions Between the Two Processes

The dynamic process of facility delivery and use has been simplified for this discussion into six elements: master planning, construction programming, project development, design, construction, and occupancy. Figure 1 depicts the process as the rim of a wheel to show its cyclical nature. The process of criteria generation, communication, and evaluation is represented as the spokes and hub of the wheel. These two processes are not independent, but have many interactions which enable the criteria generated to be effective in producing facilities which meet user requirements. The major interactions are discussed in the following sections.

Criteria Generation

Since criteria are inferred from requirements, requirements must be formulated prior to criteria generation. User requirements are the basis for many criteria. Locally specific user requirements, which provide the basis for some criteria, stem from the project development segment of the delivery and use process (solid arrow in Figure 1). User requirements which are generalized across facilities and populations of users (assumed for them) form the basis for other criteria. This is shown as part of criteria generation in Figure 1. Generation of requirements is discussed further in Chapter 4, while criteria generation is described in Chapter 5.

Criteria Communication

Once criteria are formulated, they must be communicated through formats and media appropriate to a variety of activities, decision points, and disciplines in elements of the facility delivery and use process. This is represented in Figure 1 by the arrows emanating from criteria generation (the hub) to points on the rim. Criteria communication is discussed more completely in Chapter 7.

Criteria Evaluation

The effectiveness of criteria is evaluated through feedback from the facility delivery and use process, in particular from the project

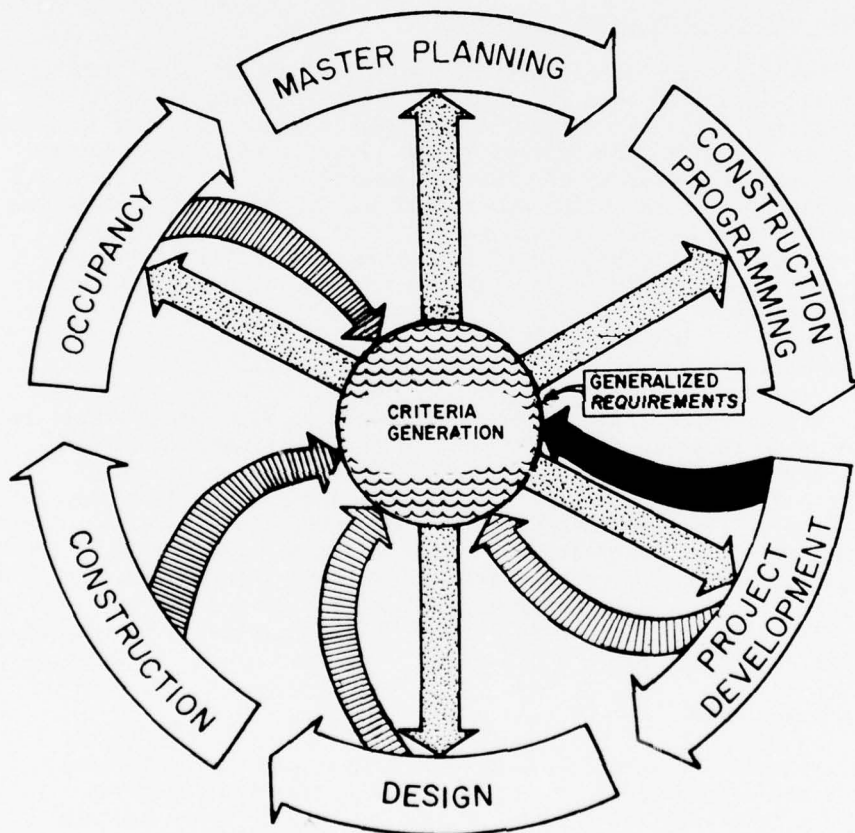
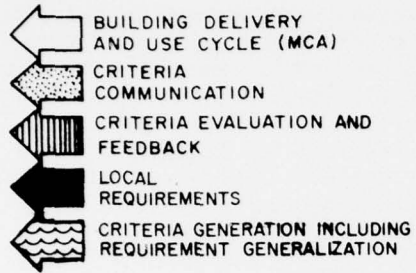


Figure 1. Interaction between facility delivery (MCA cycle) and use and criteria generation, evaluation, and communication.

development, design, construction, and mainly the occupancy segments. This feedback is represented in Figure 1 by arrows from these segments to the hub. In some cases specific procedures (such as those described in ER 415-3-11²) foster this interaction. These feedback channels identify whether criteria fit locally (project development and design), whether they are reasonable to apply (design), whether they can be constructed (construction), and how effectively they result in satisfactory solutions to requirements (occupancy). Chapter 6 contains a more detailed discussion of criteria evaluation.

Habitability Criteria Within Criteria Classifications

Criteria for facilities can be classified in many ways. One such way is according to the goal which they are designed to achieve. Some are introduced to effect economy while others are generated to achieve efficiency in delivery. Many are promulgated to insure that facilities are of high quality. Habitability criteria are all aimed at quality in providing facilities which perform effectively for the needs of organizations and people who occupy them.

Another way criteria can be classified is according to their use or point of application in the facility delivery and use process. For example, some criteria are used in planning, some in occupancy, and many in design. Habitability criteria do not fit into any one use category; they can be applied at every point in the facility delivery and use process to help achieve high facility performance for users.

One of the most common ways in which criteria are classified is on the basis of subject matter or substance. Substance itself is classified many ways for facilities--by components or subsystems (heating, lighting, structure, etc.) or by trade or discipline (plumbing, fire prevention, architecture, electrical engineering, etc.). Habitability criteria do not fall into any one of these substance categories, but extend across virtually every category because virtually every substance area has an impact on how well a facility performs for the organizations and people who occupy it. However, not every category receives the same emphasis from habitability criteria, since they do not all contribute equally to the facility's performance.

Role of Habitability Criteria

Application of criteria in the facility delivery and use process insures three basic requirements: economy of construction and operation, efficient delivery, and high quality. Habitability criteria,

²Feedback Information, ER 415-3-11 (Office of the Chief of Engineers, July 1975).

which are currently found mainly in the TM 5-800 series but will also be found in the new Design Guide series (currently being developed), relate to the quality requirement.

Master Planning

Habitability criteria play a significant role in planning activities. Periodically, existing facilities are evaluated to determine whether they are substandard. They could be substandard for a number of reasons, including health and safety factors, lack of direct support for missions, functions, and operations, or lack of indirect support for missions, functions, and operations resulting from low morale of personnel. While the criteria for determination of substandard facilities are left to the judgment of each installation commander (AR 415-15³), habitability criteria can be provided to assist local commanders in formulating their judgments. When it has been determined that a new facility is needed, habitability criteria can help in determining site size (based on parking, operations, etc.), site location (based on traffic, relationship to other facilities, and operations, etc.), and appearance.

Construction Programming

While habitability criteria do not have a major role in MCA facility programming activities, they could assist in determining which facilities should have the highest priority by aiding assessment of the impact of priorities on missions, functions, and operations.

Project Development

Habitability criteria play an indirect but significant role in project development (AR 415-20, TM 5-800-3⁴). The main purpose in project development is to establish functional requirements--the basis for generating criteria. However, in reality, criteria are used to determine what is "allowed." In doing so, only those criteria which are obviously inappropriate are detected and a variance requested. However, if a using service states the requirements for a facility based on an analysis of its mission, functions, and activities and the personnel and equipment which occupy the facility, published requirements and criteria can be reviewed to detect inappropriate or missing requirements and criteria. Habitability criteria are of particular interest to the using service at this point because they are aimed at providing a facility which effectively supports the using service's mission, functions, and operations.

³*MCA Program Development*, AR 415-15 (Department of the Army, 1969).

⁴*Project Development Brochures*, TM 5-800-3 (Department of the Army, 1974).

Design

Habitability criteria have their most important impact in the design phase. Designers and design reviewers use habitability criteria as the limits or standards for determining whether user requirements are met. Certain criteria are needed in concept design, while others are used in detailed design.

Construction

Habitability criteria have only a minor role in construction, because requirements have been converted into plans and specifications within the limits of criteria during design. However, any changes in materials or layouts should be evaluated in terms of user requirements and habitability criteria. For example, a contractor-submitted value engineering proposal must be reviewed not only for its economic effects, but for its impact on mission, functions, and operations (the qualitative value). Because of a lack of information, the impact on functional quality is not always given due consideration. Habitability requirements and corresponding habitability criteria together with guidance can effectively demonstrate the impact of changes during construction on mission, function, and operations, so that the quality of a facility is not sacrificed at such a late stage of delivery.

Occupancy

During occupancy, habitability criteria together with guidance can be most useful in maintaining a facility's functional quality. Features provided in newly delivered facilities to support organizations and people who use them are not always obvious or understood by those who manage or operate them. Knowing how to use these features effectively is very important. In facilities which have existed for a period of time, habitability requirements and criteria together with guidance can help facility managers and operators detect functional deficiencies early and prevent significant impacts on missions, functions, and operations.

While the role of habitability criteria is most significant in facility design, they also clearly have significant roles in other aspects of facility delivery and use. Table 1 summarizes these roles.

Table 1
 Summary of Habitability Criteria's Roles in the
 Facility Delivery and Use Process

Element of the Facility Delivery and Use Process	Role of Habitability Criteria
Master planning	Assist in determining if existing facilities are substandard. For planned facility, may assist in determining site size, site location, and appearance.
Construction programming	Assist in determining which facilities should have highest priority.
Project development	Analysis of functional requirements is the basis for review of published assumed requirements and corresponding criteria to detect inappropriate or missing requirements and criteria.
Design	The limits or standards for determining whether user requirements are met. Basis for trade-offs, selecting materials, achieving effective solutions.
Construction	Evaluate changes in materials or plans in terms of requirements and criteria. Assist in evaluation of value engineering proposals.
Occupancy	Assist in maintaining the functional quality of a facility. Detect functional deficiencies in older facilities.

4 GENERATING HABITABILITY REQUIREMENTS FOR FACILITIES

Since criteria are based on requirements, generation of requirements must be discussed before criteria generation, evaluation, and communication. Requirements are statement of objectives for a facility--what is to be achieved at that facility. Providing requirements for local conditions is the responsibility of the using service. For conditions extending across using services or facilities, requirements are generalized by others (such as OCE) and assumed to fit locally.

Requirements are derived from mission statements combined with human needs and organizational needs, as shown in Figure 2. Missions are structured into more specific statements of function and operations. The personnel and equipment corresponding to each operation are identified and tabulated. From these sets of information, requirements for the facility can be stated. This process has been discussed in detail by Davis.⁵

To provide functional requirements for a facility, a using service must perform an analysis like that described above. However, because in many cases activities, personnel, and equipment are uniform, or relatively uniform, many of the requirements can be assumed and stated directly when criteria are being generated. There are two potential errors when requirements are assumed: assumed requirements may not fit locally or requirements which are needed locally may not have been assumed.

For example, in most situations, it is assumed that a dining hall should be arranged to serve a certain number of troops from several units in one large space. However, at one installation an intensive language training program was structured so that students were required to converse and carry out all daily activities and transactions in the language they were learning. Students had to select food from menus in that language and communicate with serving personnel in that language. Because of the applied nature of the training and the fact that several languages were being taught, the school required separate serving and eating areas for each language.

The following example illustrates a case where a needed requirement was not assumed. In some training programs it was found that individual counseling could reduce the number of "washouts" and maintain student motivation. Therefore, some kind of counseling space was required. However, existing documents had no requirements which addressed counseling.

⁵T. A. Davis, *Conceptualization for the Generation of Habitability Requirements*, Interim Report D-69/ADA030091 (U.S. Army Construction Engineering Research Laboratory [CERL], 1976).

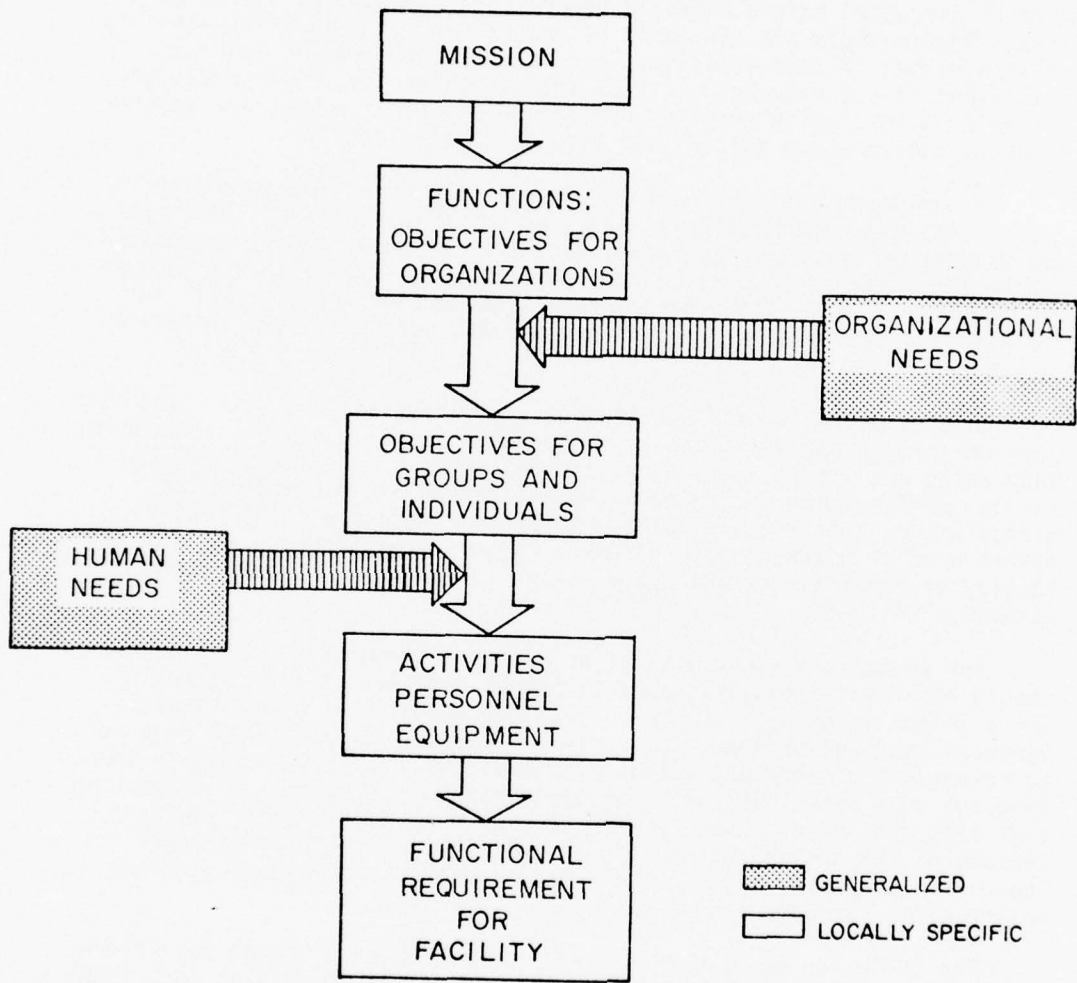


Figure 2. Generalized process for deriving functional requirements for facilities.

By assuming requirements, the using service reduces the task of stating functional requirements, but it must still complete an analysis to derive information on operations, personnel, and equipment. Instead of generating all of its requirements, the using service must simply evaluate assumed requirements to determine (1) whether they fit locally or (2) whether needed requirements are already available. The task is thus reduced to stating special requirements (as they are called in the Project Development Brochure, TM 5-800-3); these special requirements are either variances to assumed requirements or new requirements where none are assumed.

Like criteria, requirements can be classified in many ways--according to their purpose (efficiency, economy, effectiveness), content, or use. Habitability requirements deal with the quality of a facility and state facility objectives which are supportive of the missions, functions, and operations to be housed.

5 GENERATING HABITABILITY CRITERIA

Criteria Generation Procedures

Since criteria are inferred from requirements, the process of criteria generation begins with requirement statements. As habitability criteria are generated from habitability requirements, technical information must be referenced and other requirements must be considered, as shown in the simplified diagram in Figure 3.

Most importantly, criteria must be technically correct. In establishing criteria that are technically feasible and judged to result in solutions which satisfy requirements, the current body of knowledge must be referenced. This body of knowledge includes both research data and professional experience.*

Criteria must also be realistic and reasonable. Other requirements such as economy or efficiency of facility delivery tend to constrain habitability criteria to those which are practical. Other requirements can also reflect organizational goals which have resulted in policies governing personnel, operations, or equipment to be housed or accommodated by a facility.

As with the generation of requirements, generating criteria requires considerable judgment. However, the degree of judgment required can be reduced by having as much information at hand as possible. This information should include a thorough understanding of what is required, data to support the degree to which a requirement can be generalized (and therefore assumed), a compilation of all other requirements influencing the selection of possible criteria and solutions, research data about the relationships between facilities and performance (of organizations and people), health, safety, and satisfaction in specific operations using specific equipment, and professional experience in solving such problems.

*A data base which will act as a resource in the generation of habitability criteria is currently being developed at the U.S. Army Construction Engineering Research Laboratory (CERL). The data base will contain habitability information and will include a mechanism for easy access to its contents. For information see R. L. Brauer and T. A. Davis, *Development of an Objective Definition of Habitability and a Habitability Data Base*, Special Report D-79 (CERL, June 1976); D. Dressel and R. Brauer, *Initial Report on Systemizing Information to Identify or Relate Behavioral and Physical Design Parameters*, Preliminary Report D-4/AD757627 (CERL, 1973); and N. D. Lane, *An Evaluation of Architectural Information Systems*, Interim Report D-41/ADA001616 (CERL, 1974).

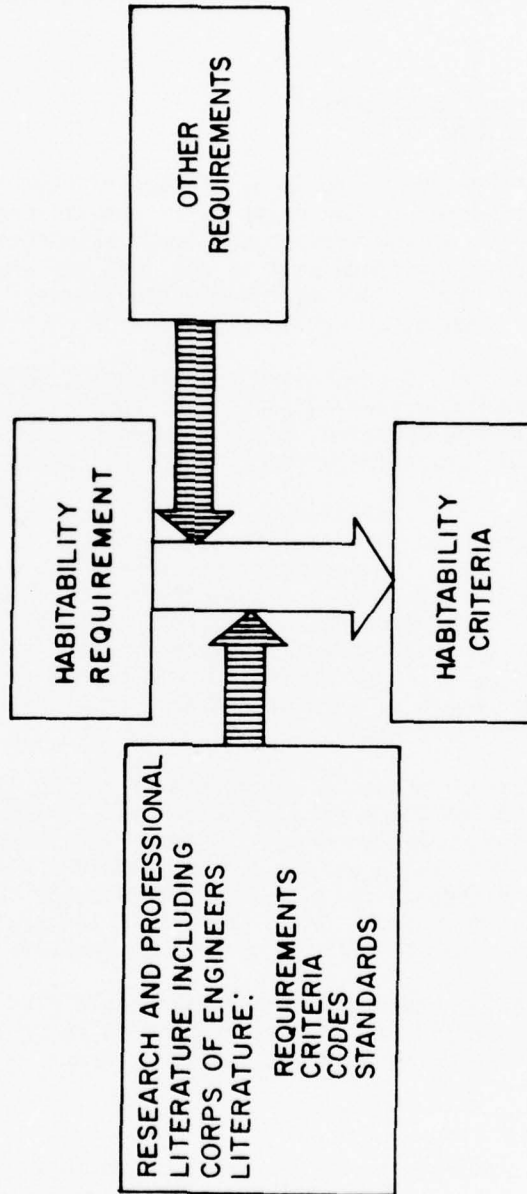


Figure 3. Simplified process for generating habitability criteria.

Figure 4 presents the detailed steps required to generate habitability criteria. Each type of information must be reviewed systematically to generate criteria which will insure effective solutions in facilities.

Potential Errors in Criteria Generation and Use

Shortcuts in the criteria generation process potentially can lead to a number of errors. For example, if special requirements (submitted by a using service) are presented without supportive evidence or data, readers may not understand what is required and why. Resulting errors could be use of inappropriate assumed requirements instead of the special requirements, or application of wrong criteria.

For requirements which have been assumed, information must be provided to show how generalizable such requirements are. If such information is not provided, corresponding criteria could be applied to facilities and situations where they are not appropriate.

At some point, criteria must be selected from candidate criteria or criteria values must be established from data. At least three errors are possible here: (1) unrealistic criteria could result if constraints have not been investigated and understood; (2) ineffective criteria could result if research data about relationships between facilities and organizations or people are incomplete or unavailable;* and (3) impractical criteria could result if professional experience is not used to identify problems of turning criteria into solutions through building materials and components.

Errors can also result when criteria are applied, particularly because of a lack of commentary or guidance. If commentary is not provided or if the correspondence between a requirement and a criterion is not clear, users having one requirement could apply a criterion belonging to a different requirement. If guidance for applying some criterion is not provided or is not clear, the criterion could be misapplied, resulting in an inappropriate or ineffective solution.

Undoubtedly, other types of errors could also result. The most important concern in criteria generation is to be aware of potential errors and to formulate criteria so that errors in application are

*For a discussion of such relationships and their utility, see T. A. Davis, *Conceptualization of Habitability Expressions for the Habitability Data Base*, Interim Report D-68/ADA029661 (CERL, 1976); and R. L. Brauer and T. A. Davis, *Development of an Objective Definition of Habitability and a Habitability Data Base*, Draft Special Report (CERL, 1976).

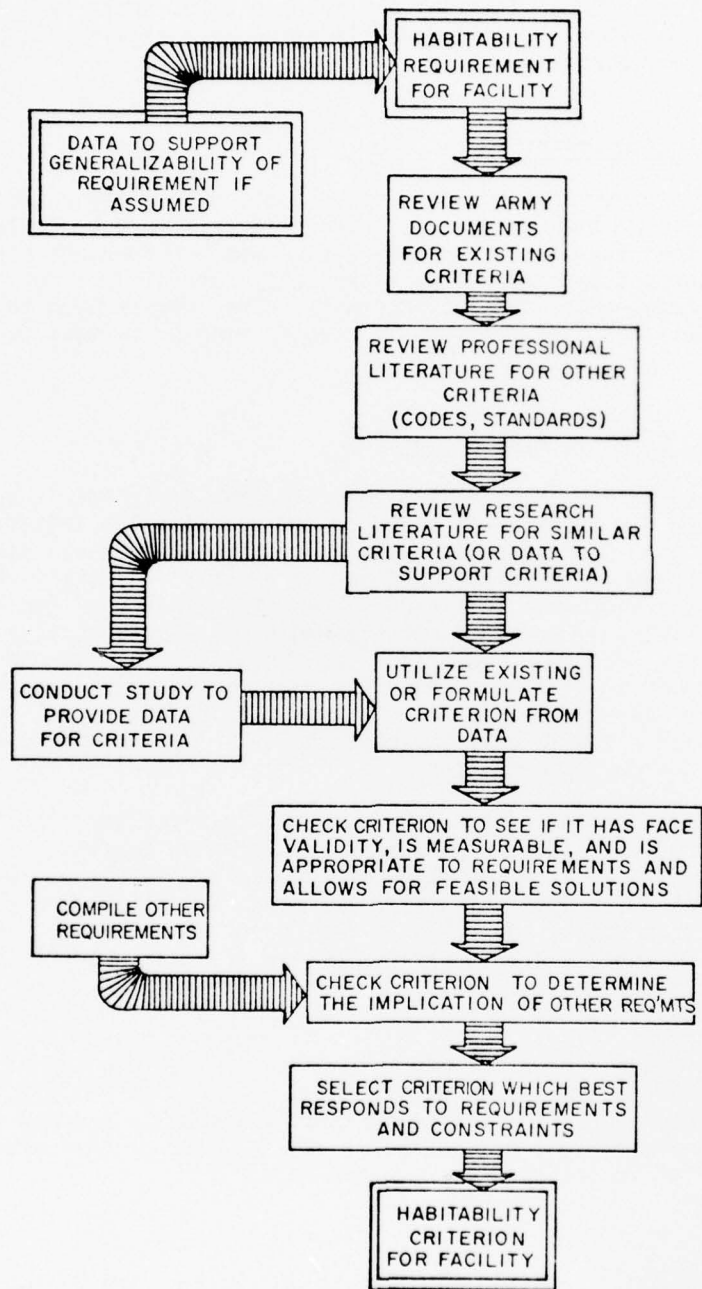


Figure 4. Detailed steps in generating habitability criteria.

avoided and effective solutions in facilities are achieved. Reducing errors in criteria themselves is the main purpose of criteria evaluation. Reducing errors in criteria application is a significant concern for criteria communication.

Validating Existing Criteria

Criteria generation also included validating or regenerating existing criteria. From time to time, existing criteria must be reviewed to determine whether they are still applicable--whether they are realistic in light of current constraints or technically correct in light of current knowledge, practice, and materials. The process used in generating new criteria is also followed in regenerating or validating existing criteria.

Procedures for Criteria Application

One way to insure that habitability criteria are properly applied is to develop and provide application procedures with the criteria, i.e., provide guidance for their application. In many cases, simply providing a design limit or standard is not enough. The skill, knowledge, and expertise of personnel in field offices of the Corps of Engineers, at Army installations, and in architect-engineer (AE) firms vary widely. These variations must be recognized. Individuals trained in one area are often responsible for more than that area, including areas about which they may have little knowledge. Providing guidance procedures for application with criteria will increase the overall probability of correct application in such cases.

Whether development of procedures for applying criteria falls under criteria generation or criteria communication can be debated. The important point is that if application procedures are developed and communicated directly with the criteria, errors in application would be reduced. This is one of the goals of the Design Guide series.⁶ Presenting application procedures with criteria also saves time for those who need such procedures.

Example of Guidance

The following example illustrates what guidance is and how it differs from requirements and criteria. The content of this example is not in itself of importance.

⁶Richard W. Cramer, "Development of Space Utilization and Design Guides," *Programming for Habitability: Symposium Proceedings*, Symposium Proceedings D-62/ADA034135 (CERL, 1975).

Background

Consider a conference space in an office building, or a similar space where people meet. One requirement for such a space would be control of odor at an unobjectionable level. The criterion for satisfying this odor control requirement is a function of the type of contaminant (usually body odor or cigarette smoke) and its concentration.

Typically, dilution with ventilation air (whether outdoor air or recirculated and cleaned air) is the solution used. If for some reason local policy rules out smoking in conference spaces, body odor would be the main concern. Ventilation systems also provide thermally comfortable conditions and adequate oxygen supplies and restrict carbon dioxide buildup from expired breath. All these factors influence the solution for the space.

Existing codes contain fairly uniform criteria based on experiments on acceptable body odor and smoke level in rooms. For this example, 13 cfm (0.37 m³/min) of fresh air per person is assumed necessary to dilute body odors to an acceptable concentration. Similarly, 35 cfm (0.99 m³/min) of fresh air per smoker must be supplied to dilute cigarette smoke to a level where smoke odor is imperceptible to smokers and nonsmokers in the space and acceptable to most people who enter the space from fresh air. It is assumed that no more than 50 percent of the adult population will be smokers.

Example Requirement, Criteria, and Design Guidance

The requirement (which has been assumed), criteria, and design guidance for the example might look like this:

- | | |
|------------------|--|
| Requirement: | For conference rooms, provide odor control so that body odors and smoke from cigarettes are not objectionable to occupants. |
| Criteria: | For control of odor by dilution with ventilation air, provide the following amounts of clean air: <ul style="list-style-type: none"> For smoke - 35 cfm (0.99 m³/min) per person For body odor - 13 cfm (0.37 m³/min) per person |
| Design Guidance: | If both contaminants are being designed for, the smoke criterion governs. However, when determining which criterion applies, make sure that the policy on smoking is known. If ventilation air can be reduced, operating costs may also be reduced because of the cost involved in heating or cooling outside air (the usual source of fresh air). |

It is reasonable to assume that in a typical group of adults, no more than 50 percent will be smokers. However, it may be well to investigate the population to be housed in more detail to determine whether this rate would usually be exceeded. If so, ventilation requirements for smoke control would have to be adjusted upward.

When applying the fresh air criteria, refer also to criteria on ventilation air used for thermal comfort. Odor control and thermal comfort criteria for ventilation air are not additive. It should also be noted that the minimum amount of fresh air required is for maintaining an adequate oxygen level and is about 4 cfm (0.11 m³/min) of outside air per person. All criteria governing ventilation air must be integrated in designing the HVAC system.

The quality of the outdoor air should be evaluated prior to design to determine whether it is sufficiently clean to be used as fresh air, particularly in large cities or near industries or highways. Air quality records should be examined to determine whether contaminants hazardous to health have built up during stagnant weather conditions and rendered outdoor air unacceptable as a fresh air source.

Care should be taken in design to insure that exhaust ports are located properly relative to intakes to avoid recirculating contaminants. Location of intakes and exhaust vents should be evaluated for adjacency, relationship relative to prevailing winds, or the effect of airflow patterns caused by the building or any of its components.

6 EVALUATING HABITABILITY CRITERIA

Criteria Evaluation

Criteria evaluation is not the same as facility evaluation. While the same or similar procedures might be used for both types of evaluation, the purpose of each is different, and the kind of judgments or inferences made are different. Facility evaluation is the process of determining whether the requirements laid down for a facility have been met; it focuses on individual buildings. On the other hand, criteria evaluation is aimed at determining whether criteria, as limits or standards, resulted in effective solutions. Criteria evaluation is directed at all buildings to which a criterion is appropriate.

Kinds of Criteria Evaluation

Of the several kinds of criteria evaluation, one is intrinsic to criteria generation while the others provide feedback to generation. The latter include feedback during design on the feasibility of solutions based on criteria, and feedback following occupancy on the effectiveness of constructed solutions (Figure 1).

Criteria Evaluation Through Feedback in Project Development and Design

As shown in Figure 1, a minor form of criteria evaluation occurs through feedback during project development and design. It is minor in the sense that it provides information about the feasibility of solutions as attempts are made to apply criteria, rather than information about effectiveness of solutions. In addition, this feedback is informal. If problems arise in implementing criteria, information comes back to OCE and is directed to people who generate criteria. This evaluation is similar to evaluation during generation, because it also anticipates or predicts effectiveness of criteria in solutions.

Criteria Evaluation Through Feedback From Completed Facilities

The most important kind of criteria evaluation is that which occurs when a facility is completed and occupied. Predicted performance is compared to actual performance. In this case the effectiveness of a criterion as applied in an actual solution is assessed. For example, if a criterion is responding to a requirement for mission performance, then the impact of the solution on mission performance becomes the measure of effectiveness for criterion governing the solution. Similarly, if a criterion is responding to a requirement for health of personnel, then the health record of personnel is a measure of the effectiveness of the criterion. In evaluating criteria performance, evidence is gathered to show that criteria predictably result in effective solutions for requirements.

Procedures for Criteria Evaluation

The main focus of this section is on procedures for evaluating criteria in completed facilities, since procedures for evaluating criteria during generation are intrinsic to the criteria generation process, and those for criteria evaluation through feedback in project development and design are informal, as previously discussed. The existing design criteria feedback program is detailed in ER 415-3-11. Procedures for this program call for site visits and visual inspection of completed facilities. Usually some local and District-level complaints surface during these inspections. Although this program has merit, procedures are informal and limited to visual assessment, which means they are of limited value for evaluating the effectiveness of criteria in providing solutions to user requirements.

Criteria evaluation in completed facilities involves making measurements which require more than visual observation. These measurements can be of two types: measurement for compliance and measurement for effectiveness.

Measurement for Compliance

Measurement for compliance involves assessing whether criteria were met. For example, if a lighting criterion called for an intensity of 100 foot-candles (1076.4 lux), the lighting level must be assessed with a light meter. If a minimum of 72°F (22°C) was called for during the heating season, then a thermometer must be used to determine if that criterion was met. If a certain number of electrical outlets was called for, the outlets would have to be counted. If a space criterion in offices called for a minimum amount of space for each work station, each work station must be measured to determine whether the criterion was met.

Although knowing whether criteria have been complied with is important, it does not provide any information about the effectiveness of the criteria in achieving satisfactory solutions. Thus, measurement for effectiveness is required.

Measurement for Effectiveness

During criteria generation procedures, the main objective is to establish limits or standards by which requirements are met. Judgment based on available research and professional literature is used to predict effective solutions for requirements. The main purpose of criteria evaluation, then, is to determine whether solutions effectively satisfy requirements as delineated by criteria.

For example, a habitability requirement might be to provide sufficient light for reading 12-point type. The corresponding criterion

might be that 100 foot-candles (1076.4 lux) are required 30 in. (0.8 m) from the floor. If there were little data in the literature about the relationships between lighting and visual tasks, then measurement for effectiveness would require that tests be run to determine if 100 foot-candles (1076.4 lux) were sufficient for reading 12-point type with a certain error rate. Before such a test could be run, it would have to be determined that 100 foot-candles (1076.4 lux) were actually provided--measurement for compliance.

Criteria evaluation through feedback from constructed facilities is most essential in areas for which there is little specific information available which would assist in setting criteria, such as requirements concerned with health, safety, morale, and performance of people and organizations. Visual observation is not sufficient; specific measurements are necessary. As more information is gained, and relationships between facilities and organizations or people are quantified, criteria can be written which insure that solutions provided in facilities will be effective in meeting requirements.

7 COMMUNICATING HABITABILITY CRITERIA

General

In order to achieve satisfactory solutions in facilities, habitability criteria must be communicated to those who apply them in the facility delivery and use process. For criteria to be applied effectively, users must (1) be able to easily identify and locate the criteria which are relevant, (2) understand the content of the criteria, (3) know how to use them, and (4) perceive the consequences of their application.

The three elements in communication which accomplish these goals are content, format, and media. Content is established by the criteria generator, who uses given or assumed requirements in determining what must be limited or controlled to achieve performance quality in a facility. Because there are many different users with different tasks at different points in the facility delivery and use process (Table 2), a printed document is clearly a necessary medium. However, other media, such as an interactive computer terminal or a standard audiovisual package, can be used for specific criteria application tasks or for training. Formats can be quite varied, depending on the intended use and content of the criteria.

Principles in Criteria Communication

As discussed in Chapter 5, guidance for applying criteria should be provided with the criteria as a means of insuring high quality in facilities. While many application procedures are being presented in Design Guides, and development of others is planned in future research and development projects, this section presents generalized principles for communicating criteria, including guidance. When applied, these principles will assist in delivering high quality facilities and in maintaining their effective use.

Criteria Documents Must Be Easily Updated and Changed

This principle impacts the structure of chapters, sections, and paragraphs as well as the type of binding. Rate of change must be considered. Not all sections change at the same rate; guidance may be updated more frequently than the criteria. For this reason, loose-leaf binding may be more economical than other forms of binding. Chapters and sections should be identified by number or letter so that they stay relatively constant, while specific paragraphs change.

Table 2
Required Habitability Information

User	Use	Habitability Information Required
Master planner	How many facilities of each type are needed. Evaluation of existing standard for adequacy. Main requirements (space, siting, parking, etc.) for facilities of a given type.	Tables and formulas which predict number, size, and type of facility. Tables and formulas for predicting main requirements for a facility.
MCA programmer	Requesting and justifying facilities. Ranking facilities for priority.	Standards for justifying facilities on the basis of mission and function. Planning-type criteria to assist in establishing priorities.
Project developer (using service and local facilities engineer)	Determining special requirements and local fit of existing criteria.	Existing requirements and criteria and the rationale behind criteria.
Designer	Development of concept or final design.	Criteria responding to requirements for specific facilities and guidance for application. Only high order criteria are needed for concept design--those affecting siting, space quantity and relationships, and major subsystems and components. More detailed criteria are needed for final design.

Table 2 (Cont'd)

User	Use	Habitability Information Required
Design reviewer	Review of concept or final design.	Same as for development of concept design plus functional requirements.
Construction contractor and inspector	None.	Criteria have been translated into plans and specifications, which are referred to.
Value engineer	Evaluating value engineering proposals.	Criteria and requirements must be referenced in formulating value engineering judgments.
Facility operator or manager	How to operate a facility effectively. Detecting deficiencies in facility performance. Formulating policy about facility use and operation.	Criteria, requirements, and guidance for using features effectively in support of operations.

Criteria Documents Must Be Thoroughly Indexed

One difficulty with large documents is locating a particular item. If people have difficulty finding what they are looking for, they will rely on memory, neglect the material, or guess. Thus, adequate indexing is necessary to insure accuracy. Because criteria are referenced by many different users for a variety of purposes, a variety of vocabularies are used to access them. Therefore, several indices are needed. Indexing might be by space type, activity, facility subsystems and components, discipline, or a number of other ways.

A Criterion Must Always Be Presented With the Requirement to Which It Responds

Because criteria cannot be applied independently from their corresponding requirements, they should always be communicated with the requirements for which there are limits or standards.

Information Presented Must Have a Consistent Layout

Formats must be consistent throughout the document. If a sequence of requirement-criteria-commentary-guidance is adopted, it should be followed uniformly. Having a consistent layout allows people to anticipate where to look in the proper section for the information they need, and can reduce scanning and reading time significantly.

Information Presented Must Be in Meaningful Order

The purpose of this principle is also to provide efficient access to needed information; it does so by focusing on the logic of a task or a sequence of tasks. For example, there is a logical basis for structuring information in a facility, space-type, environment, utility order, since such a hierarchy follows a sense of scale or level of detail.

Information Must Be Clearly Presented

Necessary information must be communicated in clear, simple language, layout, and media to minimize the time required for reading and comprehension.

Media Should Be Appropriate to the User and the Type of Information

This principle is aimed at maximizing comprehension in the minimum time. For example, if the intent is to get general ideas across, as in training, then audiovisual or graphical media might be most appropriate. If precision is required, the appropriate level of precision must be used in such media as charts, tables, formulas, or verbal descriptions.

Procedures Must Be Distinctly Identified

Users must never confuse substances (such as criteria or requirements) with procedures for their application. What a person should do must be clearly distinguished from what he/she should do something about.

Procedures for Different Users or Tasks Must Not Be Confused

As shown earlier, a number of different users apply criteria to different tasks. Consequently, a guidance for one user must be clearly distinguished from that for another. Similarly, guidance for applying one criterion must not be confused with guidance for another criterion. This principle can be accomplished through formatting and use of distinct headings. The specific means of implementing this principle depends on the overall approach to the documentation.

Habitability Criteria Should Not Be Separated From Other Types

As indicated in Chapter 3, although habitability criteria are aimed only at quality, they extend across nearly every category of criteria regardless of their substance classification. They can be most effectively applied if they are located with other criteria on the same topic. If they are placed in a separate section, they will be confusing or will simply be ignored by those who are not familiar with them.

Criteria Should Not Be Published Without Procedures for Their Application

Application procedures should not be left to the discretion of the users. Although procedures for application may often be familiar to many users or be standard practice, some persons responsible for criteria application may not be familiar with standard methods. Providing a method of application with the criteria eliminates the potential error of using inappropriate methods. This principle is not designed to provide solutions for each criterion, but to achieve uniformity in methods of application.

Criteria Should Not Be Published Without Procedures for Assessing Compliance

Procedures for assessing compliance should be provided with criteria as a basis for quality control. Compliance procedures cannot be left to the discretion of those who apply criteria.

8 SUMMARY AND RECOMMENDATIONS

This report has presented concepts concerning the generation, communication, and evaluation of habitability criteria and discussed the role of these activities within the Army's facility delivery and use process. This report completes the first phase of the research concerned with procedures for relating Army personnel requirements to architectural requirements.

It is recommended that the concepts presented here be used as the basis for second phase work--developing and testing procedures for dealing with relationships between Army personnel requirements and architectural requirements in the Army facility delivery and use process.

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