

AD-A031 000

CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/13
PROCURING TODAY'S BUILDING TECHNOLOGY: VOLUME I. A SUMMARY.(U)
SEP 76 M G CARROLL

UNCLASSIFIED

CERL-SR-D-72-VOL-1

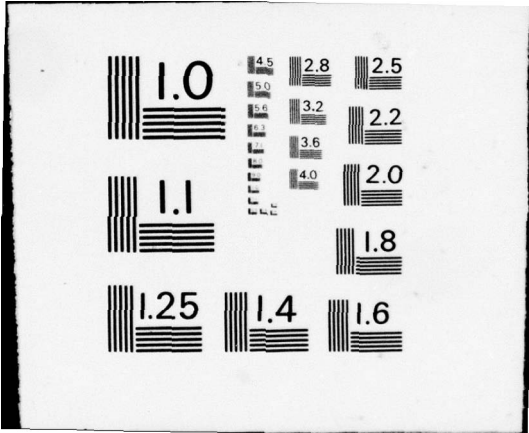
NL

1 OF 1
ADA031000



END

DATE
FILMED
11 - 76



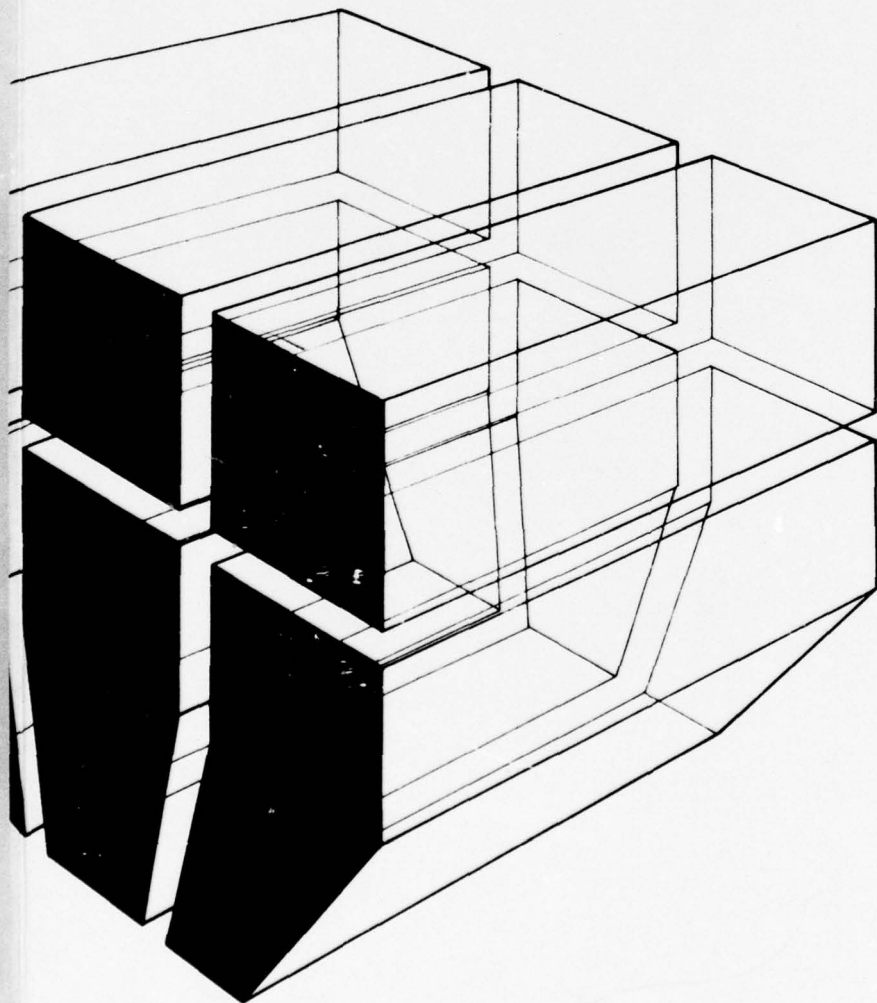
AD A031000

construction
engineering
research
laboratory



SPECIAL REPORT D-72
September 1976

PROCURING TODAY'S BUILDING TECHNOLOGY:
VOLUME I
A SUMMARY



by
Michael G. Carroll

DDC
RECEIVED
OCT 20 1976
RECEIVED
D



Approved for public release; distribution unlimited.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

***DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED
DO NOT RETURN IT TO THE ORIGINATOR***

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SPECIAL REPORT D-72	2. GOVT ACCESSION NO. 44 CERL-SR-D-72-Vol-1	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 PROCURING TODAY'S BUILDING TECHNOLOGY: A SUMMARY VOLUME I - A Summary	5. TYPE OF REPORT & PERIOD COVERED 9 SPECIAL rept.	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 0 Michael G. Carroll	8. CONTRACT OR GRANT NUMBER(s) 16 DA-4-A-762719-AT-02	
9. PERFORMING ORGANIZATION NAME AND ADDRESS CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005 Champaign, Illinois 61820	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A762719AT02-03-001	
11. CONTROLLING OFFICE NAME AND ADDRESS 12 34p.	12. REPORT DATE 11 Sep 1976	13. NUMBER OF PAGES 32
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 17 4-A-762719-AT-02 03	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) building technology procurement process industrialized building		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report summarizes the findings of a study to assess ways of pro- curing present building technology. The study analyzed the state of the art of building technology and reviewed various procurement processes within the given laws, regulations, and policies.		

DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 405 279

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

mt

↓

The results indicate that the evolution of procurement techniques has not kept pace with the evolution of building technology. The traditional procurement process--formal advertising--is not effective in procuring today's building technology. There are other procurement processes which are better in that respect; their use, however, is restricted by traditional interpretations of the laws and by the regulatory inertia of traditional procurement techniques. Nonetheless, given the general intent of Congress and given some needed revisions, there exist procurement processes consonant with the best available building technology.

↗

UNCLASSIFIED

FOREWORD

This research was performed for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A7-62719AT02, "Development of Industrialized Construction for Military Facilities," Task 03, "Development of Techniques for Use of Industrialized Building Systems," Work Unit 001, "Methods of Procurement of Industrialized Buildings."

The OCE Technical Monitor is Mr. W. Johnson.

The work was performed by the Master Planning and Systems Building Branch (HPM), Habitability and Planning Division (HP), Construction Engineering Research Laboratory (CERL), Champaign, Illinois. The CERL Principal Investigator is Mr. Edward J. Worrell. Associate Investigator is Mr. Michael G. Carroll.

Dr. D. G. Bagby is Chief of HPM; Dr. R. M. Dinnat is Chief of HP; COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Deputy Director.

Appreciation is expressed to Mr. Tibor Csizmadia, Research Architect, Master Planning and Systems Building Branch, for consultation concerning building technology and procurement processes.

ACCESSION for		
NTIS	White Section	<input checked="" type="checkbox"/>
DDC	Buff Section	<input type="checkbox"/>
UNANNOUNCED		<input type="checkbox"/>
JUSTIFICATION		
BY		
DISTRIBUTION/AVAILABILITY CODES		
Dist.	AVAIL.	SPECIAL
A		

DDC
RECEIVED
OCT 20 1976
D

CONTENTS

	<u>Page</u>
DD FORM 1473	1
FOREWORD	3
1 INTRODUCTION	5
Background	
Objective	
Approach	
Intent of Report	
Format of Report	
2 FINDINGS	8
3 BASIS OF FINDINGS	12
Evolution of Building Technology	
Factors Determining Which Building Technology Can Be Expected to Compete	
4 THE NEXT STEP	24
GLOSSARY	25
ACRONYMS	30
BIBLIOGRAPHY	31
DISTRIBUTION	

PROCURING TODAY'S BUILDING
TECHNOLOGY: A SUMMARY

I INTRODUCTION

Background

Traditionally, each building is treated as a new project and is designed, detailed, and specified by architects and engineers prior to the selection of its builders: contractors, subcontractors, suppliers, and manufacturers. This process results in custom design of each building. After bids are taken, the building is then custom built (mostly at the building site)--under the direction of the selected contractor and his subcontractors--by craftsmen, laborers, and technicians from materials and parts provided by their suppliers or manufacturers.

Alternatives to Traditional Building

The continuing industrialization of the building process now provides building purchasers with alternatives to the traditional way of obtaining a building. Depending upon the size and type, buildings are available for purchase in forms ranging from those completely manufactured in a factory and delivered to the site ready for installation to those manufactured in segments (usually called subsystems) and delivered to the site ready for assembly. When all segments of a building are not available for purchase as subsystems, those segments which are lacking can be provided in the traditional way. These manufacturing-based alternatives to the traditional way of obtaining a building are referred to collectively as "industrialized building."

A number of pioneer building programs* have demonstrated that buildings can be effectively obtained on the North American continent through the industrialized building approach, and some of the subsystems used are now commercially available. Although the degree of success varied among these programs, little doubt remains as to the cost- and time-saving potentials of obtaining buildings in this way.

* Such programs have been conducted by: Toronto Metropolitan School Board; two Montreal School Boards; Board of Education, City of Detroit; State of Florida; University of Alaska; City of Detroit; and Public Building Service/U.S. Govt. General Services Administration.

The Role of Research

Although the technology for industrialized building products is readily available and some products are already on the market, suitable vehicles are lacking for incorporating such products into the existing processes of building purchasers who have long obtained their buildings in the traditional manner. Since this industry is relatively young and dynamic and since the procurement options available are limited in use, the most effective ways to incorporate the benefits of industrialized building into a purchaser's building program are yet to be developed. Providing building purchasers with such methods is the task of research and development.

Incorporating Industrialized Building Into Corps Practices

As a large and continuing purchaser of buildings, the Army has undertaken a research and development (R&D) program whose purpose is to incorporate the use of industrialized building into its military construction (MCA) process whenever it is the most cost-effective method of obtaining buildings. To accomplish this purpose, five major elements must be developed:

- a. The capability to determine when industrialized building is more cost-effective than conventional building techniques.
- b. A source of rapidly available, current information on the characteristics of the industrialized building industry and its products.
- c. Guidance documents for incorporating the use of industrialized building into the MCA process.
- d. Suitable organizational groups, facilities, and equipment for carrying out the guidance.
- e. A feedback mechanism to insure that the process continues to function properly.

Objective

The objective of this work unit is to determine what changes are required in the military construction process for the effective procurement of industrialized building products. This information is to be incorporated into guidance documents for using industrialized

building systems, and will form the basis for requesting changes to existing laws, regulations, and policies.

Approach

The plan for accomplishing the objective is (1) to establish the conditions required to procure industrialized building products, (2) to compare the laws, regulations, policies and procedures that govern the procurement of *military construction*, (3) to identify areas requiring change, and (4) to propose suitable changes. Proposed changes will be field-tested in demonstration projects, and the successful ones will form the basis for requests to change existing laws, regulations, policies, and procedures.

Intent of Report

This report presents the findings resulting from completing the first three of the above steps and discusses the impact of these findings on the remaining step.

The findings of this report are based on laws, regulations, and policies in effect as of July 1975.

Format of Report

The report is divided into two volumes. Volume I summarizes the findings, presents a brief description of the rationale behind the findings, and outlines the upcoming actions which follow from the findings. Volume II, a complete report of the project, presents these items in greater detail.

2 FINDINGS

The following statements summarize the major findings of this study:

1. In recent years building technology has evolved significantly. The basic change has been the increased industrialization of building technology. This change presents opportunities for both new economics and efficiencies and for the development and production of improved and innovative hardware.

2. The procurement process greatly affects--perhaps determines--the building technology received.

3. In general, procurement processes have not kept pace with the evolution of building technology. Regulations, policies, and practices appear to reinforce the conventional process.

4. Effective procurement of modern building technology requires the use of alternative processes and techniques as well as the satisfaction of certain prerequisites.

5. A review of laws, regulations, and policies indicated that many of these alternative processes and techniques can be used and that many prerequisites can be met without requiring regulatory change. Table 1 shows the regulatory action required, if any, for adopting these alternatives.

Table 1
Procurement Alternatives

REGULATORY STATUS	Action Required				
	Conventional Interpre- tation of Rules	Innovative Interpre- tation of Rules	Revision of Policy	Revision of Regulations	Revision of Law
Prerequisites for the Effective Procurement of Today's Building Technology					
I. Buying Power and Pattern:					
A. Multibase Purchasing	X			ER	
B. Multiyear Purchasing	X				
II. Type and Degree of Stan- dardization					
A. Performance Standards		X			
B. Dimensional & Joining Standardization		X			
III. Strategies of Specifying Requirements:					
A. Performance Specifications		X			
B. Nonrestrictive Drawings				X	
IV. Location of Delivery Sites				X	
	(Not a regulatory issue.)				

Key:
X = Main Issue(s)
? = Unclear,
may be an issue

Table 1 (cont'd)

Prerequisites For the Effective Procurement of Today's Building Technology	REGULATORY STATUS				
	Conventional Interpretation of Rules	Innovative Interpretation of Rules	Revision of Policy	Revision of Regulation	Revision of Law
V. Contracting Methods:					
Bid-Design-Build					
1. One-Step Competitive Negotiation			X	X	
2. Two-Step Formal Advertising		X			X
VI. Organization of the Participants in the Procurement Process					
A. Talk with Manufacturer	X				
B. General and Prime Contractor Issues		X			
C. Part IB/ Part Conventional		X	?		
D. Pay for Design Solution				X	X
E. Matrix Management		X			
F. Trade Secrets	X				

Key:
 X = Main Issue(s)
 ? = Unclear, may be an issue

Table 1 (cont'd)

REGULATORY STATUS		Action Required			
Prerequisites for the Effective Procurement of Today's Building Technology	Conventional Interpretation of Rules	Innovative Interpretation of Rules	Rule Changes		
			Revision of Policy	Revision of Regulation	Revision of Law
g. Justify IBS		X			
h. Construction Manager		X	?		
i. "Fast-Tracking"			?	X	
j. Catalog				X	
VII. Constraints as a means for Achieving Other Objectives					
VIII. Power Groups		X	?		

Key:
 X = Main Issue(s)
 ? = Unclear, may be an issue

ER AR ASPR

Still to be researched as part of the Open-Systems Catalog Study. Initially appears feasible.

(Not a regulatory issue within scope of this report.)

3 BASIS OF FINDINGS

Building technology is undergoing a fundamental change. With the increased *industrialization* of products and techniques, the Corps has new technological options in developing hardware solutions. However, these new options have certain unique prerequisites for their successful application. While satisfying the peculiarities of conventional building technology, the traditional process--formal advertising--does *not* appear to fulfill the prerequisites for industrialized building technology. Continued use of formal advertising, therefore, limits the technological options available to the Corps. If, however, the procurement options are increased, the technological options available to the Corps would also increase. In this way the evolution of the procurement process would correspond to the recent evolution of building technology. A secondary benefit from analyzing management processes is the opportunity to create and use other techniques to increase management efficiency and reduce time and cost factors. This "systematizing" of management function results in benefits to any technological option--conventional or industrialized.

Evolution of Building Technology

In recent years there has been a marked increase in the industrialization of building products and techniques. In general, this development can be seen as a movement from the assembly of many products on-site by skilled craftsmen to the assembly of many products off-site by relatively unskilled labor.

These products assembled off-site are usually pre-engineered and consist of building components such as floor, ceiling, and wall panels; sections of buildings; building subsystems; and even complete buildings. Each component can exist independently and be designed to interface with a variety of other components. Components such as these are commonly referred to as "open systems." Other components and systems which are under the control of one proprietary source and have no interface capabilities are known as "closed systems." Closed systems are usually, but not necessarily, marketed as a complete building system.

Proponents of closed systems argue that they are the most economical solution. Proponents of open systems point out that closed systems encourage monopolization by large concerns and would result in a paucity of design configurations. They suggest that a national market of open systems would be a healthy atmosphere for competition among manufacturers and would allow for flexible planning and design--a significant factor among many concerning the industrialization of building. There appear, however, to be marketing potentials for both

types of systems. For example, closed systems seem appropriate for single-family dwellings and low-rise dwellings of low to medium density.

The catalyst for industrialization has been its many potential benefits. The potential time, cost, and quality benefits arise not only because of the efficiencies of prefabrication but also because of the product development potentials of an industrial environment. More specifically, the industrialization of building technology offers the following benefits:

1. Potential for the development of new, innovative products. (Unlike general contractors and A/Es, manufacturers are development oriented.)
2. Economies in labor. Manufacturing sites offer the potential of "learning-curve" economies due to repetition. Also, skilled crafts are not required in an assembly process, and wages are therefore usually lower than for on-site labor.
3. Economies through volume discounts.
4. Shorter delivery periods.
5. Elimination of the "seasonality" factor in construction.
6. More efficient, effective management of the entire building process.

Factors Determining Which Building Technology Can Be Expected to Compete

Industrialized building technology has prerequisites for its successful procurement and use which differ from those for conventional building technology. The following section discusses key procurement factors, their impact on the different building technologies, and the nature and extent of laws, regulations, and policies applicable to these factors.

Buying Power and Pattern

To enjoy the full range of benefits from industrialized building technology, buying patterns must be continuous, repetitious, and of sufficient volume. Ad hoc, nonstandard patterns of buying not only

discourage the obligation of the capital necessary to create an industrialized environment, but they also negate the potentials of existing industrial concerns. If buying patterns are craft oriented, the craft level of building technology is favored to the competitive disadvantage of industrial technology. Two tools the Corps can employ to promote this necessary industrial environment are multi-year and multi-base procurement techniques wherein projects are aggregated.

It should first be noted that if the necessary standardization is present, volume is not a critical issue, because manufacturers know there will be continuity and repetition over a period of time. However, where there are *no standards* of performance (and jointing and dimensional coordination for open systems) each project *must* justify its own economic realities. If there are no (or few) available "off-the-shelf" products, then the economics of the "buy" depends on a volume sufficient to amortize the start-up costs and to generate the efficiencies of the learning curve. If there are existing products, then volume is not as critical. It is, however, still important, as a large buy encourages competition and increases the possibilities of volume discounts.

Since the state of the art of building technology lacks the necessary standardization, it is presently important to aggregate projects to the maximum extent practicable. While the aggregation of projects within one particular district or installation is beneficial, the scale necessary for significant cost savings demands the grouping of projects across district and installation boundaries and across fiscal year lines.

The Corps can and has used multi-year and multi-base techniques to aggregate smaller projects into one large project where appropriate. A review of laws and regulations indicates that these are acceptable techniques. The only likely constraint would be the adoption of a policy which leaves all project decisions within each district. OCE is in an excellent position to encourage the grouping of projects across district, even division, lines and across fiscal year lines.

Type and Degree of Standardization

Buying patterns of volume and repetition are critical only if there is lacking the degree of standardization necessary to insure manufacturers that future purchases of their product will not require extensive retooling, relearning, redesign, or other costly adjustments. The assurance necessary for the commitment of capital to an industrial effort is dependent on a high degree of standardization.

The Department of Defense (DOD) does promote standardization since the great majority of its buildings are repetitive. Unfortunately, detailed design and technical solutions are the subject-matter standardized. This adequately accommodates conventional building technology since it is composed of craft products conducive to on-site adaptation to a detailed plan, and since such products are dimensionally standard (e.g., 2 x 4 lumber)--but it does not accommodate the state of the art of industrialized products. Each closed system has its own proprietary design and technical solution. Since these systems are pre-engineered, they are committed to a technical solution which in all probability does not satisfy the various detailed solutions that might be advertised. The manufacturer might, therefore, be prevented from effectively competing for a particular bid even though the system satisfies the functions sought in the project. The mechanism to solve this restriction is the performance concept wherein functions are bid instead of bidding just one arbitrary, detailed solution to the functional criteria.*

A review of laws, regulations, and policies indicates that the Corps *can* develop and use standards based on performance. While this approach would be sufficient for closed systems, additional standardization is needed for open systems. Standards for interchangeability are required so that manufacturer X knows that he can tool up to make a component which will be highly compatible with other components following these standards. Interchangeability standards would consist of standards for *jointing, dimensional coordination*, and possibly other factors such as tolerances. The lack of such national standards inhibits small business participation, increases the cost of open-systems assembly and construction (because the necessary "infilling" of the interface often requires expensive on-site craft work), and, in general, is an inferior marketing environment as well as a poor economic proposition. Finally, it should be noted that if national jointing and dimensional coordination standards are developed, the conventional design strategy of providing a detailed drawing is feasible as far as shape and dimensions are concerned. The presence of universally compatible components not only produces the benefits of industrialization but also increases design options, much as with conventional technology.

Efforts in the United States and Canada to create and promote this necessary standardization--such as the various school-systems

* See *Strategies of Specifying Requirements* section for a more detailed discussion of the performance concept.

projects--have been ad hoc, uncoordinated, and limited to a particular project. Efforts are presently under way to coalesce performance, jointing, and dimensional coordination standards among large owners in an effort to create a "national climate" fostering effective and efficient industrialization. The recently created Construction Research Council--composed of representatives from General Motors Corp., Sears Roebuck and Company, the City of Boston, American Telephone and Telegraph Co., PBS of GSA, the Veterans Administration, International Business Machines Corp., the Corps of Engineers, and the Port Authority of New York--has as its main goal the development of common standards acceptable to all members. However, the fact remains that there are presently *no* national or regional standards of performance, jointing, and dimensional coordination.

Despite the lack of this basic prerequisite, some projects have resulted in impressive statistics. The Toronto schools' experience shows that the cost of schools in 1970-1971 using conventional products and techniques averaged \$23.57 per square foot. Using industrialized products and techniques in 1973-1974, the costs average--*without* adjustment for inflation--\$19.02 per square foot. PBS of GSA talks of shortening building delivery periods by 2 years and saving 25 percent of life-cycle energy costs. Admittedly, many projects have been less than successful. Nonetheless, some industrialized building (IB) projects have shown comparative if not impressive results even lacking many prerequisites for industrialization. What would the statistics show if there were the appropriate national standards and buying patterns to promote continuity, repetition, and sufficient volume?

By adopting standards based on performance and by promoting standardization for the interchangeability of independent components, the Corps can contribute significantly to the advancement of building technology by allowing it to compete effectively. The Corps loses nothing by adopting this standardization approach--since functions (or performance) are what it fundamentally seeks--but it gains much: namely, the ability to effectively procure and use modern, industrial building technology.

A review of laws, regulations, and policies indicates that the Corps *can* adopt performance standards and promote standardization for interchangeability of subsystems or components.

Strategies of Specifying Requirements

The conventional strategy, around which most rules are tailored,

is the descriptive design strategy. This strategy does not adequately accommodate industrialized products since they are pre-engineered, of different detailed configurations, and not as amenable to on-site manipulation by craftsmen as are conventional products. How then do you buy products with predetermined details such as industrialized building systems?

DOD policy for buying products of different design configurations is to advertise on the basis of performance specifications. Performance specifications are specifications which require a certain function or performance without any reference as to "how" (e.g., materials, dimensions) to accomplish this function. On the other hand, a descriptive specification provides the detailed "how-to-do-it, what-to-use" solution. It is important to know that every descriptive specification or detailed drawing is based on a performance requirement. For example, why is a door designed in detail to be 7 ft high 3 ft wide except to satisfy the function of access? The given dimensions are but *one* solution to that needed or desired function. Even though reasonable and sound, a descriptive solution is arbitrary *vis-a-vis* other solutions. Procuring on the basis of performance does not place nonfunctional design constraints on the manufacturers. For this reason alone, performance requirements need to be standardized. Other reasons to use the performance concept are: it is a better gauge in determining product acceptability; it allows or encourages product improvement and innovation; it is a communication technique quite compatible with efforts to systematize the procurement process; it encourages and rewards life-cycle efficiencies such as energy conservation; and it promotes value engineering by awarding a contract to the lowest-priced solution meeting the performance requirements. Alternatives to the performance concept appear to be redundant and possibly legally unacceptable. These alternatives, followed by an appropriate comment, are:

1. Design conventionally (i.e., by providing detailed, descriptive drawings and specs). Advertising a descriptive solution limits the range of solutions to the underlying performance criteria to only one, even though many solutions are available for any given criterion. Since modern building technology is not descriptively standardized, any detailed solution automatically excludes a great number (perhaps all) of the alternative solutions. Either the bidders will not bid because their products, while meeting the implicit performance requirements, do not match the narrow (arbitrary?) mandates of the detailed solution, or those who do participate probably will have to retool--normally a costly activity. In this sense, advertising detailed solutions is quite uncompetitive *vis-a-vis* modern building technology.

2. Use a brand name or a reverse engineering drawing accompanied by an "or equal" clause. The advertisement of a particular brand-name item (or a detailed drawing or "chinese copy" of it--a practice known as reverse engineering) ostensibly appears to be fair if accompanied by an "or equal" clause which allows for alternatives. This technique is a deception. The brand-named item is in a favored position since it does not have to prove it is an "equal." Second, the use of "or equal" requires a listing of the "salient functional features" of the reference item. Alternatives must be evaluated against these features. These last two steps are the activities necessary to execute the performance concept. The use of a mandatory "or equal" clause does not, therefore, bypass the need for performance specifications. Since it must execute both a descriptive strategy and a performance strategy, it is redundant. Regulations restrict its use, as it is a technique of last resort.

3. Use multiple-brand names of reverse-engineering drawings. It could be argued that if all known industrialized solutions are advertised as acceptable, there would be no competitive disadvantages. Perhaps so, but there remain the following problems: all solutions must be known; the use of an "or equal" clause to accommodate unknown systems or systems not yet in production requires ultimately the execution of a performance strategy as discussed in the preceding paragraph; and the listing and describing of several alternatives leaves unclear what the "minimum needs" of the government are.

It should also be noted that the use of performance specifications requires a compatible drawing strategy. Drawings must not represent arbitrary details but should be consistent with the theme of specifying only function. Some acceptable strategies include a "footprint" of the site, a simple line drawing with no details, and a matrix showing the functional relationships of the rooms or any other elements.

A review of laws, regulations, and policies indicated that whereas it appears acceptable to use different specification strategies, the use of drawing strategies other than detailed, working drawings is not so readily acceptable. It is felt, therefore, that revisions will be needed for the use of different drawing strategies.

Location of Delivery Sites

Since building systems are manufactured products much larger than conventional building products, the transportation range and costs of

most systems are issues of a fundamental nature. While they are not legal issues, they do affect the competitive ability of industrialized systems. It is sufficient for this study's purpose to note that, for the present, the particular geographic location of the project site might well affect the ability of an industrialized building system to compete effectively with conventional products.

Contracting Methods

Each contracting method does not exist independently, uninfluenced by the procurement activities before and after the contracting activities. In other words, the form of contracting used depends on the overall procurement process used.

The procurement process is the total of all the decisions, communications, and activities--from project initiation through and including project use and evaluation--necessary to create a building. The traditional process is a linear arrangement of team members wherein the owner gives criteria to an A/E, the A/E creates a design and technical solution, and a general contractor--with the help of subcontractors--executes the solution. This process is commonly referred to as a design-bid-build process.

The design-bid-build process has traditionally been an ad hoc, loosely knit assemblage of independent participants. Emphasis on the management of this process has only been recent. The craft environment of conventional building technology does not demand a sophisticated management system. Recent attempts to "systematize" the procurement process indicate the design-bid-build process is often inefficient and is an inadequate arrangement of decision-making, communicating, and other activities *vis-a-vis* the state of the art of industrialized building technology.

There are, however, other procurement processes and techniques currently in use publicly and privately. They are new, still evolving, and, in general, inferior to the state of the art of the hardware. The basic alternative is the bid-design-build process. It is known by many names and has some variations, but the common factor is that the design and technical solutions are requested and not provided. Experience indicates that this process is flexible in that it can accommodate many management techniques. But most importantly, it maximizes the benefits of modern building technology by allowing it to compete effectively for building projects without any competitive injury to conventional products.

The Corps' codification of the procurement process--up to actual construction--is known as the MCA cycle. Though it is intended to be only a general scheme of decisions, communications, and activities, the MCA cycle appears to be an arrangement conducive to the conventional design-bid-build process.

The Corps' contracting method to execute a design-bid-build process is formal advertising. It suffers from the same shortcomings as the design-bid-build process. There are two Corps methods to execute a design/build process. Unfortunately, these two contracting methods--two-step formal advertising and one-step competitive negotiation--are not favored processes, as their use is restricted by DOD. The restriction of the one-step method is especially severe. The findings of this report indicate that the restrictions should be re-evaluated and subsequently removed in light of (1) the value of the methods (there is no other design/build method available to the Corps); (2) the possible misinterpretations or misunderstandings causing the restriction; and (3) the fact that other comparable federal agencies freely use a design/build process.

Also the DOD has codified different compartments into which procurement actions fit. For example, ball-point pens are usually treated as a "supply" procurement. The procuring of on-site services to construct buildings is usually treated as a "construction" procurement. It should be noted that IBs do not fit well into the conventional categories of "construction" and "supply." Different situations concerning IBs dictate different labeling and therefore different contracting forms, rules, etc. These situations and their appropriate label need to be formulated and codified.

Organization of Participants in the Procurement Process

The use of design strategies, contracting methods, or procurement processes different from those conventionally used dictates a shifting of the roles and responsibilities of the participants in the procurement process. Some of the likely changes are noted below, accompanied by comments as to their regulatory feasibility.

1. Manufacturers must become major participants in decisions affecting standards, design, and technical solutions. The regulations permit the manufacturer to have significant interaction in these decisions or activities.

2. There must be alternatives to the conventional practice of having a general contractor control the subcontractors. Regulations allow such alternatives; most notably, the government may contract directly with the subcontractors and hire a construction manager (CM)

as a consultant to perform complex managerial tasks which are normally the tasks of a general contractor.

3. Since not all elements are part of the "system," it should be possible to establish one contract for the "out-of-systems" portion and one for the systems portion. The regulations allow this bifurcation.

4. Since the risk of bidding is greatly increased on bid-design-build solicitations, it would be desirable--especially as concerns small businesses--to pay some fee for the design work in the proposals. The regulations do *not* appear to allow this payment.

5. The grouping of activities, decisions, and communications is superior to the traditional linear chain. The use of a CM and alternative communication strategies such as the performance concept largely harnesses the benefits of matrix management.

6. There may soon be problems concerning the conflict between protecting trade secrets while complying with the Freedom of Information Act.

7. Does the use of Industrialized Building Systems (IBSs) have to be justified? Regulations indicate they do. This requirement appears to be quite arbitrary, except when viewed as part of the logic of the design-bid-build process.

Also, there are other management techniques which, while offering benefits to the traditional procurement process, are especially suited for application with a bid-design-build process in the procurement of an industrialized building system. They are the construction manager approach, the "fast-tracking" technique, and the catalog approach.

A construction manager (CM) is an agent of the owner who is responsible for many sophisticated managerial tasks. Unlike a general contractor, the CM does not "stand behind" the materials, workmanship, and proper functioning of the actual building. Each specialty contractor (or subcontractor) is responsible for his portion. Ostensibly this arrangement increases risk, but the issue is not settled. Even conceding that the risk increases, proponents argue that CM benefits greatly outweigh those increases. The Public Building Service (PBS) of the General Services Administration (GSA) has experienced significant success with a CM approach. It appears the Corps can also use a CM but probably only as a consultant and not as a prime contractor.

"Fast-tracking" is a technique usually, but not necessarily, used

with a bid-design-build process employing a CM. It is a technique to overlap activities and "early bid" appropriate parts of the construction. Significant time savings are possible over the conventional linear chain of activities. PBS of GSA estimates time savings of two years. Unfortunately, the MCA's separation of design and construction activities coupled with various regulations requiring a "final design" before the initiation of advertising for construction activities negates the effective use of fast-tracking. Revisions are needed.

A "catalog" of open-systems components and even of closed systems is perhaps the most revolutionary technique in development. CERL envisions a catalog as performing the functions of centralizing data, certifying the hardware data, and pre-contracting of the hardware. Such a catalog would reduce the duplication of many procurement activities, greatly aid members of the procurement team such as cost estimators, A/Es, masterplanners, etc., and would be an excellent national instrument to provide the sorely needed forum to focus activities and energies and develop national standards. No one has such a catalog, but many desire it. CERL has a project to develop an open-systems catalog. While the general direction and purposes are known, the legal details have yet to be resolved. Initially, though, it appears that there is sufficient precedent to create and use a catalog which performs the functions of data collection, certification of data, and pre-contracting of the products.

*Constraints on the Procurement Process as a Means
of Achieving Some Other Objective*

Federal government contracts and regulations are replete with clauses and programs aimed, not at the particular subject of the contract, but rather at a larger social goal. Equal opportunity programs, small-business set-asides, labor surplus regulations, and so forth, have no direct bearing on the performability of a particular contract, other than being a possible constraint. Some of these clauses and programs may uniquely affect industrialized building technology. For example, the inappropriate application of the small business program to procurements using alternative processes and techniques may have a dysfunctional effect, since there are insufficient data at present to reliably predict what products and which bidders will win. There is logic within the small-business regulations to exempt alternative processes until sufficient data are accumulated.

Power Groups

There are also the practical problems of the reaction of power groups. Any established process contains participants with vested interests. Revisions to that process or adoption of alternate processes provokes an assessment of impact upon vested interests. It is anticipated that the increased use of IBs and alternate processes will provoke certain groups to negative reactions. This is a practical problem, probably a crucial one, but it nonetheless is not a regulatory issue within the scope of this paper.

4 THE NEXT STEP

It is recommended that the Corps proceed with the development of effective and efficient procurement processes and techniques for buying modern building technology. Specifically:

1. Verify with appropriate legal counsel and regulatory personnel the conclusions concerning interpretations (conventional and innovative) of rules;
2. Draft waiver requests for rules needing revision;
3. Develop preliminary procurement models based on waiver requests and acceptable interpretations which satisfy the prerequisites for effectively procuring today's building technology;
4. Field test procurement models;
5. Develop final procurement models;
6. Draft distinct, separate regulatory sections for each procurement model;
7. Submit sections for review, approval, and implementation; and
8. Develop procurement manuals to aid in field application of new procurement models.

GLOSSARY

- aggregation: The treatment of a group of similar building projects (possibly at several installations, or to be built in several different years) as a single project.
- bid-design-build: A general category for a procurement process whose distinguishing feature is that a design and/or technical solution is being bid for as well as its ultimate execution.
- building system: An arrangement which permits many detailed decisions about a method of construction to be determined for a range of building situations in advance of any particular building project. (See also *system*).
- closed system: A building system--normally proprietary--of such a unique design, or so controlled by the supplier, that parts outside the system can be substituted only with substantial modification or not at all. (See *open building system*).
- compatible (building system): Two or more building subsystems whose every point of functional and physical interface matches and is congruous. (See *interface*).
- component: An industrial product, as an independent unit for installation as an essential element of a building subsystem. Factory-finished product designed to be part of the complete building or system without modification on site.
- construction management: The combined operations for the authorization, purchasing, supervision, accomplishment, and acceptance of a construction project. These activities do not normally include economic feasibility studies, programming and planning, or industrial management, which would be a part of many industrialized building system (IBS) projects. The coordination of multicontract projects may be required.
- construction manager: A professional, usually retained as an owner's agent, who performs construction management.
- contracting officer: A military officer or Corps employee authorized to administer contracts and make determinations and findings thereto.
- conventional construction: Site-coordinated construction, utilizing a combination of fieldcrafted and factory-fabricated components

which are not generally precoordinated. These components therefore often require modification at the building site to provide workable joining conditions.

design-bid-build: A general category of procurement process which bids out a detailed design for construction. (Also referred to as the "conventional process.")

dimensional coordination: The establishment of a range of related dimensions for common use in sizing the components which make up those buildings.

fast-tracking: A scheduling technique involving overlapping (or simultaneous) phased design and construction (as opposed to sequential operations) to speed the building process, often requiring multiple contracts.

footprint strategy: An administration strategy in which the building is proposer-designed within an area (the "footprint") defined in RFP/RFTP plans; this requires the postponement of the design of that portion of the site within the footprint and its submission with the proposal, though the main portion of the site is prescriptively defined. Probably a single contract, this approach defines functional relationships and area requirements while allowing unique systems response.

hardware: The components, assemblies, and subsystems of which a building is constructed.

industrialized: Organized to convert raw materials into products by capital-intensive activities such as mechanization and automation as opposed to labor-intensive activities such as organized handcraft.

industrialized building (IB): The process of construction involving capital-intensive processes such as mechanization and automation as opposed to organized handcraft, a labor-intensive activity. Industrialization may apply to a part of a construction or delivery process, as with production, delivery, and erection of components. In addition to building products, industrialization may apply to process-oriented activities such as automated information transfer.

industrialized building system (IBS): (See *industrialized building and systems*).

- interchangeability: Part of the technique of mass production, which is the ability to control the dimensions of components so that they can be assembled without selection and without any attention to mating surfaces, such as cutting, fitting, butting up, etc.
- interface: A common boundary or dimensional fit between components. The act or process of assuring a positive and functional fit at that common boundary. The point of contact of construction activities.
- lead time: That length of time preceding an event required for the activities required in implementing the event.
- life-cycle costing: A method of economic building analysis which considers costs--such as maintenance, insurance, operation (including energy), repair, and replacement--which will likely be incurred throughout the life of the building, as well as initial construction costs.
- nonsystem (or "out of system"): All *conventional* portions of a building, e.g., those which are handcrafted or conventionally constructed.
- off-the-shelf: Available as a marketed stock product.
- one-step procurement: A procurement option in which competing technical proposals, together with dollar bids, are evaluated according to a pre-determined scoring scheme, the contract being awarded to the proposal having the highest score, not necessarily the lowest bid.
- open system: A building system whose subsystems or components are compatible with other subsystems or components, including those of other manufacturers, for interchangeability. Also, a catalog of parts--factory-finished, standard components of varied origin--selected by independent designers and assembled in an infinite number of ways.
- out-of-system: (See *nonsystem*).
- panel: A prefabricated planar product, often of story height or room width, sometimes loadbearing, and sometimes containing integrated utilities.
- performance concept: An organized procedure or framework within which it is possible to state the desired attributes of a material,

component, or system in order to fulfill the requirements of the user without regard to the specific means to be employed in achieving the results.

performance specification: Expression of the functions required of an object, corresponding to clearly determined use. A written description of requirements and criteria in terms of a product or a system's desired behavior (rather than in terms of its makeup and the way it should be constructed); i.e., not what a system is, but what it does. (See *prescriptive specifications*.)

precut: Factory cut and labeled materials, with little assembly work.

preengineered: A building satisfying a standard set of engineering requirements rather than user requirements; often a gable-roofed, clear-span, metal building, available "off-the-shelf."

prefabrication: The fabrication of building elements before they reach the building site.

prescriptive specification: A precise, written description of requirements for construction, indicating materials, shapes, sizes, and methods used to establish standards and to provide a product. (See *performance specifications*.)

procurement process: All the communications, decisions, and activities that occur from initiation to use when procuring a building.

project: A collection of one or more buildings under construction, along with necessary support facilities (e.g., paving and utility lines). Since the feasibility of IBS may be a function of the number of structures involved as well as their locations, it may be necessary to aggregate buildings of the same type into different groupings, herein called "projects"; a line item in a military budget, designated for construction in a fiscal year.

proposer: Any individual, firm, contractor, or building manufacturer that responds to a request for proposals on a building project.

proprietary product: A product produced by one manufacturer for one sponsor only, to his own standards. Made and marketed by one having the exclusive right to manufacture and sell; sometimes involving guarded information.

request for technical proposal: A solicitation for proposals which contains design and technical criteria plus administrative and legal provisions.

software: The rules and procedures for utilizing hardware to form a complete building; e.g., a program or design; the nonphysical elements of a system.

strategy: The method of communicating the government's requirements for a facility to potential proposers or bidders. Design strategies differ in the degree of detail which is completed by the government or left to the proposers.

subsystem: Part of a building system performing a specific function; a subordinate set of building system components, as well as the principles or rules which logically link those components together to form a functional whole which is, in itself, an indispensable entity within a construction complex. Example: The HVAC (heating, ventilating, and air conditioning) subsystem would include the chillers, fans, pumps, ducts, and controls.

system: An interdependent set or assembly, consisting of the arrangement of building components or subsystems, as well as principles or rules which logically link those components together to form a functional building whole. Normally these components are mass produced.

systems approach: A process stressing the interrelation of problem elements within an overall context.

systems building: The organization of programming, planning, designing, financing, manufacturing, constructing, and evaluating buildings under highly coordinated management into an efficient total process. The use of proprietary building systems, usually highly standardized; industrialized building, a process featuring (1) user requirements, (2) performance criteria, (3) subsystem integration, and (4) testing (or certification) of subsystems.

technological innovation: An advance attributable to a technical method or a new product which achieves a particular purpose. It can also be a significant change in the means employed to achieve a superior system of service.

two-step procurement: A procurement option where--as Step I--technical proposals are received without dollar bids, and evaluated against predetermined criteria. Those firms whose proposals were deemed "responsive" are then asked to submit a bid--as Step II--to construct the facility according to their own proposal. The contract is awarded to the lowest bidder.

ACRONYMS

A/E	Architect/Engineer
APP	Army Procurement Procedures
AR	Army Regulations
ASPR	Armed Services Procurement Regulations
CERL	Construction Engineering Research Laboratory
CM	Construction Manager
Comp. Gen.	Comptroller General
DOD	Department of Defense
DSA	Defense Supply Agency
ECI	Engineer Contract Instruction
EPA	Environmental Protection Agency
ER	Engineering Regulation
FSC	Federal Supply Code
FSS	Federal Supply Schedule
FTC	Federal Trade Commission
FY	Fiscal Year
GAO	Government Accounting Office
GSA	General Services Administration
HUD	Housing and Urban Development
IB/IBS	Industrialized Building or Industrialized Building System
ICC	Interstate Commerce Commission
ICP	Interdepartmental and Coordinated Procurement Agreement
OCE	Office of the Chief of Engineers
OMB	Office of Management and Budget
TSFA	Two-Step Formal Advertising
PBS of GSA	Public Building Service of GSA
RFP	Request for Proposals
RFTP	Request for Technical Proposals
SBA	Small Business Administration
TSFA	Two-Step Formal Advertising
USC	United States Code (Federal Law)

BIBLIOGRAPHY

- Bagby, Q. G., R. M. Dinnat, and C. A. Moyer, *Study on Potential Use of Industrialized Building for the Department of the Army* (Construction Engineering Research Laboratory [CERL], August 1971).
- Building Research Advisory Board of the National Academy of Sciences, *An Analysis of the Existing System for Obtaining Military Facilities and a Review of Construction Practices and Methods Employed by Other Federal and Non-federal Organizations*, Report for Department of Defense (January 1971).
- Building Research Advisory Board of the National Academy of Sciences, *Management of the Military Facilities Procurement Program*. Report for Department of Defense (February 1971).
- IBS Guide: An Interim Guide to Industrialized Building Systems*, 2 Volumes, Technical Report D-70 (CERL, January 1976).
- Report of the Commission on Government Procurement*, 4 Volumes, No. 5255-00007 (December 1972).
- Educational Facilities Laboratory, Inc., *Building Systems Planning Manual* (Building Systems Information Clearinghouse, August 1971).
- Building Procurement, Proceedings of a Workshop* (Industrialization Forum of Université de Montréal, December 1974).
- Joint RILEM-ASTM-CIB Symposium, *Performance Concept in Buildings: Invited Papers*, Report for National Bureau of Standards, Special Publication 361 (February 1972).
- Nash, Ralph C., Jr., and John Cibinic Jr., *Federal Procurement Law*, 2nd ed. (George Washington University, 1969).
- Pace, Dean F., *Negotiation and Management of Defense Contracts* (Wiley-Interscience, 1970).
- Public Building Service of GSA, *The GSA System for Construction Management* (General Services Administration [GSA], April 1975).
- Public Building Service of GSA, *Performance Specifications for Office Buildings*, NBS/GSA Project Number 4217416-421.00 (GSA, 1974).

Rensselaer Polytechnic Institute, *The Building Bloc Research and Design Study*, Report to Air Force Civil Engineering Center (August 1972).

Rensselaer Polytechnic Institute, *The Role of Hardware Information in Using Industrialized Building Products in Military Construction*, Report to CERL (December 1974).

Texas A & M Research Foundation, *Investigation and Study of Corps of Engineers Systems Approach to Design and Construction*, Report to Office of Chief of Engineers (May 1968).

CERL DISTRIBUTION

Chief of Engineers

ATTN: DAEN-ASI-L (2)

ATTN: DAEN-FEE-A

ATTN: DAEN-FEB

ATTN: DAEN-FEP

ATTN: DAEN-FESA

ATTN: DAEN-FEZ-A

ATTN: DAEN-MCZ-S

ATTN: DAEN-RDL

ATTN: DAEN-MCE-A

Dept of the Army

WASH DC 20314

Defense Documentation Center

ATTN: TCA (12)

Cameron Station

Alexandria, VA 22314

