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## **Building Technology Forecast and Evaluation (BTFE), Volume I:**

### **Development and Application of a Prototype BTFE Cycle**

by  
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To maximize economies in the Military Construction, Army (MCA) program, the U.S. Army Corps of Engineers (USACE) must make appropriate use of new or innovative building technologies. At present, there is no formal structured approach to monitoring the construction industry for emerging products and systems that could benefit USACE. To ensure that the most feasible, cost-effective technologies are implemented, guidance is needed for identifying and evaluating new or innovative products and construction systems.

This report describes a prototype building technology forecast and evaluation (BTFE) cycle that consists of four discrete components: (1) forecast or identification of promising technologies, (2) impact assessment (i.e., applicability to USACE), (3) prioritization, and (4) detailed evaluation. This method provides a standard, systematic protocol for assessing a technology very carefully in terms of its usefulness to MCA, allowing USACE to take a "smart buyer" approach. The BTFE cycle developed in this study is intended to be used at the "building systems" scale as opposed to the materials engineering or products scale.

The prototype BTFE cycle was used in a verification exercise to identify 21 technologies with potential application to USACE. After evaluating these technologies in more detail, two emerged as the most promising candidates. Volume I of this report describes the development and initial implementation of the BTFE cycle; Volume II explains the technology evaluation component in greater detail and describes its use in the structural examination of the two technologies identified in Volume I.

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## FOREWORD

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# **BUILDING TECHNOLOGY FORECAST AND EVALUATION (BTFE), VOLUME I: DEVELOPMENT AND APPLICATION OF A PROTOTYPE BTFE CYCLE**

## **1 INTRODUCTION**

### **Background**

Productivity in the U. S. construction industry has declined over the past few decades to the point that other nations have taken the lead in providing new facilities. This situation has a potentially damaging impact on the U. S. economy, with construction accounting for some 8 percent of our Gross National Product (GNP). A major factor that has contributed to this condition is the U. S. industry's failure to invest in research and development (R&D) to produce and optimize progressive construction technologies. The low priority afforded R&D in the United States is in sharp contrast to strategies used in nations such as Japan, where the burgeoning construction industry is investing up to 10 percent of its earnings into R&D.

To regain its competitive posture, the U. S. construction industry must begin to focus on state-of-the-art technologies that will improve productivity and lower costs, while still providing quality buildings. This effort must include the introduction of new or innovative products and construction systems. The rationale is that new or innovative technologies will have evolved because they result in (1) buildings that are less expensive to produce or (2) better quality buildings for the same price (which will impact the life-cycle cost).

The U. S. Army Corps of Engineers is responsible for a \$1.4 billion/year construction program, which includes projects funded under Military Construction, Army (MCA). As is true in the private construction industry, the economies of MCA facilities could be improved through appropriate use of new or innovative building technologies.

USACE currently has no formal mechanism to forecast, evaluate, and introduce new or innovative building technologies into its construction environment. New technologies and practices have usually been introduced on an ad hoc basis after being brought to USACE attention by various unstructured means. In addition, USACE's evaluation and implementation of such technologies often have been conducted on relatively short notice, with no time available to complete a thorough assessment. Alternatively, many useful technologies have not been implemented until they have seen positive results in other markets over the long term.

USACE needs a deliberate, systematic approach to investigating new or innovative building technologies. This process must identify or forecast promising technologies, evaluate them for applicability to USACE's specific needs, and then provide a mechanism for introducing them into the field. Such an approach will benefit USACE in two major ways:

1. The building industry will become familiar with the standard procedures, which will enable contractors to submit their products/systems according to a consistent, rational set of requirements. With this information, USACE will verify the product/system performance based on proven criteria--a confidence builder when accepting new technologies.

2. By actively and continually seeking new building technologies, USACE will adopt a proactive, rather than reactive, operating mode. Implementation of new products/ systems will be based on systematic evaluation and engineering judgment rather than a variety of nontechnical influences.

## Purpose

The purpose of this work is to: (1) provide a systematic methodology for forecasting or identifying, and then evaluating new or innovative building technologies, (2) verify this process for MCA use through testing, and (3) develop plans to implement appropriate technologies into standard MCA practice.

Volume I describes the development and initial test of the prototype building technology forecast and evaluation (BTFE) cycle. Volume II explains the technology evaluation process in more detail and describes its use in examining two structural technologies identified as promising candidates for USACE.

## Approach

To develop the prototype BTFE cycle, the literature was surveyed to study approaches already being used in the industry (e.g., Rosen and Bennett<sup>1</sup>). The findings were assessed in terms of USACE's unique requirements, and several approaches were modified and combined to provide the BTFE cycle. The cycle consists of four discrete components: (1) forecast or identification of promising technologies, (2) impact analysis, (3) prioritization for further study, and (4) detailed evaluation.

To verify this methodology, it was implemented in a prototype cycle that identified 21 new or innovative technologies with potential application to USACE. These technologies were then screened using the impact assessment and prioritization methods. Two technologies emerged as the best candidates of the original 21 selections. These two technologies were then evaluated in detail, specifically for their structural characteristics and the results are reported in Volume II. Future detailed evaluation schemes are being developed for technologies related to superstructure, roofing, exterior closure, interior construction, and electrical and mechanical components.

Finally, an implementation process was developed by considering how USACE can most effectively introduce technologies to its field operating agencies (FOAs). In particular, automated data processing (ADP) technology was assessed for potential use in managing the BTFE cycle.

## Scope

The BTFE cycle developed in this study is intended to focus on "building systems" as opposed to "products" or "materials engineering." That is, emphasis is on building technologies that involve the facility as a total entity (or major components thereof) rather than isolated materials or components. Examples are modular construction, structural systems/methods, exterior enclosure systems, and interior environments. The BTFE cycle will be expanded later to broaden its focus beyond the building systems scale to include building materials, construction processes, and civil construction technologies.

In developing the methodology, it was anticipated that the subject technologies will be developed and ready for introduction into the construction market, or will be commercially available and used in other, nonmilitary construction markets.

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<sup>1</sup>H. J. Rosen and P. M. Bennet, *Construction Materials Evaluation and Selection* (John Wiley & Sons, 1979).

## **Mode of Technology Transfer**

It is expected that new/innovative technologies identified with the prototype BTFE cycle will be demonstrated during FY90 under the Technology Transfer Test Bed (T<sup>3</sup>B) program. In addition, this methodology has been submitted to Headquarters, USACE, as a candidate for development as an industry standard under the Construction Productivity Improvement Research (CPAR) program, and a private company has proposed to be a cosponsor. Three possible mechanisms are being considered for implementing the final product: (1) establish a dedicated support center at a District office to serve all of USACE, (2) contract an external service that would be responsible to some USACE representative (e.g., the Corps of Engineers National Alternative Construction Technology Team [CENACT]), or (3) use leveraging through CPAR to establish a private agency, and then subscribe to the BTFE service it provides.

## 2 TECHNOLOGY FORECAST AND IDENTIFICATION

The proposed methodology is intended to be a proactive mechanism to identify new and innovative building technologies for potential use in USACE construction projects. New and innovative building systems, subsystems, components, technologies, and products throughout the building industry are to be identified. Initiatives from proponents of new building technologies also are to be considered.

Once the BTFE cycle is accepted, it is anticipated that USACE will conduct regular forecast and identification exercises. Upon completing the forecast cycle, USACE will assess the impact of identified technologies on its construction program. Technologies with the greatest potential impact will be selected for further evaluation.

The term "innovative technology" could refer to a product, material, component, subsystem, system, and/or assembly, rather than an entire building innovation. However, the focus of this forecast method is at the "building systems" scale, where emphasis is placed on building technologies involving major portions of a building rather than an isolated material or assembly. This clarification will make it easier to manage the information collection process.

A "new" technology is defined as one not yet commonly accepted by USACE, and possibly not yet accepted by the building industry at large. These may be technologies that are (1) established and ready for use, (2) not yet used in full-scale applications but tested and designed, or (3) still within the testing and design stages. Thus, the forecast stage is not intended to be a long-range projection of trends.

The standardized forecast/identification procedures are designed to:

1. Identify sources of information on innovative construction technologies.
2. Determine the contribution each resource will be able to make in forecasting exercises.
3. Determine which resources will be most helpful to the forecast process, and the appropriate procedure for obtaining information on innovative technologies from each.
4. Identify the most productive means of obtaining further information on innovative construction technologies.
5. Initiate and document resource contacts and other sources to facilitate subsequent cycles of the forecast procedure.

### Selection of Appropriate Resources

The method used to determine resource validity for the BTFE cycle had three distinct stages: compilation, pilot contact, and initial forecast.

### *Compilation of Resource List*

The first step was to compile a general list of possible contacts and resources within the construction industry. This list included:

- Building code organizations
- Professional organizations
- Research organizations
- Product testing laboratories
- Academic institutions
- Government agencies and institutions
- Construction trade associations
- Building product manufacturer associations
- Construction journals
- Publications/periodicals
- Designers
- Contractors.

Next, specific individuals and organizations within each category were identified through library searches and experience. Addresses and telephone numbers were obtained for use in contacting each resource.

A library search was conducted to identify publications, including magazines and journals, that contain information on innovative construction technology. Construction industry publications that have separate sections on new products and emerging technologies were listed. When possible, the authors of these sections were recorded as possible contacts to support the forecast stage.

### *Pilot Contacts*

A "pilot contact" stage occurred after the resource contact list was completed. An knowledgeable individual within each organization listed was identified. The contact for periodicals was usually the editor of the new products or features section.

The appropriate individual was then contacted and briefed on the objectives of the study. Contacts were told that they had been identified as a source of information on new and innovative construction technologies. They were asked to reference any work that they could regarding the forecast of innovative construction technologies. Specific questions were asked about any information they offered, including its format. The contacts were requested to forward copies of appropriate information. Finally, they were asked to provide suggestions for establishing the forecast process on a cyclical basis. The potential

contribution of each contact in providing further information was assessed. Also, each contact's willingness and capacity to contribute to the forecast cycle were determined.

### *Initial Forecast Process and Results*

Information obtained during the pilot contact phase of the study was used to identify the most effective mechanisms for conducting the forecast exercise. The initial version of the forecast and identification process was then developed. The following sources were found to be most appropriate:

- Journal and periodical search
- Building products trade and manufacturers' associations
- Code and testing organizations
- U.S. patents and trademark departments
- Advertisement in a major construction periodical.

These sources are all explained in detail below, along with a standard procedure for collecting and organizing the information they offer. Appendix A lists several examples of each source.

## **Types of Information Available**

### *Construction Trade Literature*

Most trade periodicals and journals have a separate section on new products or technologies and often print feature articles on emerging construction technologies. These publications are the most direct source of information. When writing articles about new or innovative technology, magazine editors usually consult experts in the appropriate field. Therefore, most have a bank of names, addresses, and telephone numbers of experts in each field of concentration within the construction industry. They query these experts to supplement articles with facts, opinions, and foresight as to where their particular specialty is headed. By asking editors for leads in finding experts, it is possible to begin generating a BTFE expert bank which is very helpful in identifying and evaluating new building technologies.

### *Building Product Manufacturer Associations*

Examples of these associations are the Construction Products Manufacturers' Council, Metal Building Manufacturers' Association, National Forest Products Association, and the Architectural Aluminum Manufacturers' Association. Membership usually consists of manufacturers and suppliers of similar products. Most associations publish newsletters and journals which are sent to their members and contain information on new technologies within their specific area of the construction industry. Their products are usually promoted from both a marketing and technical standpoint. These associations will usually add interested parties to their mailing lists to receive the same publications. Manufacturers of construction-related products and technologies should be compiled into a list for reference and possible direct contact. Once the forecast exercise is conducted as a cyclical process, most manufacturers will become aware of the work and will actively participate in the process by sending information in standard mailings.

### *Building Code Agencies*

Examples are the International Conference of Building Officials and the Building Officials and Code Administrators International. Code enforcement organizations include the Association of Major City Building Officials, Council of American Building Officials, National Academy of Code Administration, National Conference of States on Building Codes and Standards, American Insurance Association, American Public Health Association, National Fire Protection Association, and American Society of Mechanical Engineers. Among the product testing organizations are the American Society for Nondestructive Testing, American Society of Test Engineers, American Society for Testing and Materials, and International Test and Evaluation Association.

These groups publish reports listing all products and technologies that they have reviewed or tested. From these listings, individual reports on specific products can be ordered. Most of these organizations offer subscriptions to the report services for a yearly fee. Once a subscription is acquired, reports can be obtained free.

The report listings are a valuable resource for identifying new and innovative technologies. Individual product reports contain much useful information.

### *Patent and Trademark Organizations*

The U.S. Patent and Trademark Department's Division of Building Structures and Components can provide information on innovative technology. More than 65,000 patents have been issued since 1975.

The Patent Department has a data base called "Lexis." Specifically, "Lexpat" within Lexis is a full text data base of all U.S. patents. This system can be searched to identify technologies and obtain the company names and addresses.

### *Advertisement in Trade Publications*

Advertisements requesting information about innovative construction products and technologies can be placed in prominent construction trade publications to reach the smaller manufacturers. Advertisements can be classified as two types--those appearing in Government publications and those in commercial magazines. Government-printed ads are generally free of charge or require a small fee. The law requires that all products purchased by the U.S. Government be advertised in this type of publication. When advertising in commercial magazines, it is better to use the "New Release" or "New Information" sections than the classified ads to solicit the information needed. Many publications also print this information free, as a service to their readers.

### **Collecting and Organizing Information**

Once sources have been identified for building products, technologies, and systems potentially applicable to the Army construction program, the information must be collected using a systematic approach. This will ensure that appropriate information is gathered in a consistent format and that a source is examined for all it has to offer. In addition, using a structured method will optimize time during personal interviews and avoid the need to make many disruptive follow-up calls.

For each source of information to be consulted in a forecast, the following items should be identified:

- Resource consulted

- Information obtained
- How to use the information obtained
- Techniques to identify emerging systems based on pertinent facts collected from each source.

Information should be extracted and formatted as described below for each type of resource.

#### *Journals and Periodicals*

Use the following format to collect information from the literature:

NAME:

CONTACT:

- PROCESS:
- Contact relevant editor listed in the periodical's index to call for information on the publication.
  - Review the new product section in the publication.
  - Review periodic publications for specific articles on new technologies, including yearly special new product issues.
  - Use the Reader Service Card (when applicable) for further information, or contact the manufacturer directly.
  - Make initial selection of products and technologies to prepare a Technology Summary (see next section) and Impact Assessment (Chapter 3).

#### *Building Products Trade and Manufacturers' Associations*

Use the following format to collect information from these organizations:

NAME:

CONTACT:

- PROCESS:
- Contact representatives of building product manufacturers' associations and explain the work being conducted.
  - Request assistance from the association, such as publicity for the BTFE work in their journals or newsletters. This publicity could also be a vehicle for requesting to be placed on individual manufacturers' mailing lists.
  - Request placement on the association's mailing lists to receive publications and newsletters containing manufacturer and other information on innovative technologies.
  - Use their publications to identify new and innovative technologies as described in the previous section.

### *Code and Testing Organizations*

Use the following format to collect information from these professional organizations:

NAME:

CONTACT:

- PROCESS:
- Contact representatives for information on relevant published report findings or testing results.
  - Review new products or technologies that have been evaluated, and request assistance during the evaluation portion of the study.
  - Make initial selection of new products and technologies for the Technology Summary (see next section).

### *U.S. Patents and Trademarks Departments*

Use the following format for collecting information from the Patents Department:

NAME: U.S. Patents

CONTACT: Commission of Patents and Trademarks  
Attention: Patent Copy Sale, Washington, DC

- PROCESS:
- Connect with the data base "Lexis" through computer hookup.
  - Review new products or technologies that have been identified and obtain a contact's name to request assistance during the evaluation portion of the study.
  - Make initial selection of new products and technologies for the Technology Summary.

### **Preparing Technology Summaries**

For each technology identified in the forecast and identification phase of the cycle, general information is summarized and entered onto a "Technology Summary" sheet. The information presented is intended to provide:

1. A summarized reference for obtaining information on a specific technology.
2. A "checklist" of data that must be obtained in order to complete the Impact Assessment (Chapter 3).
3. A convenient mechanism for translating information efficiently into a computer-based data management system.

Figure 1 is an example Technology Summary sheet. To ensure consistency throughout the process, the same information will be required for each technology identified. To limit the quantity of information, each summary is limited to one page and each category of information is limited to four separate assertions.

Technology #_:	General name or description of identified technology.
Source of Supply:	General description of supply source/availability.
Manufacturer Code:	Reference code used to identify manufacturers of the technology within the manufacturer data base.
General Description:	General description of the technology, briefly outlining what it is used for and how it works.
System(s) Affected:	Subsystem(s) that the technology can affect if used in a building system.
Components 1: Components 2: Components 3: Components 4:	List the various components and materials used in manufacturing the product.
Installation 1: Installation 2: Installation 3: Installation 4:	Brief description of how the technology is installed.
Limitation 1: Limitation 2: Limitation 3: Limitation 4:	Limitations the system has or physical constraints it may create within the structure.
Innovative Feature 1: Innovative Feature 2: Innovative Feature 3: Innovative Feature 4:	Innovative features or improvements the product will provide.
Replaces 1: Replaces 2: Replaces 3: Replaces 4:	Building components or systems that will be replaced by the identified technology.

Figure 1. Sample Technology Summary sheet.

### 3 IMPACT ASSESSMENT FOR PRIORITIZING EVALUATIONS

It is unrealistic to assume that USACE or any other building technology user could comprehensively examine every new product emerging in the construction marketplace. More than 100 technologies could be identified as promising each year. A screening process is necessary to ensure that resources are applied to those technologies exhibiting the greatest potential benefit for USACE.

An Impact Assessment is used to prioritize the identified building technologies based on their potential application to the MCA program. Technologies receiving the highest ranking are those with the greatest promise for cost or quality benefits. Further detailed evaluations are conducted on a selective basis, based on results of the Impact Assessment.

Although the BTFE cycle defines "impact assessment" and "prioritization" as two separate phases, they are very closely related, with priority assignment depending on the results of the Impact Assessment. Therefore, both phases are described in this chapter.

An Impact Assessment can also be used to identify conditions that would suggest further detailed examination might be inappropriate. Examples of these conditions are (1) an unfavorable cost relative to the technology's intended performance and (2) the presence of a risk element that would be unacceptable to USACE. The Impact Assessment, however, is not intended to "qualify" or "disqualify" building technologies for further consideration. Rather, it is intended as a tool to prioritize the allocation of resources to technologies having greater potential benefit.

The Impact Assessment consists of two phases. In the first phase, an "MCA Impact Factor" is generated based on projected Army facility requirements, which are represented by cost. In the second phase, scalar factors reflecting cost/benefit and risk further qualify the quantitative impact based solely on cost. These phases are described in detail below.

#### Impact Factor Calculation

The MCA Impact Factor calculation is the first of the two-phase Impact Assessment process and indicates the potential application of a building technology to the MCA program. This factor addresses the applicability of a technology to Army facility types and major building systems/components comprising each facility type. The MCA Impact Factor uses building cost as the indicator.

The initial step is to determine the relative contribution of each facility type to the total MCA program. A 5-year projection is used. Any 5-year increment can be used, as long as it is meaningful for the Impact Assessment. The Programmed Amount (in dollars) for each facility type is compiled for each year and for the 5-year period.

A building technology will most likely affect only a portion of a building--a system or component--rather than an entire building. Each facility type can be divided into its major subsystems. The portion of the total building associated with each building system can be represented as a percentage of the total building cost. These data are commonly available in construction industry cost guides, such as *Means Costs Guides* and *Dodge Costs Guides*, both published annually. The Means guides are useful in impact assessment for MCA because of their similarity in system breakdown, and Dodge guides are useful because their building types most closely resemble military facilities.

As an example, if maintenance facilities comprise approximately 27 percent of the projected 5-year MCA program, and approximately 15 percent of the total cost of a maintenance building is attributable

to the exterior wall system, then it is reasonable to project that approximately 4 percent of the total MCA program over the next 5 years will involve exterior walls for maintenance buildings. Therefore, an innovative wall system applicable to maintenance-type facilities could potentially affect 4 percent of the MCA program. If the same wall system can be applied to other facility types, the effect on the MCA program will be even greater.

A given building technology may impact only a portion of a major building system. The relative contribution of the technology to the building system (by cost) must be estimated. High and low estimates define a range within which the technology can be reasonably used in typical applications.

Simple algebraic expressions are used to calculate the Impact Factor range. These are developed as follows:

1. Determine which building systems the identified technology can affect.
2. List each facility type to which the technology may apply.
3. For each facility type, list the percentage of the MCA program affected (Table 1).
4. For each facility type, list the percentage of total building cost affected by the system for which the Impact Assessment is being developed (Table 2).
5. Estimate a reasonable range (high and low) to represent the extent to which the technology in question will affect the building system. This estimate will involve a degree of construction knowledge and judgement.
6. Calculate a total system impact factor range. For each facility type, the following calculation is completed, first for the low end and then for the high end of the estimated range:

$$(\% \text{ MCA Prog.}) \times (\% \text{ Bldg Cost}) \times (\% \text{ Sys. Affected}) \quad [\text{Eq 1}]$$

This calculation is performed for every facility type, both for the low and high ends of the estimated range. Next, the factors generated for the low end of the range for each facility type are summed to determine the low end of the total system impact factor range. Finally, factors for the high end of the range for each facility type are summed to determine the high end of the total system impact factor range (Table 3).

7. Repeat the process for each subsystem affected by the technology.

It must be emphasized that this Impact Factor is intended to represent the potential application of building technologies in the context of the Army's total building requirements for the next 5 years. It is not intended to represent estimated cost or potential cost savings.

### Cost/Benefit Assessment

The MCA Impact Factor indicates the potential effect a new technology may have on the MCA program in terms of volume. A Cost/Benefit Assessment further qualifies the Impact Factor and is conducted on a qualitative basis. It is intended to indicate any identifiable characteristics that either enhance or detract from the advisability of conducting further detailed evaluation on the technology in

**Table 1**  
**Percentage of MCA Program Affected**

Building Type	1987	1988	1989	1990	1991	Total	Percent
Communications	18.2	20.5	9.8	11.6	0.0	60.1	1
Operational	60.2	52.4	135.7	61.8	31.8	349.2	5
Training	162.4	80.2	117.6	56.2	44.7	461.1	7
Maintenance	353.3	503.6	440.9	176.4	243.8	1218.1	27
Production	0.0	0.0	0.0	0.0	9.1	9.1	0
Laboratories	47.8	31.2	106.0	110.9	51.2	347.1	5
Ammun. Storage	6.7	48.6	27.6	0.0	23.7	106.5	2
Cold Storage	0.0	7.9	0.0	6.5	1.6	16.1	0
General Storage	16.2	115.4	56.4	33.8	49.1	270.8	4
Hospital	0.0	53.4	2.5	51.9	0.0	107.8	2
Dental Clinics	4.5	0.0	0.0	3.4	0.0	7.9	0
Medical Clinic	18.5	10.4	6.4	0.0	9.8	45.1	1
Administrative	45.0	135.8	148.0	80.1	56.1	465.0	7
Family Housing	0.0	0.0	0.0	0.0	0.0	0.0	0
Unmar. Enlist. Qtr	288.0	275.1	257.8	313.5	175.8	1310.2	20
Dining	37.1	19.9	29.5	33.3	28.6	148.3	2
Detached Fac.	0.0	22.3	17.7	42.8	18.3	101.2	2
Unmar. Officer Qtr	32.8	38.3	38.0	84.8	22.6	216.5	3
Support & Service	9.6	10.1	7.0	4.2	49.7	80.8	1
Welfare & Rec.	88.9	116.0	83.4	56.8	250.5	595.6	9
<b>TOTAL MCA BUILDING CONST.</b>	<b>1190</b>	<b>1541</b>	<b>1484</b>	<b>1128</b>	<b>1073</b>	<b>6416</b>	<b>100</b>

**Table 2**  
**Percentage of Total Building Cost**

Building Types	A	B	C	D	E	F	G	H	I
Communications	2	2	45	6	3	7	14	12	11
Operational	9	10	10	25	8	1	21	16	0
Training	4	6	13	17	4	24	18	13	1
Maintenance	12	7	7	15	11	8	22	9	10
Production	8	8	12	12	10	10	26	15	0
Laboratories	10	4	8	9	6	26	26	10	2
Ammun. Storage	5	5	28	11	4	17	15	9	8
Cold Storage	3	7	22	10	11	12	17	10	8
General Storage	9	17	13	13	11	8	18	8	4
Hospital	1	1	14	11	1	34	15	12	13
Dental Clinics	0	5	6	14	33	27	8	2	2
Medical Clinics	7	3	16	1	1	21	23	13	15
Administrative	3	2	14	11	3	25	23	14	5
Family Housing	12	0	19	11	3	32	15	3	7
Unmar. Enlisted Qtr.	3	2	18	14	2	25	19	10	8
Dining	6	4	24	15	6	15	7	3	21
Detached Fac.	11	6	7	18	8	11	16	23	0
Unmar. Officer Qtr.	4	2	13	18	3	30	15	8	8
Support & Service	8	6	7	18	8	27	15	13	0
Welfare & Rec.	12	5	7	17	8	25	18	5	3

\*Subsystems: A - foundations, B - substructure, C - superstructure, D - exterior closure, E - roofing, F - interiors, G - mechanical, H - electrical, and I - specialties.

Table 3

Sample MCA Impact Table Showing Total System

MCA IMPACT TABLE

TECHNOLOGY: Panelized Wall System

SYSTEM: Exterior Closure

Building Types that Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	50	75
Operational	5	13	50	75
Training	7	17	50	75
Maintenance	27	15	75	85
Production	0	12	75	85
Laboratories	5	9	60	70
Ammun. Storage	2	11	0	0
Cold Storage	0	10	75	85
General Storage	4	13	75	85
Hospitals	2	11	60	70
Dental Clinics	0	15	70	70
Medical Clinics	1	15	70	70
Administrative	7	11	50	65
Family Housing	0	11	70	80
Un. Enlisted Qtr.	20	14	50	75
Dining	2	15	50	60
Detached Facil.	2	18	70	80
Un. Officer Qtr.	3	18	50	75
Support & Service	1	18	50	75
Welfare & Rec.	9	17	70	80
Total System Impact Factor Range			7	9

question. An initial assumption made is that a technology is at least technically adequate and economically competitive with current practices. Extensive cost analysis is not required. Subsequent detailed evaluation, if determined feasible, will validate the technical sufficiency and relative economics.

To determine the cost/benefit rating for a particular technology, cost information must be obtained. Product or material price information can be requested from manufacturers or supply sources. Installation and cost-in-place information can be based on recent, similar installation experiences.

The new building technology and the materials or products it replaces must be compared. This requires a basic familiarity with USACE construction practices--i.e., construction methods typically used--and their associated costs. Conventional cost estimating data and guides can be consulted (e.g., Means and Dodge).

The other component of this factor is a benefit assessment. Since a detailed technical or life-cycle cost evaluation is not intended, a qualitative judgment of a building technology's benefit must be based on summary information. This assessment indicates if: (1) there is an identifiable performance or life-cycle benefit inherent in the technology, (2) performance is generally comparable to the current practices, or (3) there is any likelihood that use of the new technology will compromise initial or life-cycle performance.

The Cost/Benefit Assessment is conducted by making the following determinations:

Initial cost: the building technology will clearly be: (1) higher than, (2) comparable to, or (3) lower in initial in-place cost for most cases compared with typical USACE construction practices.

Operation and maintenance (O&M): the building technology clearly demonstrates the potential for: (1) higher, (2) comparable, or (3) lower O&M efforts and cost in most cases compared with typical USACE construction practices.

Performance benefits: the building technology clearly demonstrates the potential for: (1) superior, (2) comparable, or (3) inferior in-place performance characteristics compared with typical USACE construction practices.

If no clearly identifiable cost or benefit trends emerge, there is no impact on a technology's consideration for detailed evaluation. If differences in initial cost, O&M efforts and costs, or performance are clearly indicated, the magnitudes of these differences must be considered. A qualitative judgment is made as to whether the Cost/Benefit Assessment supports or discourages a technology's further evaluation.

## **Risk Assessment**

There is always a certain element of risk involved in the use of new or innovative building technologies. The magnitude of risk depends largely on the newness of the technology and its performance history in simulated and actual use. It should be noted that greater potential benefit may justify a higher acceptable level of risk. The consequence of failure must also be considered, both in the context of physical effects and the personal impacts on individuals involved with the technology.

The Risk Assessment is intended to recognize differences in the various levels of innovation and departure from typical practices. A technology that has been accepted in other construction markets inherently presents less risk to USACE than one that is still in developmental stages.

A sequential screen was developed to provide a risk classification for each identified technology. Basic product information obtained from the literature or the technology developer or proponent is consulted to complete the Risk Assessment. Questions in the screen represent increasing levels of commercialization, practice, or industry acceptance. Ten criteria were developed to provide risk classifications:

- LEVEL 9: The innovation is based on sound design principles.
- LEVEL 8: Test models on the innovation have been constructed.
- LEVEL 7: A full-scale prototype of the innovation has been constructed.
- LEVEL 6: There has been a commercial installation of the innovation.

- LEVEL 5: There have been more than 10 commercial installations of the innovation.
- LEVEL 4: The innovation has been accepted into some model building code.
- LEVEL 3: The innovation has been accepted into the Uniform Building Code (UBC).
- LEVEL 2: The innovation has been used under environmental conditions similar to those for the intended use.
- LEVEL 1: There are multiple suppliers for the innovation.
- LEVEL 0: USACE has already had successful experience with the innovation.

Technologies in the highest risk categories will generally present an unacceptable level of risk to USACE. These technologies may require further development and actual in-place use to reduce risk to an acceptable level. This risk classification discourages a technology's further evaluation.

Technologies in the middle risk categories may present an acceptable level of risk if implemented on a limited or a trial basis before general acceptance as standard practice. However, a potentially high cost/benefit assessment may make these middle risk categories more acceptable under certain conditions. This risk level may have no impact, or may support a technology's further evaluation.

Technologies in the lower risk categories have already demonstrated acceptability in other construction markets and should present an acceptable level of risk to USACE. Trial applications or general acceptance may be appropriate. This risk level supports a technology's further evaluation.

### **Setting Evaluation Priorities**

Using the results of the Impact Assessment and any qualifications indicated by the Cost/Benefit and Risk Impact Assessments, technologies considered for further evaluation are ranked in descending order of potential impact on the MCA program. The resulting list is open-ended, so that technologies can be inserted or moved to any position as future conditions dictate. This ranking helps USACE determine the best allocation of resources for conducting detailed evaluations.

Assuming no major economic or performance disadvantages have been identified, the higher ranked technologies hold the greatest potential for cost savings and technical benefit than do the lower ranked technologies. Therefore, further effort can be devoted to technologies with greater benefits or payback potential. Detailed evaluations of the selected technologies will then verify their technical and economic benefits. Further plans for implementation are made pending the results of the detailed evaluations.

## **4 BUILDING SYSTEM EVALUATION**

In the BTFE cycle, the objective of the building system evaluation is to further examine selected technologies to determine their applicability to USACE. The building system evaluation methodology is designed to be a comprehensive, systematic predictor. For example, the evaluations described in Volume II of this report used an evaluation scheme designed such that any structural technology can be evaluated consistently and systematically. Any aspect of a building system that has a direct or indirect bearing or influence on the building system's structural performance can be scrutinized during the evaluation.

Note that the evaluation method proposed here is neither site-specific nor project-specific; practical application of this method may need to consider additional elements for a specific project at a particular location. Designers/engineers involved with a project must make decisions about which specific features to evaluate.

### **Evaluation Approach**

Volume II contains a detailed description of the evaluation method for structural systems, along with two complete evaluation exercises. (Future evaluation schemes for exterior closure, roofing, interior construction, mechanical systems, and electrical systems will be developed.) To avoid unnecessary duplication, this chapter summarizes the general approach for evaluating a building technology's structural performance.

To begin the evaluation, several general attributes related directly or indirectly to structural performance characteristics are identified. For each attribute, specific subattributes are selected to describe the structural performance more explicitly. Design and construction criteria applicable to these specific attributes are then referenced from the U.S. Army, USACE, and Department of Defense (DOD) regulations, as well as from the UBC and other recognized industry specifications and standards.

The attributes table generated in this way facilitates a comparison of the required performance criteria with the actual performance characteristics of a structural system. The objective (i.e., quantitative) component of this process includes the tangible evidence related to design, construction, experimentation, field investigation, and any valid performance data. The subjective (i.e., qualitative) component includes interviews, opinions of architects, engineers, contractors, manufacturers, and owners, and publications.

A rating sheet is next developed that contains the engineering data corresponding to the objective rating and the empirical data comprising the subjective rating for each major performance attribute. The rating sheet essentially relates the data or information to the attributes, and in effect, facilitates the numerical determination or measurement of performance characteristics for any structural system.

Based on input from design professionals, attribute weighting factors were determined that reflect the relative importance of performance attributes with respect to each other. The objective of the rating sheet is to derive a System General Rating (SGR) for a given building system. The SGR obtained provides the evaluator with guidance as to the suitability of a particular building system for Army facilities and USACE construction.

### **Evaluation Protocol**

Once the general attributes are defined for structural systems, the specific attributes and means by which performance can be determined must be identified. An attribute will have different performance

indicators associated with it, depending on the item being examined. For example, the appropriate performance tests and measures for the attribute "elasticity" will differ when applied to a roofing system compared with application to sealants.

The standards, tests, and criteria by which a technology is examined should be consistent with those commonly used in USACE technical documentation whenever possible. When there are no specific performance tests referenced in USACE documents, the evaluation protocol is to use performance indicators believed to be the most reasonable measure of the technology's performance.

### **Determining Applicability**

The purpose of the evaluation is not simply to compare the technology with existing standards or other technologies, but to identify its performance *capabilities* so that any designer can judge its applicability for a specific building type. Results may indicate that a technology is suitable in all cases or under certain circumstances and not others. It also may be found that too little performance data are available or established or that characteristics must be altered in order for the technology to become suitable. This evaluation is not intended to prove a technology's conformance with Corps of Engineers Guide Specifications (CEGS) (established standard USACE guidance), but is designed to identify technologies *potentially* useful to USACE.

## 5 PROTOTYPE BTFE CYCLE RESULTS

To test the validity of the prototype BTFE cycle and obtain input for refining the procedures, a practice exercise was conducted. The first three phases of the cycle are described here: (1) forecast, (2) impact assessment for prioritizing evaluations, and (3) selection of technologies for further detailed evaluation. The final stage of the prototype cycle--in-depth evaluation--is extremely detailed and comprises Volume II of this report. A less detailed description of attribute selection and results of Volume II is provided at the end of this chapter.

### Forecast Cycle

#### *Journal and Periodical Search*

Many journals were considered for use in the forecast exercise, including: *Building Design and Construction; Buildings; Progressive Architecture; The Construction Specifier; Civil Engineering-ASCE; Concrete Construction; Engineering News Record; Concrete Products; Heating/Piping/Air Conditioning; Electronic Products; and Electronic Engineering*. The "New Product" sections and feature articles on innovative technologies were examined in several issues of each periodical. A list of identified innovative construction technologies was compiled and technical data were located for each technology. A brief description of each was developed from the available material. The sources of information and supply were also recorded for future reference. This process can be tedious; however, if the scope is limited to select publications, it can prove quite beneficial. Many new technologies were identified in this way.

Information presented in these publications was not sufficient to gain a summary-level familiarity with the technologies identified. Therefore, after the initial identification, editors of these construction-related periodicals and journals were contacted. They were questioned about their publications, and specifically, how they treat the issue of new and innovative construction technologies. It was learned that most publications do not actively seek information on new and innovative construction technologies. Most receive information on new technologies from news releases and product information sent directly to the editor by manufacturers who have the publication on a mailing list. Manufacturers realize the advertising and marketing benefits of publicity in periodicals.

#### *Building Products Trade and Manufacturers' Associations*

Based on information collected from the literature search, a comprehensive list of information requirements from manufacturers was established. This investigation focused on technologies recently introduced into the market or those still in the developmental stage. An "expert opinion" investigation was then planned as a way to obtain information.

A comprehensive list of construction technology manufacturers was needed to represent the building industry adequately. This list was compiled using information from the following resources:

1. Addresses of manufacturers identified through a search of advertisements in periodicals.
2. The U.S. Patent and Trademarks Department, Division of Building Structures and Components data base "Lexis."
3. The Electronic Yellow Pages and Trinet Establishment Data base of Dialogue Information Retrieval Service directories for different classifications of companies and manufacturers.

4. Construction trade magazines' mailing lists of advertisers that use their publication.
5. The Construction Product Manufacturer Association's list of members.
6. The VSMF Microfilm Library Service, supplied by Information Handling Services, especially the portion dealing with manufacturers and their associations.

After numerous technology manufacturers were identified, a list of information to be obtained from them was developed. Information to be solicited included:

1. Product name and description.
2. A description of which components of the construction process would be affected by the technology (i.e., foundations, substructures, superstructures, exterior closure, roofing, interior construction, mechanical, electrical, and equipment/specialties).
3. A brief description of the new building system, including general characteristics of the technology.
4. A description of any testing to which the new technology has been subjected and by whom.
5. A description of any codes with which the technology complies and a request for further information if there is no code compliance.
6. Any U.S. Patents the technology may have received or requested.
7. A description of product availability and any restrictions on where the new technology is currently available, along with shipping or assembly restrictions.
8. A description of any areas of the design or construction process that need to be altered (e.g., if the technology is used, will other parts of construction have to be changed to accommodate it, and if so, which ones).
9. Major benefits and shortcomings of the product.
10. A description of what system(s), if any, the new technology could replace.
11. A comparison between the existing system and the new technology, relative to implementation of the new system, quality, safety, and cost (i.e., higher, lower, or the same as the existing system).
12. A description of the future potential for the technology, including any specific areas of innovation.
13. Brochures and promotional information.

This expert opinion investigation was developed into a questionnaire to provide a convenient way for the manufacturer to provide information necessary to the forecast exercise. It also eliminated the need to contact each manufacturer by telephone to obtain the requested data. The questionnaire also was formatted to provide an efficient way of coding the information into a computer-based data management system (see Chapter 6).

### *Code and Testing Organizations*

Two code agencies and three code enforcement groups were contacted. Three of these groups--the Association of Major City Building Officials, the Council of American Building Officials, and the National Conference of States on Building Codes and Standards--expressed an inability to contribute to the study. Both code agencies, the Building Officials and Code Administrators International (BOCA) and International Conference of Building Officials (ICBO) were willing and able to contribute to the study. BOCA and ICBO serve in the same basic capacity, with each developing and publishing its own building code. BOCA issues "The Basic Building Code" and ICBO issues "The Uniform Building Code."

Manufacturers of construction-related products send product news releases and information to the appropriate code group so that an evaluation report on the product can be completed. If the product complies with all code requirements, it is accepted as being in compliance with the code. Once a technology complies with building codes, it becomes much more marketable.

All code organizations publish a list of their evaluation reports along with a description of the technology, its application, and other major findings of the evaluation. The only disadvantage is that the report listings do not give a very descriptive explanation of the evaluation results, and therefore, it may be difficult to obtain all pertinent information. Specific reports can be obtained, at a fee, from the code organizations. Full-year subscriptions to all reports from each organization can also be obtained for a fee.

Testing agencies were identified and listed using the periodical search results and expert opinion investigation. Three product testing organizations were contacted: the American Society for Nondestructive Testing (ASNT), American Society for Testing Materials (ASTM), and American Society of Test Engineers (ASTE). ASTE and ASTM could not assist in the study. ASNT publishes a monthly publication with a "Materials Evaluation" section and two to four feature articles on new materials, products, and technologies. ASNT also offered to provide consulting help if needed during this study.

### *U.S. Patents and Trademark Departments*

The U.S. Patent and Trademark Department's Division of Building Structures and Components maintains a data base known as "Lexis" which includes a full text data base ("Lexpat") containing information on all U.S. patents. A keyword search was performed using this data base to obtain names and addresses of manufacturers of construction technologies and, in some cases, a copy of the patent.

A representative of the Building Structures and Components Division was then contacted to determine the potential contribution of that office to the study. It was learned that information needed for this study can be found under the data base topic "Static Structures," Class 52. Class 52 contains more than 65,000 patents issued since 1975. An online search was conducted to gather appropriate information.

The following patents were obtained from the Patent Office for additional information on three technologies:

- Patent 4,272,930 - Modular Housing
- Patent 4,327,529 - Modular Solar Building
- Patent 4,325,205 - Pre-Fab Building.

Copies of these patents were obtained promptly for a minimal cost.

Each patent contained general information and a brief abstract of the product, including its name, the patent number, date of issue, inventors, and references. Detailed drawings of the invention followed, including all of those submitted to the Patent Department. Also in this document was background information, with a summary of the invention and main objectives of the product. Thus, it was found that the U.S. Patent document provides comprehensive information on the new technology or product, which is very useful when completing the technology summary portion of the forecast and evaluation exercise.

#### *Advertisement in a Major Construction Periodical*

Many small-scale manufacturers and developers of construction technologies are scattered across the nation. To reach those manufacturers who may have been overlooked in the previous steps, an advertisement was developed for popular building/construction trade publications. Independent manufacturers were encouraged, through the ad, to forward information on the product(s) they have developed directly to those conducting the forecast and evaluation exercises. *Building Design and Construction* was selected as a representative publication in which to place the ad. The response to the advertisement was positive; however, the number of responses was low. The feasibility of advertising was evaluated from the responses received and it was decided that advertisement is not a useful activity in the BTFE process. However, with the increasing popularity of more highly focused publications, and selection of a suitable one, the results could improve in the future.

#### **Promising Technologies**

Twenty-one building technologies were identified in the prototype forecast cycle. They are described below.

1. Built-up/Laminated Wood Structural Systems--an alternative to conventional wood framing members.
2. Composite Floor Systems--structural framing and floor slab construction in one system.
3. Demountable Interior Systems (Partitions, Floors, Ceilings)--space dividing systems that can be arranged and relocated.
4. Exterior Insulation Systems--weathering surface and insulation contained in one closure system external to the building's structure.
5. Fiber-Reinforced Plastic Building Systems--nonmetallic buildings that are corrosion-resistant and prevent electrical interference.
6. Fold-up Building Systems--closed panel systems including floors, walls, and ceilings which are prefabricated, transported, and unfolded for construction.
7. Glass-Fiber-Reinforced Concrete Closure Systems--lighter weight exterior wall closure systems.
8. Liftslab Construction Method--method of forming all building floor slabs at ground level and then lifting them into place.
9. Liquid Roofing Systems--monolithic roofing material that addresses the problems of brittleness, shrinkage, and seam leakage.

10. **Low-Emissivity Glazing Systems**--glazing systems designed to be more energy-conservative than others being marketed.

11. **Light-Gauge Metal Building Systems**--preengineered, noncombustible building structures which are economically competitive with wood-framed construction.

12. **Modular Concrete Forming Systems**--a quick method for forming the shell of a structure.

13. **Monolithic Dome Building Systems**--monolithic concrete dome structure for an open-span facility.

14. **Panelized Roof Systems**--prefabricated decking, insulation, and roof covering in an integrated building system.

15. **Panelized Wall Systems**--prefabricated exterior wall closure system.

16. **Space Frame Structural Systems**--roof framing systems for creating wide, column-free structural spans.

17. **Spray-Applied Insulation Systems**--an alternative method of insulating walls and ceilings.

18. **Spray-Applied, Fire-Resistive Fiberglass Systems**--an alternative, nonasbestos method of fireproofing structural members and ceilings.

19. **Standing Seam Metal Roofing Systems**--an alternative to conventional roofing systems with a high level of performance in leakage control.

20. **Truss-Framed Building Systems**--a unitized floor/wall/roof truss structural component for wood-frame construction.

21. **16-Inch Brick**--an alternative to concrete masonry construction.

Each identified technology was summarized as described in Chapter 2. Appendix B contains the resulting summary sheets.

### **Impact Assessment for Prioritizing Evaluations**

In this exercise, the period 1987 to 1991 was selected for the 5-year MCA Impact Assessment. Programmed Amounts for each facility type were compiled for each year and for the 5-year period. Appendix C shows MCA impact tables for the 21 technologies identified above. Each table contains all data necessary to calculate the total system Impact Factor range, which is the final representation of the technology's impact on a particular building subsystem. Table 4 summarizes the technologies in order of impact based on this analysis.

It should be noted again that factors other than economic impact must be considered when selecting technologies for further evaluation. For example, although spray-applied, fire-resistive fiberglass systems have a low potential impact as determined by the MCA Impact Factors, they may have very addressing the Army's need to replace asbestos-containing materials in fireproofing.

Table 4

Identified Building Technologies in Order of Impact

Technology & ID Number	Total Individual Subsystem						
	MCA Score	S	E	I	R	M	E
Fold-Up Building Systems (7)	40 =	11		12	6	4	7
Modular Concrete Forming System (13)	19 =	6	4	9			
Composite Panelized Wall System (16)	18 =	9	9				
Panelized Roofing Systems (15)	17 =	11		6			
Fiber Reinforced Plastic Building Systems (6)	16 =	7	3	6			
16 Inch Brick (1)	12 =	2	10				
Exterior Insulation Systems (5)	11 =	11					
Built-Up/Laminated Wood Structural Systems (2)	11 =	11					
Light Gauge Metal Building Systems (12)	10 =	10					
Glass Fiber Reinforced Concrete Closure Sys (8)	9 =	9					
Truss Frame Building Systems (21)	7 =	7					
Demountable Interior Systems (4)	7 =			5	2		
Composite Floor Systems (3)	7 =	7					
Low Emissivity Glazing Systems (11)	6 =		6				
Standing Seam Metal Roofing Systems (20)	6 =	4			2		
Space Frame Structural Systems (17)	6 =	6					
Liquid Roofing Systems (10)	6 =				6		
Lifslab Construction Method (9)	4 =	4					
Monolithic Dome Building Systems (14)	3 =	1	1	1			
Spray Applied Insulation Systems (18)	1 =	1					
Spray Applied Fire Resistive Fiberglass Sys (19)	<1 =	<1					

Also from the results in Table 4, the fold-up building system, which received a very high ranking, appears to be a promising technology. However, this system was not considered for further investigation because the manufacturer went out of business (although it would have made an excellent evaluation exercise). It was considered an unrealistic expenditure to investigate and was dropped from consideration.

The fiber-reinforced plastic (FRP) building system also illustrates the impact of the cost/benefit and risk qualifiers on the MCA Impact Factor. This technology, which generally resembles metal building systems, is specialized for situations where metallic noninterference is required or where highly corrosive environments are present. The cost is known to be more than \$100/sq ft for the building shell alone. In contrast, a metal building shell might cost \$15 to 25/sq ft. Life-cycle costs also favor a preengineered metal building system in all but the most extreme cases due to the high first cost. Thus, although ranking high in numerical impact, the high first cost would not offset by benefit and, therefore, the FRP building system was not considered for further evaluation.

The modular concrete forming systems and panelized composite wall systems were selected for further detailed technical evaluation. In addition to ranking high in numerical MCA impact, these technologies also exhibited favorable cost/benefit and risk factors. The complete evaluation of these two technologies is the subject of Volume II; the results are summarized below.

## **Building System Evaluation Results**

Based on the evaluation conducted in Volume II, it was concluded that both the Tunnel Forming System and the Composite Panelized System meet the general requirements of good construction practice in general and USACE criteria in particular. Although no comparison was intended, it was noted that the Tunnel Forming System is expected to perform better than the Composite Panelized System and meet the overall needs of USACE residential projects involving modular construction. When modular construction is not required or desired, the Composite Panelized System is felt to be the better option.

For the Tunnel Forming System, no full-scale tests were conducted. While such tests are not required by code, they are desirable for any new systems. The Tunnel Forming System is not a new structural concept and therefore the significance of full-scale tests was not as critical as for other systems. On this basis, the rating (SGR value) for the Tunnel Forming System could have been higher than 49. However, such tests are desirable for any new system and, therefore, this system cannot be assigned a high rating without it. It appeared that the Tunnel Forming System has created substantial impact in California, Florida, and other parts of the United States with the exception of the East Coast.

A major advantage of the Tunnel Forming System is the speed of construction, which is important for large construction projects. Because of the inherent monolithic nature, buildings using this system are very adequate structurally and are expected to perform well, even in seismic zones. A major disadvantage of Tunnel Forming System is that it is uneconomical for small projects. The principal components of this system in the United States are located in Florida and California. For a construction project located far away from these places, particularly in a remote location, use of this may not be feasible.

Full-scale tests also were not conducted for the Composite Panelized System. Again, while these tests are not required by codes, they are desirable for any new system. The absence of such test results for the Composite Panelized System would certainly lower its overall SGR rating of 45. The Composite Panelized System has created an impact internationally but less of one in the United States.

A principal advantage of the Composite Panelized System is that it is suitable for both modular and nonmodular construction as well as large and small projects. Large, modular projects would probably be more cost-effective. It is also a relatively easy method of construction. However, a major limitation of this system is the absence of an adequate infrastructure for plastered construction in the United States. Another drawback of this system is the span limitation imposed by the structural strength of the panels. This limitation could possibly be overcome in the future by conducting further R&D on this product and demonstrating its applicability on a wide range of building structures. At present, this applicability has not been demonstrated. It is recognized, however, that this limitation may not be so important for barrack-type construction, where the product could be customized to meet the span requirements for such projects. Similar to tunnel forms, location of a project far from California might lower the acceptability of this system for a particular project.

In general, regardless of the limitations found for the systems evaluated, they appear to be suitable for U.S. Army facilities and USACE construction. The actual use of such systems will depend largely on a number of other considerations (e.g., budget, project requirements). Since the cost of any structural system is important to the owner, it is recommended that a comprehensive economic analysis be conducted in the future for each system with respect to other currently prevailing conventional structural systems.

## 6 AUTOMATED MANAGEMENT OF TECHNOLOGY INFORMATION

### System Objectives

Due to the large number of new technologies aimed at building construction, a huge volume of data will be generated for each identified technology. General descriptive material on the technologies, cost information, applications, impact factor calculations, and other pertinent data will comprise the data base. A commercially available data base management system can be used to manage this information efficiently. Such a system could be used within USACE as a reference aid for selecting construction technologies to evaluate for MCA. This chapter includes a description of how a BTFE automated management system should be structured; however, the scope of this research did not include development of such a system.

To be effective, the system must allow for simple, efficient retrieval of specific technology information. It must be designed for use by novice computer operators who have little or no experience using data base programs. This condition would mandate development of a menu-driven or user-friendly operating environment that would not require much computer expertise to use. All data sorting and indexing commands must be controlled by the menus. Report generation should be preformatted and menu-driven.

It is also necessary for the system to perform mathematical calculations automatically for the Impact Assessment. Whenever possible, the calculations should be done within the data base system itself. As an alternative, the data base could interface with a spreadsheet program for these functions.

The data base on construction technologies will provide the foundation for a larger automated system to be developed in the future. The larger, more comprehensive system is envisioned as providing an online technology selection guide that can recommend promising technologies. This process could be accomplished by using the data base in an expert system shell. It is envisioned that the "Technology Selection and Recommendation System" will provide intelligent decision support to both USACE and architect/engineer firms in the private sector.

### System Concept

Information on new technologies will be compiled as part of the BTFE cycle. Selected information, obtained through product literature and directly from manufacturers, will be entered into some centralized computer system. All input functions will be controlled through this centralized location, which may be a contracted agency. This control office will complete the technology impact assessment and other preliminary calculations. A System Manager will be named to ensure the integrity of data in the system (see **System Management** later in this chapter).

Information in the data base, including the technology name, brief description of use, sources of supply and information, description of innovative features, and impact assessment data can be distributed to site offices by mailing floppy diskettes or by electronic transmission of data through telephone lines. These data will enable users to determine which technologies they would like to examine further.

Impact factors and other evaluation results will be available on the system for the technologies selected for detailed evaluations. A list of all tests conducted on each product and results of those tests will be available. For instance, the user could select a list of all technologies affecting roofing or more detailed information on one specific technology could be obtained. Online comparisons will be made between the results of each evaluation test and acceptable standards as determined by USACE.

## **Data Base Management System Requirements**

The computerized system should be implementable on a minicomputer, workstation, or any IBM-compatible personal computer (PC) with 640 kB operating memory. This configuration will enhance the system's versatility and portability, and allow room for expansion. The computers should be equipped with a modem for possible telephone transfer of data. Many USACE offices currently have access to microcomputers on which the system could be implemented.

Commercially available data base software is suitable for developing the system. The software system selected should be flexible enough to meet all the intended performance and system requirements. Some points to consider when selecting the data base software are: system integration (data base, spreadsheet, and text editor all in one system), complexity of programming language, ability to perform calculations, allowable field lengths and record numbers, and screen customization and menu creating abilities. It is also important that the data base system selected interface with commonly used expert system shells.

Input into the data base will be performed by computer operators unfamiliar with PC-based data management systems. Therefore, the input feature should be user-friendly and menu-driven. The screen should be designed to display a simple format for the data input. In addition, it is important that the operator be able to easily edit data as it is being input, as well as freely move the cursor to any point on the screen for random data entry. Instructions in the user's manual should outline all data entry procedures clearly.

Data entry fields should be titled to reflect the information provided by product manufacturers. This will ensure consistent information throughout all records in the data base system.

Data manipulation functions, such as sorting, indexing, generating reports, and calculating impact assessment will be menu-driven. Most data manipulation functions will be performed by a system maintenance group and system manager; however, reports will be generated at the user level.

Basic commands to input, retrieve, and update (edit) the data base will be similar, regardless of the software system selected. Placement of the results of command executions into report files will differ based on the software being used. It is essential that the system selected allow all command execution data manipulations to be performed at the menu level. Options for printing the information in a desired format must be available to meet the user's needs.

Due to the system's objectives, the data base structure should be easily adaptable to modification. Comments and recommendations generated upon completion of testing and during the early stages of implementation will most likely warrant system modification. In addition, the changing nature of technology requirements and available data will require the addition or deletion of fields, modification of report formats, and similar changes.

Data input for the technology descriptions and other select fields will require written text. Therefore, some method of text editing, either within the data base software or by an interface with word processing software, will be required to allow for convenient, rapid entry of data.

## **System Operating Requirements**

The primary input function will be designed to allow preliminary entry of technology data based on product information obtained from the manufacturer. Information will be translated from the technology literature (product brochures) to the input format sheet. These data will then be input directly into the data base.

Because preliminary summary information will be needed to complete the Impact Assessment, efforts should be made to obtain all information required for the summary format sheet. Some information on the summary sheet will have to be completed by an individual familiar with construction technology and techniques, such as an engineer or an architect. Technology input format sheets will be reviewed by the System Manager prior to the actual input into the computer (see **System Management** later in this chapter).

The second major input function of the data base system will be for the evaluation phase of the BTFE cycle. Architectural and engineering professionals will conduct the evaluations according to the established protocols. Computer operators will enter the results of testing performed on specific technologies into the system for future reference. The test results will be entered onto an evaluation result format sheet, and upon approval by the System Manager, will be entered into the computer system.

Functions to allow data retrieval are needed for use at several levels. Retrieval will be read-only in the field. No personnel other than the System Manager or his/her designated agent will be able to manipulate any of the data retrieved within the computer system. Technology data provided to the user will be used mainly as reference.

With the information provided in the data base, users will be able to:

1. Determine who supplies a specific technology. This information can be used for obtaining more technical data on the technology directly from the supplier or manufacturer, or to obtain information on procurement of the product.

2. Obtain information on innovative technologies that may fit a specific construction need. For instance, if renovation work is being done on a roof system, the user will be able to reference "roofing" as a subsystem and obtain data on all innovative technologies in the system that can be applied to roofing needs. At this point, the user may find a technology suitable for further investigation.

3. Browse through all records in the data base to supplement their own knowledge and awareness of innovative technologies being introduced into the marketplace for potential future use.

4. Analyze the impact assessment factors to supplement their own knowledge and awareness of innovative technologies.

5. Analyze the evaluation results on technologies determined to have the greatest impact on USACE construction projects. This process can reinforce confidence in using or specifying those technologies and can be useful in value engineering exercises.

Specifically, data retrieval functions will be designed to list all technologies in the data base according to:

1. A designated reference number for ease in obtaining more information from within the system.

2. Affected building system. This feature will enable the user to reference technologies specifically for a particular building subsystem, such as foundations and substructure.

3. Impact factor. Technologies and their calculated impact factor will be listed in descending order of impact.

4. Supplier or manufacturer.

## 5. Designation for detailed evaluation.

In addition, to these listings, the user will be able to reference a particular technology and obtain all the information that has been entered into the system on that topic. This information will come from the formatted technology summary sheets, as described earlier. Users will be able to "browse" through each record (technology) to retrieve all relevant information, in addition to generating a report (printed or on screen) of all data.

Data on the MCA 5-year program and tables on building cost percentage and building systems cost percentage will be stored within the system and used to calculate the technology impact factor. The information will be stored in the standard data base format and will be updated as necessary. Access to some information will be limited to the System Manager; however, the final impact factor calculation will be available to all interested parties. Any changes to any of the data will trigger the system to automatically recalculate the impact factor for each technology.

The system will be designed to provide users with all applicable evaluation attributes and specific tests necessary to complete the evaluation phase of the BTFE cycle. Attributes and tests will be predetermined and entered into the system on a subsystem-specific basis (e.g., all tests necessary to evaluate the structural aspects of the specific technology will be consistent for every technology with structural applications).

When a technology is selected for evaluation, it will be entered into the evaluation area of the data base. Based on the subsystems affected by the technology, a list of all applicable attributes and tests will be provided to the user on a formatted report form. When the evaluation is completed, all test results will be entered into the system for future reference.

### System Management

As noted earlier, a System Manager will be designated to oversee the functions of the data management system. The System Manager will represent all technical disciplines served within USACE and will be responsible for managing user comments and recommendations, handling problems, and making decisions about changes to the data base. This person will also provide user manuals, training, and system information as required.

All changes must be approved by the System Manager before being entered into the system. If actual system maintenance is contracted to an outside agency, the System Manager will serve as liaison between USACE and the contractor to provide guidance.

### An Information Clearinghouse System Concept

A preliminary version of the construction technology data management system has been developed. The following functional needs for the data base have been identified:

- Ability to access various pieces of data in a file from several files at any time
- Ease of updating or adding single data items or records
- Text writing abilities in each data file (for functional description of each technology)
- Mathematical capability (for evaluating technological impact).

Several file management systems for use on IBM-compatible PCs were considered in creating the technology data base and evaluation package. The Knowledge-Man™ ("K-Man") file management system by Micro-Data Corp. was selected to illustrate several required system capabilities. K-Man requires no programming knowledge by the system user after the appropriate commands and linkages between the system files are set.

K-Man software consists of an integrated data base, spreadsheet, and text editor. All of these features can be used by the system operator in a single session. One data base field can contain a maximum of 65,534 characters, which is adequate for larger fields such as the "Technology Description." Forms and menus can be used for data entry, which accommodates shorter fields efficiently. Also, as a relational data base, K-Man allows data selection from more than one table at a time.

### **Prototype System Organization**

Information is stored in a data table containing one record for each technology. The information can be updated as necessary. Each record contains standard fields (numerical and string) to hold the general descriptive information and data used in the MCA technology impact calculations. The following information is contained in the fields:

- Name of technology
- Technology reference number
- Technology type (entire building system; building component--structural, nonstructural, mechanical/electrical system)
- General description of the technology
- Sources of additional information on the technology (supplier name and address)
- Description of innovative feature(s)
- Building systems and components affected by the technology
  - Foundations (footings, piles, wall, other)
  - Substructure (slab on grade, other)
  - Superstructure (columns, beams, roof, stairs, floor)
  - Exterior closure (finishes, doors, windows, walls, insulation)
  - Roofing (special coverings, flashing, insulation)
  - Interior construction (doors, partitions, ceiling finishes, wall and floor finishes)
  - Mechanical (plumbing, fire protection, heating, air-conditioning)
  - Electrical (service, special, lighting, and power)
  - Specialties and equipment (conveying, fixed equipment, other)

- Description of technology impact
- High and low total impact of technology on each affected building system
- A set of 40 factors for each affected building system (for estimating low and high impact on technology) within 20 types of buildings in the USACE construction program.

### **Data Base Structure and Operation**

It was decided to place data into table format to increase the ease and speed of information retrieval. If one data table is determined to be inadequate, two or more tables can be structured. This configuration allows for an unlimited number of affected building systems and the relevant technology impact to be calculated.

As information is collected and the data base used, it may become apparent that some fields are not large enough or that additional fields are needed. These and other changes can be made easily without having to completely redefine the table and information input.

By entering a command, the user is guided through the available options by a series of menus. These menus are designed to allow the user to return to the main menu or exit the system at various points. Records deletion is handled through the use of one command from the system menu. The name and number of the chosen technology to be deleted are displayed as a check before the deletion actually occurs. Information in an individual field can be deleted through the modification process.

### **Data Retrieval**

All reports produced by the data base program offer the option of having output routed to the printer or to the screen. Several types of reports are possible to help the user screen the technologies for further evaluation. Each report listing offers the user an opportunity to input any technology for which further information is desired.

### **Impact Calculations**

The technologies total impact must be recalculated whenever the MCA program is updated and for each new technology introduced. These data can be changed by entering the data base in which the information is stored and modifying the appropriate cell definitions. The impact factors should be calculated interactively with the technology information input. Programming different function keys for repetitive commands may be used in the process.

## 7 CONCLUSIONS AND RECOMMENDATIONS

A prototype building technology forecast and evaluation (BTFE) cycle has been developed and implemented in a trial exercise. The BTFE cycle consists of four distinct phases: forecast/identification, impact assessment, prioritization for further study, and detailed evaluation. This process is designed to ensure that USACE's valuable resources are optimized by performing full-scale evaluations only on technologies demonstrating the greatest potential for MCA.

The first three phases of the cycle have been explained in detail. The evaluation phase is summarized for a general understanding; Volume II of this report describes the evaluation procedure in considerable depth as it is used to examine two technologies.

The prototype BTFE was used in a practice exercise, during which 21 construction technologies were identified as having potential benefit to USACE. Impact assessments were performed for all 21 technologies and the results used to prioritize these products/ systems for further study. Two technologies emerged as the most promising among the original 21 selected: modular concrete forming systems and panelized composite wall systems. The detailed evaluation of these two systems is reported in Volume II, as noted above.

Due to the amount and type of information that will be generated in the BTFE cycle, an organized management method is needed. A computer-based data management system has been proposed as the most effective way to handle this information. System requirements have been identified and a prototype has been developed using the Knowledge-Man™ file management system produced by Micro-Data Corp. This system is still in the laboratory test stages, but shows potential for serving as a decision-support tool accessible to USACE managers. Such a system would allow USACE to continually explore new or innovative building technologies and to select or further evaluate those most likely to benefit military construction. In the process of providing this support, the system would continue to expand with the knowledge generated in subsequent cycles.

It is recommended that the BTFE cycle be further tested and refined as a USACE standard methodology for introducing new and innovative technologies into practice. In addition, the data management system should be developed into a full-featured decision-support system, possibly by including expert systems technology to help USACE managers select optimal products/systems.

## **APPENDIX A:**

### **SOURCES OF INFORMATION ON NEW TECHNOLOGY**

#### **1. Periodicals and Journals**

- Advanced Materials and Processes*, American Metals Society, Metals Park, OH 44073, 216-337-5151.
- American Concrete Institute (ACI) Journal*, ACI, Box 19150 Redford Station, Detroit, MI 48219, 313-532-2600.
- American Society of Civil Engineers, ASCE Journal*, 345 E. 47th St., New York, NY 10017-2398, 212-705-7926.
- Architectural Record*, 1221 Avenue of the Americas, New York, NY 10020, 212-512-2000.
- Building Design and Construction*, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312-635-8800.
- Building Research and Practice*, 11 New Fetter Lane, London EC4P 4EE, England.
- Buildings*, 427 Sixth Ave. SE, PO Box 1888, Cedar Rapids, IA 52406, 319-364-6167.
- CSI Spec Data*, 601 Madison St., Alexandria, VA 22314, 703-684-0300.
- Civil Engineering Magazine*, ASCE, 345 E. 47th St., New York, NY 10017-2398, 212-690-3890.
- Composites*, PO Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH England, 0483-300966.
- Concrete*, 7500 Old Oak Blvd., Cleveland, OH 44130.
- Concrete Construction Magazine*, 426 S. Westgate, Addison, IL 60101, 312-543-0870.
- Construction Digest*, 7255 Woodland Dr., Indianapolis, IN 46278.
- Construction Review*, 601 Madison St., Alexandria, VA 22314, 703-684-0300.
- Construction Specifier*, Department of Commerce, Basic Industries Division, Washington, DC 20239, 202-377-0132.
- Contracting Business*, 1100 Superior Ave., Cleveland, OH 44114, 216-696-7000.
- Corporate Design and Reality*, 475 Park Ave., New York, NY 10022, 212-576-4192.
- Engineering News Record*, 1221 Avenue of the Americas, New York, NY 10020.
- Facilities Design and Management*, 1515 Broadway, New York, NY 10036, 212-869-1300.
- Heating/Piping/Air Conditioning*, 2 Illinois Center, 233 N. Michigan Ave., Chicago, IL 60601, 312-861-0880.

*Industrial Development*, 40 Technology Park, Norcross, GA 30092, 404-446-6996.

*International Architect*, Box 85, 36 Bedford Square, London W1B 3EH England.

*International Construction Week*, 1221 Avenue of the Americas, New York, NY 10020, 212-512-2000.

*Japan Architect*, Yushima, 2-Chome, Bunk Yo-Ku, Tokyo 113, Japan, 03-811-7101.

*Journal of Construction Engineering and Management*, 345 East 47th St., New York, NY 10017-2398, 212-705-7275.

*Lighting Design and Application*, 345 E. 47th St., New York, NY 10017, 212-705-7926.

*New Civil Engineer*, Thomas Telford House, London E14 9XF, England, 01-987-6999.

*Prestressed Concrete Institute*, 175 W. Jackson Blvd., Chicago, IL 60604, 312-786-0300.

*Professional Builder*, Cahners Plaza, 1350 Touhy Ave., Des Plaines, IL 60018, 312-635-8800.

*Progressive Architecture*, 600 Summer St., Stamford, CT 06904, 203-348-7531.

*Space Structures*, Crown House, Barking, Essex IG11 8JJ, England.

*Sweets Catalog*, 1221 Avenue of the Americas, New York, NY 10020.

*Thomas Register*, One Penn Plaza, 250 West 34th St., New York, NY 10119, 212-695-0500.

## **2. Building Products Trade and Manufacturers Associations**

American Concrete Institute, PO Box 19150, Detroit, MI 48219, 313-532-2600.

American Hardboard Institute, 520 North Hicks Road, Palatine, IL 60067, 312-934-8800.

American Institute of Architect., 1735 New York Ave., NW, Washington, DC 20006, 202-626-7463.

American Institute of Steel Construction, 400 North Michigan Ave., Chicago, IL 60611, 312-670-2400.

American Institute of Timber Construction, 333 West Hampden Ave., Eaglewood, CO 80110, 303-761-3212.

American Society of Civil Engineers, 345 E. 47th St., New York, NY 10017, 212-705-7496.

American Plywood Association, PO Box 11700, Tacoma, WA 98411.

American Society of Professional Estimators, 6911 Richmond Highway, Alexandria, VA 22306, 703-765-2700.

American Society of Concrete Construction, 3330 Dundee Road, Northbrook, IL 60062, 312-291-0270.

Architectural Aluminum Manufacturers Association, 2700 River Road, Des Plaines, IL 60018, 312-699-7310.

Architectural Precast Concrete Association, 825 East 64th St., Indianapolis IN 46220, 317-251-1214.

Associated Specialty Contractors, 7315 Wisconsin Ave., Bethesda, MD 20814, 301-657-3110.

Association of Wall and Ceiling Industries, 25 K St. NE, Suite 300, Washington, DC 20002, 202-783-2924.

Brick Institute of America, 11490 Commerce Park Dr., Reston, VA 22091, 703-620-0010.

Building Officials and Code Administrators, International, 4051 West Flossmoor Road, Country Club Hills, IL 60477, 312-779-2300.

Building Stone Institute, 420 Lexington Ave., New York, NY 10170, 212-490-2530.

Ceramic Tile Institute, 700 North Virgil, Los Angeles, CA 90029, 213-660-1911.

Concrete Reinforcing Steel Institute, 933 Plum Grove Road, Schaumburg, IL 60173, 312-517-1200.

Construction Specifications Institute, 601 Madison St., Alexandria, VA 22314, 703-684-0300

Expanded Metal Manufacturers Association, 600 South Federal St., Chicago, IL 60605, 312-922-6222.

Gypsum Association, 1603 Orrington Ave., Evanston, IL 60201, 312-491-1744.

Hardwood Plywood Manufacturers Association, 1825 Michael Faraday Dr., PO Box 2789, Reston, VA, 22090, 703-435-2900.

Institute for Building Sciences, PO Box 597, Florida A&M University, Tallahassee, FL 32307, 904-599-3244.

International Masonry Institute, 815 15th St. NW, Washington, DC 20005, 202-783-3908.

Metal Building Manufacturers Association, 1230 Keith Building, Cleveland, OH 44115, 216-241-7333.

National Academy of Sciences, National Research Council, Building Research Board, 2101 Constitution Ave. NW, Washington, DC 20418, 202-324-3378.

National Association of Architectural Metal Manufacturers, 600 South Federal St., Chicago, IL 60605, 312-922-6222.

National Forest Products Association, 1250 Connecticut Ave. NW, Washington, DC 20036, 202-463-2700.

National Glass Association, 8200 Greensboro Dr., Suite 302, McLean, VA 22102, 703-442-4890.

National Institute of Building Sciences, 1015 15th St. NW, Washington, DC 20005, 202-347-5710.

National Precast Concrete Association, 825 East 64th St., Indianapolis, IN 46220, 317-253-0486.

National Roofing Contractors Association, 6250 River Road, Rosemont, IL 60018, 312-512-2372.

Plastics Institute of America, Stevens Institute of Technology, Castle Point Station, Hoboken, NJ 07030, 201-420-5553.

Prestressed Concrete Institute, 201 N. Wells St., Chicago, IL 60606, 312-346-4071.

Reinforced Concrete Research Council, 208 North Romine St., Urbana, IL 61801, 217-333-7384.

Steel Deck Institute, PO Box 9506, Canton, OH 44711, 216-493-7886.

Thermal Insulation Manufacturers Association, 8341 Sangre de Cristo Road, Littleton, CO 80127, 303-933-9774.

### **3. Testing and Code Organizations and Code Enforcers**

American Insurance Association, 85 John St., New York, NY 10038, 212-669-0400.

American National Standards Institute, 1430 Broadway, New York, NY 10018, 212-354-3300.

American Public Health Association, 1015 15th St., NW, Washington, DC, 20005, 202-789-5600.

American Society for Nondestructive Testing (ASNT), 44153 Arlingate Plaza, Columbus, OH 43228, 614-274-6003.

American Society of Test Engineers, PO Box 390, Glen Ellyn, IL 60138, 312-260-1055.

American Society for Testing and Materials, 655 15th St. NW, Washington, DC 20005, 202-639-4025.

Association of Major City Building Officials, 481 Carlisle Drive, Herndon, VA 22070, 703-437-0100.

Building Official and Code Administrators (BOCA), 4051 W. Flossmoor Road, Country Club Hills, IL 60477, 312-799-2300.

Council of American Building Officials, 5203 Leesburg Pike, Falls Church, VA 22041, 703-931-4533.

International Conference of Building Officials (ICBO), 5360 S. Workman Mull Road, Whittier, CA 90601, 213-699-0541.

International Test and Evaluation Association, 5641 Burke Center Parkway, Burke, VA 22033, 703-425-8522.

National Academy of Code Administration, 1207 Park Terrace, Champaign, IL 61821, 217-352-3253.

National Conference of States on Building Codes and Standards, 481 Carlisle Drive, Herndon, VA 22070, 703-437-0100.

National Fire Protection Association, Battery March Park, Quincy, MA 02269, 617-770-3000.

Underwriters Laboratories, Inc., 333 Pfingsten Rd., Northbrook, IL 60062, 708-272-8800.

**4. Publications for Placing Advertisements**

*Construction Review*, U.S. Department of Commerce, Building Materials and Construction Division, Room 4043, Washington DC 20230, 202-377-0133.

*Building Design and Construction*, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312-634-8800.

**5. U.S. Patent Office**

U.S. Patents, Commission of Patents and Trademarks, Attention: Patent Copy Sale, Washington, DC 20231, 703-557-3341.

**APPENDIX B:**

**SUMMARY SHEETS FOR IDENTIFIED TECHNOLOGIES**

**TECHNOLOGY 1: 16-INCH BRICK**

Source of Supply: Acme Brick, Inc.

General Description: 16-inch brick is an alternative to double-wythe concrete block construction and standard brick construction. It has 3-1/2 times the compressive strength of block, enabling designers to design taller and thinner structural masonry walls. Since it is a structural masonry unit, it requires no other framing. It eliminates the need for composite wall construction, as the structural and esthetic characteristics are contained in one unit. Its inherent benefits are heat, sound, moisture and fire control as well as maintenance freedom. Its economic benefits include faster erection since each brick can be placed in the time of a 12-in. concrete masonry unit, a 30 percent savings.

System(s) Affected: a. Superstructure, b. Exterior Closure.

Components 1: 16-in. brick units made of fired clay masonry units.  
Components 2:  
Components 3:  
Components 4:

Installation 1: 16-in. brick is installed in the same way as other masonry units.  
Installation 2:  
Installation 3:  
Installation 4:

Limitations 1:  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Faster erection time than standard masonry units, with the benefits of a finished wall surface.  
Innovative Feature 2: Eliminates need for composite wall construction.  
Innovative Feature 3:  
Innovative Feature 4:

Replaces 1: Load bearing masonry wall construction (brick and concrete block), other masonry veneers.  
Replaces 2: Structural systems for smaller structures due to the bearing capacity of the 16-in. brick.  
Replaces 3:  
Replaces 4:

## **Technology 2: Built-up/Laminated Wood Structural Systems**

Source of Supply: Micro-Lam, Wood-I, others.

General Description: Built-up wood systems are an alternative to standard wood framing systems, and range from wood I-beams to microlaminated beams and joists. Recent advances in wood adhesives have produced components designed as alternatives to roof and floor structures.

System(s) Affected: Superstructure.

Components 1: Laminated and built-up wood structural members.

Components 2:

Components 3:

Components 4:

Installation 1: Components are used and installed similar to other wood structural components.

Installation 2: In some cases, metal connectors and "hangers" are used to complete the wood structural system.

Installation 3:

Installation 4:

Limitations 1: The nonpermanent image of wood products may cause some to not use the wood components.

Limitations 2:

Limitations 3:

Limitations 4:

Innovative Feature 1: More efficient use of smaller sized harvested lumber for better structural members.

Innovative Feature 2: Newly developed adhesives that expand the structural potential of the components.

Innovative Feature 3: Economy of wood construction.

Innovative Feature 4: Versatility, workability, and simplicity of wood construction.

Replaces 1: Steel joist structural systems.

Replaces 2:

Replaces 3:

Replaces 4:

### Technology 3: Composite Floor System

Source of Supply: Canam Steel Corp.

General Description: Composite floor systems are a combination of structure and floor in one system. The system combines high-strength steel joists and the floor slab into one unit to provide a stronger floor system. The design of this system allows the joists and floor to act as a monolithic structure.

System(s) Affected: Superstructure.

Components 1: High-strength steel joists and concrete floor slab.

Components 2:

Components 3:

Components 4:

Installation 1: Top channel of joists is inverted and forms are placed directly below it.

Installation 2: Concrete is poured into the forms which bonds the inverted channel of the joist to the concrete.

Installation 3:

Installation 4:

Limitations 1: Proprietary source.

Limitations 2:

Limitations 3:

Limitations 4:

Innovative Feature 1: Combination of floor structure and slab in one system.

Innovative Feature 2: System requires less material for the same span and performance than a conventional floor system.

Innovative Feature 3:

Innovative Feature 4:

Replaces 1: Conventional steel joist/metal concrete deck floor systems.

Replaces 2:

Replaces 3:

Replaces 4:

#### **Technology 4: Demountable Interior Systems**

**Source of Supply:** Donn, Hausemann, Westinghouse, US Gypsum, Armstrong, Owens Corning, others.

**General Description:** Demountable interior systems (floors and partitions) provide design flexibility within an interior space. Demountable partitions provide for the compartmentalization of partitions that are easily relocatable. Partitions are mounted in ceiling and floor channels and are then fastened together. Many finish variations are available as well as various panel sizes and shapes. Access raceways within the panels allow power, communication, and other service wiring to be installed in the panels during manufacturing and installation. Ceiling systems are meant to be adaptable. Fixtures and diffusers are quick-connect and adaptable to changes in location. Some partitions and integrated ceilings are engineered and marketed through the same source. Others are marketed independently, but are of universal design and need no special adapters.

**System(s) Affected:** a. *Interior Construction*, b. *Electrical*.

<b>Components 1:</b>	Partitions - solid wall sections, doors, sidelights, glazing, fasteners, connection accessories.
<b>Components 2:</b>	Integrated ceilings - suspension grid, light fixtures, diffusers, boots, acoustic panels.
<b>Components 3:</b>	
<b>Components 4:</b>	
<b>Installation 1:</b>	Partitions - floor and ceiling channels are attached using standard connectors
<b>Installation 2:</b>	Partitions - panels are set in channels and fastened to each other; trimming details complete the procedure.
<b>Installation 3:</b>	Ceilings - suspension is hung from structure; lighting fixtures and diffusers are installed and connected. Acoustics panels are attached.
<b>Installation 4:</b>	
<b>Limitations 1:</b>	Moveable or demountable partition is generally more expensive for initial cost.
<b>Limitations 2:</b>	An inventory of required accessory parts must be developed to facilitate changes.
<b>Limitations 3:</b>	
<b>Innovative Feature 1:</b>	Partitions - prewired, can be rearranged to accommodate different spatial requirements without major demolition.
<b>Innovative Feature 2:</b>	Ceilings - lighting, mechanical, and electrical distribution can be altered easily to reflect changes in environment.
<b>Innovative Feature 3:</b>	
<b>Replaces 1:</b>	Partitions replace conventionally constructed interior partitions, metal stud, drywall or concrete masonry.
<b>Replaces 2:</b>	Ceilings - typical suspended ceiling system has independent lighting and mechanical accessories.

## Technology 5: Exterior Insulation System

Source of Supply: Dryvit, STO, Ispo, others.

General Description: Exterior insulation systems offer an energy-efficient, economical, rapidly applied solution to exterior wall cladding. Lightweight insulating boards or tiles are applied to the exterior wall of a structure, and on this the insulating finish is applied. The system offers a lightweight, quickly erected, energy-efficient alternative to using brick veneer or precast concrete panels for the exterior wall system of a building. Framing, sheathing, insulation, and stucco material are components of the wall construction.

System(s) Affected:	Exterior closure.
Components 1:	Polystyrene boards, adhesives, fiberglass mesh, and spray-on or troweled-on finishes.
Components 2:	Sheathing.
Components 3:	Metal stud frame.
Components 4:	Sheathing.
Installation 1:	Insulation board is applied to the exterior of the prefabricated wall panel.
Installation 2:	A ground coat and fiberglass mesh are applied to exterior polystyrene (EPS) board surface.
Installation 3:	Finish coat is applied to fiberglass mesh.
Installation 4:	Caulking and weatherizing is completed.
Limitations 1:	Susceptible to physical damage around doorways and exposed areas.
Limitations 2:	
Limitations 3:	
Innovative Feature 1:	When applied to prefabricated framing, system includes support, insulation, and finish.
Innovative Feature 2:	Lightweight of system reduces dead load.
Innovative Feature 3:	
Innovative Feature 4:	
Replaces 1:	Generally replaces all nonstructural exterior cladding systems.
Replaces 2:	
Replaces 3:	
Replaces 4:	

## **Technology 6: Fiber-Reinforced Plastic (FRP) Building Systems**

**Source of Supply:** Composite Technology, Inc.

**General Description:** Fiber-reinforced plastic building systems consist of components such as framing members, roofing decks, wall panels, and fasteners, formed with plastic resin reinforced with unidirectional glass fibers. This technology is useful for facilities where electrical interference and corrosion are problems. This technology loosely resembles preengineered metal building systems.

**System(s) Affected:** a. Superstructure, b. Roofing, c. Exterior closure.

**Components 1:** Columns, beams.  
**Components 2:** Roof and deck panels.  
**Components 3:** Wall panels and fasteners.  
**Components 4:**

**Installation 1:** Components are installed similar to conventional members.  
**Installation 2:**  
**Installation 3:**  
**Installation 4:**

**Limitations 1:** High cost compared with conventional metal building construction.  
**Limitations 2:** Economical only for specialty applications such as nonmetallic or corrosion-resistant buildings.  
**Limitations 3:**  
**Limitations 4:**

**Innovative Feature 1:** Glass fibers provide strength, stiffness, dimensional stability, and heat and impact resistance.  
**Innovative Feature 2:** Components are lightweight and will not corrode.  
**Innovative Feature 3:** Structures constructed using FRP technology eliminate electrical interference.  
**Innovative Feature 4:**

**Replaces 1:** Conventional steel framing and covering materials.  
**Replaces 2:**  
**Replaces 3:**  
**Replaces 4:**

## Technology 7: Fold-up Building System

Source of Supply: Hendrich Corporation

General Description: The Fold-up Building System is a closed-panel system consisting of floors, walls, and ceilings which are hinged together. Individual hinged sections are connected to form an entire structure. Sections are hoisted and unfolded by a crane at the job site for erection. The sections are factory-assembled using closed-panel techniques, with all wiring and plumbing built into the sections.

System(s) Affected: a. Superstructure, b. Roofing, c. Interior construction, d. Mechanical, e. Electrical.

Components 1: Folding sections composed of wall, floor, and ceiling panels.  
Components 2: Electrical, mechanical, and plumbing fixtures preplaced in units.  
Components 3: Constructed of any of several materials per design specifications.  
Components 4:

Installation 1: Units are hoisted and unfolded by crane onsite.  
Installation 2: Hinged panels are fixed with connecting bolts.  
Installation 3: Electrical/mechanical/plumbing connections done onsite.  
Installation 4:

Limitations 1: Limited to three-story construction.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Factory prefabrication enhances construction quality.  
Innovative Feature 2: Sections on a single trailer can provide enough components for a 1200 sq ft house.  
Innovative Feature 3: 1200 sq ft structure can be erected in 8 hr.  
Innovative Feature 4: Use of hinged sections makes construction faster than with individual panels.

Replaces 1: Conventional construction of smaller facilities.  
Replaces 2: Panelized and preengineered construction.  
Replaces 3:  
Replaces 4:

## **Technology 8: Glass-Fiber-Reinforced Concrete Closure System**

Source of Supply: GII Corp., others.

General Description: Glass-fiber-reinforced concrete closure systems (GFRC) provide exterior curtain wall cladding. GFRC is a portland cement-based composite reinforced with glass fibers. The glass fibers add flexural, tensile and impact strengths, resulting in a strong, lightweight construction material. The "moldability" of GFRC increases architectural applications for the product.

System(s) Affected: Exterior closure.

Components 1: Exterior closure panels.  
Components 2:  
Components 3:  
Components 4:

Installation 1: Panels are prefabricated at manufacturing plants according to custom needs.  
Installation 2: Panels are hung on exterior panels in nonload-bearing situations.  
Installation 3: Custom molding provides integral corners and returns, which facilitate shape, size, and finish versatility.  
Installation 4:

Limitations 1: Use of GFRC panels limited to nonload-bearing situations.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Lightweight and lower in cost compared with precast concrete.  
Innovative Feature 2: Shape, size, and finish versatility.  
Innovative Feature 3: Will not burn or emit fumes.  
Innovative Feature 4: Good resistance to water and vapor penetration.

Replaces 1: Conventional cladding materials such as brick veneer, concrete block, metal siding, and precast concrete panels.  
Replaces 2:  
Replaces 3:  
Replaces 4:

## **Technology 9: Liftslab Construction Method**

Source of Supply: Textar Construction Corp.

General Description: Liftslab construction involves casting concrete floor and roof slabs on top of each other at ground level, and then lifting them in one piece to their final position.

System(s) Affected: Superstructure.

Components 1: Reinforced concrete slabs, jacks for raising slabs.  
Components 2:  
Components 3:  
Components 4:

Installation 1: Slabs are poured at ground level, including reinforcement and conduits.  
Installation 2: Lifting system is attached to slabs with specially embedded anchors.  
Installation 3: Slabs are lifted into place and attached to columns.  
Installation 4:

Limitations 1: Generally economical for structures of five stories or more.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Precasting slabs at ground level and lifting them into final position.  
Innovative Feature 2: Reduces labor required for forming horizontal planes (floors and ceilings) within the building system.

Innovative Feature 3:  
Innovative Feature 4:

Replaces 1: Conventional methods of forming floor slabs in buildings.  
Replaces 2: Structural beams and joists used to carry floor loads.  
Replaces 3:  
Replaces 4:

## Technology 10: Liquid Roofing Systems

Source of Supply: Chevron USA, Inc.

**General Description:** Liquid roofing systems are composed of a polymerized black liquid which, when mixed with an activator, becomes an elastomer that fully cures in 24 hr. It forms a barrier to water and most aqueous reagents. It may be spray- or squeegee-applied and retains physical characteristics in hot or cold environments. These systems directly address the problems of dimensional stability, hot seaming or welding, age embrittlement, and shrinkage. It has application in both new and retrofit uses.

System(s) Affected: Roofing.

Components 1: Liquid roofing system composed of a polymerized black liquid and an activator.

Components 2:

Components 3:

Components 4:

Installation 1: The liquid is applied with a spray gun or squeegee onto the roof surface.

Installation 2: Will fully cure in 24 hr.

Installation 3:

Installation 4:

Limitations 1:

Limitations 2:

Limitations 3:

Limitations 4:

Innovative Feature 1: Can be applied as a seamless, monolithic membrane.

Innovative Feature 2: Can be used in retrofit applications without removing old insulation.

Innovative Feature 3:

Innovative Feature 4:

Replaces 1: Single-ply roofing.

Replaces 2: Built-up roofing.

Replaces 3:

Replaces 4:

## Technology 11: Low-Emissivity (Low-E) Glazing Systems

Source of Supply: Commonly available.

General Description: Low-E glazing is designed to reduce heat loss within a building through radiation. Low-E glazing transmits shortwave infrared energy but reflects long-wave energy. For example, when sunlight enters a building through low-E glazing, absorbed shortwave energy is reradiated as heat or long-wave energy, which is blocked from leaving the building by the properties of the low-E glazing. This system can be considered for glazing applications as well as for a curtain wall.

System(s) Affected: Exterior closure.

Components 1: Glazed sections of curtain wall.  
Components 2:  
Components 3:  
Components 4:

Installation 1: Low-E glazing is installed in the same way as conventional glazing in a curtain wall system.  
Installation 2:  
Installation 3:  
Installation 4:

Limitations 1: This technology is relatively less effective outside of northern climates.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Low-E glazing uses radiative concepts to accomplish its objectives.  
Innovative Feature 2: 32 percent less heat is claimed to escape through window than is lost through a double-glazed window.  
Innovative Feature 3: 90 percent of the radiated heat within a building is claimed to be retained.  
Innovative Feature 4:

Replaces 1: Conventional double or triple glazing.  
Replaces 2:  
Replaces 3:  
Replaces 4:

## **Technology 12: Light-Gauge Metal Building Systems**

**Source of Supply:** Madray Enterprises Inc., Melco Building Systems Inc., Paragon Steel Structures, Inc., Perka Buildings, Steel Frame Buildings, Inc., Thermasteel, others.

**General Description:** Light-gauge metal building systems are preengineered and constructed of light-gauge galvanized steel members. Framing members are made of cold-rolled 16- or 18-gauge studs, rafters, joists, and trusses.

**System(s) Affected:** Superstructure.

**Components 1:** Prefabricated structural steel components made of light-gauge steel.  
**Components 2:** Roof trusses/rafters.  
**Components 3:** Wall panels.  
**Components 4:** Floor trusses/joists.

**Installation 1:** Preengineered, prefabricated components are transported to site for erection.  
**Installation 2:** Components are connected with self-tapping fasteners.  
**Installation 3:**  
**Installation 4:**

**Innovative Feature 1:** Components have greater load-carrying capability for similar dimensions in wood.  
**Innovative Feature 2:** Termite and corrosion resistance.  
**Innovative Feature 3:** Fabrication reduces onsite construction time.  
**Innovative Feature 4:** Increased fire resistivity.

**Replaces 1:** Wood stud framing.  
**Replaces 2:** Steel bar joist framing.  
**Replaces 3:** Load-bearing masonry.  
**Replaces 4:**

### Technology 13: Modular Concrete Forming Systems

Source of Supply: Modulux Assoc.; Outinord Universal Co.; Aarding Forms; Strickland Systems, Symons Concrete Products, others.

General Description: Modular concrete forming systems are three-dimensional concrete forms that expedite cast-in-place concrete construction. The forming system enables the simultaneous casting of vertical wall elements and horizontal deck elements to form a series of monolithic volumetric building modules. Using high-early concrete, forming, pouring, and stripping can be accomplished on a 24-hr cycle.

System(s) Affected: a. Superstructure, b. Exterior closure, c. Interior construction.

- |                       |  |
|-----------------------|--|
| Components 1:         | Steel formwork composed of modular three-dimensional sections, incorporating horizontal and vertical formwork. |
| Components 2:         | Bulkheads, curbs, and other forming accessories.   |
| Components 3:         | High-early concrete is used to enable a 24-hr place-and-strip cycle.   |
| Components 4:         |  |
| Installation 1:       | Floor slab is placed and form is positioned above it with a crane.   |
| Installation 2:       | Form is positioned and expanded, openings are blocked out, and reinforcing, plumbing, and conduit are placed.  |
| Installation 3:       | Form is closed and concrete pumped to complete the structural frame.   |
| Installation 4:       | After curing, form is released and removed; ends can be closed with conventional construction.                 |
| Limitations 1:        | Plan configurations somewhat limited by cellular nature of formwork and construction type.                     |
| Limitations 2:        |  |
| Limitations 3:        |  |
| Limitations 4:        |  |
| Innovative Feature 1: | Increased construction speed due to the volumetric configuration of formwork and early curing concrete.        |
| Innovative Feature 2: | Some forms have hydraulic features for expanding and collapsing the formwork, reducing labor time.             |
| Innovative Feature 3: | One pour allows completion of walls, floors, and ceilings.   |
| Innovative Feature 4: |  |
| Replaces 1:           | Conventional two-dimensional formwork.   |
| Replaces 2:           | Interior walls, floors, and ceilings constructed of conventional materials.                                    |
| Replaces 3:           |  |
| Replaces 4:           |  |

## **Technology 14: Monolithic Dome Building Systems**

Source of Supply: Monolithic Constructors Inc., others.

General Description: Monolithic dome structures provide dome-shaped, clear-span enclosures. This enclosure is a thin-shelled concrete dome sprayed over an inflatable form, with reinforcing incorporated. Urethane coatings are sprayed onto the concrete for insulation and durability.

System(s) Affected: a. Superstructure, b. Exterior closure, c. Roofing.

Components 1:	Inflated air form, reinforcing concrete/shotcrete, and urethane.
Components 2:	System requires thin-shelled concrete, steel reinforcing bars, urethane chemicals, and concrete footings.
Components 3:	
Components 4:	
Installation 1:	Circular concrete footing and floor slab are poured.
Installation 2:	Air form is inflated and urethane foam is sprayed onto the inside of the form.
Installation 3:	Reinforcing steel is applied and concrete is spray-applied to the interior of the dome.
Installation 4:	
Limitations 1:	Economical primarily for large, clear-span structures only.
Limitations 2:	Circular buildings only.
Limitations 3:	Minimum placement opportunity for doors and windows.
Limitations 4:	
Innovative Feature 1:	Rapid, expedient construction of large-span structures.
Innovative Feature 2:	Optimized use of structural materials.
Innovative Feature 3:	Thermal massing of concrete shell.
Innovative Feature 4:	
Replaces 1:	Replaces conventionally constructed large-span facilities.
Replaces 2:	
Replaces 3:	
Replaces 4:	

## Technology 15: Panelized Roof Systems

Source of Supply: Aluma Shield Industries, Alumax Building Specialties, Bally Engineered Structures, E.G. Smith Construction Products Inc., ECI Building Components, Inc., H.H. Robertson Co., Insulated Panel Systems Inc., Molenco, Panel Systems Inc., others.

General Description: Panelized standing seam or concealed fastener roofing systems are most often composed of sandwich panels that provide the interior finish surface, exterior surface, insulation, and roof in one product. Common panels provide combinations of wood product and or metal skins with a core of polyisocyanite foam. The panels are usually fabricated to cover 48 sq ft and span 72 in. on center. The basic elements of the system include the roofing components (e.g., decking, insulation, nailbase) and in some cases, structural components (e.g., integrated joists).

System(s) Affected: a. Roofing; b. Superstructure (deck).

Components 1: Metal and/or wood product skinned sandwich panels.  
Components 2: Clips, fasteners, and accessories.  
Components 3:  
Components 4:

Installation 1: Panels are prefabricated and installed on purlins.  
Installation 2: Fastening is done either by standing seam or concealed fasteners.  
Installation 3:  
Installation 4:

Limitations 1: Attachment must accommodate expansion and contraction.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Combination of exterior weathering surface, insulation, and interior finish in one product.

Innovative Feature 2:  
Innovative Feature 3:  
Innovative Feature 4:

Replaces 1: Metal deck, insulation, and built-up roofing.  
Replaces 2:  
Replaces 3:  
Replaces 4:

## **Technology 16: Composite Panelized Wall Systems**

**Source of Supply:** Covintec International Inc., Truss Tech Building System.

**General Description:** Composite panelized wall systems provide the superstructure and exterior closure systems of a building, or can be applied to a structural frame in a curtain wall application. The panels consist of a polymer foam core, wire reinforcement, and field-applied shotcrete. Panels can also be used as floor and roof decks for relatively short-span applications. Electrical conduit can be built into the panels.

**System(s) Affected:** a. Exterior closure, b. Superstructure.

**Components 1:** Wall panels, connectors, built-in mechanical, electrical and plumbing systems.  
**Components 2:** Shotcrete applied in the field to erected panels.  
**Components 3:**  
**Components 4:**

**Installation 1:** Panels are prefabricated.  
**Installation 2:** Panels are erected; fastened together.  
**Installation 3:** Shotcrete is applied to interior and exterior surfaces.  
**Installation 4:**

**Limitations 1:** Limits on span capabilities when used for floors and roofs.  
**Limitations 2:**  
**Limitations 3:**  
**Limitations 4:**

**Innovative Feature 1:** Monolithic structure by virtue of onsite shotcreting of interior and exterior wall surfaces.  
**Innovative Feature 2:** Prefabrication reduces onsite labor time.  
**Innovative Feature 3:** Integration of structure and closure components.  
**Innovative Feature 4:**

**Replaces 1:** Conventionally constructed bearing wall systems or structural frame systems.  
**Replaces 2:** Curtain wall systems.  
**Replaces 3:**  
**Replaces 4:**

## Technology 17: Space Frame Structural Systems

Source of Supply: Inryco, General Electric Unistrut, Space Structures, Inc., others.

General Description: Precngineered space frames are three-dimensional trusses composed of steel press-formed or tubular struts connected at nodes. They are more structurally efficient than two-dimensional framing systems. The triangular geometry enables wide-span capabilities.

System(s) Affected: Superstructure.

Components 1: Structural tubing or press-formed members made of steel.

Components 2: Connector nodes or gussets.

Components 3:

Components 4:

Installation 1: Frame is assembled by joining tubes or members to connecting "nodes."

Installation 2: Frame is supported by columns or bearing walls, depending on individual design.

Installation 3: Frame is usually assembled on the ground and then raised and connected to columns.

Installation 4:

Limitations 1: Generally economical only for long-span requirements.

Limitations 2:

Limitations 3:

Limitations 4:

Innovative Feature 1: Minimum number of different types of parts are assembled on the ground.

Innovative Feature 2: Provides a lightweight solution for long-span construction compared with girder-truss construction.

Innovative Feature 3: Construction permits easy access for mechanical work.

Innovative Feature 4:

Replaces 1: Conventional structural steel, truss-girder, and beam construction.

Replaces 2:

Replaces 3:

Replaces 4:

## **Technology 18: Spray-Applied Insulation Systems**

**Source of Supply:** American Sprayed Fibers Inc., Associated Foam Manufacturers Inc., others.

**General Description:** Spray-applied insulation provides an alternative method of insulating walls and ceilings. A major advantage of spray-applied insulation is its ability to cover irregular surfaces. Spray-on insulation is applied by blowing or pumping it through equipment onto the surface or into cavities of the wall to which it adheres. It will bond to glass, wood, metal, concrete, brick, urethane, styrofoam, and fiberglass.

**System(s) Affected:** Exterior closure.

**Components 1:** Spray-on insulation material; mineral fiber, glass fiber, urethane foam.  
**Components 2:**  
**Components 3:**  
**Components 4:**

**Installation 1:** Insulation is applied by blowing or pumping onto the surface or within wall cavities.  
**Installation 2:** When curing, the insulation forms a uniform skin over the surface.  
**Installation 3:**  
**Installation 4:**

**Limitations 1:** Cannot be used where urethane is not permitted.  
**Limitations 2:**  
**Limitations 3:**  
**Limitations 4:**

**Innovative Feature 1:** Quick installation.  
**Innovative Feature 2:** Uniform coverage over irregular surfaces or cavities.  
**Innovative Feature 3:**  
**Innovative Feature 4:**

**Replaces 1:** Conventional insulation systems.  
**Replaces 2:** Fiberglass batt insulation, Perlite, polystyrene boards.  
**Replaces 3:**  
**Replaces 4:**

## Technology 19: Spray-Applied, Fire-Resistive Fiberglass Systems

Source of Supply: American Sprayed Fibers Inc., others.

General Description: Spray-applied, fire-resistive fiberglass systems provide an alternative to asbestos-based materials used in fireproofing structural steel construction. The system can be used in retrofit applications to replace asbestos fireproofing. An advantage of the spray-on system is its ability to be applied over irregular surfaces.

System(s) Affected: Superstructure.

Components 1: Spray-on insulating material.  
Components 2:  
Components 3:  
Components 4:

Installation 1: Applied by blowing material onto surface.  
Installation 2: Forms the surface in such a way that air pockets are removed.  
Installation 3: Uniform blanket of fireproofing/insulation is achieved.  
Installation 4: Adheres to glass, wood, metal, concrete, brick, urethane, styrofoam and fiberglass.

Limitations 1: Must be protected from water.  
Limitations 2:  
Limitations 3:  
Limitations 4:

Innovative Feature 1: Can be applied directly over asbestos, eliminating the cost for asbestos removal.  
Innovative Feature 2: Can be applied on irregular surfaces over a variety of materials.  
Innovative Feature 3: Asbestos-free fireproofing.  
Innovative Feature 4:

Replaces 1: Asbestos-based insulating materials.  
Replaces 2:  
Replaces 3:  
Replaces 4:

## **Technology 20: Standing Seam Metal Roofing System**

**Source of Supply:** Butler Mfg. Co., Armco Building Systems, Star Building Systems, ECI Building Products, Varco-Pruden Building Systems, others.

**General Description:** Standing seam metal roofing systems consist of prefinished corrugated roofing panels applied over roof perkins, fastened together by continuously crimping a vertical seam. They are an alternative to conventional systems such as built-up roofs, single-ply roofs, and asphaltic shingle roofs. Attachment to the structure is in such a way that enables the roof panels to expand and contract without overstressing structural members or other roofing components. Standing seam roofing systems are commonly provided as complete, integrated systems, with all roofing components provided by a single source.

**System(s) Affected:** Roofing.

**Components 1:** Roof panels, flashing, curbs, gutters, downspouts, fasteners, boots.  
**Components 2:**  
**Components 3:**  
**Components 4:**

**Installation 1:** Clips are fastened to roof perkins.  
**Installation 2:** Panels are laid over purlins and clips (over insulation, if applicable).  
**Installation 3:** Automatic seaming machine crimps closed panels seams and clips.  
**Installation 4:**

**Limitations 1:** Somewhat more expense than built-up or single-ply roofing.  
**Limitations 2:**  
**Limitations 3:**  
**Limitations 4:**

**Innovative Feature 1:** Can be applied to both new and retrofit applications.  
**Innovative Feature 2:** High level of performance in leakage control attributable to the location of seams up to 2 in. above the weather surface.  
**Innovative Feature 3:** Prefabrication of all components; quick installation.  
**Innovative Feature 4:** Less sensitive to environmental conditions. Applicable to both low-slope and steep-slope considerations.

**Replaces 1:** Built-up roofing, single-ply roofing, shingle roofing.  
**Replaces 2:**  
**Replaces 3:**  
**Replaces 4:**

## Technology 21: Truss-Framed Building System

Source of Supply: Commonly available.

General Description: The truss-framed building system consists of a unitized assembly of roof truss, wall studs, and floor truss fabricated into a single planar vertical component. Truss frames are erected on a foundation, stabilized, and sheathed to complete the enclosure.

System(s) Affected: Superstructure.

Components 1: Composite truss members.

Components 2:

Components 3:

Components 4:

Installation 1: Trusses are placed flat on foundation or slab.

Installation 2: Truss frames are lifted into vertical position, braced laterally, and sheathed.

Installation 3: Doors, windows, hardware, and interior finishes are attached conventionally.

Installation 4:

Limitations 1: Use is limited to small buildings, due to allowable shipping dimensions.

Limitations 2:

Limitations 3:

Limitations 4:

Innovative Feature 1: Prefabrication of components, which reduces construction time considerably.

Innovative Feature 2:

Innovative Feature 3:

Innovative Feature 4:

Replaces 1: Conventional construction.

Replaces 2:

Replaces 3:

Replaces 4:



## MCA IMPACT TABLE

Technology Identification 1

TECHNOLOGY: 16-Inch Brick Building System

SYSTEM: b. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by The System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	60	80
Operational	5	13	60	80
Training	7	17	60	80
Maintenance	27	15	70	90
Production	0	12	0	0
Laboratories	5	9	50	80
Ammun. Storage	2	11	0	0
Cold Storage	0	10	0	0
General Storage	4	13	0	0
Hospital	2	11	0	0
Dental Clinics	0	15	60	80
Medical Clinics	1	15	60	80
Administrative	7	11	60	60
Family Housing	0	11	50	60
Unmar. Enlisted Qtr.	20	14	50	60
Dining	2	15	40	60
Detached Facil.	2	18	50	80
Unmar. Officer Qtr.	3	18	50	60
Support & Service	1	18	50	80
Welfare & Rec.	9	17	50	80
Total System Impact Factor Range			8	10

MCA IMPACT TABLE

Technology Identification 2

TECHNOLOGY: Built-up/Laminated Wood Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	80	90
Operational	5	24	80	90
Training	7	13	80	90
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	0	0
Ammun. Storage	2	28	0	0
Cold Storage	0	22	60	80
General Storage	4	13	80	90
Hospital	2	14	0	0
Dental Clinics	0	5	80	90
Medical Clinics	1	6	80	90
Administrative	7	14	80	90
Family Housing	0	19	80	90
Unmar. Enlisted Qtr.	20	18	80	90
Dining	2	24	80	90
Detached Fac.	2	7	80	90
Unmar. Officer Qtr.	3	13	80	90
Support & Service	1	7	80	90
Welfare & Rec.	9	7	60	80
Total System Impact Factor Range			9	11

## MCA IMPACT TABLE

Technology Identification 3

TECHNOLOGY: Composite Floor Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	70	80
Operational	5	24	70	80
Training	7	13	70	80
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	70	80
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	70	80
Dental Clinics	0	6	70	80
Medical Clinics	1	6	70	80
Administrative	7	14	70	80
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	70	80
Dining	2	24	0	0
Detached Fac.	2	7	0	0
Unmar. Officer Qtr.	3	13	70	80
Support & Service	1	7	70	80
Welfare & Rec.	9	7	70	80
Total System Impact Factor Range			6	7

MCA IMPACT TABLE

Technology Identification 4

TECHNOLOGY: Demountable Interior Partition/Floor Systems

SYSTEM: a. Interior Construction

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	17	50	70
Operational	5	10	0	0
Training	7	24	40	60
Maintenance	27	8	0	0
Production	0	10	0	0
Laboratories	5	26	50	70
Ammun. Storage	2	17	0	0
Cold Storage	0	12	0	0
General Storage	4	8	0	0
Hospital	2	34	20	30
Dental Clinics	0	31	30	50
Medical Clinics	1	31	30	50
Administrative	7	25	60	70
Family Housing	0	32	0	0
Unmar. Enlisted Qtr.	20	25	0	0
Dining	2	15	0	0
Detached Fac.	2	11	10	20
Unmar. Officer Qtr.	3	30	0	0
Support & Service	1	27	60	80
Welfare & Rec.	9	25	20	40
Total System Impact Factor Range			3	5

MCA IMPACT TABLE

Technology Identification 4

TECHNOLOGY: Demountable Interior Partition/Floor Systems

SYSTEM: b. Electrical

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	13	30	50
Operational	5	6	0	0
Training	7	13	40	60
Maintenance	27	9	0	0
Production	0	15	0	0
Laboratories	5	10	30	60
Ammun. Storage	2	9	0	0
Cold Storage	0	10	0	0
General Storage	4	8	0	0
Hospital	2	12	0	0
Dental Clinics	0	5	30	50
Medical Clinics	1	5	30	50
Administrative	7	14	40	60
Family Housing	0	3	0	0
Unmar. Enlisted Qtr.	20	10	0	0
Dining	2	3	0	0
Detached Fac.	2	23	20	30
Unmar. Officer Qtr.	3	8	0	0
Support & Service	1	11	0	60
Welfare & Rec.	9	5	30	50
Total System Impact Factor Range			1	2

MCA IMPACT TABLE

Technology Identification 5

TECHNOLOGY: Exterior Insulation Systems

SYSTEM: Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	70	85
Operational	5	13	70	90
Training	7	17	65	85
Maintenance	27	15	85	90
Production	0	12	85	90
Laboratories	5	9	65	90
Ammun. Storage	2	11	0	0
Cold Storage	0	10	80	90
General Storage	4	13	80	90
Hospital	2	11	50	60
Dental Clinics	0	15	50	80
Medical Clinics	1	15	50	80
Administrative	7	11	60	80
Family Housing	0	11	50	70
Unmar. Enlisted Qtr.	20	14	50	70
Dining	2	15	0	0
Detached Fac.	2	18	75	90
Unmar. Officer Qtr.	3	18	50	70
Support & Service	1	18	50	60
Welfare & Rec.	9	17	60	80
Total System Impact Factor Range			9	11

MCA IMPACT TABLE

Technology Identification 6

TECHNOLOGY: Fiber-Reinforced Plastic Building Systems

SYSTEM: a. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	80	90
Operational	5	24	80	9
Training	7	13	80	90
Maintenance	27	7	60	90
Production	0	12	60	90
Laboratories	5	8	40	90
Ammun. Storage	2	26	0	0
Cold Storage	0	22	60	90
General Storage	4	13	80	90
Hospital	2	14	0	0
Dental Clinics	0	6	80	90
Medical Clinics	1	6	80	90
Administrative	7	14	60	90
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	0	0
Dining	2	24	80	90
Detached Fac.	2	7	80	90
Unmar. Officer Qtr.	3	13	0	0
Support & Service	1	7	60	90
Welfare & Rec.	9	7	60	90
Total System Impact Factor Range			5	7

MCA IMPACT TABLE

Technology Identification 6

TECHNOLOGY: Fiber-Reinforced Plastic Building Systems

SYSTEM: b. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	19	80	90
Operational	5	7	80	90
Training	7	4	80	90
Maintenance	27	11	80	90
Production	0	10	80	90
Laboratories	5	6	80	90
Ammun. Storage	2	4	0	0
Cold Storage	0	11	80	90
General Storage	4	11	80	90
Hospital	2	1	80	90
Dental Clinics	0	3	80	90
Medical Clinics	1	3	80	90
Administrative	7	3	80	90
Family Housing	0	3	80	90
Unmar. Enlisted Qtr.	20	2	80	90
Dining	2	6	80	90
Detached Fac.	2	8	80	90
Unmar. Officer Qtr.	3	3	0	0
Support & Service	1	8	80	90
Welfare & Rec.	9	8	80	90
Total System Impact Factor Range			5	6

MCA IMPACT TABLE

Technology Identification 6

TECHNOLOGY: Fiber-Reinforced Plastic Building Systems

SYSTEM: c. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	25	35
Operational	5	13	25	35
Training	7	17	25	35
Maintenance	27	15	30	40
Production	0	12	30	40
Laboratories	5	9	25	35
Ammun. Storage	2	11	0	0
Cold Storage	0	10	30	40
General Storage	4	13	30	50
Hospital	2	11	0	0
Dental Clinics	0	15	0	0
Medical Clinics	1	15	0	0
Administrative	7	11	0	0
Family Housing	0	11	0	0
Unmar. Enlisted Qtr.	20	14	0	0
Dining	2	15	0	0
Detached Fac.	2	18	0	0
Unmar. Officer Qtr.	3	18	0	0
Support & Service	1	18	0	0
Welfare & Rec.	9	17	0	0
Total System Impact Factor Range			2	3

MCA IMPACT TABLE

Technology Identification 7

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: a. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	80	90
Operational	5	24	80	90
Training	7	13	80	90
Maintenance	27	7	80	90
Production	0	12	80	90
Laboratories	5	8	80	90
Ammun. Storage	2	26	0	0
Cold Storage	0	22	80	90
General Storage	4	13	80	90
Hospital	2	14	0	0
Dental Clinics	0	6	80	90
Medical Clinics	1	6	80	90
Administrative	7	14	80	90
Family Housing	0	19	80	90
Unmar. Enlisted Qtr.	20	18	80	90
Dining	2	24	80	90
Detached Facil.	2	7	80	90
Unmar. Officer Qtr.	3	13	80	90
Support & Service	1	7	80	90
Welfare & Rec.	9	7	80	90
Total System Impact Factor Range			10	11

MCA IMPACT TABLE

Technology Identification 7

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: b. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology		
			Low	I	High
Communications	1	19	70		90
Operational	5	7	70		90
Training	7	4	70		90
Maintenance	27	11	70		90
Production	0	10	70		90
Laboratories	5	6	70		90
Ammun. Storage	2	4	0		0
Cold Storage	0	11	70		90
General Storage	4	11	70		90
Hospital	2	1	0		0
Dental Clinics	0	3	70		90
Medical Clinics	1	3	70		90
Administrative	7	3	70		90
Family Housing	0	3	70		90
Unmar. Enlisted Qtr.	20	2	70		90
Dining	2	6	70		90
Detached Facil.	2	8	70		90
Unmar. Officer Qtr.	3	3	70		90
Support & Service	1	8	70		90
Welfare & Rec.	9	8	70		90
Total System Impact Factor Range			4		6

MCA IMPACT TABLE

Technology Identification 7

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: c. Interior Construction

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	17	40	60
Operational	5	10	40	6
Training	7	24	40	60
Maintenance	27	8	20	50
Production	0	10	20	50
Laboratories	5	26	40	60
Ammun. Storage	2	17	0	0
Cold Storage	0	12	20	50
General Storage	4	8	20	50
Hospital	2	34	0	0
Dental Clinics	0	31	40	60
Medical Clinics	1	31	40	60
Administrative	7	25	50	70
Family Housing	0	32	70	90
Unmar. Enlisted Qtr.	20	25	70	90
Dining	2	15	20	50
Detached Facil.	2	11	20	50
Unmar. Officer Qtr.	3	30	70	90
Support & Service	1	27	40	60
Welfare & Rec.	9	25	50	70
Total System Impact Factor Range			9	12

MCA IMPACT TABLE

Technology Identification 7

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: d. Mechanical

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	14	20	40
Operational	5	18	20	40
Training	7	18	20	40
Maintenance	27	22	0	0
Production	0	25	0	0
Laboratories	5	25	10	30
Ammun. Storage	2	15	0	0
Cold Storage	0	17	0	0
General Storage	4	17	0	0
Hospital	2	13	0	0
Dental Clinics	0	23	10	30
Medical Clinics	1	23	10	30
Administrative	7	23	20	40
Family Housing	0	15	30	40
Unmar. Enlisted Qtr.	20	19	10	30
Dining	2	7	10	30
Detached Facil.	2	16	10	30
Unmar. Officer Qtr.	3	14	10	30
Support & Service	1	15	20	40
Welfare & Rec.	9	18	10	30
Total System Impact Factor Range			2	4

MCA IMPACT TABLE

Technology Identification 7

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: e. Electrical

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	13	70	80
Operational	5	6	70	80
Training	7	13	70	80
Maintenance	27	9	70	80
Production	0	15	70	80
Laboratories	5	10	70	80
Ammun. Storage	2	9	0	0
Cold Storage	0	10	70	80
General Storage	4	8	70	80
Hospital	2	12	0	0
Dental Clinics	0	5	70	80
Medical Clinics	1	5	70	80
Administrative	7	14	70	80
Family Housing	0	3	70	80
Unmar. Enlisted Qtr.	20	10	70	80
Dining	2	3	70	80
Detached Facil.	2	23	70	80
Unmar. Officer Qtr.	3	8	70	80
Support & Service	1	11	70	80
Welfare & Rec.	9	5	70	80
Total System Impact Factor Range			6	7

## MCA IMPACT TABLE

Technology Identification 8

TECHNOLOGY: Glass Fiber Reinforced Concrete Closure Systems

SYSTEM: a. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	40	60
Operational	5	13	40	60
Training	7	17	40	70
Maintenance	27	15	60	70
Production	0	12	60	60
Laboratories	5	9	40	90
Ammun. Storage	2	11	0	0
Cold Storage	0	10	60	70
General Storage	4	13	60	70
Hospital	2	11	30	50
Dental Clinics	0	15	40	60
Medical Clinics	1	15	40	60
Administrative	7	11	30	50
Family Housing	0	11	0	0
Unmar. Enlisted Qtr.	20	14	30	50
Dining	2	15	30	50
Detached Facil.	2	18	60	70
Unmar. Officer Qtr.	3	18	30	50
Support & Service	1	18	40	50
Welfare & Rec.	9	17	40	60
Total System Impact Factor Range			6	9

IMPACT TABLE

Technology Identification 9

TECHNOLOGY: Fold-up (Hendrich) Building Systems

SYSTEM: b. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	0	0
Operational	5	24	0	0
Training	7	13	70	80
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	0	0
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	70	80
Dental Clinics	0	6	0	0
Medical Clinics	1	6	0	0
Administrative	7	14	0	0
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	70	80
Dining	2	24	0	0
Detached Facil.	2	7	0	0
Unmar. Officer Qtr.	3	13	70	80
Support & Service	1	7	0	0
Welfare & Rec.	9	7	0	0
Total System Impact Factor Range			8	10

## MCA IMPACT TABLE

Technology Identification 10

TECHNOLOGY: Liquid Roofing Systems

SYSTEM: Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	19	90	95
Operational	5	7	90	95
Training	7	4	90	95
Maintenance	27	11	90	95
Production	0	10	90	95
Laboratories	5	6	90	95
Ammun. Storage	2	4	90	95
Cold Storage	0	11	90	95
General Storage	4	11	90	95
Hospital	2	1	90	95
Dental Clinics	0	3	90	95
Medical Clinics	1	3	90	95
Administrative	7	3	90	95
Family Housing	0	3	90	95
Unmar. Enlisted Qtr.	20	2	90	95
Dining	2	6	90	95
Detached Facil.	2	8	90	95
Unmar. Officer Qtr.	3	3	90	95
Support & Service	1	8	90	95
Welfare & Rec.	9	8	90	95
Total System Impact Factor Range			6	6

MCA IMPACT TABLE

Technology Identification 11

TECHNOLOGY: Low-Emmissivity Glazing Systems

SYSTEM: Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	30	50
Operational	5	13	30	50
Training	7	17	30	50
Maintenance	27	15	10	30
Production	0	12	10	30
Laboratories	5	9	30	50
Ammun. Storage	2	11	0	0
Cold Storage	0	10	0	0
General Storage	4	13	0	0
Hospital	2	11	40	60
Dental Clinics	0	15	40	60
Medical Clinics	1	15	40	60
Administrative	7	11	40	70
Family Housing	0	11	20	40
Unmar. Enlisted Qtr.	20	14	30	40
Dining	2	15	40	60
Detached Facil.	2	18	20	40
Unmar. Officer Qtr.	3	18	30	40
Support & Service	1	18	40	60
Welfare & Rec.	9	17	20	40
Total System Impact Factor Range			3	6

## MCA IMPACT TABLE

Technology Identification 12

TECHNOLOGY: Light-Gauge Metal Building Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	75	90
Operational	5	24	75	90
Training	7	13	75	90
Maintenance	27	7	40	60
Production	0	12	0	0
Laboratories	5	8	75	90
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	0	0
Dental Clinics	0	6	75	90
Medical Clinics	1	6	75	90
Administrative	7	14	75	90
Family Housing	0	19	75	95
Unmar. Enlisted Qtr.	20	18	75	95
Dining	2	24	20	40
Detached Facil.	2	7	75	90
Unmar. Officer Qtr.	3	13	75	95
Support & Service	1	7	75	90
Welfare & Rec.	9	7	75	90
Total System Impact Factor Range			8	10

MCA IMPACT TABLE

Technology Identification 13

TECHNOLOGY: Modular Concrete Forming Systems

SYSTEM: a. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	0	0
Operational	5	24	0	0
Training	7	13	40	60
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	40	60
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	60	80
Dental Clinics	0	6	20	40
Medical Clinics	1	6	20	40
Administrative	7	14	30	50
Family Housing	0	19	80	95
Unmar. Enlisted Qtr.	20	18	80	95
Dining	2	24	0	0
Detached Facil.	2	7	20	40
Unmar. Officer Qtr.	3	13	80	95
Support & Service	1	7	20	40
Welfare & Rec.	9	7	30	50
Total System Impact Factor Range			5	6

MCA IMPACT TABLE

Technology Identification 13

TECHNOLOGY: Modular Concrete Forming Systems

SYSTEM: b. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	0	0
Operational	5	13	0	10
Training	7	17	10	20
Maintenance	27	15	0	0
Production	0	12	0	0
Laboratories	5	9	20	40
Ammun. Storage	2	11	0	0
Cold Storage	0	10	0	0
General Storage	4	13	0	0
Hospital	2	11	20	0
Dental Clinics	0	15	10	40
Medical Clinics	1	15	10	40
Administrative	7	11	10	40
Family Housing	0	11	40	60
Unmar. Enlisted Qtr.	20	14	40	60
Dining	2	15	0	0
Detached Facil.	2	18	55	90
Unmar. Officer Qtr.	3	18	40	60
Support & Service	1	18	10	40
Welfare & Rec.	9	17	10	20
Total System Impact Factor Range			2	4

MCA IMPACT TABLE

Technology Identification 13

TECHNOLOGY: Modular Concrete Forming Systems

SYSTEM: c. Interior Construction

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	17	20	30
Operational	5	10	0	0
Training	7	24	20	30
Maintenance	27	8	0	0
Production	0	10	0	0
Laboratories	5	26	20	30
Ammun. Storage	2	17	0	0
Cold Storage	0	12	0	0
General Storage	4	8	0	0
Hospital	2	34	30	50
Dental Clinics	0	31	20	40
Medical Clinics	1	31	20	40
Administrative	7	25	20	40
Family Housing	0	32	10	20
Unmar. Enlisted Qtr.	20	25	50	80
Dining	2	15	0	0
Detached Facil.	2	11	50	60
Unmar. Officer Qtr.	3	30	50	80
Support & Service	1	27	50	60
Welfare & Rec.	9	25	50	60
Total System Impact Factor Range			6	9

MCA IMPACT TABLE

Technology Identification 14

TECHNOLOGY: Monolithic Dome Building Systems

SYSTEM: a. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	0	0
Operational	5	24	0	0
Training	7	13	0	0
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	0	0
Ammun. Storage	2	26	90	95
Cold Storage	0	22	80	90
General Storage	4	13	80	90
Hospital	2	14	0	0
Dental Clinics	0	6	0	0
Medical Clinics	1	6	0	0
Administrative	7	14	0	0
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	0	0
Dining	2	24	0	0
Detached Facil.	2	7	0	0
Unmar. Officer Qtr.	3	13	0	0
Support & Service	1	7	0	0
Welfare & Rec.	9	7	0	0
Total System Impact Factor Range			1	1

MCA IMPACT TABLE

Technology Identification 14

TECHNOLOGY: Monolithic Dome Building Systems

SYSTEM: b. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	0	0
Operational	5	13	0	0
Training	7	17	0	0
Maintenance	27	15	0	0
Production	0	12	0	0
Laboratories	5	9	0	0
Ammun. Storage	2	11	90	95
Cold Storage	0	10	90	95
General Storage	4	13	90	95
Hospital	2	11	0	0
Dental Clinics	0	15	0	0
Medical Clinics	1	15	0	0
Administrative	7	11	0	0
Family Housing	0	11	0	0
Unmar. Enlisted Qtr.	20	14	0	0
Dining	2	15	0	0
Detached Facil.	2	18	0	0
Unmar. Officer Qtr.	3	18	0	0
Support & Service	1	18	0	0
Welfare & Rec.	9	17	0	0
Total System Impact Factor Range			1	1

MCA IMPACT TABLE

Technology Identification 14

TECHNOLOGY: Monolithic Dome Building Systems

SYSTEM: c. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	19	0	0
Maintenance	27	11	0	0
Production	0	10	0	0
Laboratories	5	6	0	0
Ammun. Storage	2	4	95	100
Cold Storage	0	11	95	100
General Storage	4	11	95	100
Hospital	2	1	0	0
Dental Clinics	0	3	0	0
Medical Clinics	1	3	0	0
Administrative	7	3	0	0
Family Housing	0	3	0	0
Unmar. Enlisted Qtr.	20	2	0	0
Dining	2	6	0	0
Detached Facil.	2	8	0	0
Unmar. Officer Qtr.	3	3	0	0
Support & Service	1	8	0	0
Welfare & Rec.	9	8	0	0

Total System Impact Factor Range

1

1

MCA IMPACT TABLE

Technology Identification 15

TECHNOLOGY: Panelized Roof Systems

SYSTEM: a. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	19	80	95
Operational	5	7	80	95
Training	7	4	80	95
Maintenance	27	11	80	95
Production	0	10	80	95
Laboratories	5	6	80	95
Ammun. Storage	2	4	0	0
Cold Storage	0	11	80	95
General Storage	4	11	80	95
Hospital	2	1	80	95
Dental Clinics	0	3	80	95
Medical Clinics	1	3	80	95
Administrative	7	3	80	95
Family Housing	0	3	80	95
Unmar. Enlisted Qtr.	20	2	80	95
Dining	2	6	80	95
Detached Facil.	2	7	80	95
Unmar. Officer Qtr.	3	3	80	95
Support & Service	1	8	80	95
Welfare & Rec.	9	8	80	95
Total System Impact Factor Range			5	6

## MCA IMPACT TABLE

Technology Identification 15

TECHNOLOGY: Panelized Roof Systems

SYSTEM: b. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	3	80	95
Operational	5	7	80	95
Training	7	13	80	95
Maintenance	27	7	80	95
Production	0	12	80	95
Laboratories	5	8	80	95
Ammun. Storage	2	28	0	0
Cold Storage	0	22	80	95
General Storage	4	13	80	95
Hospital	2	14	80	95
Dental Clinics	0	6	80	95
Medical Clinics	1	16	80	95
Administrative	7	14	80	95
Family Housing	0	19	80	95
Unmar. Enlisted Qtr.	20	18	80	95
Dining	2	24	80	95
Detached Facil.	2	7	80	95
Unmar. Officer Qtr.	3	13	80	95
Support & Service	1	7	80	95
Welfare & Rec.	9	7	80	95
Total System Impact Factor Range			9	11

MCA IMPACT TABLE

Technology Identification 16

TECHNOLOGY: Panelized Wall Systems

SYSTEM: a. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	50	70
Operational	5	24	50	70
Training	7	13	50	70
Maintenance	27	7	20	40
Production	0	12	20	40
Laboratories	5	8	50	70
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	20	30
Dental Clinics	0	6	50	70
Medical Clinics	1	6	50	70
Administrative	7	14	50	70
Family Housing	0	19	80	5
Unmar. Enlisted Qtr.	20	18	80	95
Dining	2	24	50	70
Detached Facil.	2	7	50	70
Unmar. Officer Qtr.	3	13	80	95
Support & Service	1	7	50	70
Welfare & Rec.	9	7	50	70
Total System Impact Factor Range			6	9

## MCA IMPACT TABLE

Technology Identification 16

TECHNOLOGY: Panelized Wall Systems

SYSTEM: b. Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	50	75
Operational	5	13	50	75
Training	7	17	50	75
Maintenance	27	15	75	85
Production	0	12	75	85
Laboratories	5	9	60	70
Ammun. Storage	2	11	0	0
Cold Storage	0	10	75	85
General Storage	4	13	75	85
Hospital	2	11	60	70
Dental Clinics	0	15	70	70
Medical Clinics	1	15	70	70
Administrative	7	11	50	65
Family Housing	0	11	70	80
Unmar. Enlisted Qtr.	20	14	50	75
Dining	2	15	50	60
Detached Facil.	2	18	70	80
Unmar. Officer Qtr.	3	18	50	75
Support & Service	1	18	50	75
Welfare & Rec.	9	17	70	80
Total System Impact Factor Range			8	10

## MCA IMPACT TABLE

Technology Identification 17

TECHNOLOGY: Space Frame Structural Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	70	80
Operational	5	24	70	80
Training	7	13	70	80
Maintenance	27	7	75	85
Production	0	12	75	85
Laboratories	5	8	70	85
Ammun. Storage	2	26	0	0
Cold Storage	0	22	70	80
General Storage	4	13	70	80
Hospital	2	14	50	50
Dental Clinics	0	6	70	80
Medical Clinics	1	6	70	80
Administrative	7	14	70	80
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	0	0
Dining	2	24	70	80
Detached Facil.	2	7	70	80
Unmar. Officer Qtr.	3	13	0	0
Support & Service	1	7	70	80
Welfare & Rec.	9	7	70	70
Total System Impact Factor Range			6	6

## MCA IMPACT TABLE

Technology Identification 18

TECHNOLOGY: Spray-Applied Insulation Systems

SYSTEM: Exterior Closure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	2	5	10
Operational	5	13	5	10
Training	7	17	5	10
Maintenance	27	15	5	10
Production	0	12	5	10
Laboratories	5	9	5	10
Ammun. Storage	2	11	0	0
Cold Storage	0	10	5	10
General Storage	4	13	5	10
Hospital	2	11	5	10
Dental Clinics	0	15	5	10
Medical Clinics	1	15	5	10
Administrative	7	11	5	10
Family Housing	0	11	5	10
Unmar. Enlisted Qtr.	20	14	5	10
Dining	2	15	5	10
Detached Facil.	2	18	5	10
Unmar. Officer Qtr.	3	18	5	10
Support & Service	1	18	5	10
Welfare & Rec.	9	17	5	10
Total System Impact Factor Range			1	1

## MCA IMPACT TABLE

Technology Identification 19

TECHNOLOGY: Spray-Applied, Fire-Resistive Fiberglass Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	2	4
Operational	5	24	2	4
Training	7	13	2	4
Maintenance	27	7	2	4
Production	0	12	2	4
Laboratories	5	8	2	4
Ammun. Storage	2	26	0	0
Cold Storage	0	22	2	4
General Storage	4	13	2	4
Hospital	2	14	2	4
Dental Clinics	0	6	2	4
Medical Clinics	1	6	2	4
Administrative	7	14	2	4
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	2	4
Dining	2	24	2	4
Detached Facil.	2	7	2	4
Unmar. Officer Qtr.	3	13	2	4
Support & Service	1	7	2	4
Welfare & Rec.	9	7	2	4
Total System Impact Factor Range			>1	>1

MCA IMPACT TABLE

Technology Identification 20

TECHNOLOGY: Standing Seam Metal Roofing Systems

SYSTEM: a. Roofing

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	19	60	70
Operational	5	7	60	70
Training	7	4	60	70
Maintenance	27	11	60	70
Production	0	10	60	70
Laboratories	5	6	60	70
Ammun. Storage	2	4	0	0
Cold Storage	0	11	60	70
General Storage	4	11	60	70
Hospital	2	1	60	70
Dental Clinics	0	3	60	70
Medical Clinics	1	3	60	70
Administrative	7	3	60	70
Family Housing	0	3	60	70
Unmar. Enlisted Qtr.	20	2	60	70
Dining	2	6	60	70
Detached Facil.	2	8	60	70
Unmar. Officer Qtr.	3	3	60	70
Support & Service	1	8	60	70
Welfare & Rec.	9	8	60	70
Total System Impact Factor Range			4	4

MCA IMPACT TABLE

Technology Identification 20

TECHNOLOGY: Standing Seam Metal Roofing Systems

SYSTEM: b. Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	10	15
Operational	5	24	10	25
Training	7	13	10	15
Maintenance	27	7	20	25
Production	0	12	20	25
Laboratories	5	8	10	15
Ammun. Storage	2	26	0	0
Cold Storage	0	22	20	25
General Storage	4	13	20	25
Hospital	2	14	10	15
Dental Clinics	0	6	20	25
Medical Clinics	1	6	20	25
Administrative	7	14	10	15
Family Housing	0	19	0	0
Unmar. Enlisted Qtr.	20	18	10	15
Dining	2	24	20	25
Detached Facil.	2	7	20	25
Unmar. Officer Qtr.	3	13	20	25
Support & Service	1	7	10	15
Welfare & Rec.	9	7	20	25
Total System Impact Factor Range			2	2

## MCA IMPACT TABLE

Technology Identification 21

TECHNOLOGY: Truss-Frame Building Systems

SYSTEM: Superstructure

Building Types That Could Be Affected by the Technology	Percent MCA Bldg. Program Affected by the Building	Percent Bldg. Cost Affected by the System	Percent System Affected by the Technology	
			Low	High
Communications	1	22	50	70
Operational	5	24	50	70
Training	7	13	50	70
Maintenance	27	7	0	0
Production	0	12	0	0
Laboratories	5	8	50	70
Ammun. Storage	2	26	0	0
Cold Storage	0	22	0	0
General Storage	4	13	0	0
Hospital	2	14	50	70
Dental Clinics	0	6	50	70
Medical Clinics	1	6	50	70
Administrative	7	14	50	70
Family Housing	0	19	70	80
Unmar. Enlisted Qtr.	20	18	70	80
Dining	2	24	0	0
Detached Facil.	2	7	50	70
Unmar. Officer Qtr.	3	13	70	80
Support & Service	1	7	50	70
Welfare & Rec.	9	7	50	70
Total System Impact Factor Range			5	7

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