

# 1.1 Workshop Introduction

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Let me take this opportunity to welcome each of you to NIST and to Gaithersburg, Maryland. I would like to take this opportunity to present some information on recent developments concerning federal research and development funding, some of which pertains to work being discussed here today.

## Construction and Building Subcommittee

### **Background:**

The National Science and Technology Council (NSTC), a cabinet-level group charged with setting federal technology policy, coordinates R&D strategies across a broad cross-section of public and private interests. NSTC has established nine research and development committees, including the Committee on Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of U.S. industry through federal technology policies and programs. The Subcommittee on Construction and Building (C&B) of CCIT coordinates and defines priorities for Federal research, development, and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infra-structure.

### **Mission of the Subcommittee on Construction and Building (C&B):**

The mission of C&B is to enhance the competitiveness of U.S. industry, public and worker safety and environmental quality through research and development, in cooperation with U.S. industry, labor, and academia, for improvement of the performance of constructed facilities. C&B addresses Administration goals to:

- Forge partnerships with industry to strengthen America's industrial competitiveness and create jobs.
- Make environmental protection, safety, and energy efficiency fully consistent with other business objectives.

### The Construction Industry

Construction is one of the Nation's largest industries and a critical asset for enhancing the international competitiveness of U.S. industry. In 1994, new construction and renovation combined amounted to \$850 billion, about 13% of the GDP, and provided employment for over 10 million persons. Constructed facilities shelter and support most human activities. Their quality is vital to the competitiveness of all U.S. industry, the safety and quality of life of the people, and environmental quality.

## C&B Member Agencies:

Agencies (listed below) participating in the Subcommittee include agencies with responsibilities as owners and operators, regulators, and researchers.

Department of Agriculture (Forest Service)  
Department of Commerce, Co-chair (National Institute of Standards and Technology)  
Department of Defense (Corps of Engineers)  
Department of Energy, Co-chair  
Department of Health and Human Services (National Institute for Safety and Health)  
Department of Housing and Urban Development  
Department of Interior (U.S. Bureau of Mines) (U.S. Geological Survey)  
Department of Labor (Occupational Safety and Health Administration)  
Department of Transportation (Federal Highway Administration)  
Department of Veterans Affairs  
Consumer Products Safety Commission  
Environmental Protection Agency  
Federal Emergency Management Agency  
General Services Administration  
National Aeronautics and Space Administration  
National Science Foundation

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### New Construction:

New construction put in place in 1994 represents about \$508 Billion (which is about 60% of the total construction market). The breakdown between the five sectors of the industry; residential, commercial, industrial, institutional, and public works is as follows:

Commercial	10%
Residential	46%
Industrial	14%
Institutional	4%
Public Works	28%

### Life Cycle of Constructed Facilities:

Construction includes the whole life of the project: initial planning and programming, design, procurement, construction, occupancy and maintenance,

condition assessment, retrofit and renovation or removal. This whole life viewpoint is necessary to give realistic attention to values and costs of constructed facilities. For instance, for an office building, the annual operating cost, including salaries of occupants, roughly equals the initial construction cost. The primary value comes from the productivity of the occupants, which depends on the capability of the building to meet user needs throughout its useful life. Some technical innovations in facilities, such as those for durability, efficiency, or improved safety against natural disasters, may add to the initial cost but reduce the life cycle cost. Different sectors of the industry and their customers place different emphases on the importance of life cycle cost.

## **Industries of Construction:**

Construction involves many industries including:

- Architectural and engineering design
- Finance
- Construction
- Insurance
- Construction equipment manufacture
- Facility management
- Materials manufacture
- Security
- Installed equipment manufacture
- Cleaning services
- Furnishings manufacture
- Fire protection
- Maintenance and repair
- Demolition

## **Vision:**

The vision for the construction and building industries is:

### *Competitive*

High quality constructed facilities support the competitiveness of U.S. industry and everyone's quality of life.

### *High Quality*

U.S. industry leads in quality, speed and economy in the global market for construction products and services.

### *Efficient and Sustainable*

The construction industry and constructed facilities are energy efficient, sustainable in use of resources, safe and healthful.

## *Hazard Resistant*

Natural and manmade hazards do not result in disasters.

## National Construction Goals

The C&B Subcommittee has studied research priorities expressed by the construction industry in industry forums and in proposals for the Advanced Technology Program of the Department of Commerce. Two priority thrusts; better constructed facilities, and health and safety of the construction workforce, were defined for focus of research, development and deployment (RD&D) in the construction and building area. The C&B program plans to make technologies and practices capable of achieving the goals under these thrusts available for general use in the construction industry by 2003. The baseline for measuring progress against the goals will be today's business practices. Therefore, reliable baselines and measurement tools need to be established and developed.

Long delivery time, waste and pollution, and construction work illness and injury contribute substantially to unnecessary increases in the cost of construction. Therefore, achievement of these goals will reduce construction cost and make housing more affordable through reduction in first cost and life cycle cost.

The C&B program and goals were reviewed with a focus group of industry leaders convened on April 5, 1994, by the Civil Engineering Research Foundation. These leaders strongly endorsed the goals.

## Goals - Rationale:

### Better Constructed Facilities

- 50% Reduction in Delivery Time

Reduction in the time from the decision to construct a new facility to its readiness for service is vital to industrial competitiveness and project cost reduction.

During the initial programming, design, procurement, construction and commissioning process, the need of the client for the facility is not being met; needs evolve over time so a facility long in delivery may be uncompetitive when it is finished; and the investments in producing the facility cannot be recouped until the facility is operational. The need for reduction in time to project completion is often stronger in the case of renovations and repairs of existing facilities because of interruption of ongoing business.

Owners, users, designers and constructors are among the groups calling for technologies and practices reducing delivery time.

- 50% Reduction in Operation, Maintenance and Energy Costs

Operation and maintenance costs over the life of the facility usually exceed its first cost and may do so on an annualized cost basis. To the extent that prices for energy, water, sewage, waste, communications, taxes, insurance, fire safety, plant services, etc., represent costs to society in terms of resource consumption, operation and maintenance costs also reflect the environmental qualities of the constructed facility. Therefore, reductions in operation and maintenance and energy costs benefit the general public as

well as the owners and users of the facility.

- 30% Increase in Productivity and Comfort

Industry and government studies have shown that the annual salary costs of the occupants of a commercial or institutional building are of the same order of magnitude as the capital cost of the building. Indeed, the purpose of the building is to shelter and support the activities of its occupants. Improvement of the productivity of the occupants (or for an industrial facility, improvement of the productivity of the process housed by the facility) is the most important performance characteristic for most constructed facilities.

- 50% Fewer Occupant Related Illness and Injuries

Buildings are intended to shelter and support human activities, yet the environment and performance of buildings can contribute to illnesses and injuries for building users. Examples are avoidable injuries caused by fire or natural hazards, slips and falls, legionnaires' disease from airborne bacteria, often associated with a workplace environment (sick building symptoms) and building damage or collapse from fire, earthquakes, or extreme winds. Sick building symptoms include irritation of eyes, nose and skin, headache, and fatigue. If improvements in the quality of the indoor environment reduce days of productive work lost to sick days and impaired productivity, annual nationwide savings could reach billions of dollars. Criminal violence in buildings is a safety issue which can be

addressed in part by building design. Reductions in illnesses and injuries will increase users' productivity as well as reducing costs of medical care and litigation.

- 50% Less Waste and Pollution

Improvement of the performance of constructed facilities that shelter and support most human activities, provides major opportunities to reduce waste and pollution at every step of the delivery process, from raw material extraction to final demolition and recycling of the shelter and its contents. Examples are reduced energy use and greenhouse gas emissions and reduced water consumption and waste water production. Waste and pollution also can be reduced in the construction process: construction wastes are estimated at 20-30% of the volume of landfills.

- 50% More Durability and Flexibility

Durability denotes the capability of the constructed facility to continue (given appropriate maintenance) its initial performance over the intended service life, and flexibility denotes the capability to adapt the constructed facility to changes in use or users' needs. High durability and flexibility contribute strongly to the life cycle quality of constructed facilities since they usually endure for many decades.

### **Health and Safety of Construction Workforce**

- 50% Reduction in Construction Work Illnesses and Injuries

A factor affecting international competitiveness is the cost of injuries and diseases among construction workers. Although the construction workforce represents about 6 percent of the Nation's workforce, it is estimated that the construction industry pays for about one-third of the Nation's workers' compensation. Workers' compensation insurance premiums range from 7 to 100 percent of payroll in the construction industry. Construction workers die as a result of work-related trauma at a rate that is 2 and 1/2 times the annual rate for workers in all other industry sectors (13.6 deaths per 100,000 construction workers, as compared to 5.5 deaths per 100,000 workers in all other industry sectors). Construction workers also experience a higher incidence of nonfatal injuries than workers in other industries.

### **Strategy:**

To help the construction and building industries meet the above goals, the member Federal Agencies of C&B will:

- Work with industry
- Provide baselines and measures of performance
- Focus Federal R&D programs on automation, high performance materials and systems, measurement, and sustainability
- Provide tools for a more efficient regulatory process
- Provide tools for acceptance of innovation
- Use Federal construction for technology demonstration

- Set goals and milestones for the program and measure effectiveness

### Working with Industry

The Construction and Building Subcommittee's program and goals were reviewed with a focus group of industry leaders convened on April 5, 1994, by the Civil Engineering Research Foundation. The response of the focus group is described in the Construction Industry White paper "Innovation in the U.S. Construction Industry: An Essential Component for America's Economic Prosperity and Well Being." The white paper is an industry perspective of methods and means that, if jointly supported and implemented by the public and private sector, promise to transform the construction sector into the high technology/high skill sector America requires. Construction industry leaders strongly endorsed the goals established by C&B. The industry leaders urged expanded dialogue and the immediate initiation of actions.

On December 14-16, 1994 industry leaders held a White House Construction Industry Workshop on National Construction Goals organized by the Civil Engineering Research Foundation. The workshop's purpose was to provide an industry perspective on the priorities among proposed construction goals and develop recommendations for an appropriate implementation plan. Participants in the workshop included representatives from design, construction, labor, construction equipment, building materials and mechanical equipment, finance, insurance, owners, codes, etc.

### **Industry Perspective:**

The results of the White House Construction Industry Workshop are reported in a CERF report "National Construction Goals: A Construction Industry Perspective. The workshop noted that the five sectors of the construction industry: residential, commercial, industrial, institutional, and public works differ in the participants involved, methods of financing, legal factors, project timing, the desire for or acceptance of innovation, the importance first cost or operating cost, market forces, and customer involvement. Consequently, they differ in their ranking of relative importance of the proposed goals. For example, residential construction specifically identified reduced first cost (directly coupled to reduced delivery time) as their most important goal. Goals that are considered of highest priority to the industry are identified in the chart (Figure 1.1.1) as double diamond, and those of lesser priority with a single diamond.

Meeting the goals will require advances in technology, demonstration of those advances, and leadership to bring about the important non-technical changes called for by industry. Lack of present knowledge makes less feasible the important goals for Productivity and Comfort, and Occupant Health and Safety. The workshop encouraged research in these important areas to make advances toward these goals possible in the near future.

Goal:	Residen- tial	Commer- cial	Institu- tional	Indus-trial	Public Works	Rank
Delivery Time	**	*	**	**	*	1
Operation Maintain- ence and Energy	*	**	*	*	**	2
Produc- tivity and Comfort		*	*			5
Occupant Health and Safety	*					6
Waste and Pollution	*				*	5
Durability and Flexibility	**	*			*	3
Worker Health and Safety	*		*	*		4

Figure 1.1.1: Industry priorities for construction goals identified by C&B

### Non-Technical Barriers:

At the April 1994 Focus Group the construction industry took note of the following major non-technical barriers to the introduction of technical innovations:

- Lack of Leadership
- Regulatory Barriers
- Liability
- Adversarial Relations, and
- Financial Disincentives

The following additional barriers were cited by industry at the December 1994 Workshop:

- Parochialism
- Increasing scarcity of skilled labor
- Fragmentation of the industry
- Inadequate owner involvement

Barriers are pervasive and more than anything else prevent or retard the application of badly needed innovation in the construction industry.

### Barrier Removal:

Industry representatives identified a number of changes needed to remove barriers to private sector investments in technology required to meet the goals.

- a speed-up in the regulatory process, i.e., obtaining the necessary approvals,
- tort reform to avoid unreasonable liability from using innovations,
- performance standards and conformance assessment mechanisms to enable users and regulators to assess and accept new materials, products, and systems,
- education of builders, managers, regulators in information systems and data, and training of craft workers to increase the pool of skilled labor and to promote safe operating practices,
- a closer working relationship between all parties in the facility design and construction process, particularly in the early stages of planning and design, and
- formation of a construction coordination council that would guide private activities and speak for the industry to bring about some of the needed changes in the system.

### Technology Advances:

Advances in seven areas of technology have been identified as contributing to a more competitive construction industry and helping to meet the goals for the industry.

1. *Information and Decision Technologies*

- Integrated data bases and information systems
- Knowledge systems as successors to standards and books
- Integrated project information systems
- Construction management technologies
- Collaborative decision making environments
- Post-occupancy evaluation systems

2. *Automation in Design, Construction and Operation*

- Simulation and visualization
- Computer-aided design
- Computer-integrated construction
- Advanced sensors
- Construction robotics
- Building automation systems
- Computer-aided facilities management
- All weather construction

3. *High Performance Materials, Components, and Systems*

- Advanced materials
- Advanced components
- Whole building systems
- Connections
- Mechanisms, models and data for life cycle performance
- Assessment and quality assurance technologies
- Renewal engineering
- Recycling and reuse
- Functional flexibility
- Improved water sealants
- UV barriers

4. *Environmental Quality*

- Energy conservation
- Indoor air quality
- Remediation of contaminated construction sites
- Sustainable development (ecological quality, conservation of non-renewable materials, etc.)

5. *Risk Reduction Technologies*

- Fire protection
- Toxic exposures
- Earthquake risk reduction
- Wind risk reduction
- Other hazards

6. *Performance Standards System*

- Performance standards for products and processes
- Test methods and data for life cycle performance
- Conformance assessment system
- Certification system
- Data bases availability and accessibility

7. *Human Factors*

- Cognitive processes and uses of information
- Physiology
- Ergonomics
- Environmental and person-machine interactions
- Team building and workforce efficiency

**Plan for Deployment:**

Barriers to the acceptance of new technology include the lack of knowledge of

what is available, the benefits to be gained, the risks involved in initial uses of new technologies, and simply human resistance to change. A key part of this multi agency program is the showcasing of new technologies and methods for overcoming barriers. Federal construction and renovation projects provide an excellent showcase for these innovations, and enable all stakeholders to gain comfort with change.

Executive Order 12902, Energy Efficiency & Water Conservation at Federal Facilities, of March 8, 1994, requires that when an agency constructs at least five buildings in a year, it shall designate at least one building, at the earliest stage of development, to be a showcase highlighting advanced technologies and practices for energy efficiency, water conservation, or use of solar and other renewable energy. The order also requires that each agency designate one of its major existing buildings to become a showcase to highlight energy or water efficiency and attempt to incorporate solar and other renewable technologies, and indoor air quality improvements. Each agency is required to develop and implement plans and work in cooperation with the Department of Energy, and where appropriate, in consultation with the General Services Administration and other appropriate agencies to determine the most effective and cost effective strategies to implement these demonstrations. Efforts of the C&B can facilitate visibility for these projects and help underscore their significance to the housing and construction industries.

### Federal Construction R&D Budget (\$ Million)

The Administration has assigned priority for research and development to Construction and Building for the FY 1996 budget as "Activities that support the residential/commercial building construction industry and its suppliers in the development of advanced technologies aimed at increasing the productivity of construction, improving product quality (including energy efficiency and improved indoor air quality), use of renewable resources, and increased worker health and safety.

The following table reflects the changes proposed in the President's budget for construction R&D for fiscal year 1996 compared with the budget enacted for fiscal year 1995.

Agency	FY95 *	FY96 **
Dept. of Energy	59.5	63.9
National Science Foundation	55.0	57.3
Dept. of Commerce (NIST)	16.9	22.9
Dept. of Defense (Army Corps of Engineers)	0	15.8
Dept. of Agriculture	7.9	7.4
Dept. of Housing and Urban Development	2.0	2.0
<b>TOTAL</b>	<b>141.3</b>	<b>169.3</b>

\* FY95 enacted budget

\*\* FY96 President's budget request

Figure 1.1.2: Federal construction R&D

NOTE 1: In addition to the above budget figures, many agencies have C&B related research and development listed primarily for other NSTC activities, for instance, the National Institute of Occupational Health and Safety, Department of Health and Human Services, budgeted \$14.3 million to construction worker and building occupant safety and health in FY 95 and FY 96.

NOTE 2: Other Federal agencies including the General Services Administration and the Department of Veterans' Affairs are involved in the deployment of new technology in construction but do not budget funds for construction research and development.

### Closing:

Of course an important question is: what is the transition between a Presidential priority, a Presidential request, and actually having the funding here on October 1, 1995. I think the answer is that we can expect this Congress to be skeptical of all the President's requests. I think whether this succeeds or fails it depends entirely on whether our mission is being pursued effectively. We must provoke economic growth by working with industry to develop and apply new technology, measurements and standards. If the industry that we are serving -- the industry that we are working with -- feels this is important and chooses to let Congress know that, we have a good chance of getting the resources. I think our purpose with you over these two days is to be sure that the technical content of the program is one that merits support by industry and merits support by the federal government. Then we will have to look at the people whose concern is for technology policy to determine indeed whether Congress comes through with the funds this year.

I was asked earlier this morning for some information regarding MEP. The Manufacturing Extension Partnership is a nationwide network of technology transfer centers. These are not federal centers. These are organized by universities and industry associations, and they receive initially 50% of their funding from states

or the private sector and the remaining 50% of their funding through NIST. There are constant negotiations with Congress on how long the government share of the funding will endure. There are regular reviews of the program. But the thought -- and the President's objective -- is to have 100 technology transfer centers nationwide so that every businessman is within an easy drive of the center. They were originally set up for the scenario where a small machine shop wants to purchase the automation equipment that will let it compete in its market but doesn't have all the knowledge needed to make this transition. The purpose of the MEP center is so that the owner can drive there, touch, feel, taste and pick up the portfolio of software and hardware that should be incorporated in his business and get assistance and training in learning how to use it. A real example of small to medium sized industry that makes things is the construction industry. We are working with the National Association of Home Builders and the Association of General Contractors in order to include construction elements in the MEP technology transfer centers.