Performance: Imperative for Safety, Security, and Competitiveness in the 21st Century

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Abstract

Following the collapse of the World Trade Center (WTC) towers on September 11, 2001, NIST developed a Public-Private Response Plan. It consists of an investigation of the collapses, an R&D program to transform the findings into actionable recommendations, and a dissemination program to engage industry and government into implementation of recommendations. The elements of the plan are now well underway. In addition, during the past 12 months, other activities have been launched that focus on the needs for (1) broad research on critical infrastructure protection, (2) use of information technology to transform the Nation's building regulatory process, (3) and revision of a capital facilities project roadmap to include homeland security. When all these activities are considered in total, it is concluded that the ability to measure and predict building performance is crucial to safety, security, and competitiveness of the industries of construction. To realize this ability, collective efforts should be made to develop standards for electronic representation of buildings, interoperability of building performance analysis software, life cycle information knowledge bases, and performance of systems for capturing construction site data in real time.

Keywords: Tall buildings, Building investigation, Building collapse, Homeland security, Building regulations, Building-integrated processes, Building life-cycle performance

Introduction

Much has happened in the United States since the first Global Leaders Summit in Garston, England, in April of 2002. I would like to briefly summarize a number of these events or developments and then focus on what I see as the central issue that faces us arising from all of them, and especially the implications for developers or owners of tall buildings. The central point is simple: *The ability to measure and predict building performance is crucial to safety, security and competitiveness in the 21st century*. The course we need to take to achieve this is not. I will conclude with some observations on how we might approach attaining this challenging goal.

Update on Activities in the USA

Public-Private Response Plan. At the first Global Leaders Summit on Tall Buildings, I described what National Institute of Standards and Technology (NIST) had set out to do in response to the attacks of September 11. Specifically, I outlined the Public-Private Response Plan developed by NIST in partnership with a large number of private and public sector bodies. At that time, the plan was little more than that, except that I had committed a significant fraction of the resources of the Building and Fire Research Laboratory to this effort. As you may recall, this was conceived as a roughly, $56 million, four year effort. The Response Plan, as shown in Figure 1, is comprised of three elements. The first is a two-year investigation of the WTC collapses as a follow up to the Building Performance Assessment Team Report sponsored by the Federal Emergency Management Agency (FEMA) and carried out under the auspices of the American Society of Civil Engineers (ASCE) to derive lessons learned from this disaster. The second is an R&D program designed to transform the findings into actionable recommendations for improvements to practice standards and codes in the United States. The third is a technical assistance and dissemination program to engage industry and state and local governmental leaderships in implementing these improvements. (Details are accessible at http://wtc.nist.gov.) I'll say a few words about each of them.

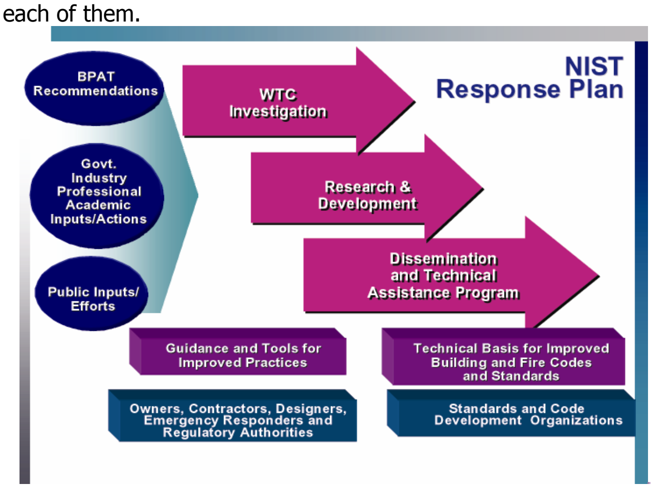

Figure 1.

WTC Investigation. On August 21, 2002, after a great deal of discussion and over 50 presentations to public and private sector bodies and leaders, and two Congressional Hearings, Congress appropriated $16 million for the 2 year WTC investigation. The focus of the investigation is on the three buildings that collapsed – towers WTC 1 and WTC 2 and the 47-story building that collapsed later in the day of September 11, WTC 7. The objectives of the investigation include the explicit understanding of the collapse mechanisms and the role of the aircraft impact, the consequent fires and other actions. The investigation will also examine human behavior and response to these events specifically regarding the roles of the fire services and the building occupants in the initial response and evacuation. NIST has collected over two hundred pieces of steel from the towers including miraculously, one of the structural assemblies actually hit by one of the aircraft. Figure 2 shows a schematic of the structural members of the upper floors of the north fact of WTC 1. The colored members are the ones in the possession of NIST. We held an open public meeting in New York City in June to review our preliminary plans for the investigation and invited broad public comment as well. I have appointed Dr. Shyam Sunder, Chief of the Materials and Construction Research Division as leader of the investigation. Dr. Sunder has an ScD from the Massachusetts Institute of Technology (MIT) and has considerable experience with investigations and analysis of complex structural systems.

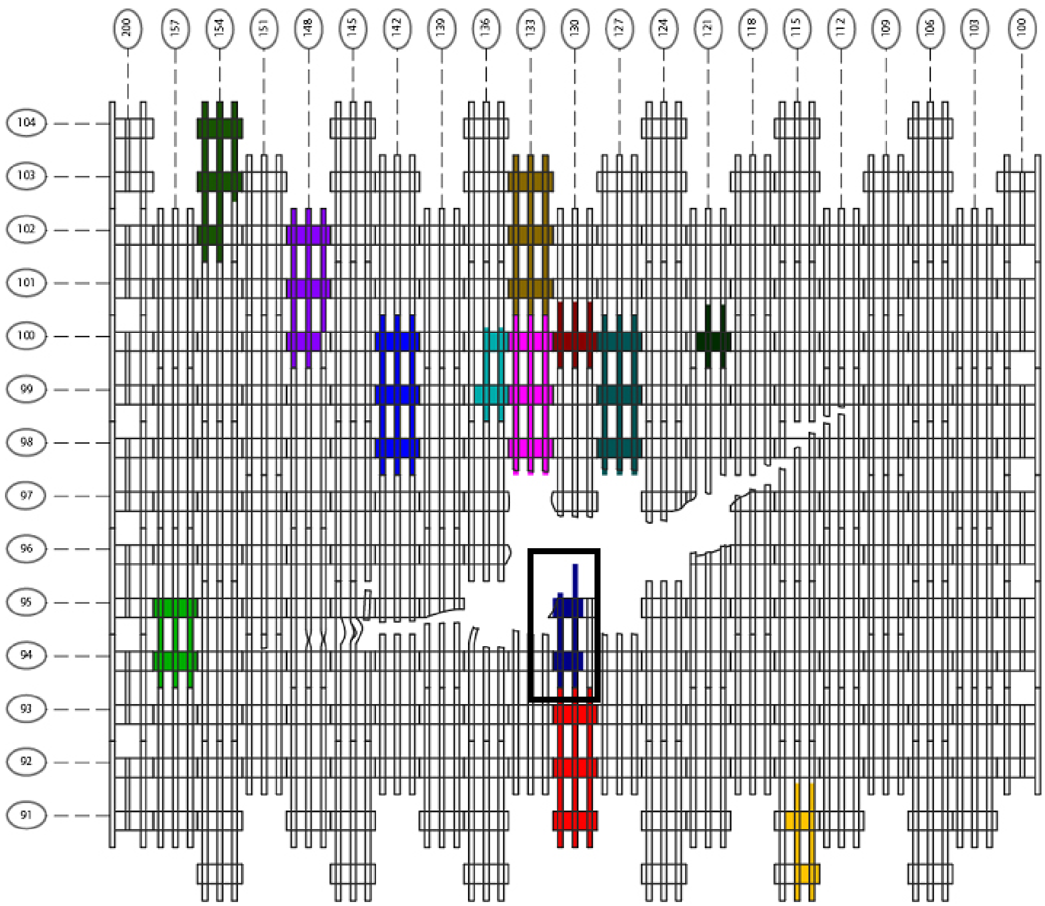

Figure 2.

Dr. William Grosshandler, Chief of the Fire Research Division is associate leader of the investigation. We have a team of some 22 NIST scientists and engineers on the investigation. Their efforts will be complemented by a like number of private sector experts and contractors, selected mostly in open competition to support various tasks in the investigation. The overall scheme of the investigation is shown in Figure 3. Full details of all the projects are available on the web at http://wtc.nist.gov. A major aspect of this effort will be to conduct a full computer-based simulation-recreation of the events of September 11 - the impact of the aircraft, the fires, the efforts at escape and rescue and the collapses. Progress reports on the investigation are being posted on this web site also.

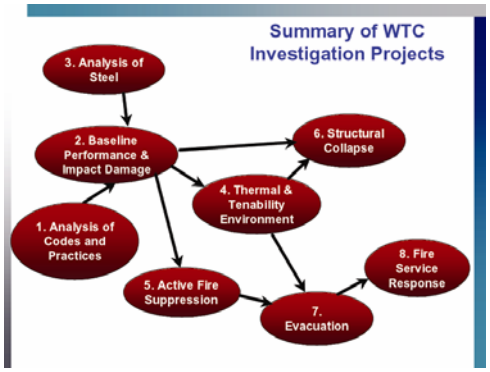

Figure 3.

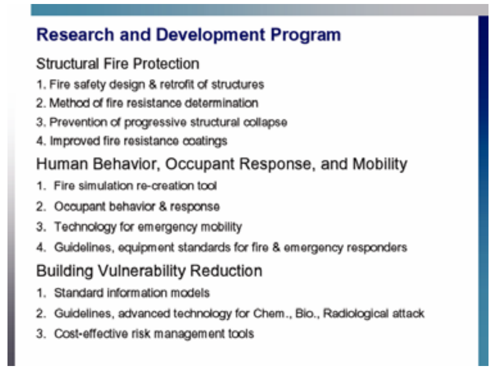

Figure 4.

R&D Program. You may recall the R&D program was designed to transform the findings of the investigation into actionable recommendations for improvements to practice, standards and codes. This program is also intended to produce cost-effective enhancements to building security, safety and performance. A list of the projects in this program is shown in Figure 4. Many of the topics listed here address issues that were well identified long before September 11, 2001, but for a variety of reasons little had been done about them. Now that situation has changed. Note that most of these projects are relevant to tall buildings. Work on as many of these projects as we can find funds to support is already underway. As conceived, this is at least a $40 million program that will take four to five years, if not longer, to complete. The level of funding this year should be $4 million with further increases being sought for the out years. We are actively seeking partnerships, both public and private, in carrying out this important work. To date we have signed agreements with China and the UK for related work and are seeking involvement of a number of additional international bodies as well. Dr. Grosshandler has lead responsibility for the R&D program. Our current thinking about the plans for each project is accessible at www.bfrl.nist.gov. I am sure Dr. Grosshandler would appreciate hearing from any who are interested in this work.

Dissemination and Technical Assistance Program. The third element of the Response Plan is a dissemination and technical assistance program, through which we intend to develop the support and advocacy of industry leaders for the needed changes to practice, standards and codes. We expect this program to include demonstrations of the benefits and cost-effectiveness of the recommended changes. We already have initiated a variety of activities in support of this program through the Construction Industry Institute, the Civil Engineering Research Foundation, the Infrastructure Security Partnership and the National Conference of States on Building Codes and Standards, and the FIATECH Consortium. I will say a few more words about these later. Dr. James Hill, Deputy Director of the Building and Fire Research Laboratory, NIST, has the lead on this element of the program.

National Construction Safety Team Act, Public Law 107-231 [1]. One of the ideas introduced in the context of the initial Response Plan has now become law. This was a proposal to create an analog to the National Transportation Safety Board that would enable rapid, open, thorough and authoritative investigations of building disasters, either natural or man-made. On September 17, 2002 President George Bush enacted PL 107-231, The National Construction Safety Team Act. This act applies retroactively to the WTC investigation. It requires the Director of NIST "… to provide for the establishment of investigative teams to assess building performance and emergency response and evacuation procedures in the wake of any building failure that has resulted in substantial loss of life or that posed the potential for substantial loss of life." Teams are to be launched within 48 hours of an event, and may include private as well as public sector experts. The act provides the Director of NIST with the authority needed to conduct thorough, timely and objective investigations. Also, the act calls for the establishment of a Federal Advisory Board to oversee the work and review the findings of these teams. We are currently in the process of vetting candidates for the Advisory Board and hope to have it operational within two months. Dr. Hill has responsibility for developing the procedures for implementation of this act. The act charges NIST with responsibility to report to Congress on the status of actions taken relating to its recommendations. It is important to note that this act does not change the constitutional responsibility of state and local governments for building regulation in the United States. Rather, it simply creates within NIST an authority to derive lessons to be learned from disasters and offer recommendations to these state and local bodies.

Homeland Security. In response to the attacks of September 11, President Bush established an Office of Homeland Security within the White House. In July 2002, that office published a report outlining a National Strategy for Homeland Security. Subsequently, on November 19th, the Congress enacted legislation creating a Department of Homeland Security within the Federal government. Specifically, the new Department of Homeland Security (DHS) will have three primary missions:

- Prevent terrorist attacks within the United States,
- Reduce America's vulnerability to terrorism, and
- Minimize the damage from potential attacks and natural disasters.

The national strategy for homeland security is largely the responsibility of private sector bodies which in the United States own most of the physical infrastructure of the Nation – airlines and other transportation facilities, utilities, pipelines, ports, manufacturing, buildings of all types, etc. This department is being organized as we speak. Many existing federal agencies have been pulled together into this department including the Federal Emergency Management Agency and the United States Coast Guard.

Private sector firms frequently ask, what should I do? What good will it do? and what will it cost? This points to the need for quantitative tools for making decisions about the relative effectiveness of alternative security measures. NIST is working closely with the Department of Commerce and the Department of Homeland Security transition teams to develop such quantitative tools and assure that needed standards are developed and promulgated using the resources of the U.S.'s national voluntary consensus standards making process. (Details are accessible at www.homelandsecurity.gov).

"Making the Nation Safer." In June 2002, a group of the Nation's leading researchers published a report from the National Research Council entitled, *"Making the Nation Safer: the Role of Science and Technology in Countering Terrorism*" [2]. In the chapter entitled, "Cities and Fixed Infrastructure," this report states, "An important issue, …is whether a similar fire in the World Trade Center and/or similarly constructed megastructures could cause the buildings to fall even without airliner impacts" (p 8-14). They call for more research on fire resistance rating practices and for improving the fire and blast resistance of buildings. Significantly, the report also recommends research to determine "…the most expeditious means of integrating performance standards within building codes to cover technologies that resist blasts, impacts, and the consequences of fire" (p. 8-16). The report suggests that NIST take a lead role in such efforts. The report also urges efforts to advance probabilistic risk analysis modeling approaches.

OSTP Workshop. On September 23-24, 2002, the President's Office of Science and Technology Policy (OSTP) hosted a workshop on *Critical Infrastructure Protection Research and Development Priorities* [3]. The workshop was sponsored by the Construction and Buildings Subcommittee of the Committee on Technology under the President's National Science and Technology Council (which I co-chair), the American Society of Civil Engineers and the American Society of Mechanical Engineers. Dr. John Marburger, the President's Science Advisor, keynoted the meeting. Over 90 senior industry leaders and government officials came to exchange facts and information on the security of the built environment. The workshop was convened to develop priority recommendations on key topics of concern, specifically relating to buildings. The top four recommendations of this group were:

1. Use of a consistent, objective and integrated system of *risk-based assessment methods* to identify priorities for investment of limited resources,
2. *Performance-based measures* for assessing and mitigating specific vulnerabilities and for bringing streamlined regulatory processes and beneficial innovations into practice,
3. A decis*ion support matrix* of technologies, practices and subject matter experts available to facility owners, builders, designers and first responders,
4. *Facility knowledge systems for first responders*, so when they approach facilities subject to extreme events, they have access to the information they need to effectively and safety proceed.

The National Alliance for Building Regulatory Reform. The Alliance is an initiative of the National Conference of States on Building Codes and Standards (NCSBCS) in the United States [4]. The Alliance was formed in June 2001, at a conference on the integration of information technology in the building regulatory system. Many state and local governments are under mounting pressures to go "e-government" and to make their services available 24x7 on the internet. This conference focussed on the implications of this movement on the building regulatory establishment in the United States. As you might expect, it was concluded it makes little sense to just "IT-ize" the traditional regulatory system; therefore the focus of the Alliance is on building regulatory streamlining and reform.

The goal of the Alliance is "to use information technology to transform the Nation's building regulatory process to enable the Nation's construction industry ***to build faster, better, safer and at less cost***. The leader of the Alliance, Robert Wible, Executive Director of NCSBCS, has concluded that our current building regulatory system restricts widespread use and market aggregation for new products and technologies. He cites at least one instance where additional costs for unnecessary inspection delays have added as much as $100,000 per day to project costs. He states that, "in the U.S., some 44,000 units of state and local governments adopt and enforce construction codes and standards. Isolated bureaucracies and regulatory overlap/duplication cause conflict and confusion between government, the public and the construction community, slowing down construction process, reducing competitiveness, and safety. All this makes it difficult for neighboring jurisdictions to coordinate disaster protection and provide immediate disaster response assistance to each other." One issue uncovered in this initiative is the lack of academic research into the building regulatory process and alternatives that may be enabled by recent advances in technology. The Alliance seeks to…

- Identify and share best practices related to the hardware and software, and restructuring of the architecture of our current regulatory system to reduce regulatory costs to construction by up to 60%
- Promote common standards for digital signatures, simple common e-permits, plans review, field inspection software, and common systems requirements that include interoperability.

The Alliance consists of representatives of the organizations listed on Figure 5. An early product from the Alliance is an inventory of software available to state and local governments. The inventory is accessible at www.ncsbcs.org.

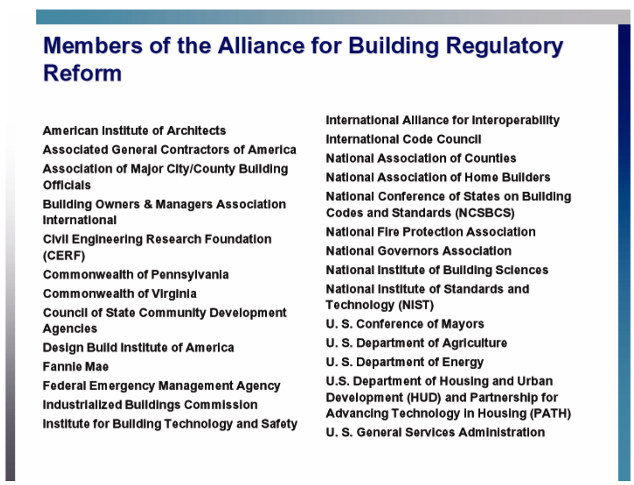

Figure 5.

Also, the Alliance is working to establish the database resource needed for the Facility Knowledge system for first responders noted above. The Alliance held a workshop at NIST in December 2002 with representatives of a number of fire service organizations and local fire departments to outline their information requirements for such a database.

Capital Facilities Projects Roadmap [5]. In 2000, the Construction Industry Institute (CII) in the United States launched a not-for-profit spin-off named FIATECH (Fully Integrated and Automated TECHnology). The purpose of this consortium is to advance the cause of fully integrated and automated capital facility project processes. The focus is on facility life cycle planning and operations and the development of technologies to enable breakthrough changes in building design, construction, operations, maintenance, repair, and renovation. In 2001, FIATECH, with support from a number of federal agencies, initiated a roadmapping process for the construction industry. In November of 2002, NIST and others sponsored a follow up workshop aimed at refining and updating the roadmap, especially in light of all that has transpired since September 11, 2001, relating to homeland security, and to develop specific project plans for moving along the envisioned path. This workshop built on the results of all of the other activities noted above.

The overall vision for the capital projects/facilities industry is of a highly automated project and facility management environment integrated across all phases and processes of a facility's life cycle as illustrated by Figure 6. It envisions one time data entry, with all the information needed being available on demand when and where needed to enabling radical reductions in cycle time and costs of planning, design, and construction and similar benefits in maintenance, repair and renovations. Not surprisingly, top priority programs currently identified in this roadmap include the following:

- Master facility life cycle model for project planning and management
- Construction industry data/information/knowledge repository
- Integrated procurement and supply network
- New materials, methods, & products development and implementation technologies
- Intelligent jobsite
- Intelligent facility life cycle optimization

Understandably, a substantial research and development effort would be required to achieve any one of these program objectives. FIATECH is reaching out to all parties to the U.S. construction and buildings community public and private in this roadmapping effort as it refines the plan and develops more specific project deliverables and priorities. Participants to date include members of the Construction Industry Institute, the International Alliance for Interoperability, the National Institute of Building Sciences, the Civil Engineering Research Foundation, the Construction and Buildings Subcommittee, National Science Foundation, the Design-Build Institute and representatives from a number of federal agencies. There is a significant level of research already underway in centers around the world towards aspects of each of the program objectives, and, in some instances, with remarkable results. Tall buildings and other complex facilities should benefit greatly from the projects being defined as part of this roadmap. The CIB initiative on Rethinking the Construction Process is addressing similar issues. It has held three workshops around the world to collect data for the undertaking. NIST hosted the second workshop in 2002. The first of these workshops was in Japan and the third is planned for Manchester, UK, in early 2003. A follow-up conference, "Revaluing Construction – the International Agenda," was held in Manchester, UK, February 3-4, 2003. It is good to see collaboration among participants in these various efforts.

Vision for Fully Integrated and Automated Capital Facility Project Processes

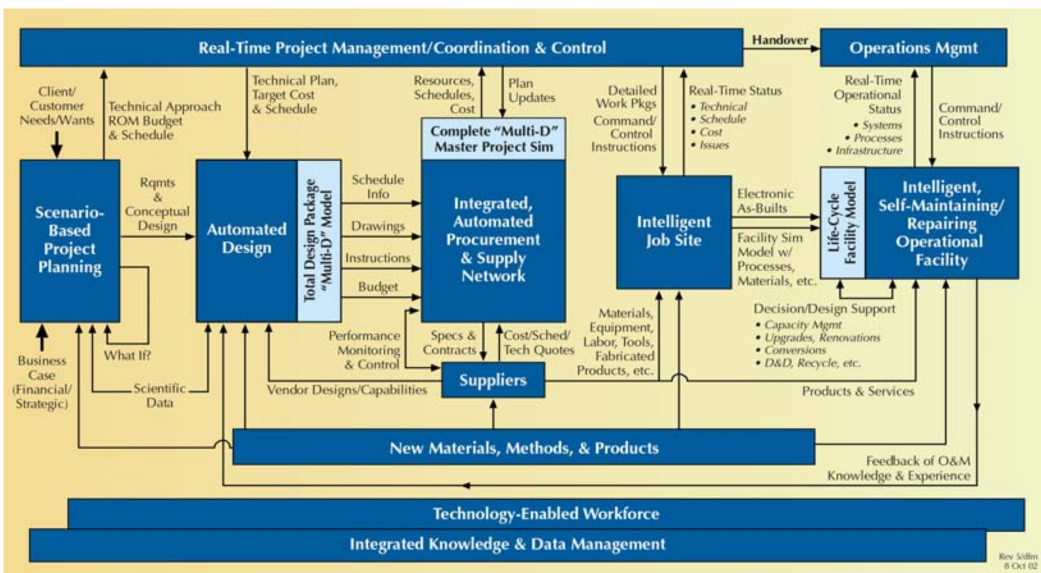

Figure 6.

Enterprise Integration Act, Public Law177-207 [6]. The last activity I want to mention is not directly associated with 9/11 but it does fit in with the previous topic and may help tie all these things together. This is a piece of legislation that was passed in the United States last year as well. It is entitled the, "Enterprise Integration Act of 2002." This law requires that NIST work with industry to develop a series of roadmaps for information technology integration within a number of critical industries including construction, homebuilding, shipbuilding as well as aviation, electronics and other areas of manufacturing and then report its findings and recommendations to the U.S. Congress. The law was inspired in part by a NIST study of the cost of time lost due to lack of interoperability in the automobile supply chain in the United States. That study estimated those losses to be $1 billion/year just for the supply chain of a handful of automobile manufacturers! NIST has commissioned a similar study to examine the costs of lack of interoperability in the construction process. That report should be available later this year. NIST's effort under this act related to construction will build on the work already initiated by FIATECH and bring national attention to the needs and opportunities facing this industry.

Central Point

Each one of the activities reported above deals at some level with heightened concerns about security, safety and/or the over all performance of buildings and how state-of-the-art technology can improve their cost-effectiveness and ultimately the competitiveness of the construction and building industries. Similar activities concerning security and safety of buildings and/or the performance of the industries of construction are underway in most of the countries represented at this meeting. This brings me back to the central point of my remarks, i.e.,

> ***The ability to measure and predict building performance is crucial to safety, security, and competitiveness in the 21st Century***.

All of the activities I have just discussed deal with aspects of safety, security or competitiveness in the construction industry. Each of them would be enhanced with improved ability to quantitatively measure and predict building performance, yet all of them tend to sidestep the reality of the tremendous amount of research needed to do so. To make sure we stay together on this point let me digress for a moment to say a bit more about what I mean by the ability to predict building performance and why it is so important.

Measurement/prediction of building performance. To me building performance means the ability of a building to positively support and sustain the activities that take place within it. To help quantify building performance, I'll define it alternatively as the *net value added by a building over its useful life*, or the *excess of benefits over the costs* associated with providing, operating and maintaining it.

Why is this so important? We have built, occupied and used millions of structures without such explicit knowledge in the past. Why is this information so important now or in the future? We are very good at quantifying the load capacity of the building's structure, and we are beginning to be able to quantify a building's fire safety performance for specified fire hazards. We are quite good at predicting a building's energy and water use, but not so good at predicting the comfort of its occupants. We are, at best, on the threshold of being able to measure the health and safety influences of a building on its occupants, but still lack effective means to predict in quantitative terms the influence of alternative designs on the productivity of their occupants. However, there is abundant anecdotal evidence that these influences can be very large. Recent data on occupant health and safety points to the high costs associated with unhealthy building conditions reflected in occupant sickness, lost workdays and lowered productivity. According to the Indoor Air Quality Handbook [7], it is estimated that the potential annual savings and productivity gains are: $6-$14 billion from reduced respiratory disease; $2-4 billion from reduced allergies and asthma; $15-$40 billion from reduced symptoms of sick building syndrome; and $20-$200 billion from direct improvements in worker performance that are unrelated to health. (As an aside, there have been some exciting new developments in research related to understanding of building influences on human health and behavior/productivity. It would be ideal if there were researchers around the world dedicated to conducting such research. Hopefully the programs of CIB and its many academic and institutional members can be directed to bring resources to such questions over the coming years.)

Global economic and competitiveness pressures are driving decision-makers to do everything "better, faster, safer and at lower cost." Specifically, decision-makers want to know what value physical facilities contribute to their enterprises. They want to know how much difference specific safety or security measures will make and whether or not they will be cost-effective if implemented. Product developers are reluctant to innovate unless they can demonstrate the net benefit to the customer of a "better" product, particularly in the building market where so many products are specified to meet dated prescriptive requirement and there is little incentive to differentiate products. Designers and contractors or constructors seeking means to reduce costs and cycle time face only diminishing margins unless they can find ways to capture the value they help create in "better" buildings and facilities. Code officials, whose principal concerns are compliance, i.e., "does it meet the code," typically have little incentive or interest in solutions that provide more than the minimum required to meet the law. Owners tend to discourage other than traditionally prescribed solutions because they aren't sure they can capture added benefits from solutions better than what is specified in the code. The implication of what I'm suggesting is what if they could? What if owners could capture the "value add" of a building that is better than just code compliant? What if the designer or contractor could capture the value add of making a building "better" by increasing its life cycle performance?

In other words, the ability to measure and predict the consequences of distinct differences in building performance would open a whole new array of options for making buildings better and for better rewarding those who risk choosing to do so. In an environment of global competitiveness this is the only attractive way forward, i.e., develop quantitative tools to optimize building performance in the context of life cycle use.

How do we measure Building Life Cycle Performance? This said, how do we approach being able to measure and predict building performance? How do we measure the influence of a building on the performance of its occupants or on the success of the enterprise within it? Figure 7 provides a suggestive framework for addressing this question. It depicts the inputs to the facility, its interactions with the occupants and the net consequences of these interactions. The overall metric for building net value add is measured across this whole complex system. Ultimately, doing what is suggested by this figure will require years of research to get answers to a host of as yet unanswered questions and a broad new set of capabilities including, I suspect, most of the following:

- Models of the human, economic, social, and environmental context in which a building is/is to exist.
- Fundamental understanding of physical phenomena governing building performance in context of life cycle use.
- Fundamental understanding of building influences on human health and behavior/productivity.
- Incisive measurement systems to obtain such knowledge.
- Verified computer-based models/simulations for proof.
- Practicable predictive tools to deliver such knowledge.
- Accessible infrastructure (data, etc.) to support them.

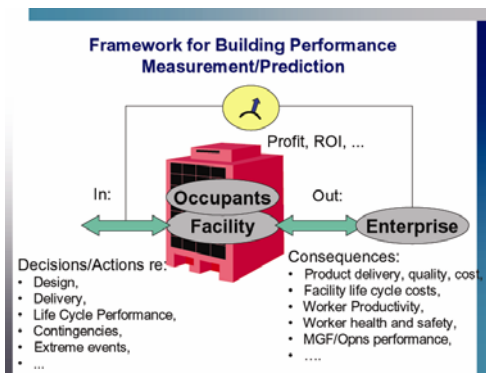

Figure 7.

Until recently, we simply have not had the technologies or the means needed to address these questions. The combination of advances in information, computing, sensing, modeling and simulation technologies and the pressures generated by many of the events driving the activities described earlier are rapidly changing this situation for many of the physical aspects of, at least, the facility-related physical aspects of this system.

Therefore, let us simplify the framework to that shown on Figure 8. There is much that can be done now to model and predict building performance as defined in this simplified system. However, there are even significant gaps in our ability to predict important aspects of building life cycle deterioration, reliability, etc., that remain to be understood. Of even greater concern is the absence of critical underlying definitions, protocols, standards and conventions needed to effectively characterize buildings, their constituent parts and systems for use in realizing models or field-able measurement systems of the sort depicted on Figure 8. This is a need that we can and must address now.

Target Standards. I am convinced there is much to be gained from a collective effort to provide the following target standards:

Target for near term development of international standards for…

- electronic representation of buildings,
- interoperability of building performance analysis software systems,
- life cycle building/facility information knowledge bases,
- performance of fielded systems for real-time building/facility/construction-site data capture.

These are, most likely, essential building blocks for developing the ability to measure and predict building life cycle performance or for optimizing construction processes. The existence of such standards also would significantly accelerate the development of a number of breakthroughs in construction and building. Significant activity is underway at centers around the world to address some of these standards needs, including notably the efforts of International Alliance for Interoperability (IAI) International [8]. At the CIB World Congress in Wellington in 2000, [9] I opined that we are entering an era of unprecedented breakthrough change in construction and buildings.

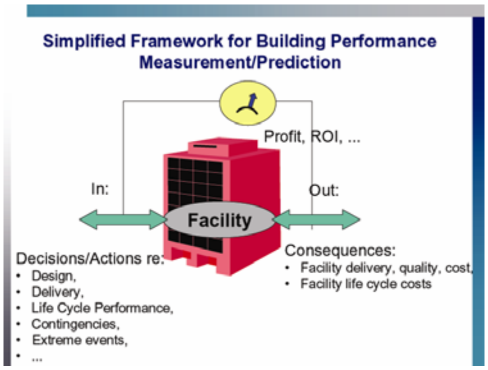

Figure 8.

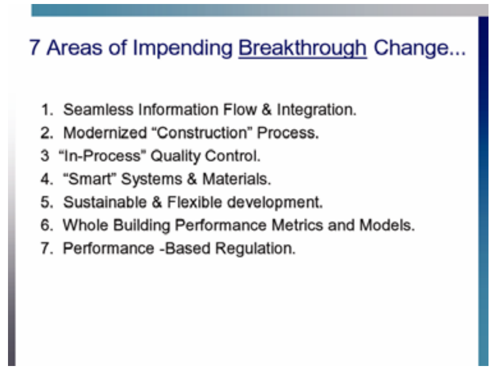

Figure 9.

Specifically, I suggested that the seven areas of breakthrough change listed in Figure 9 are imminent. The existence of the set of target standards outlined above would enable most of them as follows:

1. Seamless Information Flow & Integration. This is the vision of FIAPP, fully integrated project processes, one time data entry, seamless information flow across and among players, life cycle stages. The forenamed standards are essential to such integration.
2. Modernized "Construction" Process. Full use of state of the art IT, sensing, feedback/model-based control systems and automation technologies as now practiced in many areas of manufacturing requires these standards for its development.
3. "In-Process" Quality Control. Buildings and facilities that work as designed when they are assembled and continue to do so for their useful lives; facilities with predictable reliability and safety so that modern systems of process quality control can be applied to replace antiquated notions of building regulation and health and safety compliance management. The listed standards are a necessary but not sufficient for achieving this. Clearly however, such standards would go a long way to motivating product developers to move on this direction.
4. "Smart" Systems and Materials. Smart systems know what to do to work right and if they begin to drift from desired performance they either self-correct/heal or notify those who can do it for them with minimum delay or service interruption. The situation here is similar to that above. Some might argue that until building life cycle performance metrics exist there will be little movement in this direction. I don't agree. There is so much being done on this front in other fields that as such products become available, standards such as I have identified will encourage others to use these standards and work on key aspects of building performance metrics needed to sell the product innovations they support.
5. Sustainable and Flexible Development. Cost-effective technologies for facility life cycle quality and performance optimization assuring minimum impact/burden on future generations. Life cycle databases and fielded real time measurement systems will enable the research needed to achieve these goals.
6. Whole Building Performance Metrics and Models. The combined abilities to model and simulate whole building performance and measure in meaningful quantitative terms the net value contribution of the facility in terms of the metrics important to the owner/occupants. The first part of this is enabled by the listed standards. Hopefully, that, in itself, would motivate researchers to pursue the balance of the needed knowledge for comprehensive measurement/prediction of building life cycle performance.
7. Performance-Based Regulation. Real performance-based regulation with the measurement and predictive tools required to implement it cost-effectively, and to assure community goals - in terms of safety, security, health, etc. - are met. This, most likely, will be one of the last pieces to fall into place. Those who produce the new products enabled by 1 to 4 above will most likely be able to lead the movement to true performance-based regulation and derive the greatest benefits from it.

The case for such collective action is convincing.

Summary

I have outlined a series of events which have taken place in the United States as a consequence of, or otherwise subsequent to, 9/11/01 and the first Global Leaders Summit. Similar activities are taking place elsewhere. I have suggested that these events point to the need for a concerted global effort to produce, in the near term, a set of international standards to guide the rapid introduction and adoption of information and advanced sensing technologies into buildings and construction. These in turn, I have argued, will enable a broad set of innovations which will not only benefit the industries of construction but also move us closer to the "Holy Grail" of quantitative measurement and prediction of building life cycle performance.

Clearly, no one of us has all the resources or competencies needed to produce these standards. Nor, I suspect, would many of us be likely to accept or seek the adoption of standards for such use that were developed entirely, and/or held proprietarily, by others. That leaves us one choice. That is to work together to put these standards in place. We look forward to partnering with those among you who agree. Thank you.

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