Proceedings of a Workshop to Review PATH Strategy, Operating Plan, and Performance Measures

Michael Cohn, Editor, National Research Council

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Michael Cohn, Editor

Board on Infrastructure and the Constructed Environment
Division on Engineering and Physical Sciences
NATIONAL RESEARCH COUNCIL
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Preface

The Department of Housing and Urban Development (HUD) asked the National Research Council (NRC) to review and comment on its 2005 draft *PATH Program Review and Strategy, Performance Metrics, and Operating Plan*. A public-private initiative started in 1998, the Partnership for Advancing Technology in Housing (PATH) is dedicated to accelerating the development and use of technologies that improve the quality, durability, energy efficiency, environmental performance, and affordability of housing in the United States.

To accomplish this task, the NRC established a planning group to conduct a one-day workshop. The workshop participants included the planning group and representatives of PATH's diverse stakeholders. They discussed PATH's proposed program goals and measures and provided suggestions for improving them. These workshop proceedings provide an edited, but inclusive, transcript of that discussion. The appendixes give details on project logistics and include a reprint of the draft PATH performance metrics and operating plan provided to the workshop participants as well as additional written comments received from participants after the workshop.

There was no attempt to develop consensus findings and recommendations. It is hoped nevertheless that the feedback provided by these proceedings will prove useful.

The NRC and the planning group recognize the contributions of the workshop participants and appreciate this opportunity to help guide the future of a program that is vital to improving the design, construction, and performance of American homes.

Manuel Gonzalez, *Chair*
Workshop Planning Group

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1
Introduction

Michael Cohn
National Research Council

The National Research Council's (NRC's) involvement with the Partnership for Advancing Technology in Housing (PATH) started in 2000 with a three-year review and assessment of the PATH program. The resulting report, *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing,*[1] included a series of recommendations regarding the focus of the PATH program's goals and the performance measures used to manage the program and assess progress in its formative years. Subsequently, the Department of Housing and Urban Development (HUD) asked the NRC to convene a workshop to assess PATH's most recent draft strategy, operating plan, and performance measures to determine their responsiveness to the recommendations in the *2002 Assessment* and their suitability for guiding PATH into the future.

The Workshop Planning Group includes members of the 2000-2002 NRC assessment committee as well as new members who offer a fresh look at the PATH program. Experienced in housing design, development, construction, real estate, research, and performance evaluation, they planned the workshop and will also lead the workshop discussions.

The workshop is focused on the draft *PATH Program Review and Strategy, Performance Metrics, and Operating Plan*, which all participants had a chance to review.[2] Workshop participants will comment on a number of questions: Do the goals of the PATH program convey a clear idea of what PATH is trying to achieve? Are the performance measures effective in assessing progress toward the goals? Do the goals and measures provide an adequate indication of innovation in the housing industry? Workshop participants will also discuss possible strategies for improving communication among all the players in housing and housing innovation.

The workshop begins with an overview by Carlos Martin, PATH program manager, who will describe why HUD sponsored this activity. Manny Gonzalez, from KTGY Group, Inc., will summarize the NRC's *2002 Assessment* recommendations and HUD's response. Sarah Slaughter, from MOCA Systems, will address the grand ideas that shape innovation in home construction and the role that government programs play in promoting innovation. Mel Mark, from Pennsylvania State University, will discuss overarching issues related to performance measures and why they are important to PATH and the success of the program. These presentations are intended to frame the workshop issues and set the stage for the workshop discussions of PATH's draft strategy, operating plan, and performance measures.

The workshop discussions will focus on the three major PATH goals, with each session led by a member of the planning group and including several people who were instrumental in producing studies and reports that are referenced in the PATH strategy. The final discussion will focus on the path forward and how the goals and performance measures can be improved to increase the probability of the success and growth of PATH.

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[1] National Research Council, 2003, *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing*, The National Academies Press, Washington, D.C.

[2] The draft document (version 8/26/05) that was provided to workshop participants is forthcoming at PATHNET.org.

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Peter Drucker, the management guru, highlighted the importance of performance measures when he noted, "You can't manage it, if you can't measure it." However, this simple truth often causes a dilemma because, as Albert Einstein pointed out, "Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted." HUD is looking to this group to discover the truth that will help solve this dilemma.

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2
Overview of HUD Objectives

Carlos Martin
Department of Housing and Urban Development

PATH is the only federal government program specifically focused on the housing innovation pipeline. The Department of Housing and Urban Development (HUD) is continuously looking for ways to improve this program. In 2000, HUD sponsored the National Research Council (NRC) assessment of PATH. That study of the NRC Committee for Review and Assessment of the Partnership for Advancing Technology in Housing resulted in the report *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing.*[1] At that time, the early development of PATH presented many difficulties.

The Department of Housing and Urban Development has made major changes in the structure of PATH in response to the recommendations of *Promoting Innovation*. The most significant recommendation was that the program should focus more on the issues of barriers to the innovation process including studies to better understand those barriers.

Initially, about 15 percent of PATH's budget was used to address barriers. At this time, addressing barriers constitutes about 80 percent of the PATH budget, including issues such as how consumers value innovative technologies, the training of the labor force to understand and use new technologies, liability concerns for builders and architects, research and development tax credits for manufacturers, and financial incentives for consumers. Identification of these issues came out of a variety of recent initiatives for overcoming barriers to innovation.

Another significant recommendation addressed by the NRC assessment was that PATH should also focus on the diffusion and adoption of innovation in housing and the behaviors and the practices within the market. PATH completed a groundbreaking study of innovation diffusion among homebuilders and has started to look at how they respond to specific technologies. PATH is also looking at consumers' perceptions of housing technologies and manufacturers' commercialization processes.

Since the beginning of the NRC's assessment, the number of people accessing both PATHNET and the industry companion ToolBase has quintupled. Another change has been increased exploration of a variety of outreach media, such as print advertising and other marketing tools, with ongoing collaborations with publishers such as Reed, Handley, Wood, publishers of *Fine Home Building*, and McGraw-Hill Construction. PATH currently has ongoing communications with homebuilders through local National Association of Home Builders newsletters and is developing an outreach program with Home Depot.

The NRC's assessment clearly stated that, in spite of some difficulties, PATH should be continued. The program received legislative support in 2005 with an appropriation of $5 million for FY2006—40 percent less than the program started out with—but it means that it can continue and, hopefully, grow. There has also been discussion of possibly moving PATH to another office within HUD.

[1] National Research Council, 2003, *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing*, The National Academies Press, Washington, D.C.

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Other agencies that address housing innovation, such as the Department of Energy, National Science Foundation, and the National Institute of Standards and Technology, are experiencing similar budgetary pressures. There is an increasing need for collaboration in the planning of these programs.

The NRC assessment also noted that for the PATH program to improve, it needs to have effective performance measures. HUD provided workshop participants with the PATH operating plan and the performance measures in hopes of obtaining a critical review of the proposed performance measures and suggestions for new ways of measuring performance. As a follow up to this workshop, and after further discussions with the Office of Management and Budget regarding the performance measures, PATH will develop its first independent evaluation using those measures.

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3
Overview of the 2003 NRC Assessment of PATH and HUD's Current Response

Manuel Gonzales
KTGY Group, Inc.

In the 2003 NRC assessment of PATH,[1] the committee believed that the program initially placed too much emphasis on research and development; but during the course of the three-year study, it was evident that PATH was making an effort to refocus. The current draft strategic plan provided by the Department of Housing and Urban Development (HUD) for the workshop reflects that shift. The 2003 NRC assessment committee recommended that PATH continue as a federal program focused on identifying, understanding, and removing barriers to innovation in housing, disseminating information, and increasing industry investments in the development of new technologies.

The 2003 NRC assessment noted that because PATH was a new and evolving program, ongoing expert review of the program's performance and its response to those reviews are especially important. Effective program assessment is essential to PATH if it is to be efficiently managed. The NRC assessment report stated that "the program should be evaluated based on whether the activities it undertakes are likely to help achieve its goals and on the quantity and quality of the results of these activities. If PATH undertakes the right mix of high-performing activities, then improvement in measures of innovation in the housing industry can be attributed, at least in part, to PATH."

The draft operating plan and performance measures for PATH should be reviewed to determine if the goals depict innovation in the housing industry and are accurately communicated, and if the measures are effective for assessment of progress toward those goals. This is not an assessment of what PATH has done as much as an evaluation of the plan and metrics for the future.

[1] National Research Council, 2003, *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing*, The National Academies Press, Washington, D.C.

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4
The Value of Technological Innovation in Home Construction and the Role of Government/Industry Partnerships in Promoting Innovation

Sarah Slaughter
MOCA Systems

I have spent considerable time looking at innovations and their diffusion and commercialization. Not only did I study innovation for many years, but also I have been living the process for the last ten years. Ten years ago I headed a team at the Massachusetts Institute of Technology (MIT) Civil and Environmental Engineering Department that started developing a construction simulation system through research sponsored by the National Science Foundation. After about five years, many of the industry participants in that research started asking us if they could start using the simulation technology. In response, I started a company called MOCA Systems and I left MIT in 2000 to further develop and commercialize the simulation system. We have been working on the whole process of commercialization and diffusion. At this point, I am a recovering academic and truly believe in the importance of the PATH mission to advance technology.

Looking at the challenges that are specific to the housing industry, it is important to consider innovation from the owner or occupant's point of view. Consumer objectives for housing improvement include:

- More healthful;
- Safer (in natural disasters);
- More sustainable;
- Affordable to buy;
- Affordable to run;
- Available more quickly; and
- Easier to maintain, repair, and upgrade.

We hear a lot of stories about mold, not only from post-Hurricane Katrina flooding, but also in the living environments of people in different parts of the United States. In some climatic areas, the issue of a healthful home is critical.

A second aspect that cannot be ignored, especially after a year of several natural disasters, is the ability of houses to withstand these extreme conditions. A home should be a safe haven in the case of a natural disaster—whether it is a blizzard, a flood, a hurricane, or an earthquake. For example, a group of students have designed a new type of home that can withstand the forces found in a tsunami for areas in the South Pacific.

Consumers are also concerned about the materials used in home construction and how they can be made more sustainable and make the most efficient use of environmental resources. This includes energy efficiency, as well as the use of construction materials.

Affordability is an important issue. Many young people today cannot afford to live anywhere near a major city. Some of them are commuting two hours into a city because they cannot find affordable housing closer to their workplace. This makes a huge impact on economic development in our country.

Homes also need to be affordable to operate. Anyone who has looked at the cost of heating his or

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her house is concerned about increasing energy efficiency. Consumers are also concerned about the cost of maintenance activities that are required to keep a house in good condition and to keep the value of their primary asset.

The amount of time required to build a house is also a concern. For all of the people who are in the Gulf Coast area, the speed at which new houses are going to be delivered is absolutely critical. Once built, houses may exist for several hundred years. In Boston, there are houses that have been around since the 1600s. We need to recognize that houses need to be durable and also be able to accommodate changes over time.

The original PATH goals were to:

- Reduce cost by 20 percent,
- Reduce environmental impact by 50 percent,
- Reduce maintenance costs by 50 percent,
- Improve occupant safety by 10 percent, and
- Improve worker safety by 20 percent.

The NRC assessment determined that these goals were inappropriate for PATH. They may be inappropriate for PATH, but these types of goals are consistently used to manage companies. However, in construction we always say they are not possible. We can do it in construction if we really focus on how they can be accomplished most effectively. It is not impossible, since many innovative techniques, materials, processes, and equipment are available to achieve these goals if they can be applied effectively.

For an entrepreneur, there are really only two ways to succeed. One is to respond to an existing demand—provide a faster computer or a better soap. The second is to create demand. Responding to demand and creating demand are very different strategies and they have different measurements in terms of their effectiveness, time periods, risks, and distributions of benefits.

In residential construction, the primary drivers of demand for innovation are the builders, which include the general contractors and the specialty contractors, and the owners or consumers of the homes (Table 4.1). In residential construction, as opposed to commercial construction, there is an enormous variety of owners, from the individual who owns one or two houses, to an organization, like the Air Force, that owns thousands of homes.

Owners are responsible for financing the house and for funding long-term operations and maintenance. This becomes an important leverage point in the construction industry. Builders, both the general contractors as well as the specialty contractors, influence innovation because they are responsible for buying materials, installing equipment and specialty systems, and using construction tools and equipment.

The manufacturers influence both the general and specialty contractors. Also, there is the influence of the architects and engineers. When we think about the design of a building—the specific layout and the specification of the systems and materials that are installed, the architects and engineers can be a key leverage point for bringing in new technologies. They tend to seek new information and to use their resources to identify the technologies that are available, assess their impacts, and use this information in different environments.

The differences in innovation in residential construction compared to commercial construction are in part due to a less direct involvement of architects and engineers for specific buildings. Architects that work with large residential builders do not have the same influence on the selection of material and systems as they do in commercial construction. For commercial construction, there is a direct contract between the owner and the architect/engineer (A/E) and the A/E is responsible for identifying the critical needs and translating them into innovative designs and specifications. In residential construction there is much less involvement of the A/Es. Consequently, A/Es do not provide a strong a conduit for the identification and use of innovations in residential construction.

In commercial construction there is often a direct relationship between the builders and the material producers and suppliers. In residential construction, because there are many more and smaller

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builders, the distribution channel acts as a filter, or in some ways as a barrier to communications between the manufacturers and the buyers of the products. The filtering of communications in the distribution channel influences the diffusion of innovations in the residential construction industry.

Commercial projects, by their nature, use a larger volume of materials than do residential projects. This impacts the strategies for the manufacturers and how they focus their resources to bring out new technologies and reach the critical mass for sustainable diffusion in the industry, which often entails focusing on commercial markets rather than residential applications.

The large builders in residential construction can be an incredible leverage point. There is often a direct connection between the choices offered to the owner and the builders' preferences for equipment, processes, and materials. In residential construction the builder says, "This is what we build, would you like to buy it?" In commercial construction, the owner says, "This is what I want, who is going to build it for me?"

For residential construction, there are three major sources of innovations: manufacturers, builders, and owners. The types of innovations that manufacturers, builders, and owners come up with are very different and the benefits that they are looking for are also very different. The diffusion of innovations is driven by the balance between the relative benefits and the costs, and the distribution of the costs, risks, and benefits.

There is often a focus, particularly in the construction industry, on manufacturers as a key source of innovation. Manufacturers are looking for commercialized products, often innovations that can be imbedded in a physical object or system. The reason that they are coming out with these new products is that they expect higher margins, an expanded market share, or a new market share.

TABLE 4.1 Sources of Innovation

Source	Type of Innovation	Benefits
Manufacturers	Commercialized Products	Higher Margin Expanded Market Share New Market
Builders, including specialty contractors	Process Construction Integration Prototype Products	Higher Margin Faster Better Reputation
Owners	Prototype Process Prototype Product	New Function Better Performance Lower O&M More Attractive

There are builders, both general contractors and specialty contractors, who innovate all the time. If you have ever gone to one of the watering holes where the builders hang out after work, you would hear that they are constantly talking about the problems they ran into that day, and what they did to solve them. There is a constant identification of problems and the solutions to those problems because they have to keep the construction going. They can't stop to call up the engineer or the manufacturer, and then wait weeks for an answer.

Builders come up with two types of innovations: process and product innovations. Process innovations offer the potential for the builders to become more efficient, more productive and effectively use resources to achieve a higher profit margin. Builders are also motivated to adopt innovations that increase the speed of construction, because if they are on a project too long, fewer houses are going to be

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built and sold.

The other type of innovation is the use of new and better products. Builders are concerned about their reputations and the reputations of the products (i.e., homes) that they produce. The selection of a homebuilder is often based on a reference from the last home buyer. Builders are constantly innovating by integrating components produced by a myriad of manufacturers. They have to solve the problem of how the elements are going to work together. Builders often come up with prototype innovations for products. They will say, "I need a tool or a component that does this" and develop it.

Interestingly, owners will also innovate by solving specific problems. They are generally not going to obtain the benefits from improving the construction process. What they want is a house that has a new functionality, for example, the newest telecommunications, and they often innovate in how to add this functionality without ruining the house.

Then there are aspects of better performance. Anyone who is paying higher fuel bills this winter is going to start looking at how to improve the energy efficiency of their house. They may be putting plastic over the windows or doing a lot of other things to improve performance. The homeowner may also be looking for lower maintenance costs. If New England winters are tough on wood siding, owners want alternative materials that provide better performance and at the same time maintain or improve a home's comfort and aesthetic appeal. The types of innovations developed by homeowners are prototypes because they are not going to obtain the benefits from using that innovation over time. Rather, they are looking to solve their current need.

There are two drivers of the diffusion of innovations: creating demand (also called technology push) and responding to demand (also called demand pull).

In the early days of personal digital assistants (PDAs), nobody really knew that they needed one. Now everybody has them. I have one built into my phone. In the case of PDAs, the demand was created. It was technology push. The risk for an innovator is that they may not be able to reach the critical mass of demand to achieve full diffusion.

In residential construction, the fragmentation of the market makes it difficult to reach that critical mass of buyers. The early adopters are difficult to find and communicate with. Manufacturers of new products may go to every homebuilding show and still only meet a small fraction of the potential market in any one geographical area. The fragmentation of the residential construction industry makes a technology push approach very difficult.

Because every single house is different, risk is also an issue. Given technologies A, B, and C and adding D as the innovation, but switching A to put in F, could lead to everything falling apart. A classic case is the delamination of fire retardant plywood. It was approved, it performed well under certain conditions, but when it was used in a new condition, there were massive failures that put homebuilders at incredible risk. When applying technology push, there is a need to identify the risks associated with innovations, particularly when there is a constantly changing set of complementary technologies that are all being incorporated into buildings.

The identification of benefits and who captures the benefits can be a risk for the technology source. For example, if there is a great innovation, but the only people who can obtain that innovation are large-scale builders, then the manufacturer needs to prove to the large-scale builders that they will benefit from that innovation. That then leads to the central aspect of technology diffusion—dissemination of information.

The type of information required for housing differs so significantly throughout the United States—from Alaska to Hawaii, from Florida to Maine—that when a technology source is trying to create demand, it may face significant issues in deciding what information is going to be applicable to each user. The user may be either the builder or the homeowner. The diversity of environmental requirements, preferred design styles, and the application of technologies differ, and so does the information needed to create demand.

There is also the information about the application of new technologies. There is an incredibly diverse work force associated with homebuilding. Even within a single trade there are different training programs. How much and what kind of information does the manufacturer need to provide—in what

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format, in what language, how much of it is text and how much of it is pictures? The answer to these questions becomes critical to the success of a new technology.

The final issue regarding information is keeping the fragmented, diverse, and constantly changing set of users of the innovations up to date with information about the long-term impacts and particularly issues regarding the integration of technologies. When using technology push, there needs to be a continuing relationship between the early adopters, the mid-adopters, and the late adopters to maintain the diffusion momentum of that innovation.

There are interesting exceptions to the impact of these market risks for technology push in residential construction. Two of them are non-profits and the federal government. In these sectors, organizations can effectively develop technologies that are needed, as well as develop the demand because they are not affected by market risk in the same way as a private company.

For the government, the expenditure of public funds for anything that is connected with a public good can be easily justifiable. Improvement of worker safety and improvement of energy efficiency are examples. During the fuel crisis in the 1970s, there was a big push to develop technologies that responded to the increasing fuel prices; this had an enormous impact on the housing industry.

Universities can be an incredible source of information for technology push in developing basic theories and approaches and translating them into physical forms and processes by developing prototypes. However, there are risks when the government and universities are the sources of technology push. There can be a gap between the development of applied technology and the commercialization of that technology because of organizational mandates.

MOCA's experience in creating a commercialized software system from the results of research undertaken at the MIT is a perfect example. It took a lot of effort to commercialize that technology. The gap between the development of applied technology and creation of a commercialized product is where there is huge risk. The question is, Who bears that risk and under what conditions?

PATH can effectively respond to the requirements associated with technology push in several ways. One is to facilitate demand development. There are a number of specific areas in which that can be fairly easy to accomplish. In some cases, there may be existing relevant demand, but the demand may not have been identified so that someone can respond by developing an innovation. Another is to publicize the benefits and the relative risks in a way that helps adopters make decisions based on the distribution of the costs and benefits. Potential adopters will adopt a new technology when the benefits are greater than the risks. Interestingly, regulations can also drive demand. Requirements for energy efficiency have led to improved construction and more efficient appliances. Regulations have also driven demand for innovation in the auto industry.

In residential construction, both the financial and insurance sectors have contributed to creating demand for innovation. An insurance company can lower premiums for the use of technologies that make a house safer and more resistant to natural hazards. Other organizations, like utilities, create demand by offering rewards to people who reduce the consumption of energy in their houses.

Reducing risks can also increase demand. There are a number of different ways in which the federal government and other organizations can reduce the risk of adopting innovations. One of them is to develop capacity. By increasing capacity, the heterogeneity in user population is decreased. For example, a consistent training program for residential electricians reduces risk by increasing homogeneity of information and facilitating its flow. There are also ways to look at distribution channels to determine how products and services are being delivered to the different user groups. For example, Internet search engines that can help buyers to find what they are looking for can create an incredible shift that allows the direct acquisition of materials, systems, components, and equipment and the relationships between buyers and suppliers.

Production equipment can also influence the development and diffusion of technologies. For example, Air Products, Inc., developed a coating system for low emissivity (low-E) windows. They wanted to sell specialty gases that were used to apply this coating. At first, none of the window manufacturers wanted to use the technology because it required new production equipment. So Air Products developed the production equipment and leased it to the window manufacturers on a long-term

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basis in order to overcome that particular obstacle. Low-E windows now have a 95 to 99 percent market share. It took two and a half years to achieve that kind of market penetration. This is an example of looking at elements in the production chain to determine what is needed to use diffuse innovation.

Tests and standards are a way of decreasing the risk inherent in the diffusion of innovations. The rate of diffusion is increased when information is immediately available and people in different parts of the country know what works well for their specific conditions and how a product has performed with other systems.

Pulling together potential buyers and potential commercializing entities to bid on the rights to commercialize innovations can stimulate pre-commercialization efforts, but requires full disclosure of what it will take to transform applied research into a commercial product.

When using demand pull to diffuse innovation, the first step is to identify what is actually going on and problems that people are running into. When starting the work that eventually became MOCA, I worked with builders to determine what problems they were encountering. I stayed on the construction sites, watched what they were doing, watched what the problems were, and talked to the builders about the problems they were encountering. In this way, I learned about the specific systems and processes. Identify the problems provided an opportunity to present solutions.

There is demand for innovation from both builders and consumers. Consumers have incentives to look at long-term performance, and builders do not win bids when their projects don't work well for consumers. When the needs of both builders and consumers are aligned, the strength of that demand increases.

Within the consumers' critical requirements are aspects of short-term versus long-term performance, as well as accommodation for change. Frank Lloyd Wright came up with a beautiful Usonian house that was made from cast-in-place concrete. It had many wonderful attributes, but it was not flexible in accommodating changes over time, and most people like to add on to and change their house. The Levittown house is an example of built-in flexibility. When first built, they were all the same. Now they are all different. The fact that they were working off the same basic structure often cannot be seen. Being able to accommodate change over time can be important.

PATH can facilitate direct contact between the sources of demand and innovation. Often an organization has an innovation but doesn't know how to get to the people who would be able to use it. There are issues that are associated with applicability, relevance, and the distribution of benefits and costs. Creating showcase environments can work for these situations. There can also be special convocations of producers and users within certain geographic areas or market segments, allowing a direct connection between the sources of the innovation and the users of the innovation.

In commercial construction, a new product, system, process, or equipment may be slightly wrong when first introduced. Maybe the flange is in the wrong place, or maybe it is just too large in one dimension. If the manufacturers do not have direct connections with the users, they do not know why the product is not selling. If there is direct connection between the sources of the innovation and the users of the innovation, there can be renewal, revision, modification, and improvement of those innovations to meet user requirements.

The distribution of information can also be modified. Ten years ago, architects, engineers, and builders all had volumes of the *Sweets Catalogues* on their shelves. When they needed information about possible products to solve a problem, they would pull out the book and look through it. Now, *Sweets Catalogues* are online, and there are also alternatives, such as using an Internet search engine. However, this can be a problem, because the quality of the information is not known. There has been an incredible increase in the availability of information without a system to evaluate the quality of the information from so many different sources. In construction, the distribution channels for information are changing, but there is also an increased risk from those different sources.

Manufacturers of equipment and other high-tech companies constantly talk to their users. They know the users have been modifying their product. For example, in a medical laboratory, any given piece of testing equipment will probably be modified within a year. It either needs to be connected up with something that was never anticipated, or the users have discovered how to make it work more efficiently.

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A lot of manufacturers visit their lead users—the ones who are most likely to come up with those prototype processes and prototype products. Often, the users will share that information because if the equipment is improved, the user will not have to bear the costs associated with the modification. As mentioned earlier, owners can be sources of innovations—particularly large, high-stakes owners, such as the U.S. Air Force. The issues they are facing in rebuilding damaged housing or building new houses for new deployments and base realignments are creating intense needs for better, more efficient, systems. They are going to be a source of innovation because they are raising the bar higher and higher. They are telling architects, engineers, and builders that building a thousand houses cannot take 12 years or even five years, it has to be done in a year and a half. That raises the bar.

My research team at MIT found that the rate of innovation and the implementation of innovation increased as the owner's expectations went up. When an owner says, "I know it is going to be difficult, but I want this pharmaceutical R&D lab built in nine months," most of the builders say, "I can't do that so I am not even going to bid on this project." But a couple of builders will step forward and say, " I think I can do it if you will let me try this, that, and the other thing." If the owner's requirements are high enough, innovation will happen. The benefits will accrue to the different parties despite the risks, especially if there is an acknowledgment of risks on the owner's part.

To summarize, from an owner's point of view, improving the quality, cost effectiveness, and availability of housing in the United States is critical. PATH's objective is to leverage the existing opportunities or existing assets in the housing industry, including commercial, government, and academic. To accomplish this, PATH needs to understand the distribution of the benefits, the distribution of the costs, and capabilities of the various sectors.

Another element of a program to advance technology—and this is where Operation Breakthrough and a lot of other previous programs by the federal government did not focus—is to look at how to create a sustainable momentum. The objective should not be to fund this program indefinitely, but to develop a set of capabilities, approaches, and assets, which can be intellectual assets as well as physical assets, that will sustain innovation in the housing industry. There needs to be a long-term approach, not just a year-to-year approach.

DISCUSSION

MR. EMRATH: When you talked about insurance incentives as a leverage point noting that an insurance company might give the owner a cost reduction if the home was safer, do you have an example of where that has occurred?

DR. SLAUGHTER: In industry there is disaster insurance, which is now being offered to owners of large commercial properties, as well as occupants of commercial properties. The idea is that if you are in a high-risk industry, or if you are in a high-risk location, that you would be able to buy insurance. One part of the discussion, but I don't know that they have moved forward on it, is whether certain characteristics of buildings would lower the insurance rate associated with the natural or man-made disaster insurance.

So, for instance, if you had a "hardened" building that protects against damage from a bomb, your insurance rate would be lower because the probability of damage to the property and injury to occupants would be reduced.

MR. WEBER: Just to expand on that, the Institute for Business and Home Safety, which is spearheaded by the insurance industry, does offer guidelines for what they call "fortified for safer living" homes, and many of their members offer discounts for meeting those guidelines.

MR. ENGEL: Usually the insurance industry says we need more data when you ask for a discount on home insurance. It has been one of the most difficult things HUD has tried.

I think some of the structure discussed in the presentation is absolutely right, but within the context of a homebuilding industry, it doesn't work. In commercial industry, yes, if someone is building an office building, he has very specific requirements. That is not the case in homebuilding.

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DR. SLAUGHTER: In some cases you have a very concentrated large owner, like the Air Force. In that case, they do have a very specific set of demands. You have somebody who owns and leases apartments. They may also have a specific set of demands and they may be looking particularly at operation and maintenance costs.

You are right. When you look at the majority of single-family homes and non-rental properties, there is a diffuse demand and a variation and heterogeneity in the demand. Yet, we continue to build homes and they sell. Part of the risk that homebuilders take is the heterogeneity of demand. They attempt to predict what it is and what is going to be important to a potential buyer.

For example, remember when "great rooms" were the big style and a new house had to have this great big room. The builders had to guess what proportion of their potential buyers were going to want a "great room" and build houses that have them. Then there was a change in preferences to smaller, cozier, but open plan layouts. Shift in demand becomes a very high point of risk for builders, particularly if they are building in advance of their contact with the owners. In Japan and in Finland, there has actually been a very interesting shift in terms of the communication of the owners' needs to the builders. In some cases the consumers say, "This is what I want before you build my house." There are a lot of large-scale builders in the U.S. who do that right now.

MR. HODGES: I would like to speak to that. Builders have become very nimble at meeting very specific customized requirements of their customers. We call it mass customization. My company now has 3,000 floor plans and we have 150 different granite countertops from which the consumer can choose. Consumers are very explicit about what they want and builders have to meet that demand. However, consumers do not demand technologies that improve performance but do not alter the appearance or size. Builders have become quite nimble at meeting a very diverse and very exquisite set of fit and finish demands of the consumer. The consumer doesn't come in saying, "This is the type of roof shingle I want" or "This is the HVAC system I want because it does the following things." They are uninformed. Were they to be informed, believe me they would ask and we would find a way to deliver it. So, I think the capacity is there. It is just the countertop the consumer wants. That is what they are interested in and they ask a lot about it.

MR. EMRATH: One of the points is that appearance is really important. If it looks nicer, consumers definitely will drive that innovation. The issue here is about something where the benefit isn't so obvious.

DR. SLAUGHTER: But there are ways in which the builder can present those questions to the homeowners. Not asking which HVAC system they want leaves the definition of the choices up to the homeowners, since they have no idea what their choices are and the effect of each possible choice. But if the builder says: "This is the initial cost for each one of these air conditioning systems and this is what the long term operating costs are," they are going to be able to make their choice.

Consumers will be able to make those choices if there is an analysis or ordered logic. Builders can provide buyers with up to 15 different attributes and then list the different levels of importance for the attributes or performance on those different attributes. The consumers will consistently sort on those specific attributes to show exactly what their relative priority is and their price points. Builders have offered the opportunity to choose fit and finish, but have not offered that opportunity for all the systems.

There are some people who had recently built their houses on the Gulf Coast to much higher standards than required by the building code. It was an option that was offered by their builder. The result is that their homes were the only ones left standing. If improved performance is offered as an option, the owners will be able to make a choice based on their own values and priorities.

MR. HODGES: I agree with that but there are lots of problems. For example, when estimating the long-term operating costs there are a lot of assumptions regarding future costs for energy, labor, and materials. The prospective owners, sometimes for a good reason, may not believe what someone tells them about how much they will save.

DR. SLAUGHTER: That was the case when the appliance ratings came out. If you have a teenager and they stand there with the door to the refrigerator open, the efficiency rating on that refrigerator has no meaning. The way a system is used may eliminate any advantages to an innovative

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design.

MR. HATTIS: We are really touching the fringes of a very important issue related to the housing industry. I mean, the PATH goals relate to improved performance in a variety of areas that are somewhat abstract, like durability, safety, welfare, and affordability, not just in terms of the initial performance of the house, but over the life of the building. We are dealing with an industry that, as we have heard from the examples of countertops and so forth, is primarily product-oriented, not performance oriented and oriented to first cost, not life-cycle cost and benefit.

What PATH has to do in this area is change those two ingrained characteristics of the housing industry and if that won't happen, then PATH will probably have marginal success. If that happens, PATH will have remarkable success.

DR. SLAUGHTER: Large-scale builders, who build the houses, sell them to the new owners, and then they end their relationship with the owners. However, there is also the huge population of small residential builders, who will work on a house for multiple generations. For example, I was living in a house that was built in the early 1700s in eastern Pennsylvania. Four generations of carpenters, who lived in that neighborhood, had been working on that house. There are builders that focus on the first and initial costs and there are builders that focus on the long-term costs. These different populations respond to innovation in different ways.

MR. CHAPMAN: Two comments: (1) Do not forget that builders are generally very market driven; and (2) the whole system from financing, appraisals, and resales, is set up to deal with upfront-cost and not with long-term sustainability.

On another matter, the problem we have with technology diffusion in this industry is with the supplier. The supplier dictates what can and cannot be done. I am in Santa Fe, New Mexico. There are products that are simply not available to me. There are also products that are available today that will not be available tomorrow. If I make a technology jump with a new widget for a home to make it perform better, it may be available for the next six months and after that it is no longer available. I am forced to go back to using something that I used previously because it is the only thing I can get. That is a wide-spread problem in the housing industry. When it comes to barriers, we need to consider the supply chain as a key part of the process.

DR. SLAUGHTER: There are ways to address that problem. Other industries have adopted a just-in-time supply strategy, to streamline the supply chain and eliminate the need for large warehouses with inventories that need to be redistributed. Through Internet search engines, builders can deal directly with the manufacturers. If a manufacturer knows that Albuquerque is a great place for its product, maybe it will devote resources to Albuquerque; however, they may not know it if they go through a distributor in Texas.

MR. KASTARLAK: I think there is more to that issue. In your flow chart of the innovation process (Figure 4.1), the role of the architect is almost an afterthought. That shouldn't be. Why? Because I don't know how doctors or lawyers would feel if they were not in control of their own profession. Architects in this situation are not in control. Yet architects have introduced many innovations.

Beyond that, you pointed out the issue of externalities. Decisions are made because people like living certain ways. Some people can afford whatever they want. PATH should concentrate on the more difficult issues where the people cannot afford many options, but are looking for a decent home.

We have to follow the money trail to learn where the money is going, why decisions are being made the way they are, and then take measures to affect the process.

There should be a push for radical solutions that maximize the public benefit and help housing become more cost-effective and sustainable. In other words, PATH should create a brand that will be recognizable by every home buyer as representing improved value.

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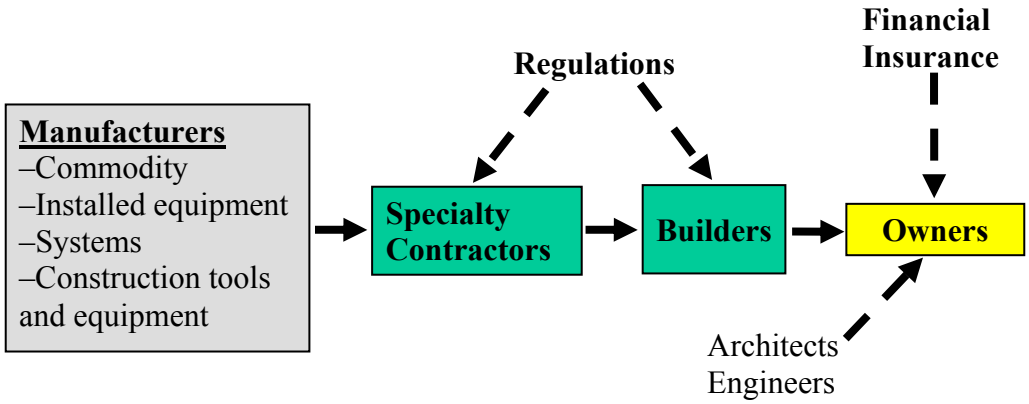

FIGURE 4.1 Innovation value-added chain.

DR. WHITE: If you were sitting where the PATH staff is now, what advice would you give them about how to take the ideas that you presented and turn them into steps that the PATH program can take now and in the future?

DR. SLAUGHTER: I think that various touch points I have listed in Table 4.1 offer significant opportunities. PATH needs to understand and focus on the incentives that motivate all of the parties in the partnership. Manufacturers have an incentive to get their product out to customers. PATH can leverage those basic incentives for any commercial organization to make money most effectively. Universities and government labs have an incentive to get their research widely known to prove that they have an impact and provide a benefit, and to prove that they have been using their resources effectively. If PATH can leverage those internal organizational incentives it will be able to effectively advance technology in housing.

By knowing what all of the incentives are and what resources are available from all sources, PATH can facilitate the process of bringing them together. Facilitation is a very appropriate role for the federal government.

MR. HODGES: I think the draft strategy is excellent. The list of barriers is fairly complete, but I could add about eight more. Being a homebuilder, I recognize that it is an industry that has hundreds of years of tradition unhampered by progress. That is largely because builders do not accept responsibility for building sciences and technological advancement. We don't see it as part of our job.

If you look at the 20 largest homebuilders, there is only one that has a research and development component. We all look admiringly at Pulte Homes, because it has a building sciences component in the organization. K. Hovnanian is about to launch one in emulation of Pulte. For the top 100 homebuilders, purchasing is the innovation gateway to the organization. It is where decisions about what to buy and how to build homes are made.

There is not a purchasing agent for homebuilders in the U.S. who cares about innovation. They care about dollars per square foot, bricks and mortar costs, and doing it fast because they have lots of communities to set up and homes to build. Their bonus is based on bricks and mortar costs. To them, innovation creates more work because they need to change the construction documents. If the innovation is a different roof shingle installed the same way, then they will use the new roof shingle; however, if it involves a change at the construction site, the purchasing guy is not interested.

Until the homebuilding industry becomes committed to the notion that research and development is partly our responsibility, we are not likely to promote innovation or force it into our organizations. That is a massive barrier that did not make the list. I think it needs to be understood because we have got to get homebuilding companies to understand that they have a role. It is not just the purchasing agent's job to decide what materials we use to build our homes. Builders need to have a research and

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development component.

MR. PETERSEN: For me at Pulte, it has been a four-year battle just to get to where I am within the company because there is no financial incentive to do R&D. Pulte would not have a building science component if Bill Pulte did not understand the long-term benefits. The building industry is driven by very short term financial outcomes.

R&D is a difficult sell and it is a struggle day after day to bring R&D into homebuilding because consumers do not want pay for it. The incentive within Pulte is long-term by differentiating the brand. Home buyers will look for a Pulte home because we differentiate ourselves by using better products and by having better processes, but that will take years to accomplish.

MR. HODGES: The division president, whose bonus is based on return on invested capital, is not going to spend money on R&D.

When you make the division use better products and better processes that cost more money you need to get a bulletproof vest. I convinced the company to invest in a building sciences operation, which we are about to launch.

MR. PETERSEN: It is a daily struggle, but I am having some success with getting the voice of the customer back to the suppliers. That is what I am really focusing on now. I have the clout with the suppliers because I can deliver a market for 50,000 or 60,000 homes a year if they develop the right product. That is where I am really starting to see the impact, because it does not cost a lot of money to be the voice of the customer back to those suppliers.

I am starting to get the real bang for the buck for the company by influencing what the manufacturers develop. We are able to influence what our supply chain develops for us to ensure they are going to serve the long-term interests of the home buyer.

MR. HODGES: My short-term strategy is that my company is going to build 50 million square feet of housing in 2006. I went to my company and said I will find technologies that will save $1 a square foot. Let me have a couple million dollars and I will get you $50 million. Now I have their attention. It wasn't about building better houses with sustainability. It was about saving a dollar a foot and we will do it.

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5
Defining Success and Performance Measures for the Evaluation and Management of PATH

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A topic that arises from the discussion of program evaluation involves logic models and how to look at the draft PATH strategy, operating plan, and performance measures. I am going to talk about how these translate into benefits for the program.

In this context, we are going to talk about some selected aspects of the current version of the PATH model and raise some questions that should recur in the three PATH goal discussion panels. I do not want to say "here is the answer," but "here are some of the questions."

Very often, when evaluators are brought to the table, or when performance measurement people come to the table, they start with the development of a logic model. This is a means of capturing and communicating a theory of change, a theory of action, and a notion of what it is that the program does and how that translates into benefits.

There are multiple variants that use different terms, but for our conversation we will use the term logic models. An evaluation logic model usually includes inputs, activities, outputs, and outcomes. PATH has adopted a frequently used form of a logic model that measures performance by tracing the flow of inputs, activities, outputs, and outcomes.

Inputs are the program's resources, such as its budget, staffing, and physical resources that are allocated to the program or that come from partnerships. Activities are the things that are done. Sometimes when people are talking about this, they use verbs. These are programs that have been created, things that are done in one way or another to get to the objective. Outputs are products. For example, an activity may be creating a curriculum for a training program for builders. The outputs are the sessions that are conducted and how many people received training. The outputs then would be the sessions that are conducted and how many people received the training, similar to McDonald's count of how many hamburgers they have served. Then we consider *outcomes*, the effect the output has on the goal.

Sometimes I like to think about a logic model as a set of dominoes. It is like knocking over a series of dominoes. Eventually the last domino falls or the program achieves a certain goal. Sometimes these logic models include facilitating conditions that make it easier or inhibiting conditions that may make the program less likely to be successful.

When people talk about logic models, what they are suggesting is an "if-then" logic. If we do this, then this other thing will result. If we put these training programs out there, certain kinds of learning will occur and if that learning occurs, then certain kinds of changes will occur in practices. For example, if we train builders about R&D, they will understand its value and they will undertake R&D activities that will provide innovative technologies that improve the value of houses. One of the problems that one sees as an evaluator is that people sometimes list these things, but there is not much of a logic to connect them. The dominoes do not all fall.

PATH has applied a logic model to its operating plan and performance measures. Looking at a page from the metrics, there are inputs such as staff time, industry expert time; activities such as forums; and outputs or products that lead to the goals such as reduced or eliminated barriers.

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The reason evaluators and others go through these exercises, known as a "formative evaluation," is that the process is supposed to make the program better. There are benefits in just doing this kind of logic modeling, first, because it imparts a better understanding of the goals and the processes being managed and , second, because it gets people rowing in the same direction.

Various partners and staff members sometimes have very different perspectives on what a program is supposed to be doing. That means they are likely not to be bringing actions together to try to achieve the same objectives. The effort gets diffused, sometimes in conflicting directions. Simply having an agreement on what the program is about, what it is doing, and perhaps most importantly, where it is trying to go, can be beneficial.

Similarly, there is sometimes a formative function in making the program plan more rational. Joe Wholey, who is one of the pioneers in evaluation logic modeling, showed in one of his first examples that the program managers were trying to do too many things. When they looked at a picture of the whole program plan, they saw that they could not reasonably have all of the components in the plan, given the resources that were available. That may also be true for PATH. This kind of revelation does not always happen, but it is not an uncommon consequence of going through an evaluation logic model exercise.

Evaluators use logic models and move from logic models to various indicators, measures, and metrics because this provides a way of guiding a summative evaluation or bottom-line judgment. Does the program work? Is it functioning effectively? Is it beneficial?

Without some specificity about the objective and without some prior agreement about what kinds of measures might capture the objective, it is difficult to know whether the program works. It is hard to have agreement if there is no rational basis for judgment. This is, of course, one of the motivations for the Government Performance and Results Act (GPRA) and various other initiatives that have pushed agencies to undertake performance measurement.

There are some complications and challenges, but our time is limited, so I am going to focus on the potential benefits. A good evaluation system is one that supports results oriented management. If Joe Wholey were here, he might tell a story about the U.S. Coast Guard (USCG) that illustrates the benefits of evaluations. The Coast Guard developed a performance measurement system using data of a kind they had never collected before. From this performance indicator system, they observed that there were unusually high rates of injuries and even fatalities in certain aspects of the seaborne industries. I don't know how many of you have read the book *Tommy Tugboat* to your children, but it turns out that Tommy Tugboat is a very dangerous place to work. USCG had never collected data that allowed them to slice and dice by the different parts of the industry. Once they had the performance data, they saw where the problem was, and it guided them to create new programs and regulations that resulted in a precipitous decline in injuries. We started with a quote from Peter Drucker: "If you are not measuring it, how can you manage it?" If you have no idea, how do you know if you need to make changes or stay the course? How do you know which things need your attention the most? Results-oriented management is one of the reasons that one tries to get performance metrics, despite the challenges.

A list of some of the criteria that we might use to think about evaluation models includes:

- Practicable—Is it feasible to implement with the given resources?
- Plausible chain—Is there a logical sequence that is likely to achieve goals?
- Quality—Are measurements available for assessment of goal achievement that are valid and not easy to game?
- Adequate—Does it provide short-term outcome measurements needed by management?

I have the word "practicable," which essentially means the extent to which it can be carried out in practice. When we think about this criterion, we are asking if we can implement the plan, given the resources. Simply, is the program doable in terms of these planned activities?

A second criterion is the plausibility of the logic chain. There is a set of activities that the resources will support. They are supposed to result in certain products, which we call outputs, which in turn are supposed to lead to medium- and long-term outcomes. Considering the logic chain as a column

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of dominoes, are those dominoes lined up in a way that if the first one is knocked over, the rest of them will fall, or are one or two dominos out of place so that the series of events will not be carried forward? How plausible is the chain? Simply because a chain has been laid out does not mean that it is likely to lead to the stated results.

The third criterion is quality of measurement. Will the quality of measurement actually assess achievement of the goal? This is particularly important for long-term goals. Begin by examining the specific metrics and performance indicators to ensure they are countable. How is PATH going to show it has reduced *X* percent of the barriers or reduced the severity of the barriers by *X* percent? This is obviously critical because communicating successes requires a means to demonstrate it.

The validity of the measure is also a critical criterion. There should be no question that it is measuring what it purports to measure. If a metric is about reduction of barriers, is it really capturing in some honest sense a reduction of barriers or is it just a number that that does not tell much about barriers?

Evaluators are increasingly concerned that the measures do not become an end in themselves. One of the things that first got the economist who co-wrote *Freakonomics* public attention was coming up with a statistical algorithm to detect teachers who were cheating on standardized tests of their students. They were basically giving out the answers to manipulate the result, which means the test scores had no relation to what the children were learning. Obviously, measures that do not allow that kind of manipulation are desired.

An issue that sometimes gets lost is the adequacy of the measurement for supporting day-to-day management decisions. Sometimes we focus all of our attention on the long-term objectives, which we are not going to reach this year or perhaps next year or perhaps the year after that. If we trying to implement management by results, we need to have indicators that are shorter term that have certain other characteristics that allow us to make day-to-day decisions based on feedback about how things are going. A measure might be sufficient to tell if long-term results are attained, but not be useful for day-to-day management because it is too distant in time or too general.

By looking at the draft PATH plan in terms of a logic model it suggests that there are three primary parts or goals that facilitate completing the program mission. One of those has to do with removing barriers, another with technology transfer through dissemination of information, and the third with facilitating R&D. For each goal there are three objectives. Each of the objectives is described by something that looks like a conventional logic model. For each objective there are inputs (the resources it takes), the activities to be undertaken, the outputs or products of these activities, and then the short- and long-term outcomes.

The organization implies that we are trying to get to the mission with multiple pathways. Each of these pathways has specific outcomes and the resources we have to achieve those longer-term outcomes.

PATH should be applauded for having separated input, activities, outputs, and outcomes in a way that links them to specific long-term outcomes and objectives. Often an evaluator will walk into an organization that has gone through a planning process like this to find they have lumped input, activities, and so on into five buckets. The evaluator cannot determine which activities are supposed to achieve which outcomes.

The problem now is to examine each performance measure in terms of the criteria mentioned earlier to determine to what extent it is feasible to implement this entire plan given the resources that are available. We already heard that the resources are now less than when this plan was first developed and many of inputs are coming from various partners with unknown levels of commitment.

In the discussion following Dr. Slaughter's presentation there were several interesting points about several different audiences and types of builders, as well as various roles within the large homebuilding organizations, and architects, consumers, and suppliers. Dr. Slaughter noted a variety of mechanisms including technology push and demand pull. The role of branding came up as well as research following the money in a variety of ways. There are obviously many opportunities for program activities that fit the PATH mission, which is both a blessing and a curse. PATH is faced with the problem of determining which is likely to be most beneficial.

The issues of practicability and the consequences of practicability are worth some discussion.

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We are beginning to describe what is called an aspirational model, that is, what PATH could be. There is a potential danger with any model that is built on what is possible or what might be possible at some point in the future. The program may be judged according to those standards and metrics regardless of the level of resources that are currently allocated.

PATH also needs to ensure the plausibility of the logic chains. This judgment needs to be made by people with knowledge and expertise in housing and innovation in the housing industry. For example, how likely is it that PATH can develop a branding capability? Does PATH have the necessary focus, and size to get enough exposure that branding is a plausible activity? Do the dominoes in the PATH model connect or are additional steps required to get to a single long-term outcome? If the objective is to create pull by building demand from consumers, maybe there are activities that need to go together to converge on that one single long-term outcome.

Quality measurements to assess attainment of a goal need to support rational management decisions. Long-term achievements and immediate management require somewhat different kinds of metrics. In either case they should have validity to ensure they are measuring what they claim to be measuring. If the objective is reduced barriers, the user of that metric should be convinced that it actually reflects the value of reduced barriers. Another consideration that can be important is whether there is a comparison standard to measure changes over time.

Cost of the performance measurement activity is also important. A $5 million program cannot use a set of metrics that is going to cost $7 million to implement. It is essential to determine the feasibility of the measures given budget constraints. For results-oriented management, there is a set of criteria that come up more strongly than when considering the long-term objectives. That is, did we get the job done? It should be possible to desegregate the measures to examine different regions of the country or different sectors of the industry to see the trends. Large national homebuilding companies may be responding differently than smaller builders, and builders in the South may respond differently than builders in the West.

An additional complexity is that management decisions require current information. If data are not available until three years later, the data will not help make the current decision. Managers often turn to proxies or indirect measures, but it is often difficult to know if they accurately represent the intended objective. As an example, the National Science Foundation wants to increase the nation's scientific proficiency. How valid are third grade test scores as a predictor of long-term human capacity? Does this indicator work well enough to help make decisions?

The questions we have been addressing will recur during the panel discussions. Is the activity plan commensurate with the level of resources and if not, what can be done? Where do you make finer choices? What do you give up? Is it plausible? If PATH has a great set of activities that are not plausible, what good is it to use resources on those activities?

After focusing on the details of the logic model, it is import to determine if the program actually accomplishes its mission. Do the individual long-term objectives and the long-term outcomes support the mission? There are sets of evaluation questions that help determine the level of confidence in the program. There is a need to know if the changes that are measured are the result of the program activities. If all the large builders create internal research units, can we be confident that PATH made some difference or are the observed changes due to these other activities?

DISCUSSION

MR. KASTARLAK: It seems to me that perhaps we can add one more word to the lexicon of housing. In addition to sustainability and affordability, there is also attainability. PATH can build its logic model beginning with that as the end objective. Start from there and walk backwards.

DR. MARK: Absolutely; I started on the left-hand side because that is how we read in this country. Another approach is to start on the downstream side with the objective and then work backwards to plan how to get there. In fact, when it is done well, planning typically is an iterative

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process. It works backwards to how is it going to get there and then forward to determine if there are resources to do that. Are the dominoes going to fall?

MR. KASTARLAK: Yes, but there is more to that because you might end up changing your goal.

DR. MARK: Absolutely, this process can change the goals in ways that are desirable or in ways that are not desirable. Sometimes this results in "goal displacement—for example, if we are interested in children's education, but we get fixated on test scores because we can measure them. Test scores are good for some purposes, but maybe they are not the be-all and the end-all. The goal can be changed in ways that are not commensurate with the mission. For example, the mission statement is so broad and vague that it would enable you to do anything, which means it is really not the best mission statement. The process will help to highlight such inconsistencies.

MR. ENGEL: On the one hand, the program wants to show all the pieces that need to be done and on the other hand, as you pointed out, there is a resource constraint. Is there a method to show both aspirational and plausible goals and measures? I would hate to submit something that was only a piece of the puzzle and didn't show the whole complexity, but the issue you raise of resource constraints is very appropriate.

DR. MARK: I am going to let a couple of my evaluation colleagues jump in if they will, but first I will say I think you have actually hit it precisely. The draft demonstrates the big picture. Here are the levers that we can push for which we have adequate resources to push and these that we have a case for saying they are most likely to make a differences. The plan can then show next steps PATH would include. I do not know if OMB likes that, but it certainly can be part of a presentation. Here are our key priorities given where we are now. Subsequent activities would likely involve other activities. If the plan indicates the program is going to do everything right now, it is a bit like hoisting oneself on one's own petard.

MR. FREEDBERG: Ultimately all of these short- and long-term outcomes must relate back to the larger mission. The new mission statement really says that the mission is to improve housing technology innovation in order to improve housing values, affordability, energy efficiency, and so forth.

Looking at the outcomes, I don't see specific references to those values or the components of the values that are the mission of the program. Those are very difficult things to measure. How much more affordable is the housing as a result of these activities? How do you address that in a logic model?

DR. MARK: You do clearly want those long-term outcomes to be in the service of that mission. If they are not, you have mission creep. In your question, you have shifted, perhaps inaccurately, from what the mission is. I suggest that we not answer that question now, but when we look at each of the three pieces over the next three sets of panels, that should be a question that is in your mind.

DR. SLAUGHTER: I think that goes directly to the previous question about working your way backwards. If the goal is to increase availability, the program should be able to increase the speed at which houses are produced. By working backwards, determine how to do it. Then there is the issue of prioritization. There is the issue of how effective PATH will be in achieving those various elements. Industries that are revenue and profit motivated are going to be effective at reducing the cost of a specific unit, especially if they can increase their profit margin. I think prioritization of the long-term goals is the justification for federal expenditures in this area.

DR. MARK: I am not going to argue with that. What I will say is my understanding of the purpose of this session is to provide input to PATH about the current draft plan in ways that it can take into consideration before that plan goes forward organizationally. I am not sure we need to answer every question, but I agree with you that we could do this in multiple ways, but we can't go through all of those ways today.

DR. MARTIN: Just to answer some of your questions about the process. In most of this discussion, the background document defines the history of what happened, but the mission actually was established by the PATH Industry Committee two and a half years ago. Then that was translated to the goal and the three sub-goals.

MR. GONZALEZ: The criteria of practicability, plausibility, and so forth will help to focus the

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discussions as the workshop addresses the different goals. As was noted, the objectives of the discussions are not to eliminate parts of the draft operating plan, but rather to give them input and help to determine how PATH can be most effective and where it can have the most impact.

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Discussion of PATH Goal I—Remove Barriers and Facilitate Technology Development and Adoption

PANEL MEMBERS' OPENING COMMENTS

MR. SPEAR: By way of introduction, my name is John Spear; I am a Houston-based housing architect, real estate investor, and broker. I am a member of the American Institute of Architects (AIA) and participated in the 2002 Assessment and in the group that planned today's workshop. For this panel we are pleased to be joined by David Hattis, who is an architect and president of Building Technology, Inc. Mr. Hattis was responsible for the April 2005 PATH report entitled *Overcoming Barriers to Innovation in the Home Building Industry*. We are also joined by David Conover, who is senior advisor for the International Code Council. Our nation's building codes and regulations are generally perceived, not necessarily correctly, as a major barrier to housing innovation. Our third panelist is Bulent Kastarlak, who is a seasoned housing architect from Palm Beach, Florida. He is representing the American Institute of Architects national housing committee. Mr. Kastarlak will comment on identifying and removing barriers from an architect's perspective and on how AIA can work with PATH's other partners to pursue this goal.

Before we proceed, I would like to make my own brief comments on the draft strategy, program plan, and metrics that are before us today. I think the draft demonstrates that PATH's staff did indeed listen to and understand NRC's 2002 assessment recommendations. Although the draft has some inconsistencies, the goals are accurately communicated and many of the proposed activities and measures should be effective if there is enough money to fund them.

I continue to wonder how PATH can achieve its mission in light of its severe budgetary constraints and the continuing uncertainty about its very existence. For those who may not be aware of the history, the current administration has been zeroing it out of the administration's proposed budgets every year since 2001. Congress has taken the initiative to reinstate it each year, but at steadily decreasing funding levels. As we have learned this morning, PATH's budget is now $5 million.

The PATH budget is set forth in some detail in the last part of the operations and management section of the draft. Suffice it to say that the barriers goal activities are only a small part of the PATH budget. For FY 2005 it is $330,000, which is less than one-third of the ToolBase budget alone. Nonetheless, as suggested in the 2002 NRC assessment report these activities are an important part of the program.

Especially in the context of these funding uncertainties, it appears to me that the draft strategy and operating plan fail to convey a sense of priority among PATH's goals and related activities. I would prefer to see a clear statement of the relative importance of the proposed activities. Prioritization is particularly important because it appears that PATH is trying to do a wide variety of things that may or may not be possible given budgetary constraints.

On a more reassuring note, we should keep in mind that the four and one half to six full time equivalent (FTE) staff that HUD assigns to PATH activities are not funded out of the PATH appropriations because they are funded from HUD's general funds. So there is somewhat more to the program than just the $5 million appropriated for program activities.

To help start our discussion, I would like to read brief parts of the draft PATH strategy. The inclusion of "barriers" as an inherent component of technological change is critical to PATH's new

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strategy and goals because it directly confronts the real and the perceived reasons for the lack of housing technology innovation. In previous studies, scholars and industry analysts described the "barriers" both as having ambiguous sources and as being incredibly insurmountable. In either case, no real causality was proven and no policy enacted. This acceptance of the industry's market and production realities is a major shift toward full analysis and pragmatic "barrier" reduction.

The NRC report *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing* (2003) makes repeated reference to barriers to innovation and removal of barriers to innovation; in fact, it suggests that PATH be charged with removing barriers and facilitating technology development and adoption.

After listing the barriers the draft 2005 PATH report goes on to disqualify most of the commonly identified barriers, such as the cyclical nature of construction, the dominance of small firms, the lack of integration of the industry, heavy reliance on subcontractors, and diverse building codes, as having no empirical support or being beyond evaluation.

The draft strategy identifies seven barriers that "… are such a part of the homebuilding industry that their resolution involves strategic planning of what can be done in the short-term with regard to circumventing their influence on the innovation process, and what can be done in the long-term to reduce or eliminate them." The barriers of this magnitude that were identified include:

1. Building codes that prohibit innovation.
2. Risk and liability involved in developing or adopting new technology.
3. Insufficient financial incentives for generating and adopting innovation.
4. Poor skills and training in every profession and vocation of the homebuilding industry that prohibit innovative thinking and experimentation. [With the exception of architects, of course!]
5. Multiple preconstruction parties that intervene between innovators and adoption decision-makers, such as vendors, suppliers, and retailers, e.g., Home Depot.
6. Post-construction parties that determine how the final consumer values the innovation. These are appraisers, private home inspectors, financiers and lenders, and insurers.
7. Significant economic cycles with highs and lows that are not conducive to innovation.

We will learn more about these barriers and the counterintuitive conclusion from the 2005 PATH overcoming barriers study from another panel member in a minute.

The draft background document concludes that "as described, each of these barriers (is) inscribed into the method of producing and selling homes in the US—in fact, they are institutionalized. Because there are few parallels between these phenomena and other industries, unique and focused strategies must be undertaken for each."

Goal I has three objectives; first, to identify current and potential barriers and to measure their impact. The metric for this objective is the number of identified barriers that are studied. The second objective is to develop practical methods to overcome current barriers. The metric for that is the PATH effect on the cost and the amount of time innovators spend on addressing barriers. The third objective is to develop alternative future processes to eliminate barriers. The metric is PATH's effect on eliminating barriers.

MR. HATTIS: I have to start by saying that my comments may not actually answer the question that we were asked. We all know the question asked by the tourists on 42nd Street in New York City—how do I get to Carnegie Hall? The answer to that question is—practice really hard. However, that is the wrong answer if the tourist is looking for directions.

I will start with a brief overview of the overcoming barriers study and its recommendations. I will also try to tie them back to the original questions about the HUD draft.

The overcoming barriers study was not strictly a research project, but more accurately, a collection of anecdotal information and experiences with barriers to innovation in housing. The study included discussions of three expert panels on the three categories of barriers described in the NRC report. There are multiple barriers in each category. For example, in the risk category, risk to whom—

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the owner, the code enforcement official, the builder, or the supplier? Risk is a barrier for all participants but a different barrier for each.

Another category was industry participant preferences. We heard earlier today that consumers are not concerned about innovation, and builders, with a few exceptions, are not looking for or concerned with innovation. The perception of the panel participants was that a common barrier is the lack of information.

Each panel met for a day and a half or two days to develop a set of observations on the assigned category. The panels developed nine recommendations. Some of them relate directly to the issue of communicating the barriers goal.

The first recommendation is that there is a need to raise consumer awareness of the importance of improved performance, not the importance of innovation. The innovation is there to improve performance. If the consumers are not aware of the importance of performance or how to measure it, then there is a need for a program to raise awareness and provide measures. The PATH mission has not been communicated to or adopted by consumers.

The second recommendation was to find ways to mitigate risks—builders' risks specifically, but also risk to others. It was found that builders generally do not adopt an innovation that entails significant additional risk. They are not in the business of innovating or advancing the state of the art. They are trying minimize the risks to their profitability.

The third recommendation was that small manufacturers need special assistance to overcome barriers. Apparently larger manufacturers know how to overcome barriers. It was noted that some of the requirements that are sometimes considered to be barriers are there for a purpose, usually to reduce some risk. BTI together with McGraw-Hill is currently undertaking a survey of how manufacturers develop and commercialize innovations to identify the differences between large and small manufacturers.

The fourth recommendation talked about the need for a better understanding of the supply chain of successful innovations. Understanding the supply chain is crucial to getting new products from manufacturers to the ultimate customer. Even though there is no set list of supply chain participants, I would say that they are not adequately represented at this workshop. For example, we mentioned Home Depot as a supply chain element for consumers, but it is not a principal supply chain participant for production builders. The supply chain is evolving in that the concept and function of dealer is changing. They are beginning to undertake some of the functions traditionally done by builders and manufacturers. PATH is sponsoring a program at Virginia Tech to look at the relationship of the supply chain to the diffusion of innovation.

The fifth recommendation is related to supply chain in that it concerns partnerships with subcontractors' associations. Providing every stakeholder with the information they need is a PATH goal, that is, everybody from the product manufacturers to the regulators, to the builders, through the subcontractors to the consumers. The essential information needed by each stakeholder is not always available.

Skipping the sixth recommendation for now, the seventh recommendation was that innovators, particularly small enterprises, need help to understand the building regulatory system. I should note that regulatory barriers were not part of the scope of this project. The focus was non-regulatory barriers. Nonetheless we found that the small enterprises do not understand how to navigate the regulatory system and there is no clear and consistent guidance. They are told that they need to go to the evaluation service at some point in the development. They are also told that they need to go to the American Society for Testing and Materials (ASTM) to develop standards. They are told that they need to go to the code hearings and try to get something into the building code. Nobody explains to them and those actions are related and sequential decisions.

The eighth recommendation is related to something mentioned by Dr. Slaughter, which was creating demand and using large-scale procurements to help remove barriers to innovation. For example, if the Air Force uses a new technology for a project consisting of a thousand houses, then that project becomes a demonstration for that technology that can be a source of information about that innovation.

The ninth recommendation is about improving education for the construction industry. Most high

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school students do not see the home construction industry as a viable career option today. The result is the deteriorating quality of the construction labor pool.

I began my career as a traditional architect designing buildings, a lot of it housing. I had an opportunity to become involved with innovation and technology through the Ford Foundation Educational Facility Laboratory programs. The program included development of performance-based procurement of building systems to help improve educational programs. They found that if they issued requests for proposals for 30 school buildings at one time, they increased their ability to require the builders to meet certain performance criteria, which naturally led to a number of innovations.

The significance of the barriers study recommendations to the PATH performance measures is the need to raise consumer awareness of the importance and value of improved building performance. The emphasis is on awareness of the performance of the product in terms of energy efficiency, durability, disaster mitigation, and so forth.

We currently lack the tools needed to adequately describe housing performance. I am not talking about performance measures to assess the program, but rather performance measures that will ensure the program success.

The sixth recommendation was to provide stakeholders with the information they need because the information that they now get is generally the information that whoever is selling the product wants to give them. Much of the information that is currently available is intended to increase sales, not necessarily to help potential adopters make informed decisions. The *Sweets Catalogue* contains the information the manufacturer wants to give us. Builders need consistent, unbiased, dependable information about product applications and performance.

I agree that the PATH program appears to have too many objectives and measures for the scale of the resources that are available. More global, intermediate measures that could be communicated and understood might be more effective.

There is also a need to link measures to the contributions of PATH partners. For example, if every workshop participant were paid at their normal billable rates for attending this meeting, the cost would probably be between 2 and 5 percent of PATH's $5 million budget.

MR. CONOVER: I will try and briefly answer the four questions listed in the agenda. However, first I would like to comment on an earlier statement from the perspective of an engineer involved in the building codes. The point I want to make is that many people focus on the model code as a barrier. In the past, 50 or 60 years back, there was a crazy quilt of different regulations, but that is not the case today. The impact of the code enforcement process is also a factor. There are 44,000 units of local government in the United States. Unless they are preempted by state or federal government, they have the authority to enforce the code as they see fit. The model code organizations have put forward a single model, but it is still in the process of local adoption. Even after nationwide adoption, there will still be room for local differences in interpretation and enforcement. It is like going into different churches: they sing a little differently; they talk a little differently; some pass the collection plate twice and some just once.

Mr. Hattis made reference to the building code regulatory system as a barrier. That may be true from some perspectives, but the regulatory system can also be seen as creating opportunities. This dichotomy relates to whether or not the regulatory activities are undertaken concurrently with technology R&D or after the R&D is completed. For example, the technology for stationary fuel cells is still being developed, yet the regulatory framework has been adopted and is ready for implementation. This is due in part to the foresight of the Department of Energy to create an infrastructure that will accept the technology.

In regards to the agenda question, is the goal communicated accurately? I think it would be better stated as facilitating technology development and adoption through removal of barriers. These are two separate items, removal of barriers and facilitating removal. Removal is a means to the end. What PATH is trying to do is facilitate.

Codes and standards are considered barriers, but if they are properly crafted and rationally applied, they also provide opportunity and reduce risks. Appliance efficiency standards are an example. I think that was Public Law 94-163 that created federal appliance efficiency standards. It provided a push

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for innovation and replaced a crazy quilt of different rules and regulations that hampered manufacturers. Manufactured housing regulations, 24 CFR Part 3280, are another example.

How important is this goal? The goal has a variable importance depending upon the definition of barriers and their impact on the goal. There are lots of barriers and opportunities to identify and assess them to determine their effect on innovation.

Who is the audience and how do they define success? I guess the audience could be considered anyone in the U.S. that lives in a house or apartment, which is just about everyone. They could also be people that are professionally involved, such as the people involved in R&D and marketing new technologies, and users, such as builders and do-it-yourself homeowners. It is basically anyone who is involved in the process and factors that are important to them. The most universally important factor is money, i.e., cost effective operations and profitability.

Are there performance measures to measure success? It all gets back to time or money, and time is money. The key metric is dollars. Changes in barriers, code changes, creation of new programs, and energy consumption are intermediate measures that can also be used.

MR. KASTARLAK: Having heard very eloquent and to-the-point remarks from my colleagues here, I will add a few things to what they have said and wrap up this introduction to our workshop discussions.

It seems to me that we are looking toward a state of affairs in the housing industry that is not sustainable. In West Palm Beach, Florida, where I live, the average house costs as much as PATH's annual program budget. This is the reality. What can PATH realistically expect to accomplish?

In my opinion, PATH has done an excellent job organizing and structuring the logic model of inputs, activities, outputs, and outcomes. However, budget constraints completely eliminate that as a particular line of reasoning or action. Achieving the goals will depend on what people in the housing industry contribute and that will require identifying and measuring results that are important to the industry. They probably couldn't care less whether there is an innovation unless it improves their bottom line.

To answer the specific question in the workshop agenda, Is the goal communicated? I can reply that it is, but it depends on whether that goal is attainable and for that reason we have to assess the resources allocated to the program. If there are limited resources, we need to determine the importance of this goal to the development of the new technology in housing.

The goal of a federal government program should be to promote innovation that will do public good. Twenty percent of this country's population is in need of decent housing. Technology that will reduce that gap should be a priority.

DISCUSSION

MR. SPEAR: I would like to focus for a moment on another objective for our meeting to suggest possible strategies for the dissemination of this information to interested parties in the homebuilding industry. One of the most effective tools for overcoming or removing barriers innovation in the homebuilding industry could be the new program called Concept Home that PATH is working on with its industry partners. I address this question to Mr. Chapman, who has participated in this program. My question is in your view is the Concept Home demonstration at the annual builders' show an effective way to overcome barriers to innovation among builders and architects?

MR. CHAPMAN: That is really a tough question to answer. The International Builders' Show attracts more builders and industry participants than any other event in the U.S. The participants are especially concerned about innovation and new ideas. It is a great place to start. If you want to communicate with builders and industry people, then that is the right place to go.

The problem is that the Concept Home is not nearly as radical as a lot of us would like it to be. It is fraught with problems from a regulatory standpoint. It is taking a very small step and yet the regulatory barriers have the potential to be huge. This is especially true of the demonstrated technologies at a local

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level. The local regulators and politicians are not in the audience at the housing show. As discussed earlier, there is a morass of different code enforcement bodies throughout the nation with building inspectors whose personal decisions affect the adoption of innovative technologies.

It is the right place to be, but somewhere in this process we need to determine how to reach out to communities and to people who are not directly involved in the housing industry, but have a tremendous influence.

MR. KASTARLAK: In my community there are 72 steps to get from a pre-application conference to occupancy permits. There are obviously many people involved in that process. It seems that reform is needed.

One example of how to communicate the importance of housing performance to consumers is the permanent exhibit for building systems in Munich, Germany. The exhibit displays mechanical, electrical, and structural systems and how they are integrated in a house.

MR. HATTIS: I would like to respond to the question of dissemination of information and channels of communication. Every barrier has somebody who benefits from that barrier. Barriers are not there abstractly. Therefore, barrier removal needs to be communicated to those stakeholders. Those stakeholders are probably not at the builders' show.

It was mentioned that the Concept Home has many innovations but is fraught with regulatory problems. It may be necessary to address barrier removal more incrementally, innovation by innovation, rather than a whole house.

MR. CHAPMAN: I don't want to leave a misconception about the Concept Home. It is incremental. It may be too incremental. The fact that we are using a whole house to demonstrate technologies is unique, but for the most part it uses existing systems that are completely code-conforming. A lot of people thought the house is not innovative enough because it is not creating new systems. The Concept Home is an incremental approach, but having said that, there are still regulatory barriers.

The Concept Home is basically in conformance with most of the existing codes. But there are so many details that cause regulatory problems.

When asking if the International Builders' Show is an effective channel of communication or if there are better venues elsewhere, the answer is that every opportunity needs to be used. The battle is getting to the people who are resisting innovative changes.

MR. CONOVER: It is difficult to tell if the problem is with the code official, the person that does plan review and inspection, or the whole system including zoning, environmental, and other issues. For example, I have a stream within a hundred yards of my house. If I want to put on an addition, I have to go through the county environmental regulatory process, which has nothing to do with the building code or the building official. It is important to know if the problem is building regulations in general and the specific issues that are causing problems. Yes, the code can be a barrier, but there are a lot of other things that are often more significant.

With respect to the Concept Home, one approach to the regulatory issues could be having a jury of regulatory authorities, representing the building, fire, plumbing, mechanical, and other regulatory specialties, review the house to determine whether it is consistent with the test standards and code requirements to determine if it meets the code. A report of that panel's findings would facilitate the acceptance of the Concept Home and help deal with local idiosyncrasies.

Singapore is an example of an ideal building regulatory system with one code and one ministry where everybody does it the same way. Here, there are 44,000 systems. There are ongoing efforts to make them work together over time, but a national code and regulatory system cannot be mandated. The concept of standard automated plan reviews, and of interoperability with manufacturers' specifications, is being discussed as a way to automate the process and make it more consistent.

The local building official does not test a heat pump to approve it. The official looks at the equipment label to see if it has been independently tested to prove that it meets regulatory standards. A house is similar, except that it is an assembly of those components. A system of automated submittals of standardized criteria could be developed at the national level and inspection at the local level could ensure that it is built as proposed. Computer-based interoperability provides an opportunity to do this. In ten

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years, the building regulatory system in the United States could look like this.

MR. KASTARLAK: That is the direction architects and engineers would like to see the regulatory system take.

MR. SPEAR: Some of the NRC committee members and many of today's workshop participants would like to see PATH grow into a program for performance certification or to provide a recognized "seal of approval" for technological innovations. That process could be the basis for developing a PATH brand identity similar to EnergyStar.

A consistent and predictable level of effort is needed for branding to succeed. But PATH continues to face federal budgetary restrictions and uncertainties. In 2001, the administration started zeroing out PATH's budget and refused to let PATH distribute its literature. In my view that is not the way to enhance PATH's credibility with stakeholders and industry partners nor to build the kind of program that can influence decisions needed to reduce the barriers to innovation.

PARTICIPANT: A $5 million budget can make a difference but only after people know what PATH is. If you ask 100 purchasing managers of home construction companies across the United States if they know what PATH is, 99 of them would say they have no idea. I presume the Good Housekeeping Seal became valuable only after it was around for a long time and people knew what it meant. The same is true for Consumer Reports. PATH cannot establish a brand until everybody knows what it is and the value it adds. First, PATH needs to be generally recognized, and then the brand begins to have value. Unfortunately, PATH does not yet have broad recognition of the good work that is being done.

MR. SPEAR: Recognition requires a consistent program.

MR. CHAPMAN: The code organizations and other established systems for certification and approval can facilitate the recognition of PATH and add to its capability to push technologies forward.

PARTICIPANT: If a new technology is approved by the building code organization it does not replace the approval of the old technology. The building official decides what he or she will accept. The official might not believe that the new technology is better and be reluctant to accept a technology that has not been proven effective over many years. An education program is needed to help officials understand the value in new technologies. The code official has the power to make the builder construct the house the way the official wants it built.

MR. CHAPMAN: As a former chairman of the Construction Industry's Commission of New Mexico, which is responsible for adopting all the codes for the state, I know the system is fraught with conflicting interests. Positions of individual organizations are often based on self-interest instead of engineering principles and test results.

Building regulation is a very convoluted, difficult process. That is why a program to reduce the effect of barriers posed by the regulatory process is needed and why government involvement can make a difference.

MR. GONZALEZ: Codes and regulations are recognized as a huge barrier, but there are probably others that could be addressed to achieve PATH's goals.

MR. NOSSE: It gets down to the essence of our governmental system of home rule. There are many political decisions involved when the federal government is promoting change in local government activities. PATH's role should be to foster an educational process.

MR. ENGEL: There are two other major barrier issues. One is potentially solvable, but the second is probably unsolvable, given the legal system in this country.

The first one is educating stakeholders to provide an understanding of the value of innovation. That can be addressed by developing programs for lenders, consumers, regulators, and so forth. The other one involves assigning risk and financial responsibility. If a house fails, that failure might cost tens of thousands of dollars or one hundred thousand dollars to correct. The risk is great and the potential benefit to any one stakeholder is probably minimal. That is going to remain a problem until there is a method to rationally and equitably assign and share risks.

MR. CHAPMAN: Another barrier that has been alluded to is the cyclical nature of the housing industry. It can create a problem for new technologies that do not have the resources to stay through the slow periods of the market. One of the changes that has happened in the homebuilding industry is that

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there are now long-term players, such as Mark, K. Hovnanian, Pulte, and Centex, which produce about 30 percent of new housing. The other 70 percent of the marketplace are generally short-term players that are in and out. Lee Evans, a former consultant to the housing industry, now retired, was fond of saying to homebuilders that your propensity to go broke in this business never changes and if you stay in it long enough, you will. There is a lot of truth to that and the result is that homebuilders never complete their fixed plant. The moment the fixed plant is complete, the builder sells and starts all over again. Our company just started its 40th year, but there are not many 40-year-old homebuilding firms in this country.

Adopting a new technology takes planning. A dollar per square foot can be saved on a house, but it might take three or four years to implement. The delayed reward has no impact on an industry that is driven by short-term outcomes. To get the attention of builders, a new technology needs to save a dollar per square foot on the next house.

MR. SPEAR: Do we have any additional barriers that people would like to propose for discussion?

Hearing none, I will use the panel chair's prerogative to wrap up with a description of a useful concept from the late University of California at Berkeley professor Horst Rittel. In his seminal paper published in 1973, Dr. Rittel identified a class of "tame" problems, susceptible to rational analysis and satisfactory solution through traditional linear processes, and an altogether different class of problems—characterized by systems and processes that are richly interrelated with a number of factors, with a host of stakeholders with conflicting views, that are burdened with a number of externalities and interconnected with so many other parallel systems that they become very, very difficult to solve—known as "wicked problems." I think that the barriers issue we have before us in this segment of today's workshop is in fact a "wicked problem," one that cannot be solved like a tame problem reasonably might be, but one that PATH in its time will address and in the process help move innovation in the homebuilding industry forward.

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Discussion of PATH Goal II—Improve Technology Transfer, Development, and Adoption Through Information Dissemination

PANEL MEMBERS' OPENING COMMENTS

MR. GONZALEZ: The next goal that we will discuss concerns information dissemination. To start the discussion, I would like to introduce Randy Cantrell from Virginia Tech.

DR. CANTRELL: I am here today on behalf of Virginia Tech's Center for Housing Research. I am standing in for the center's director, Dr. Theodore Koebel, who has a prior engagement. I am an adjunct research professor at the Housing Center, and also an employee of the National Association of Home Builders Research Center (NAHBRC).

Dr. Koebel's written statement is in Appendix E. The goals, obviously, pertain to research undertaken by Dr. Koebel and others for the report *The Diffusion of Innovation in the Residential Building Industry* (listed as a reference in Appendix E and available on PATHNET.org), which found that it is very difficult to identify any particular segment or cluster of homebuilders that are early technology adopters or innovators. The industry appears to have fairly unique diffusion trends. In many industries, small manufacturers have a large impact on innovation. However, in the homebuilding industry, the larger manufacturers and builders are the predominant innovators.

There are clusters of more innovative builders in every segment, but the small single-family production builders seem to stick with the more proven technologies. These smaller builders are driven by consumer demand. They will use innovations that are focused on marketability and increased profits. As in most industries, the propensity to adopt new technologies is ingrained in the culture of an organization. They are unlikely to change quickly because of PATH or any other initiative. Their approach is to see if it works before they use it. However, they are scanning the environment routinely to find an advantage. Some larger homebuilding corporations have a dedicated individual focused on finding or creating innovations to improve their product or competitive advantage.

NAHBRC is aware that the diffusion of innovation in the housing industry is a complex problem that is barely understood. Based on the current level of understanding, the PATH program goals seem very ambitious. However, this ambition has increased knowledge of innovation in housing. PATH is refining its approaches to these challenges and moving in the right direction.

PATH is the best federal program we have seen to date for increasing the knowledge of innovation in housing construction and promoting innovation. PATH is sponsoring several ongoing research efforts to model the innovation diffusion process using NAHBRC's data on the diffusion of highly innovative products. Another study is looking at the commercialization processes used by large manufacturers and another is looking at the role of the supply chain in spreading innovation.

In regard to the PATH goal of information dissemination, a non-commercial, independent source of information about new technologies is essential to the promotion of innovation in housing. The source of the information needs to be transparent and users need to have the ability to do independent assessments or verifications. Too often innovators withhold information about their innovation in fear that others will use the idea. There needs to be an independent group that can verify the validity of the innovators' claims while allowing them to maintain ownership of intellectual property. There may be benefit rendered by combining goals 2A1 and 2A3, to establish and maintain centralized, industry generated sources of credible, relevant information.

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The metrics for Goal 2A should be designed to find the gaps in current distribution of information to determine how and why sources of information are not used. Just to know that we have a given percentage of builders using a source is not enough; we also need to know why they are going to that source and others are not.

Goal 2B is to understand stakeholders' behaviors, attitudes, and needs for information about new technologies. This goal addresses the processes that drive the adoption of innovation.

The third goal is to change behavior through access to relevant information and materials on innovation and innovators. These activities and performance measures need to account for the differences in the ways people adopt innovations. The early adopters, early majority, and so forth obtain and use information differently. PATH needs to recognize that the success of a new technology depends as much on the early majority as it does on the first adopters.

DISCUSSION

MR. GONZALEZ: It has been demonstrated that dissemination of information is practicable. ToolBase, PATHNET, and the demonstration projects have all contributed to the dissemination of information on new technologies. The question remains, however, whether the logic chain is valid, and this information has led to the increased development and diffusion of innovations in housing. We do not know the quality of the information, or if PATH is disseminating the information that decision makers need. Will the chain of falling dominoes get to the last tile? The proposed metrics may not provide this information.

This portion of the workshop is for general discussion to give PATH an idea of how to place those dominoes to reach as many people as possible and support the program's mission. It would also be helpful to hear some anecdotes about the effectiveness of the current efforts to disseminate information.

MR. ASDAL: I would like to comment on ToolBase, PATHNET, and the PATH-sponsored research reports from the perspective of a builder/remodeler and former high school principal. For centuries, researchers have produced research reports and then disseminated their findings. This helps the progress of mankind, but it is separate from learning experiences. PATH filled an archive with wonderful research that has not led to learning experiences. PATH will not be able to further its mission until it bridges the gap between information and learning. A simple way to do it is by using some educational templates.

The Web is wonderful for both dissemination of information and providing learning experiences. Sarah described it very appropriately when she said that you can Google all the information you want. Before the Web, you could use the phone to get all the information and before that you could drive around the country. But getting information is not the same as changing behavior.

The goal of education is to create behavior change, not a bigger repository of research findings. The learning process requires the conversion of compelling information into learning points and activities that convey their meaning. The process on the Web needs to be fast paced and geared to the medium and average adult attention spans.

To change behaviors, the activities and output metrics should focus on learning. It is not a big deal to post a class on the Web and once that is done, PATH can start to change behavior. Use of the learning system could be promoted by trade unions or manufacturers' incentives for builders.

MR. SPEAR: There is an excellent example already in place, the HUD-funded affordable housing design advisory Web site at www.designadvisor.org. Architects, builders, neighborhood reinvestment groups, and academic institutions have been partners in this activity. The site has interactive educational sessions. The PATH Web sites have links to the design advisor Web site. PATH and its partners could take a similar approach.

DR. O'BRIEN: The University of Texas has a program called Utopia, which is designed to take the knowledge that is found within the University of Texas and make it widely available. The UTexas.edu Web site has a link to the Utopia home page. It is geared to K through 12 education but it is

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an example of what is possible.

The Utopia program has a funding mechanism for faculty members who have material ready to go into the system. It is not an expensive process and a similar process could be added to PATH research grants. To do it well requires some knowledge and expertise that could be provided through PATH.

DR. SLAUGHTER: A lot of companies, particularly service-based organizations, focus on supplying solutions, which is essentially what PATH is doing. The first step is to determine what are the most prevalent questions or the problems that need to be solved. The second step is to package the information as solutions. When people want to know how to put in caulking, they can go to the place where it says this is how to caulk. Defining information as a solution is a total transformation from applied research at one end to commercialization at the other end of the value-added chain.

There are examples of performance measures for solution-based information. For example, Amazon.com has a constant feedback mechanism on the value of its information that is an industry standard. Amazon has a system for determining how often the information is used and if the information is useful. There are many existing paradigms for measuring the dissemination and the usefulness and value of information with respect to current problems.

MR. ENGEL: When PATH started, an Internet search for tankless water heaters listed PATH on the first page. Now, PATH is on page 7 or 8. That can be a measure of success. The technology has gone beyond PATH into the marketplace. Is the fact that we are no longer included on the first page a measure of PATH's dissemination of information? We do not know. There are many other factors outside PATH that led to increased Internet activity for tankless water heaters. Once people are no longer using us, then we have done our job, or there are better sources of information.

DR. SLAUGHTER: That may not be a good indicator because Google and other search engines place Web references according to fees paid by vendors and others. It is going to take some additional research to determine PATH's influence.

MR. ENGEL: Nobody was paying for listings five years ago.

DR. SLAUGHTER: Right, but the algorithm was different then. At that time a Web page went to the top based on the number of hits. But there are methods to measure the value of Web-based information. As I mentioned, Amazon.com provides information on and reviews of the products it offers for sale. At the bottom of the blurb is a button where the shopper can respond to say if the information is useful. That provides immediate data on which to base revisions and management decisions as well as a long-term performance measure. Performance measures need to be timely and provide relevant information to program managers.

DR. WONG: This kind of feedback mechanism can be useful but it can be gamed. There are cases where authors have provided biased feedback that invalidates the results.

PATH also needs to consider the demand for information and the source of that demand. Since Hurricane Katrina hit the Gulf Coast, people are concerned about energy prices, which led them to contact organizations such as the American Petroleum Institute (API). API wants to assure people that the rising cost of fuel is not an oil company conspiracy and assist them by telling them how to reduce their demand. To do that, they need sources of information. PATH needs to think beyond dissemination to a broad audience and also consider dissemination targeted to certain institutions, such as API.

MR. GONZALEZ: Going back to the discussion of tankless water heaters, there is obviously some degree of success, even if it cannot be measured. Something has obviously happened. I don't think we have been able to measure much of anything, but that technology is at least going in the right direction.

Regarding the target for dissemination of information, if PATH chooses the right target, it may have more impact and it might be easier to measure its impact. It would be interesting to hear from the workshop participants about who the most effective target audience might be. In terms of the domino analogy, by choosing the right target, the first one might kick down ten more dominoes as opposed to a single domino standing out there on its own.

MR. HODGES: It is obvious that homebuilders are a prime target, but which of the 60,000 homebuilding companies in the United States does PATH need to reach and which people in the

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company? Is it the vice president of construction, the purchasing director, or both? Who is looking for the information and how do we get it to them?

PATH might be instructed by Malcolm Gladwell's *The Tipping Point*, which is based on the premise that ideas, social behavior, messages, and products sometimes behave like outbreaks of infectious diseases. Gladwell discusses how in a given system some people and actions matter more than others. PATH needs to identify the mavens, the connectors, and the salesmen that are likely to value the information and move it along throughout their organizations and networks. The first part is to find the people who are creating a demand for the information, who have the greatest propensity to look for that information. The information needs to be presented so that they understand and use it. Whose job is it in the homebuilding company to understand that information?

I think PATH can reach a tipping point (create a social epidemic) by addressing issues of profound importance. Every two years some major technological issue comes up in the homebuilding business. Right now, it is water intrusion and storm water management. A focused effort can have more impact than trying to be all things to all people, or providing opportunities for 50 different technologies. Builders should know PATH is a resource for learning about an important issue. PATH can provide a tipping point. It can be the source that makes things happen for important issues instead of trying to be all things to everyone.

Right now, storm water management is a critical issue, so that is the subject of meetings inside the company and in the professional community. It is not that difficult to find the storm water management mavens and provide them with information that they and others can act on. The information from PATH might create the tipping point for positive change.

DR. MARTIN: By focusing on topical issues, PATH runs the risk of being associated only with that one issue.

MR. HODGES: I would rather have PATH be associated with one issue than be the definitive source for nothing. I am not suggesting that it is all or nothing. PATH can have diversity and at the same time focus on one or a few issues that may change over time. The point is to be able to create a tipping point that in turn creates value for the dissemination of information. Hit the hot buttons of the industry more than the buttons that do not matter that much. Focus on the issues builders care about, the issues that are scaring them and keeping them awake at night. Help builders find ways to mitigate that problem.

DR. MARTIN: My concern is whether a focused information dissemination program is sustainable.

MR. EMRATH: I understand that is a risk, but I think the greater risk is that the key people do not know PATH. If builders know that PATH is focused on current issues of interest and it provides valuable information, then they will come.

MR. HODGES: Once builders or consumers have used it once and it has provided valuable information that satisfied their current needs, then they will learn that PATH is a valuable resource. They will develop a conditioned reaction to go to PATH when they need information. If PATH resonates with its audiences, then they will keep coming back.

MR. GONZALEZ: This sounds like putting demand pull above technological push because it will attract more people.

DR. VANEGAS: To use Mr. Gladwell's analogy, the Centers for Disease Control (CDC) is a model of a very effective program. Of course its annual budget is a little larger than PATH's. Nevertheless, everybody knows what the CDC is and that it is the definitive source for information on communicable diseases. They have an excellent system for dissemination of information. CDC is not just about basic research. It is about finding solutions to problems.

MR. HODGES: The point was made earlier that builders are more concerned about short- rather than long-term benefits. If a builder is worried about water intrusion, because one big claim will put the company out of business, then a technology that addresses this problem has immediate short-term value.

MS. BURT: One of the problems in using CDC as a model is that CDC is the federal government's civilian focus for activities it is doing. However, federal activities concerning the homebuilding industry are diffused in a number of federal agencies. In addition to several offices in

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HUD, there are related programs in the Department of Energy, Environmental Protection Agency, U.S. Department of Agriculture, and others. The agencies have some common goals and try to work together as much as possible, but the process is difficult. There is a need to develop an interoperability of agencies so that demand for specific information can be seamlessly directed to the most appropriate source and eliminate competitive efforts. The American people want the federal government, not any specific agency, to provide the solution to their problem.

MR. ASDAL: The fundamental mission of PATH is not to do research but to coordinate the efforts of all the agencies and the private sector. If PATH is not doing that for federal government programs, it needs to be done.

MS. BURT: I am not saying that coordination is not happening. The problem is specifically in regard to where people go for information. The average person does not know enough about federal programs to identify the best place to go for their specific information needs. The agencies are cooperating but are relying on the audiences to understand the programs well enough to know where to go.

MR. ASDAL: The average person does not care which agency provides the right answer. In theory, PATH is supposed to pull it together. If there is internal competition for which agency gets the most hits, then we probably need a different approach.

MS. BURT: I did not say that the agencies are competing for attention. I am saying that people do not necessarily know where to go for information.

DR. MARK: Alleviating that need for the consumers to figure out where to go is one of PATH's functions. In other words, PATH needs to be the place for one-stop shopping, because the user does not care if the information is drawn from Department of Energy, U.S. Department of Agriculture, or any other source. In some ways this discussion has identified a solution, as well as articulating the problem. In addition to people getting information, there are also other problems in interagency coordination.

DR. VANEGAS: The Whole Building Design Guide (www.wbdg.org), which is a Web portal, is another possible model. A portal for information does not reinvent something that another group has already done, but rather it provides a method to easily find and move to that source.

MS. BURT: I have to say that I think we have made tremendous progress in the three primary agencies, EPA, HUD, and DOE, in coordinating our activities so that we do not do the same thing. The agencies are still addressing the issues of how best to get information out.

MS. SHIPMAN: Even CDC's Web site acts as a portal for information. Information on a particular disease might come from NIH, but the user does not need to know that. The Internet is designed to integrate and interconnect multiple sources.

MR. HEITZMANN: I am working on redesigning ToolBase. ToolBase currently operates as a portal with links to many sources. ToolBase is trying to draw people in by highlighting what we think are topics of current interest. For example, responding to the recent hurricanes, ToolBase is steering people toward materials, mold resistance, gypsum, alternatives to plywood, and other topics of interest.

The most important thing is ensure that the popular search engines list the site. ToolBase is using methods that do not require a fee. Entries at the very top of the list are always paid advertising, but users know that and usually skip over them. ToolBase showed 9,000 pages of tankless water heaters this past November, which surpasses the companies that are selling them. Nevertheless, Toolbase needs a better understanding of the audience and the information those people want to see.

MR. ENGEL: PATH does not necessarily want to reach the head of the company. It wants to reach the people within the company. The problem is finding the target person. Each company has a different structure. The person's title and place in the organization chart is different in Pulte than in Centex or any other company. PATH has not yet been able to develop a strategy to identify those key people.

MR. HODGES: Use the building industry's media structure. Place an advertisement that says; "Here is your path to information." Those resources are there and many media companies would provide the space as an industry service. A one-time spot will not work. It requires long-term consistent exposure.

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All the purchasing guys will be reading the magazines and see that PATH has information on their current topic of interest. Once they go to PATH for information, their contact information can be used to build a database.

MR. SPEAR: Seminars at national and local builders' trade shows can also be effective. Provide PATH materials where the target audience is going to be.

DR. MARK: Part of the earlier discussion was about branding as an activity that PATH could do. In essence, this recent discussion has been about branding PATH, that is, the marketing of PATH as an entity. There is a whole host of ways of going about that depending upon the particular audience. Sometimes it is copies of free media that get to the consumers. Sometimes it is finding the key information conduit. There was a campaign in the environmental area to give swordfish a break from the fishing industry. The proponents did not try to reach consumers. They got a few chefs to support their cause, who then got more chefs on board and then things snowballed. It was a fairly effective campaign. The right approach depends upon the target group. There is a set of approaches that can be taken once that group is identified. It is marketing PATH as opposed to marketing some technological innovation.

MR. KASTARLAK: What we are talking about is name recognition. The public needs to know PATH, where to contact PATH, what PATH does, and so forth, rather than the other way around. This means that PATH has to advertise that it is the principal source of information about homebuilding in this country.

PATH needs to advertise to get brand recognition. It also needs to ensure that once it makes contact with its target audience, it provides the kind of comprehensive, high-quality, unbiased, transparent information that has been discussed earlier. It also needs to ensure that the information addresses the audience's interests and provides what they need to know. Faced with the reality of limited resources, PATH's dilemma is finding the optimum balance between funding activities that provide content and activities that provide outreach. That balance point will probably change over time, so it will take an ongoing effort.

DR. SLAUGHTER: PATH's industry partners can promote the program by telling peers that it is incredibly useful, particularly in problems faced by key people on hot-buttons issues. PATH's partners are the program's peer reference.

MS. BURT: That will work if the partners decide to do it.

DR. SLAUGHTER: PATH can also be promoted as a way for builders or manufacturers to differentiate their company from the competition. By being associated with PATH they are associated with the best practices. It is a point of enhanced reputation for the participants.

DR. MARTIN: That is actually one of our goals—that builders will be differentiated based on PATH.

MR. COTCHEN: McGraw-Hill Construction can look for ways to assist PATH by posting information on our Web site. Public service advertisements are also a possibility. There is also an opportunity to connect PATH to editorial departments of various McGraw-Hill magazines, such as *Architectural Record*, *Engineering News Record*, *Design Build*, *My House*, and 10 regional publications. All these magazines are looking for good content. There may be additional ways that the McGraw-Hill Construction Group can work with PATH.

DR. MARTIN: HUD believes that what the workshop has been calling branding—that is, getting more people to recognize the PATH name and know what the program has to offer—will help the program succeed.

DR. MARK: We have mixed two different aspects of branding. They work together but they are distinct. One is name recognition and the association of that name with a set of products and services. This is something that PATH needs to accomplish on its own. The other is using the PATH name to represent a set of values or attributes that people will want to be associated with. The model will depend on the objective. Manufacturers want to be associated with EnergyStar because consumers recognize that as adding value. This creates a dilemma, because name association creates a conflict when providing solutions to problems for builders and others involved in the housing industry, who are looking for unbiased information.

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MR. GONZALEZ: Five years ago, PATH's name was known only to a limited number of people who had been involved with a PATH activity. Over time, anyone who has been in contact with the program recognizes its value. At the same time there has been slow but steady growth in name recognition. The fact that McGraw-Hill is participating in this workshop and publishers such as Hanley Wood have been helping out, speaks to the momentum for even greater recognition. The question then is what can be done to increase that momentum.

One of the related issues we are dealing with is targeting the channels of communication. Broad name recognition is not enough. PATH needs to be known and used by the people that make a difference in the development and diffusion of innovation in housing. PATH needs to connect with the senior vice president of purchasing.

DR. MARTIN: It would help if those key people did not change jobs so often. The problem is two-fold, making the contacts and keeping them up-to-date.

MR. HATTIS: Improved communication with the dealers and other supply chain participants provides a good opportunity. A major plumbing supplier who attended the barriers workshop had never heard of PATH or visited any of PATH's Web sites. Participation in the barriers workshop was his introduction to PATH.

Construction product dealers are the link between the right person at the manufacturer's end and the right person at the builder's end. Connect to the dealers and they will lead PATH to the right people in the building community. Successful dealers are interested in the same issues that their customers are interested in. The supply chain should be a targeted audience for strengthening PATH dissemination activities.

MR. HODGES: Dealers are a good conduit to the smaller builders, but the larger builders no longer negotiate with dealers. They negotiate directly with the manufacturers and the dealers provide logistics. The dealers' conversations with large builders' purchasing agents are about how many trucks are available and how fast the product can be delivered. The point is very relevant to the smaller builder, but there are two separate kinds of audiences.

DR. VANEGAS: The universities are educating more students to go into the construction industry. Many universities also have links to the manufacturers. Universities can also be a conduit because they provide a very rich environment that connects with a lot of constituencies. There are student chapters of professional and trade organizations and many universities have industry advisory counsels that provide an existing network. There is also a national consortium of university housing research programs that is a focal point for housing issues.

MR. SPEAR: That is especially true for the major state land grant universities, such as Texas A&M, which has a strong training program for builders. This topic came up in the NRC review that urged greater PATH involvement with land grant universities connected with the USDA extension service.

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Discussion of PATH Goal III—Advance Housing Technologies Research and Foster Development of New Technology

PANEL MEMBERS' OPENING COMMENTS

DR. VANEGAS: I would like to introduce the panel that will start our discussion of goal III. First is Dr. Matt Syal, who serves as a professor and the graduate program director of the Construction Management Program at Michigan State University, which is one of the few schools in the country that integrates planning, design, and construction. He is also the research director of the Housing, Education, and Research Center. His Ph.D. is from Penn State University and he has worked in many positions for construction firms in the United States, India, the Middle East, and Africa. He also serves in several advisory and consulting capacities for construction in government organizations.

Next is Dr. Chris White, who works at the Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST). He is the NIST contact for PATH-sponsored efforts to develop methods for measuring the durability of materials. He is working with large industrial consortiums representing more than 90 percent of the nation's output in sealants and caulking. His second focus is to provide the economic rationale for the adoption of new methods. Chris is an analytical chemistry polymer scientist with a Ph.D. from the University of Wisconsin-Madison and a former NRC postdoctoral fellow.

The focus of this session is Goal III, which is to advance housing technologies research and foster development of new technology. The discussion questions that we will be addressing are the same as those addressed in the previous sessions.

DR. SYAL: I am speaking form the perspective of university faculty. Our interests are to see how universities can do research and outreach, and bring housing design and construction into college classrooms. I am also speaking for the National Consortium of Housing Research Centers (NCHRC). The consortium members represent about 19 land grant universities with active housing research programs.

I will be talking about the *NSF-PATH Housing Research Agenda Workshop Final Report*, which is available on the PATHNET.org Web site. The report documents a year-long effort sponsored by the National Science Foundation (NSF) and PATH to develop a research agenda and a February 2004 conference of NSF-PATH researchers and members of the NCHRC. The agenda focused on basic or fundamental research (as opposed to applied research), which are the types of research projects generally undertaken at universities. PATH recognized early on that the best approach to stimulating housing technology research at universities was through a partnership with the NSF. The result is a program of university-based research that has steadily improved over the past five years. The program has sponsored about four or five projects a year, but most importantly it has helped universities create a critical mass of housing researchers.

Both PATH and NSF decided that to have a sustainable program, they needed to set up a visionary agenda of what they wanted to do over the next 10 to 20 years. I coordinated the effort of developing an NSF housing research agenda, along with a couple of the folks. One of them, Dr. Mark Hastak from Purdue University, is here. Another one from the University of Central Florida could not attend this workshop. In 2004, we invited about 45 researchers, who had direct or indirect interest in housing, to participate in a forum. The forum addressed five potential areas of research: construction,

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management and production; structural design and materials; building enclosures, energy, and indoor air quality; community and the economy; and systems interactions and the whole-house approach.

In determining the appropriateness of Goal III, we should consider how PATH can bridge the gap or make the link between basic research and applied research, and between university resources and the needs of the industry. We should also consider how to use university-based research to both develop content and disseminate information to builders and consumers.

DR. WHITE: Earlier today we talked about the pipeline for delivering innovation to builders and the type of information they need. This is essentially recognition that there is no department of building science within the federal government. There is essentially no pool of money that allows a large agency to go after and solve the kinds of fundamental problems that we have been talking about.

Because resources are scarce, PATH needs to think about how to best use the limited resources. PATH's total budget is very small considering the cost of doing research. PATH needs to use its funds to leverage other resources within the government, industry, and academia. Creation of that leverage is hampered by that fact that there is no central government or private organization for building science technology.

DR. VANEGAS: The development of housing technology is at the intersection of physical sciences, engineering, and business. Business decisions include consideration of both risk and return. The development and diffusion of technology also requires input from social sciences in order to measure the ultimate outcomes and impacts. Housing technology is not a simple term.

Research is part of a continuum that leads to development, then to demonstration, and to deployment. It is a continuum because once a technology is deployed, the cycle goes back to research to determine its performance. PATH is at the core of what the Department of Commerce calls the value of debt. The value of research appears when a technology becomes successful, but the true cost of R&D to make a technology commercially viable is seldom known.

Fully Integrated and Automated Technology (FIATECH), an organization concerned about technology for the capital construction industry, is a good organizational model of an industry-driven consortium for technology R&D, demonstration, and deployment. I am on the board of directors and find it a very interesting exercise. The Construction Industry Institute (CII) is another example of a collaborative approach to R&D for construction.

There is a tendency to segregate research, education, and practice. A conscious effort is needed to bring them together. This fact leads most universities to have active outreach programs to communicate with consumers and professionals. It is often very difficult to communicate the value of basic research to those outside academia. PATH can help bridge that gap.

DISCUSSION

MR. ENGEL: Given this morning's discussion that PATH may have too many goals and objectives, and that the program's limited resources are spread too thin, and given also the fact that the Department of Energy has a significant building technology development program, albeit one that is focused on energy, would it make sense for PATH to eliminate R&D as a goal and focus on the barriers and information dissemination goals?

MR. SPEAR: That may be effective as long as PATH keeps demonstration projects and programs like the Concept Home. R&D to develop new technologies could be left to others.

DR. O'BRIEN: Research for the development of materials and technologically advanced products can come from industry, but R&D for improved, more efficient processes and policies needs to come from another source, such as PATH—for example, the PATH-sponsored study at Virginia Tech on the innovation process. PATH should continue to sponsor research with an emphasis on the innovation process. There will always be people in industry, academia, and government doing research to make a better widget, but research on innovation in housing is not likely to happen without a champion like PATH.

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Regarding the suggestion to look to CII as a model, CII does not have housing anywhere on its radar screen. However, CII has done a good job of understanding government and industry construction issues, benchmarking and identifying best practices, and developing education programs. It has a complete feedback loop that helps its industry sponsors improve their processes.

DR. VANEGAS: CII is a example on how government and industry as owners, suppliers, and building contractors can work together with academia to develop a vibrant research program.

MR. HATTIS: I would like to address Dr. Syal's point on the relationship between basic and applied research. A model that comes to mind is FEMA's National Earthquake Hazard Reduction Program, which has been in existence for about 15 years or more. It has a budget of about $100 million per year. It is much larger than PATH, but it is small by comparison to many other federal research programs. It bridges the gap between basic and applied research. It sponsors research on materials and structures (including wood, which relates to residential construction) and applies developing changes to the codes and standards that regulate building construction in earthquake areas. The earthquake codes and standards today are completely different from what they were ten years ago and this is the result of a program that coordinated the efforts of NSF, NIST, USGS, and FEMA. The problem is very different from the one PATH is addressing, but it is a model of a successful program that has been able to get appropriations year in and year out. They have advocates in Congress. It also helps that every once in awhile there is an earthquake in California.

DR. SYAL: Should PATH do research? It is not a question that can be answered yes or no. Large homebuilding companies, like Pulte and K. Hovnanian, are starting their own research programs. However, they will probably think of the results of that research as being proprietary information. It is unlikely that they would publish the results of their research unless it gives their company an advantage.

If they need some basic research done, they have the resources to get a private or academic consultant to do the research. They can also team with local and national builder associations, suppliers, and supply chain organizations.

Small and medium builders generally do not have the resources needed to sponsor research. Sometimes they can initiate programs with local extension services or local universities that have a funding source such as PATH. The critical mass of housing researchers will likely dwindle without federal funding support. Without PATH funding, the group that will suffer most will be the small and medium-size builders.

DR. WHITE: Innovation in other industries is driven by funding. For example, research in biomedical sciences is currently experiencing tremendous growth that is spurred by federal funding. At the same time universities, such as Tulane, are shutting down their civil engineering programs because NSF has decided that it is not an area they are going to fund.

The only source of funding for housing technology research is PATH. If PATH stops funding research, the only information PATH will have to disseminate will be product literature from manufacturers. There are some problems that are so big that they require a very large research effort. PATH cannot support such large programs but it needs to be part of that effort.

As a point of information, the National Earthquake Hazard Program is now a NIST program.

DR. HASTAK: I would like to think that the partnership in PATH stands for partnership between academia, industry, and the government. As academia focuses more on research and dissemination of that information, continued funding from PATH has become very important. If research funding is cut, it will not only cut down on the development of new technologies, but will also cut down dissemination of information. It will also cut down on education because schools will not be able to sustain the current programs. I think it is extremely critical for PATH to continue funding research.

MR. WEBER: The Portland Cement Association's PATH-funded research has been an excellent way for the association to work with other sectors of the homebuilding industry such as the Steel Framing Alliance, and the Structural Insulated Panel Association. PATH provides a nonproprietary forum where PCA members and others can pool resources for research. This approach to federal funding to support industry cooperative efforts is also used by the Federal Highway Administration. PATH funding makes a difference.

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DR. VANEGAS: The lack of funding may be due to not asking the right questions. Housing researchers need to broaden their vision and to look at how they can address the problems that currently have large funding programs. For example, every university is building a brand new bioengineering, bioscience, bio-whatever laboratory. A lot of bio-based materials can have a tremendous impact on the housing industry. Housing researchers are not partnering with the people that are getting the big bucks. Nanotechnologies are another example of an area of intense research interest. There are some potential things for construction such as steel that is ten times lighter and ten times stronger, where nanotechnology could impact the housing industry.

Worldwide, housing is a $3.4 trillion industry. In the United States it is $1.1 trillion. Improving an industry of this size should be worth investing more than $5 million per year.

DR. WHITE: Nonetheless, researchers are going to answer the questions of the people who are paying the bill.

DR. SLAUGHTER: Federal organizations are usually buffeted by political vicissitudes. The challenge is how to create a sustainable momentum. Operation Breakthrough was incredibly exciting for the people who were involved in it, but support for the program was not sustainable. There are not a lot of people around who were involved in Operation Breakthrough. Many people do not know what it was, what came out of it, or the specific technologies that were demonstrated, many of which are incorporated in buildings. PATH needs to create a program that is sustainable. In 15 years, the program may not be called PATH anymore, but it may continue as ongoing links among its partners.

One of the issues we have been exploring is the role of manufacturers and the supply chain. PCA is represented at the workshop, but more of these organizations need to be involved. Manufacturers can be an effective leverage point. For example, if DuPont has come up with an ultra-strong material using nanotechnologies, you can bet they want to get their share of the construction industry. It may be commercial or housing or both. If they can reduce their risk by participating in a partnership with governmental research labs, university research labs, or industry research labs, they will do it. The money begins with the manufacturers. If PATH wants to leverage R&D dollars, then go to where the money is.

DR. WHITE: That is the model that we have built for PATH-sponsored research at NIST. There are 20 companies under specific Cooperative Research and Development Agreements. They encompass the entire output of several industries, such as caulk and coatings. We leverage the PATH money with matching funds from industry. The goal of this approach to PATH research is to create a sustainable pool of resources that can be adapted to other problems as they are identified.

Part of the problem that PATH has encountered is that administration changes resulted in a loss of support and funds. DOE faces similar problems, but DOE can show that it consistently delivers value from the research it does. That is what PATH needs to do.

DR. MARTIN: Over the past year, we have looked at other similar federal government-private partnerships. We are trying to identify approaches that are likely to lead to a sustainable program.

DR. JACKSON: I am Ric Jackson. I am the director of FIATECH, which was referenced earlier as a possible model for PATH. FIATECH is a consortium of owners, operators, contractors, suppliers, research organizations, and a few academic organizations that pool their resources to address capital construction issues of mutual concern that have a technology solution. The technological solution often exists, but the issue is that the construction industry has been slow to adopt it.

Part of our discussion today is how FIATECH attracts industry participation. It has been a long process. FIATECH was started by people in industry who were concerned that the industry was suffering because the results of research and innovation were not being deployed and flowing to their bottom-line profitability.

It is difficult to get people in an industry to work together, but effective people saw value in pooling their resources. They see value in working on projects that affect their bottom line and they see value in attracting others to pool their resources. FIATECH is focused on getting people to work together to solve problems.

DR. MARK: How much does FIATECH charge for membership?

DR. JACKSON: The dues structure was recently revised. Membership fees are based on a

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company's revenue. FIATECH's founders had been in other organizations that charged one large fee for all participants. They thought that the large fee was a barrier to participation by small companies. They based the membership fees for FIATECH on a company's revenue and in the case of government or academic organizations on the research budget. The average fee is about $35,000, which includes participation in two projects. There is an additional fee for participation in more than two. If the research budget is under $5 million, then the fee is $10,000 and that includes participation in one project.

MR. SPEAR: If PATH were to come to an organization such as the American Institute of Architects, it might be willing to contribute to a collaborative research fund. It seems that most of PATH's current partners are receiving funding from PATH rather than contributing to a research funding pool.

DR. VANEGAS: The role of academic institutions in preparing the homebuilding professionals of the future places them in the forefront of cultural change. They are in a position to foster a homebuilding culture that values research and innovation. They can disseminate knowledge of PATH's mission through their graduating classes. Investing in academic research provides more than the results of a research project.

MR. GONZALEZ: In California, concerns that the spotted owl issue would affect lumber delivery spurred research in steel frame construction. This is an example of demand pull determining research priorities, because the building industry needed to adapt to changing conditions to survive. If PATH can determine what that demand is, then it can sponsor research that can have an immediate effect on the housing industry, whether it is energy, materials, or processes. The issues may not necessarily involve high-tech innovation. The demand may be for new uses for things that are out there.

DR. O'BRIEN: A lot of the discussion today has been focused on the end customer being the person who purchases a home. Home buyers are generally most interested in the bottom line. They want a home that works for them, is beautiful, affordable, and energy efficient. Chances are they plan to sell the home in five years. However, if the customer is defined to also include municipalities and public service providers, such as electric utilities and wastewater services, then there is an opportunity for another potential partnership. Energy and water companies provide incentives for homeowners to use new innovative technologies to lower the demand on the public systems. For example, I built two homes in the last five years and in both communities, the energy efficiency standards for new homes were set by the local government. These organizations have an incentive to invest in education, outreach, and the development of new technologies

MR. CHAPMAN: Over the years, NAHB has looked to manufacturers and high-production builders to provide funding for almost everything. They get hit up probably 15 to 20 times a day for large contributions. The research that they are involved in typically is going to be proprietary, as was mentioned. There certainly is some room for partnerships, but they are unlikely to be big financial supporters of PATH.

A group of builders started an organization called the National Center for Housing in the Environment (NCHE). The object was to develop a source of reliable, untainted data on environmental issues that could help developers and builders with projects that were being challenged on environmental issues. They needed good data to support their projects, but most environmental data was biased because the Sierra Club or other groups sponsored it. The center's object was to develop good data, even if it was bad for the housing industry. Unfortunately there was no support from high-production builders and manufacturers to help sponsor that organization, primarily because they wanted short-term deliverables.

When mold became a big issue, it took NAHBRC about two weeks to raise $750,000 for research on mold in housing. This supports the earlier discussion about focusing on hot-button issues. Builders and manufacturers are looking at their bottom line and are motivated by short-term results. Even a large builder is not concerned about houses that will be built 20 years from now. It is next year's production, or at most the next five years' production, that is a concern.

It is very exciting see Pulte committed to research and innovation, but if there is a 2 percent spike in interest rates, that program is in jeopardy. That is the reality PATH has to deal with.

DR. WHITE: A purely demand-driven research model might have difficulty responding to short-

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term demand. When a demand is identified, it is going to take time to develop the capacity to get that research done. Even if you have all the money in the world to make it happen, it is not going to happen without a research infrastructure in place. It is important for PATH to have programs that maintain a research infrastructure.

MR. CHAPMAN: The NAHB spends most of its money and effort lobbying Congress about tax and budget issues that affect the business climate for builders. NAHB, the realtors, and others will spend a fortune on this battle because it has a huge and immediate impact.

I think all the ideas we are talking about on funding are correct and should all be pursued. The public-private partnership is important and is essential to the sustainability of PATH. It is a tough nut to crack, and there are times when there are opportunities and times when there are not. When I spoke to the High Production Builders Council about the NCHE, they could not have been more polite or showed me out the door faster.

DR. HASTAK: In CII's research model, projects are led by an academic, but they also have teams of industry partners working with and advising the project team. Industries contribute both funding and expertise to CII research. They bring excellent ideas and keep the academics in touch with what is really important to practitioners. As a partner, industry should be sitting at the table discussing the current hot issues and what is needed for short- and long-term solutions to their problems.

MR. CHAPMAN: That is the role the PATH Industry Committee plays. That is how the goals were redefined. That is why so much of the work that PATH has done has changed. I think it has been a long process for PATH to get where it is and a great deal of that progress has been due to the involvement of industry groups. PATH is staffed by a very responsive group that pays a lot of attention to industry and academic feedback.

MR. PETERSEN: Pulte started its own R&D program for one reason. Pulte builds 40,000 to 50,000 homes a year. With that volume, if there is a problem, the answer to that problem is needed quickly. Pulte needs to control the agenda and the schedule. It does that by controlling the budget. Pulte has not made any of the manufacturers it works with sign confidentiality or proprietary agreements for the innovations it has developed. Everything is available to any other homebuilder. That is how we get industry to work with us. If we told them they were only going to have a market of 50,000 homes, they would not have an incentive to spend their time and effort to work with us.

A lot of technologies have been developed to address energy efficiency, but in solving the efficiency problem they created humidity problems. When the housing industry has done R&D, it has not done a good job of integrating new technologies into existing systems. System integration requires good-quality R&D. Ensuring that R&D has the support of basic research that provides the information needed for systems integration is a possible role for PATH. The R&D needs to be followed by the dissemination of information to ensure proper installation and operation of the new technologies. That follow-through is often missing.

I am from Michigan where I am surrounded by automotive engineers who love to work on their own homes. When they look at high-tech housing components, they are reminded of maintenance nightmares associated with technology that has gone. For them, housing innovation has a stigma, but technology has gotten a lot better and more reliable in the last five years. However, the stigma is there from the past 15 or 20 years when high-efficiency homes and tighter building envelopes were first introduced.

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Proceedings of a Workshop to Review PATH Strategy, Operating Plan, and Performance Measures
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9
PATH Forward—Program Plan and Performance Measures

WRAP-UP COMMENTS

MR. GONZALEZ: The final segment of the workshop addresses the synthesis of PATH's three goals, nine objectives, and 53 outcomes that are presented in the draft document. One objective of the workshop is to give PATH some sense of priorities in order to maximize the impact of its limited resources. Up until now we have addressed the three goals as having equal weight, but now we will discuss possible priorities while keeping in mind what is feasible and practicable.

This discussion will be led by Dr. Melvin Mark.

DR. MARK: PATH has been extremely responsive to previous NRC recommendations. The draft strategy, operating plan, and performance measures are a direct response to what PATH heard from the NRC and others. There have been a number of comments along the lines that there is a need for focus, especially given resource constraints and a budget that is smaller now than when the planning took place. The workshop group has recognized the need to focus, but then there were discussions that pulled the possible focus in most of the directions that are presented in the draft and some additional ones. We will not try to develop a consensus, but we should be able to develop a sense of priorities and the optimum balance of a diffuse versus a focused approach.

We also need to get back to some issues of specific metrics to determine which measures are most important to PATH's stakeholders, and what information HUD needs to manage the program. It is clear from today's discussions that there are stakeholders with tangible interests and these interests are diverse. We are faced with the question of whether or not PATH can be all things to all people.

This discussion will start with introductory statements from Mike Chapman, president of Chapman Homes and chairman of the PATH Industry Committee; Ross Heitzmann, from NAHBRC; and Anny Wong, a political scientist at RAND and a coauthor of the *Building Better Homes* report.

MR. CHAPMAN: Everybody participating in this workshop is familiar with PATH and how far it has come. When PATH was first proposed most people thought it would only result in a report that would sit on a shelf to gather dust. Most people were not sure it would be worth an investment of their time. Several years were spent wrangling over which government agency would take the lead role. PATH started with goals assigned by the administration that the NRC committee found to be overly ambitious for a small program, influenced by many factors outside the purview of PATH, and very difficult to measure. The program staff worked with all of its partners to develop more appropriate goals and respond to many other suggestions to improve the program. At the same time its budget was shrinking and its supporters had to fight to keep it going. To see PATH come from that kind of beginning to develop the strategy and operating plan we are reviewing shows that if it survives, it can overcome any obstacles to its success. A key factor that will influence success will be the continued coordination of a private/public partnership.

PATH may have some lessons to learn from a HUD program in the late 1970s and early 1980s called the Joint Venture for Affordable Housing. I think it may be one of the best programs that I have ever participated in. The goal of the program was to demonstrate how innovative builders and developers could create affordable housing if they are not constrained by zoning and building codes and standards. All exceptions to the codes and standards needed to be well documented, based on sound engineering, and maintain the health and safety of the house and community. Also, as a HUD program, the availability of

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FHA loans was assured.

At that time, affordability was the major concern in the housing industry. I do not think we have given up on that objective, but it is getting more difficult. My company's demonstration project was phase one of a three-phase development in Santa Fe, New Mexico.

The exceptions to the codes and standards allowed us to cut development and building costs by more than 25 percent per house. There was an earlier reference to using innovation to save one dollar per square foot. I do not know the cost of the houses in that case, but it is probably a savings of one percent or less. The 25 percent savings was accomplished by addressing every detail such as the placement of electrical plugs and eliminating door bells and using door knockers. The trigger for action was the opportunity for saving $75 per house.

The demonstration was a tremendous success; people were waiting in line to purchase the houses. All 50 houses were sold almost immediately. Unfortunately, this success was not extended to the second phase because of political objections to affordable housing in the community. Without the regulatory exceptions, second-phase prices jumped 25 percent.

The city of Santa Fe now wants affordable housing. The city requires 30 percent of the houses in all new developments to be affordable and meet certain other requirements regarding the mix of units for different housing needs. Affordability is now achieved with a subsidy, which is about $100,000 per house. The subsidy results in a corresponding increase in the cost of the other 70 percent of the houses. Furthermore, the city maintains an ownership position in the subsidized houses that limits the equity growth of the owners. There are probably many more efficient ways to provide affordable housing. This situation is not unique to Santa Fe. PATH focuses on using new technologies to solve housing problems, but there are many other issues that builders and consumers need to deal with.

MR. HEITZMANN: Speaking for NAHBRC, the shift of PATH's goals to focus on the process of innovation instead of its outcome was the right thing to do. The draft program plan is clearly thought out, very detailed, and focused in the three most appropriate areas: barriers, dissemination of information, and advancing R&D. Even with the limited funding, all three should be maintained as part of the PATH program. The metrics should have more differentiation by giving them weights. Some of the outcomes are more important than other outcomes.

Benchmarks for the performance measures should be consistent with the amount of program funding. PATH also needs to ensure that the measures actually measure the desired outcome. Many of the outcomes are very difficult to measure or the cost of an effective measure would be prohibitive. It is very difficult to measure changes in the rate of technology diffusion. The number of people accessing PATH Web sites and the number of documents that are down loaded can be measured, but that does not show how much difference PATH has made.

DR. WONG: The draft PATH program strategy, operating plan, and performance measures document indicates that PATH is making changes and becoming a better program. The logic model delineating the program activities and measures of the inputs, outputs, and outcomes should lead to an even more effective program.

The draft document is, overall, a good first effort, but there are some problems caused by the way certain terms are used. For example, the use of the term "innovation" is expectably pervasive. But innovation can and does refer to many different things. To begin with there are product innovations and process innovations. The various audiences that PATH is addressing approach these types of innovations in different ways. A builder might be concerned about an efficient process for installing windows, but a consumer might only be concerned about its durability or energy efficiency.

The term "barriers" is another example. Again, the perspective of the audience is very important. The barrier may affect any of the PATH participants, so there is a need to address them all on their own terms. PATH participants are all motivated by their own incentives to do the things they do, and make the choices that they make. Understanding barriers includes knowing where the barriers are in order to identify the opportunities to start changing the incentive structure.

Another concern is the term "housing." The term is used to refer to a wide array of possible audiences, often without distinguishing their characteristics. The concerns of first-time home buyers are

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very different from those of luxury home buyers, and the needs and concerns of people building or buying single-family homes are very different from those involved with multifamily dwellings. New housing issues differ from those of existing housing stock.

The amount of funding allocated to PATH cannot adequately support all of the goals and activities listed in the plan. The program would be difficult to support even with significant contributions from PATH partners. The list of activities in the draft is an excellent start, but it is more of a menu than a plan. The plan needs to also have priorities and show how those priorities are likely to change over time. It may be more effective to address all of the goals by focusing on each of them consecutively rather than addressing them all at the same time.

Performance measures are important but the cost of collecting and maintaining performance data should be a key consideration in determining which metrics to use. The number of proposed activities and measures magnifies this problem. There should also be consideration of a centralized database to support the information needed by management as well as support the reporting and oversight functions. As mentioned earlier, practicability should be the first criterion for performance measures.

The discussion question should be revised from: Are the goals realistic? to, Are the priorities realistic? I agree that research at universities is important. Basic research is important; however, that research should be applicable to the needs of PATH's partners. It is the responsibility of the government to fund the growth of a knowledge base as a public good. Part of this knowledge base is the university system that also trains architects, engineers, and homebuilders who will be charged with achieving PATH's goals.

The value of research in academic institutions or industry is not a matter of basic or applied research. The issue should be whether the research is mission driven. PATH as a government program has the role of a convening authority. It needs to bring people together to define problems, and then create the opportunities to initiate research to solve those problems.

It is generally more effective to advance technology by using demand to pull than to use R&D to push. This is due to the way the housing market works. This puts a priority on outreach and information dissemination and research that identifies current problems. PATH should consider working with the media and trade organizations to let them know that PATH is a resource for housing innovation information. PATH can be an effective source for reporters as well as provide information directly to end users.

The original PATH goals of durability, energy efficiency, environmental soundness, and so forth, are consistent with the values of home buyers and homebuilders. They are not effective performance measures, but they are a connection with PATH's audiences and should not be lost. The values, mission, and goals should not change over time. However, priorities should change as conditions and specific problems change from year to year.

DISCUSSION

DR. MARK: I want to thank the members of the panel and start the workshop discussion. To start, does the draft program plan need to have fewer activities or at least specify priorities? One way of conceptualizing priorities is in terms of scheduling. This is important, because communicating to OMB that PATH is going to accomplish all of these objectives without clear priorities may be a recipe for failure.

DR. O'BRIEN: FIATECH has a capital projects technology roadmap, which is not exactly analogous to an operating plan, but it is a research plan for the future that goes beyond what FIATECH itself hopes to accomplish. The roadmap helps to create a centralized agenda that other organizations can use to coordinate their activities with FIATECH. There is also value in just articulating a broader program.

DR. MARK: That is often called an aspirational model. Such models have real value, but they may not be useful as plans for success.

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DR. JACKSON: The FIATECH roadmap is an aspirational model. It is a vision of the future, as well as a description of where the organization is at present. Instead of 161 projects laid out against a seven year time frame, it defines what the organization wants to be in seven years. The roadmap includes a vision, a starting point, an ending point, and a path to get from here to there.

FIATECH expects to achieve that vision even though it does not have the resources. It is not, nor should it be, the only organization that will contribute to the realization of the vision. The roadmap is a document we use to communicate with industry and other organizations to help coordinate activities and find opportunities for collaborations.

The roadmap is a research, development, and deployment agenda to achieve a vision. For example, when you want to build something, you have a plan for what you want to do. You know in what time you are going to get it done and you know what resources you need to do it.

DR. VANEGAS: It would be a disservice to eliminate things from the PATH operating plan that diminish the overall vision. In order to take this approach there needs to be vision that defines priorities and a focus that communicates those priorities.

DR. SLAUGHTER: Aspirational roadmaps and operating plans are very different. This workshop is about a plan that OMB is going to review to determine if PATH is an appropriate use of government funds. This is very different from a document for coordinating activities of disparate organizations. OMB is not concerned with whether or not PATH has a vision. The draft document is very important to the future of PATH. Its specificity, achievability, and appropriateness are critical. It is not a visioning document. It is akin to a contract between PATH, the administration, and Congress.

MR. KASTARLAK: PATH should not be viewed as a panacea. It was never intended to be. It was simply the prescription for innovation in the housing industry. But we have to also keep in mind that innovation is not an end in itself. PATH also needs to have a social purpose and social benefit. The program is based on the assumption that more innovation and better products will improve housing. That is a big assumption.

It is also possible for PATH to have more than one plan—one to use for its contract with OMB and the other to use as an aspirational model to communicate with its various audiences and stakeholders. PATH developed an elaborate plan for improving research and increasing the development and diffusion of innovative technology. Keep that as a reference. Keep it in sight. But then present a plan for how it should be done with the resources that are provided.

MR. ENGEL: Setting priorities for PATH is important, but very difficult. From the discussion today, I do not think this workshop could achieve a consensus. The needs are so great for all three goals that there is a case for each of them being a priority. Priorities cannot be determined by a vote; the outcome will depend on who is voting. It has to be based on a sound intellectual analysis and resource management.

DR. MARK: Nevertheless, a straw vote could provide some useful information. Each participant has two votes that can be used to identify two priority goals or to identify the importance of one. This is important because there was discussion earlier about the reaction to the research goal being eliminated. [There was a show of hands to indicate priority preference for each goal.] There was some difference but it does not appear to be significant.

Since we have established that all three goals need to be addressed, are there any linkages or crosscutting issues that can help set priorities? Is there an integrated set of activities that can address core concerns and core stakeholders?

MR. SPEAR: The NRC 2002 study noted that it was important, just as important as these three goals, that PATH have effective program administration. This is addressed at the end of the draft background document, but has not been addressed in the operating plan and performance measures. Effective administration and predicable funding commitments are crosscutting issues that affect all the components of the mission. Without effective program administration the goals and activities are merely hypothetical. The limited funding that PATH has been allocated places greater emphasis on collaborative arrangements with other government and private organizations. The absence of effective administration and predicable funding is a disincentive for partners, who need to know that their contributions will have

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a reasonable chance for a useful outcome.

MR. CHAPMAN: The characteristics of the housing industry (size, cyclical nature, diversity, complexity of supply chain, and so forth) make it very difficult to measure incremental changes and the effects of specific factors. Performance measurement of the housing industry is not nearly as straightforward as a typical manufacturing process that has more control of production goals and processes. Chances are that PATH's goals and metrics will never be as defined as we want them to be.

Previous discussion of prioritization suggests that PATH will continue to work on all of its goals simultaneously. The scheduling of activities will be dictated more by opportunities to leverage PATH's efforts than by an intellectual assessment of the program. Plans are important, but flexibility that can respond to opportunity can be a larger factor in determining success.

PATH has done a great job in terms of its ability to leverage activities. A lot of the effort of the Industry Committee has focused on creating opportunities for PATH to leverage its investments. But it is a complex process that is neither linear nor direct.

MR. KASTARLAK: The current plan seems to represent three simultaneous linear processes without any linkages. In reality, it is not going to happen that way. It may be necessary to develop a model of how the activities will work together over time.

DR. MARTIN: There was an earlier version of the chart that indicated the linkages between activities, but it became too complex and impossible to communicate.

DR. MARK: That is a common problem for performance measurement and logic modeling. As mentioned earlier, PATH may need several versions of its operating plan for different audiences: a simple, straightforward version for external audiences and a more complicated version for internal purposes

MR. ASDAL: The objective of this exercise is to communicate that PATH has created value for its $5 million funding so that the people who control the budget will fund the program in the future. PATH spent a lot of time in 2001, 2002, and 2003 building technology roadmaps. But these roadmaps do not communicate what PATH has accomplished or the progress toward its goals. PATH has sponsored research on cement panels and whole-house remodeling that have provided valuable information, but there is no way to show their contributions toward the program objectives. The roadmap should provide a means of measuring progress. It should also be able to show the best routes as priorities and the activities needed to get from point A to point B, starting with basic research, to demonstration projects, and diffusion in the market. There may be new projects that do not fit on PATH's map that need to be delegated to others.

MR. EMRATH: I want to return to the earlier discussion of the difficulty of measuring PATH's effect on the housing industry. It is easy to track how many people visit a Web site, but there is a quantum leap between that and tracking diffusion of innovation in housing. PATH is not unique in this respect. Other HUD programs have faced similar problems in developing performance metrics. Other programs have been allowed to settle for less than perfect measures. The overseers, administrators, and stakeholders got together to identify the measures that were practicable. PATH has a $5 million budget, which is not enough to do involved assessments such as surveys. Many surveys can cost more than $5 million. Perhaps determining performance measures for PATH will require some negotiation.

MR. ENGEL: I think that point is well taken. Even if an outcome is measurable, the cost of applying the measure may not be justified. The size of PATH's budget is certainly a limit on what can be measured. There are many beneficiaries of PATH who would testify that the program has made a difference, but that difference cannot be cost-effectively measured. Should OMB consider the notion that the industry thinks it made a difference to be an acceptable outcome measure?

MR. WEBER: Many industry partners have performance data to justify their expenditures. PCA conducts homebuilder and homeowner surveys. There may be a way to show how PATH influences the outcomes of those surveys.

MS. SHIPMAN: Performance measures are secondary to the strategic plan. The strategic plan is about where the program should be going, and where the opportunities and barriers are. The annual plan and metrics are more pedestrian. The measured outcomes should have a direct relationship beyond the

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intermediate goal and have a link to the mission.

DR. SLAUGHTER: PATH performance measures need to relate to the values of the people who are determining its budget. PATH is contributing to creating safe shelter for everybody. It is not about innovation for innovation's sake. It will be difficult to get people passionate about a reduction in the rate of diffusion or a reduced barrier to the adoption of a new technology.

If PATH wants to have a champion and a population that turns to PATH for solutions, then it needs to identify and address the critical issues that are important to that population. The measures need to show if PATH's activities provide immediate benefits to homeowners and homebuilders.

DR. MARK: There have been a number of comments that take this discussion back to the issue of alignment with mission.

MR. HATTIS: We heard that PATH does not have enough money to both develop an effective program and implement effective performance measures. There is general agreement, at least among the workshop participants, that PATH does a good job of allocating its $5 million to a variety of contracts. The people who are in the best position to measure the results of this effort are the contractors, who know more about what they have been doing than anyone else does.

Instead of having a separate track for developing performance measures, it can be incorporated into each activity. It may add to the cost of activities, but that approach is probably more efficient than a separate activity. Contractors can propose performance measures that assess their work and provide performance data as part of the contract deliverables. It would be part of their scope of work. That will help contactors manage their activities as well as help PATH manage its programs. If the contractor has subcontractors they could apply the same approach. PATH could provide guidance and help to develop a consistent methodology for all contractors to use by identifying the performance measures that are most cost-effective.

DR. MARK: There are a number of workshop participants who could help guide a contractor-based performance measurement system.

DR. WONG: The idea of the annual plan needing to be coherent with the strategic plan is important. The three goals are part of the strategic plan. Priorities should be part of the annual plan that changes over time. Both plans, and the interrelationship of activities, need to be presented, but they do not need to be in the same document.

The draft document presents a full menu of what can be done. It can be used to convey this message to OMB or any other interested party. PATH then needs to present its priorities and schedule for accomplishing its established goals.

The concept of having contractors provide performance data is appealing, but PATH needs to take an active role in defining the metrics to ensure that they are valid and not susceptible to gaming. It can be a collaborative process.

MR. ASDAL: It would be easier for PATH to develop program performance measures and develop a branding program if there were a housing rating system to assess housing performance criteria other than energy efficiency, such as a durability rating system and a value rating system. Consumers do not know what a good house looks like. NAHB publishes square footage costs and the number of housing starts. The government tells us about homeownership rates. The realtors will tell us the average price of housing. But nobody is assessing the quality or telling the consumer how to recognize a good house. A simple rating system that anyone can understand could be used by insurance underwriters, bankers, and tax assessors, and tied to incentives. If people got behind building better houses and consumers knew what one looked like, not just higher ceilings, more bathtubs, more square footage, or more density, then American homes would quickly improve.

The components of a unified house rating system could include measures such as moisture control, energy efficiency, durability, maintenance cycles, and operating costs. The various criteria could be weighted and combined into a single number that represents a house value. The consumers can know that if a builder is producing houses that are rated 84 it is better than others that are rated 67, and they can compare both cost and value. If a remodeler can take a house rated 64 and increase its rating to 72, he or she can show the added value for the completed work.

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DR. MARK: I want to thank all workshop participants for a very constructive and thoughtful discussion. I would also like to thank the panelists for their contributions.

MR. GONZALEZ: It may have sounded like there was a lot of conversation and no real definitive answers, but we have provided PATH feedback on its draft strategy, operating plan, and performance measures that PATH can use to complete its plans. There were a lot of wonderful ideas put forward that will be captured in the workshop report to help create future opportunities.

Just because the workshop has concluded does not mean the dialogue needs to end. If anyone has additional ideas or suggestions please send them in writing to the NRC or directly to PATH.

Thank you for a very productive workshop.

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Appendixes

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A
Statement of Work

As a follow-on activity to the Committee for Review and Assessment of the Partnership for Advancing Technology in Housing (PATH), the Board on Infrastructure and the Constructed Environment (BICE) will conduct a workshop to review and comment on HUD's PATH Program Review, Strategy and Performance Metrics, and FY05 Operating Plan. The workshop participants will be asked to comment on the draft plan and measures and whether (1) the goals are accurately communicated; (2) the measures are effective for assessing progress toward the goals and can be feasibly monitored; and (3) the goals and measures provide adequate depictions of innovation in the homebuilding industry. The participants will also be asked to suggest possible strategies for the dissemination of this information to interested parties in the homebuilding industry.

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B
Biographical Sketches of Workshop Planning Group Members and Key Presenter

PLANNING GROUP

Manuel Gonzalez, *Chair,* is a principal at KTGY Group, Inc., in Irvine, California, an award-winning planning and design firm focusing on single and multi-family residential projects. In his previous position, Mr. Gonzalez was director of architecture in charge of residential planning and design for Kaufman and Broad—the nation's largest on-site homebuilder, constructing over 21,000 homes in 1999. Under the direction of Mr. Gonzalez, Kaufman and Broad received widespread industry recognition and design awards. Prior to this position Mr. Gonzalez was a partner with Johannes Van Tilburg and Partners where for ten years he directed the design of award winning single family and multi-family residential projects and master planned communities. Mr. Gonzalez was a member of the NRC Committee for the Review and Assessment of the Partnership for Advancing Technology in Housing and recently served as chair of the Housing Committee for the Los Angeles chapter of the American Institute of Architects. He holds a bachelor of architecture degree from the University of California, Berkeley, and a graduate degree in architecture from the University of Southern California.

Melvin M. Mark is a professor of psychology at the Pennsylvania State University, president of the American Evaluation Association (2006), and editor emeritus of the *American Journal of Evaluation*. He has conducted federally funded evaluations in the areas of prevention programs for at-risk youth, federal personnel policies, and industrial modernization and has been involved in evaluations of state and local programs. An award-winning teacher, he has published numerous papers and chapters on the theory and design of evaluations. He is co-editor of *Social Science and Social Policy; Multiple Methods in Program Evaluation; Realist Evaluation: An Emerging Theory in Support of Practice*; and the forthcoming *Handbook of Evaluation* (with Ian Shaw and Jennifer Greene). He is co-author (with Gary Henry and George Julnes) of *Evaluation: An Integrated Framework for Understanding, Guiding, and Improving Policies and Programs* (Jossey-Bass, 2000). He received his Ph.D. from Northwestern University in 1979.

John K. Spear is a practicing architect and real estate broker and developer specializing in affordable housing. He is knowledgeable about technical, architectural, financial, and social issues related to affordable housing and community development. He was a founder and longtime board member of American Institute of Architects (AIA) Houston's Community Design Assistance Center, providing technical assistance to neighborhood and non-profit groups in building high-quality affordable housing. He is also president of Richwood Realty Advisors and of several LLCs that invest in residential rehabilitation and new housing infill in Houston's core neighborhoods. As a practicing architect he advises clients on issues including site analysis and design review. He was chair of the AIA's Housing Committee in 2001, and until late 2004 represented AIA in the creation and development of HUD's Web-based tool, the Affordable Housing Design Advisor. He holds a B.A. and a B. Arch. from Rice University and a master's degree in environmental design in urban development from Yale University.

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Jorge Vanegas is a professor in the Department of Architecture and director of the Center for Housing and Urban Development of the College of Architecture at Texas A&M University. Previously, he had an appointment as professor and group leader of the Construction Engineering and Management Program in the School of Civil and Environmental Engineering of the College of Engineering at the Georgia Institute of Technology. Dr. Vanegas was also an associate researcher in the Georgia Tech Institute for Sustainable Technology and Development and in the applied research, technical assistance, and outreach programs of the Sustainable Facilities and Infrastructure Branch and of the Center for Sustainable Urban Revitalization, within the Safety, Health, and Environmental Technology Division of the Electro-Optics, Environment, and Materials Laboratory at the Georgia Tech Research Institute. He has documented and disseminated the results and findings from these projects in over 120 publications in technical refereed journals, technical conference proceedings, and technical reports, in which he is the author or co-author, and in over 100 invited lectures and presentations at various technical forums. Dr. Vanegas is a member of the American Society of Civil Engineers, the Committee on Sustainability of the Technical Activities Council, the American Society for Engineering Education, the Urban Land Institute, and the Society of Hispanic Professional Engineers. He serves as a member of the board of directors of the FIATECH Consortium and on the external advisory boards for several research and education centers. Dr. Vanegas was born in Bogotá, Colombia. He received a B.S. in architecture from the Universidad de los Andes in 1979, worked for four years, and moved to the United States in 1983. In 1991, he became a U.S. citizen. Dr. Vanegas received an M.S. degree in 1985, and a Ph.D. degree in 1988, from the Construction Engineering and Management Program of the Department of Civil and Environmental Engineering at Stanford University.

KEY PRESENTER

Sarah Slaughter was the CEO and president of MOCA Systems, Inc., through 2005, and the developer of MOCA Systems' construction simulation system. Before founding MOCA Systems in 1999, she was a professor in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology (MIT) specializing in construction management. Prior to joining MIT, she was a professor of civil and environmental engineering at Lehigh University and a researcher at the National Science Foundation-sponsored Center for Advanced Technology for Large Structural Systems. She has researched innovations in design and construction for over 20 years and has published over 50 articles and books on this topic. She is a recognized leader in her field and has been selected for several prominent committees and awards. She received all of her degrees from MIT, including a B.S. in civil engineering, an M.S. in civil engineering and technology and policy, and a Ph.D. in civil engineering and management science.

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C
Workshop Agenda and Participants

DECEMBER 9, 2005, AGENDA

8:30 a.m.	Welcome, introductions, workshop process—Michael Cohn, NRC
8:40 a.m.	Overview of HUD objectives—Carlos Martin, HUD
8:50 a.m.	Overview of the 2000-2002 NRC assessment and HUD's current response to the NRC findings and recommendations—Manny Gonzalez, KTGY Group, Inc., Workshop Planning Committee
9:15 a.m.	The value of technological innovation in home construction and the role of government/industry partnerships in promoting innovation Sarah Slaughter
10:00 a.m.	Break
10:15 a.m.	Defining success and performance measures for the evaluation and management of PATH Melvin M. Mark
11:00 a.m.	Goal I—Remove barriers and facilitate technology development and adoption Discussion Leaders • John Spear, Architect/Realtor, Workshop Planning Group • Dave Conover, International Code Council • David Hattis, Building Technology, Inc. • Bulent Kastarlak, AIA Housing Committee Discussion Questions • Is the goal communicated accurately? • How important is the goal to the development and diffusion of new technology in housing? • Who is the audience and how do they define success? • Are there performance measures to measure success?
12:00 p.m.	Lunch
1:00 p.m.	Goal II—Improve technology transfer, development, and adoption through information dissemination

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Discussion Leaders
- Manny Gonzalez, KTGY Group, Inc., Workshop Planning Group
- Randall A. Cantrell, Virginia Polytechnic Institute and State University and NAHBRC

Discussion Questions
- Is the goal communicated accurately?
- How important is the goal to the development and diffusion of new technology in housing?
- Who is the audience and how do they define success?
- Are there performance measures to measure success?

2:00 p.m. Goal III—Advance housing technologies research and foster development of new technology

Discussion Leaders
- Jorge Vanegas, Georgia Institute of Technology, Workshop Planning Group
- Matt Syal, Michigan State University
- Chris White, National Institute of Standards and Technology

Discussion Questions
- Is the goal communicated accurately?
- How important is the goal to the development and diffusion of new technology in housing?
- Who is the audience and how do they define success?
- Are there performance measures to measure success?

3:00 p.m. Break

3:15 p.m. PATH forward—The program plan and performance measures—Wrap-up discussion

Discussion Leaders
- Mel Mark, Pennsylvania State University, Workshop Planning Group
- Anny Wong, RAND
- Mike Luzier, NAHB
- Mike Chapman, Chapman Homes, PATH Industry Committee

Discussion Questions
- Is the draft strategy and operating plan the right paradigm?
- How do we define programmatic success?
- How are priorities established and what should they be?
- What are realistic goals given the current funding level?
- How could these goals change if the funding level changed?
- Possible strategies for the dissemination of this information to interested parties in the homebuilding industry

4:30 p.m. Adjourn

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PARTICIPANTS

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Bill Asdal, Asdal & Co. Builders
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Matt Barnum, McGraw-Hill Construction
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Liza K. Bowles, Newport Partners
Dana Bres, Department of Housing and Urban Development
Hayden Brown, National Institute of Standards and Technology
Wendy Butler Burt, Department of Energy
Randall A. Cantrell, National Association of Home Builders Research Center
Valerie J. Caracelli, Government Accountability Office
Michael Chapman, Chapman Homes
Michael Cohn, National Research Council, BICE
Dave Conover, International Code Council
Don Cotchen, McGraw-Hill Construction
Michael Crosbie, Steven Winter Associates, Inc.
Paul Emrath, National Association of Home Builders Housing Policy Research
David Engel, Department of Housing and Urban Development
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D
Summary Operating Plan and Performance Measures

NOTE: This appendix is a reprint of "PATH Performance Metrics and Operating Plans," a section in a larger draft document titled *PATH Program Review and Strategy, Performance Metrics, and Operating Plan* (Version 8/26/2005) that was provided to workshop participants and is forthcoming at PATHNET.org.

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Partnership for Advancing Technology in Housing

We will create…

An innovation pipeline

An innovation resource

An innovation infrastructure

We will be successful when…

The cost & time to innovate is reduced.

Innovations are readily adopted.

Innovation funding increases.

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Performance Metrics

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Goals & Objectives

Mission:

To facilitate the development of new technology and advance the adoption of new and existing technologies to improve US housing

Metric:
The Level of Homebuilding Production "Innovativeness"
This is a composite indicator of Barrier Reduction; Technology Adoption, and R&D Investment

	An innovation pipeline		*An innovation resource*		*An innovation infrastructure*	
GOALS	I	Remove barriers and facilitate technology development and adoption	II	Improve technology transfer, development, and adoption through information dissemination	III	Advance housing technologies' research and foster development of new technology
OBJECTIVES	I•A	Identify current and potential barriers and measure their impacts	II•A	Establish and maintain non-commercial information sources on innovation	III•A	Establish sustained public and private R&D investment & resources
	I•B	Develop practical methods to overcome current barriers	II•B	Understand behaviors, attitudes, and needs regarding innovation information	III•B	Clarify and assist innovators with processes from technology transfer to market penetration
	I•C	Develop alternative future industrial processes that eliminate barriers	II•C	Have relevant information materials on innovation and innovators for different parties	III•C	Have comparative standards for innovation performance, cost, and benefits & agendas

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Goal I • Objectives & Long-Term Outcomes

An innovation pipeline

GOAL I — Remove barriers and facilitate technology development and adoption

Metric: Average Total Cost & Time from Conception to Market Penetration for PATH Identified Research

Baseline: ***Goal:***

OBJECTIVES					
I•A	Identify current & potential barriers to measure their impact *Metric: Number of Expert-Identified "Barriers" Studied*	I•B	Develop practical methods to overcome current barriers *Metric: PATH Effect on Impact (cost & time) of Barriers*	I•C	Develop alternative future processes to eliminate barriers *Metric: PATH Effect on Impact (cost & time) of Barriers*
I•A•1	Regular assessment of previously identified barriers' impact on innovation	I•B•1	Practical mechanisms for addressing newly identified barriers (from I•A•2)	I•C•1	Strategies in response to newly identified barriers (from I•A•2)
I•A•2	Regular identification of new or potential barriers to innovation	I•B•2	*Codes:* ICC-ES Reports Improvement & Institutionalizing	I•C•2	*Codes:* Performance-Based Regulations
I•A•3	Establishment of a sustained expert forum for barrier analysis	I•B•3	*Risk:* Individual Programs with Manufacturers' & Builders' Insurers	I•C•3	*Risk:* Innovation Insurance Programs
		I•B•4	*Incentives*: Consumer Programs with Utilities & Insurers; R&D Tax Credits for Manufacturers	I•C•4	*Incentives*: Consumer Utility Subsidies & Insurance Reductions & Multiple Tax Credits
		I•B•5	*Labor Skills*: Specific Site Training Tools & Professional Education Innovation Modules	I•C•5	*Labor Skills*: General Labor Training & Professional Curricular Standards
		I•B•6	*Purchase*: Retail Sales Initiatives; Architects' Spec Sheets	I•C•6	*Purchase*: Suppliers' Promotional Materials
		I•B•7	*Valuation:* Appraiser/Inspector Professional Standards (e.g., comparables)	I•C•7	*Valuation:* Appraiser/Inspector Training Requirements
		I•B•8	*Housing Cycles:* TBD	I•C•8	*Housing Cycles:* TBD

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Goal I • Objective I.A Metrics Map

I•A Identify current & potential barriers to measure their impact

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OBJECTIVE

Inputs	Activity	Output	Outcome (Short-Term)	OUTCOMES: Outcome (Long-Term)
Staff Time; $; Research Planning and Methods	Barriers Impact Studies	Quantitative, Longitudinal Studies on Specific Barriers' Impacts	Implementation Plans for Studies for Long-Term Policy (I-C)	I.A.1 *No. of Measures for Determining Policy Effects on Barriers*
Staff Time; $; Industry Expert Time; Meeting Forums	Barriers Identification Forums	Qualitative Agenda-Setting & Prioritization for Barriers Studies	Implementation Plans for Studies for Short-Term Policy (I-B)	I.A.2 *Reduced or Eliminated No. of Barriers Identified*
Staff & Industry Time & Interest; Public-Private $	Barriers Reduction Collaboration Forums	Plans for Periodic Innovation Barrier Meeting	Public-Private Commitments to Participate	I.A.3 *% of Event Commitments Completed Annually*

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Goal I • Objective I.B Metrics Map

OBJECTIVE

I•B **Develop practical methods to overcome current barriers**

An innovation pipeline

Inputs	Activity	Output	OUTCOMES: Outcome (Short-Term)	Outcome (Long-Term)
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight	Practical Policy Activity *[Holder for Future Barriers]*	TBD	TBD	I.B.1 *TBD*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight; ES Commitment	Study ES Process; Outreach to ICC Jurisdictions to Enforce ES Reports	ES Recommendations for Improvements; ES Guidelines & Training for Local Jurisdictions	ES Expedited Services; Prelim Reliance on ES Reports by Local Jurisdictions	I.B.2 *No. Manufacturers Using ICC-ES*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight; Commitments	Prototype Insurance Initiative (Same insurer for manufacturer & builder)	Outcome of insurance on innovation rate and party satisfaction	Increased prototype initiatives	I.B.3 *Number of Innovation Insurance Programs*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight; Commitments	Consumer Utility & Insurance Programs; Analysis of R&D Tax Incentives	Clearinghouse of consumer programs; Policy options for expanding R&D tax credits	Expansion of consumer programs; Policy Implementation of R&D Credits	I.B.4 *Consumer Utilization Rate of Incentives; Tax Credit Studies*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight; Training Media	Innovators' Training Assistance On-Site; Prof'l Curriculum Review	On-Site Training Packages for Trades; Curricular Standards Recommendations	Site Training Monitoring; Dissemination of Curricula Standards	I.B.5 *% of Trained Labor/Innovation; No. of University Programs*
Staff Time; $; Barriers Identification Forum; Retail Sellers' Commitments	Prototype Innovation Marketing with Retailers	Documented Sales Changes and In-Store Program Adjustments	Retailers' & Architects' Long-Term Commitments to Marketing/Spec'ing Innovation	I.B.6 *No, of Innovations Marketed by Two Largest Retailers; No. of Spec Sheets*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight	Add'l Valuation Studies; Development of Comparable & Installation Listings; Architect Spec Sheets	Comparable Database; Quality Installation Database; Spec Sheets & Documented Design Spec Growth	Appraisers' & Inspectors' Use of Database; Appraiser, Inspector, Architect Outreach	I.B.7 *% of Innovations Included in Various Databases (if applicable)*
Staff Time; $; Barriers Identification Forum; Add'l Expert Insight	Macroeconomic Analysis of Building Activity and Innovation Rates	Studies Suggesting Optimal Strategies during Different Phases of Cycle	Planning for Cyclical Changes Past PATH	I.B.8 *NA*

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Goal I • Objective I.C Metrics Map

An innovation pipeline

OBJECTIVE

I•C Develop alternative future processes to eliminate barriers

OUTCOMES

Inputs	Activity	Output	Outcome (Short-Term)	Outcome (Long-Term)
Staff Time; Practical Policy Feedback; External Commitments	Long-Term Policy Activity *[Holder for Future Barriers]*	TBD	TBD	I•C•1 *TBD*
Staff Time; Practical Policy Feedback; Code Group Commitment	Performance-Based Codes Prototypes & Advocacy	Prototype Performance-Based Codes	Monitoring and Evaluation of Prototype Programs	I•C•2 *% Code Provisions Drafted in Performance Basis*
Staff Time; Practical Policy Feedback; Insurance or Gov't Commitments	Prototype Innovation Insurance Initiative	Insurance-Firm Lead or Federal Insurance Program for Innovations: Prototype Cases	Monitoring and Evaluation of Prototype Programs	I•C•3 *No. of Innovation Insured Under Program*
Staff Time; Practical Policy Feedback; Insurance & Gov't Commitments	Consumer Programs Advocacy; Innovation Adoption Tax Credit Studies	Consumer awareness; Innovation Tax Credits Recommendations	Expansion of consumer programs; Implementation of all R&D Credits	I•C•4 *No. of Consumer Programs; No. of Tax Credit Programs*
Staff Time; Practical Policy Feedback; Trade & University Commitments	Full Labor Training Programs & Certifications; Curriculum Standards Advocacy	Program Agreements; Curricular Standards Adoption	On-Site Training Programs for Trades; Curricular Standards Requirements	I•C•5 *% of Trained Labor; No. of Accredited University Programs*
Staff Time; Practical Policy Feedback; Suppliers' Commitments	Prototype Innovation Marketing with Suppliers	Documented Sales Changes and Program Adjustments	Suppliers' Long-Term Commitments to Marketing Innovations	I•C•6 *No. of Innovations Marketed by 50 Largest Suppliers*
Staff Time; Practical Policy Feedback; Appraisers', Inspectors', & Architects' Commitments	Professional Training Requirements on Innovation	Standards for Certification	Increased Innovation Certification	I•C•7 *% of Certified Professionals In 3 Fields*
Staff Time; Practical Policy Feedback	TBD	TBD	TBD	I•C•8 *NA*

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Goal II • Objectives & Long-Term Outcomes

An innovation resource

GOAL	OBJECTIVES		OUTCOMES
II			
Improve technology transfer, development, and adoption through information dissemination ***Metric:** Avg. Cost & Time from Market Introduction to Proportional Market Share Penetration for PATH Identified Technologies* ***Baseline:***			
II.A	Establish & maintain sources of non-commercial innovation info *Metric: % of Users Relying on Peer-Determined Non Commercial Sources*	II.B	Understand behaviors, attitudes, and needs regarding innovation info *Metric: % of manufacturers & builders with access to market research*	II.C	Change behavior through relevant information materials on innovation and innovators *Metric: Proportion of "Innovator," "Early Adopter," & "Early Majority"*
II.A.1	Centralized, credible sources of innovation information	II.B.1	Perform & disseminate studies of homebuilding participants' "innovativeness"	II.C.1	Homebuyers' selection of builders based on innovation information
II.A.2	Industry training on information quality and credibility	II.B.2	Sustained public-private funding of homebuilding participants' "innovativeness" studies.	II.C.2	Homeowners' selection of remodelers based on innovation information
II.A.3	Industry-generated relevant, credible information	II.B.3	Innovators' awareness of market segments in order to target "innovativeness."	II.C.3	Homebuilders' design & construction of innovative homes
				II.C.4	Homebuilders' marketing of innovative homes based on innovativeness
				II.C.5	Remodelers' design & construction of innovative remodels
				II.C.6	Remodelers' marketing of innovative services
				II.C.7	Manufacturers promotion of innovative products

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Goal II • Objective II.A Metrics Map

An innovation resource

OBJECTIVE

II.A **Establish & maintain sources of non-commercial innovation info**

Inputs	Activity	Output	Outcome (Short-Term)	Outcome (Long-Term)
Staff time; $; Unbiased Research Skills & Staff	Tool Base ® & PATH Generated Info	Technology Inventory New Content (Website and Materials)	ToolBase @ PATHNet Utilization (Tech Inventory)	[redacted] *ToolBase Utilization Rates*
Staff time; $; Outreach Staff & Training	Manufacturer Information & Market Training	Manufacturer Commercialization Tools (Marketing Assistance)	Marketing Assistance Program Utilization	[redacted] *No. of Non-Commercial Information Sources*
Staff time; $; Monitoring Staff	Tool Base ® & PATH Collected Info	Technology Inventory Content Management (Website and Materials)	ToolBase Utilization (Tech Inventory)	[redacted] *Utilization Rates of Non-Commercial Information Sources (non-PATH)*

OUTCOMES

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Goal II • Objective II.B Metrics Map

An innovation resource

OBJECTIVE

II-B Understand behaviors, attitudes, and needs regarding innovation info

Inputs	Activity	Output	Outcome (Short-Term)	Outcome (Long-Term)
Staff time; $; Market Research Firm Commitments; Federal Agency Commitments	Market Research Agenda Forum; Research Project Scoping and Funding	Preliminary Research Data and Analysis	Coordination of Non-Commercial Research Data with Commercial; Utilization of Non-Commercial Data	II-B-1 *Proportion Completed of Market Research Agenda*
Staff time; $; Market Research Firm Commitments; Federal Agency Commitments	Advanced Research Project Scoping and Funding; Prelim Data	Research Funding and Commitments for Execution	Short-Term Funding Increases For Market Research	II-B-2 *Total Research Funding Proportion to Sales Consistency*
Staff time; $; Market Research Results; Dissemination Vehicles	Market Research Dissemination & Monitoring	Public or Targeted Access to Research Results	Preliminary Utilization by Innovators without Market Research Resources	II-B-3 *Utilization of Market Research Data*

OUTCOMES

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Goal II • Objective II.C Metrics Map

An innovation resource

II.C **Change behavior through relevant information materials on innovation & innovators**

OBJECTIVE

Inputs	Activity	Output	Outcome (Short-Term)	OUTCOMES Outcome (Long-Term)
Staff Time; $; Media Access & Commitments; Technical Information (Tech Inventory, Tech Sets, Concept Home)	Homebuyer Outreach	Journals, TV (PSA), Events, Incentives, Builder Mat's, PATHNet, Mfctr. Ads/Links, Realtor/Appraiser/HOA Mat'ls	Homebuyer assimilation and action (home purchase)	II.C-1 *Proportion of Homebuyers Purchasing Homes w/ 5 + PATH Tech's*
Staff Time; $; Media Access & Commitments; Technical Information (Tech Inventory, Tech Sets, Concept Home)	Homeowner Outreach	Journals, TV (PSA), Events, Incentives, Retail Outreach, Remodeler Mat's PATHNet, Mfctr. Ads/Links; HOA Mat'ls	Homeowner assimilation and action (home remodel)	II.C-2 *Proportion of Homeowners Remodeling Homes w/ 5 + PATH Tech's*
Staff Time; $; Trade Media Access & Commitments; Builder Commitments (Tech Inventory, Tech Sets, C Home)	Homebuilder Technical Outreach	Trade Journals, Events, Training/Demos; Trade/Supplier/ Code Outreach, Mfctr. Links; PATHNet; Architect Mat'ls	Homebuilder assimilation and action (home design & build)	II.C-3 *Proportion of Homebuilders Building Homes w/ 5 + PATH Tech's*
Staff Time; $; Trade Media Access & Commitments; Builder Commitments (Tech Inventory, Tech Sets, C Home)	Homebuilder Marketing & Sales Outreach	Trade Journals, Events, Incentives; Sales/Realtor Training; Mfctr. Ads; PATHNet	Homebuilder assimilation and action (home sales based on special marketing)	II.C-4 *Proportion of Homebuilders Marketing Homes w/ 5 + PATH Tech's*
Staff Time; $; Trade Media Access & Commitments; Remodeler Commitments (Tech Inventory, Tech Sets, C Home)	Remodeler Technical Outreach	Trade Journals, Events, Incentives; Training/Demos; Trade/Appraiser/Architect Outreach, Mfctr. Links; PATHNet	Remodeler assimilation and action (home design & remodel)	II.C-5 *Proportion of Remodelers Remodeling Homes w/ 5 + PATH Tech's*
Staff Time; $; Trade Media Access & Commitments; Remodeler Commitments (Tech Inventory, Tech Sets, C Home)	Remodeler Marketing & Sales Outreach	Trade Journals, Events, Incentives; Sales/Realtor Training; Mfctr. Ads; PATHNet	Remodeler assimilation and action (remodel services based on special marketing)	II.C-6 *Proportion of Remodelers Marketing Svcs. w/ 5 + PATH Tech's*
Staff Time; $; Manufacturer Commitments & Resources, Tech Inventory	Manufacturer Outreach	Mnfctr. Training & Assistance; Ads/Links; Commercialization Tools; Distributor/Supplier/Trade/ Builder Outreach Assitance	Manufacturer assimilation and action (product sales)	II.C-7 *Market Shares for all PATH Identified Technologies OR Avg share of firm sales by innovative products launched in the last 10 years*

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Goal III • Objectives & Long-Term Outcomes

An innovation infrastructure

GOAL

III **Advance housing technology research & foster development of new technology**

Metric: Total R&D Investment as a Percentage of Industry Sales

Baseline:

Goal:

OBJECTIVES

III•A	Establish sustained public and private R&D funding & agendas *Metric: Total R&D Investment as Percentage of Industry Sales*
III•A•1	Sustained Federal basic research funding for research institutions
III•A•2	Sustained Federal applied research funding for institutions & industry
III•A•3	Ongoing collaboration with international research agencies and programs
III•A•4	Sustained state and local funding of applied research & development
III•A•5	Sustained non-profit & private foundation funding of research
III•A•6	Sustained trade association & industry collaborative funding of applied research & development
III•A•7	Sustained venture capital funding for development, prototype, and commercialization
III•A•8	Sustained internal R&D funding among manufacturers and builders
III•A•9	Public-private seed research projects based on priorities (III•C•4) and using above funding

III•B	Clarify and assist innovators with processes from technology transfer to market penetration *Metric: Average Cost & Time from Conception to Market Introduction*
III•B•1	Sustained Federal technology transfer programs (Federal and university research to industry)
III•B•2	Sustained & coordinated state and local technology transfer programs (e.g., MTDC, VA CIT, DC VIP, etc.)
III•B•3	Networks of research technology transfer programs in housing (from institutions to industry)
III•B•4	Channels for technology transfer from non-housing to housing industries
III•B•5	Relevant development planning, commercialization, and market assessment tools for innovation
III•B•6	Sustained business planning technical assistance programs for small innovators
III•B•7	Sustained technical assistance for evaluating individual firms' R&D capacity & needs
III•B•8	Sustained public-private support of testing facilities

III•C	Develop comparative standards to assess innovation performance, cost, benefits, & agendas *Metric: Indirect (Planning) R&D Investment as % of Industry Sales*
III•C•1	Industry collaborations for performance criteria development
III•C•2	Industry acceptance of performance criteria
III•C•3	Sustained public-private funding for performance criteria testing
III•C•4	Public-private research agenda forums and priority-setting ("Roadmaps")

OUTCOMES

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Goal III • Objective III.A Metrics Map

An innovation infrastructure

III•A Establish sustained public and private R&D funding & agendas

OBJECTIVE

Inputs	Activity	Output	OUTCOMES: Outcome (Short-Term)	Outcome (Long-Term)
Seed $, Staff Time, University Proposals, NSF Agreement	NSF-PATH Program	University Research Projects; Current & Future Academic Interest; Potential Academic Research Centers	Sustained Academic Interest; Combined Federal Academic Research Funding	III•A-1 Tot Fed $ to Academic Research
Seed $, Staff Time, Agency Cooperation	Joint Research Agendas; Fed'l Applied Research Funds	Applied Research & Development Project Results;	Sustained Federal Interest; Combined Federal Applied Research Funding	III•A-2 Tot Fed $ to Applied Research
Staff Time; Int'l Agency & Research Org. Cooperation	Current Research Findings Sharing Events ; Joint Research Agendas	Int'l Research Collaborations On Agendas and Projects	Sustained Int'l Research Interest; Combined Int'l Applied Research Agendas	III•A-3 Annl Int'l Exchange Events
Staff Time; Seed $, State Agency & EPSCOR Agreement	Collaborative Fed/State Research Funds	Collaborative Fed/State Research Projects	State Interest In Housing Research	III•A-4 Tot State/Local Appd Research $ (Proportional to Sales)
Staff Time; Seed $, Foundation Interest & Agreements	Identify Foundations; Convene Events for Agendas; Develop Prelim Projects	Foundation Agreements; Prelim Results of Agendas And Projects	Foundation Independent Funding of Research Projects; Intra-Foundation Collaboration	III•A-5 Tot Foundation Appd Research $ (Proportional to Sales)
Staff Time; Seed $, Assoc. Interest & Agreements	Identify Trade Associations (w Research), Model Research Programs; Prelim Collaboration	Association Research Efforts (Mktng or Projects); Collab. Project Results	Association Independent Funding of Research Projects; Intra-Association Collaboration	III•A-6 Tot Association Research # & $
Staff Time; VC Assoc. & Agency Interest & Agreements	Identify & Access VC Funds for Industrial Collaborations For Large & Small Manftrs.	Prelim Venture Capital Investments & Collaborations	Ongoing Venture Capital Investments & Collaborations	III•A-7 Tot Private Investment $; Avg $/Tech (Proportional to Sales)
Staff Time; Seed $; Trade Association Assistance; Company Interest	Prelim Research Projects w/ Individual Firms or Collaborations	Prelim Project Results & Documentation; "Next Step" Discussions	Sustained Internal Research Interest & Agenda Setting (Firm & Collaboration-Level)	III•A-8 Avg. Firm Investment $ (Proportional to Sales)
Staff Time; Seed $; Roadmaps	Roadmap Research Projects w/ Individual Firms or Collaborations	Research Results; Updating Of Roadmaps	Progress towards Roadmaps; Commitments For Above Activities	III•A-9 Tot Roadmap Research Matching $

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Goal III • Objective III.B Metrics Map

An innovation infrastructure

III•B **Clarify & assist innovators with processes from technology transfer to market penetration**

OBJECTIVE

Inputs	Activity	Output	Outcome (Short-Term)	Outcome (Long-Term)
Staff Time; Seed $; Tech Scanning; University & Industry Commitments	PATH-Related Tech Transfer Efforts (Basic to Applied)	Tech Transfer Results (Successes & Lessons Learned); Federal Sharing	Independent Tech Transfer by Basic Researchers & Industry; Federal Collaborations	III•B•1 *Federal TT $ & Programs*
Staff Time; Tech Scanning; State TT Program Interest & Commitments	State/Local TT Outreach	State TT Interest in Housing	State TT Commitments to Housing	III•B•2 *No. of State TT Housing Programs*
Staff Time; PATH TT; Institutions Interest & Commitments	Network-Building of Independent Tech Transfer Efforts (Basic to Applied)	Best Practices in Housing TT; Clearinghouse of TT Programs	Increased Usage of & Reliance on Independent TT Programs	III•B•3 *Total Independent TT Programs*
Staff Time; Seed $; Thorough Industry Knowledge	PATH Tech Scanning	Tech Scan Reports for TT Use	Non-Housing Interest in Housing Markets; Material for PATH & Non-PATH TT	III•B•4 *No. of Housing Product Sales Efforts by Non-Housing Firms*
Staff Time; Seed $; Industry Needs Assessments	PATH Commercialization Tools	Tools for Manufacturers (esp. Small)	Use by Manufacturers; Dissemination by Commercialization Centers	III•B•5 *No. of Manufacturers Using Tools*
Staff Time; Seed $; Commercialization Center/SB Interest	Commercialization Center/SB Outreach	Commercialization Center/SB Use of PATH Tools	Commercialization Center/SB Development of Add'l Tools Focus on Housing Innovators	III•B•6 *% of Manufacturers Using R&D Assistance Services*
Staff Time; Seed $; PATH Barriers Studies; Cooperative Commercialization Outreach	R&D Capacity Evaluation & Assistance	Tools & Guidebooks for Increasing Internal R&D Capacity	Use and Assimilation of Knowledge from Tools & Guidebooks	III•B•7 *Percentage of Firms Ranked as Mid- to High-Innovators*
Staff Time; Seed $; Active & Certified Testing Facilities	Testing Facility Clearinghouse & Outreach to Innovators; PATH Field Evaluations	Clearinghouse & Innovators Guide to Testing Facilities	Increased & Appropriately Timed Use of Testing Facilities& 3rd Parties	III•B•8 *Percentage of Fully Tested Innovations at Market Introduction*

OUTCOMES

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Goal III • Objective III.C Metrics Map

An innovation infrastructure

III·C **Develop comparative standards to assess innovation performance, cost, benefits, & agendas**

OBJECTIVE

Inputs	Activity	Output	Outcome (Short-Term)	Outcome (Long-Term)
Staff Time; Seed $; Industry Time & Interest; Legal Counsel	PATH Beyond-Code Performance Testing Protocols (e.g., Durability)	Performance Testing Protocol for Different Performance Areas	Industry Commitment to Produce and Test Products with Testing Protocol	III·C-1: *No. of Performance Testing Protocols*
Staff Time; Industry Time & Above Commitments	Testing Protocol Outreach	Implementation of Testing Protocols for Beyond Code Performance.	Monitoring of Industry's Use of Testing Protocol in Product Development & Marketing	III·C-2: *Percentage of Maintained Commitments*
Staff Time; Industry Time; Results of Outreach Monitoring; Prelim Assessment of Impact	Testing Protocol Expansion	Plan & Execution for Add'l Systems' Testing Protocols for Beyond Code Performance	Implementation and Monitoring 0f New Testing Protocols for Beyond Code Performance	III·C-3: *No. of Non-PATH Testing Protocols*
Staff Time; Seed $; Industry Time; Researchers' Time	PATH Roadmaps	Roadmap Reports; Public-Private Commitments For Follow-Up Research	Roadmap-Based Research Projects; Commitments for Other Public-Private Agendas	III·C-4: *Percentage of Executed Research Projects; No of Roadmaps*

OUTCOMES

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Operating Plans: Past

Note that the following analysis of past PATH activities only includes those that are relevant to the new PATH goals and objectives. Activities relevant to the previous PATH goals are not included here. As such, the total of individual activities' budgets will not equal the full PATH appropriations listed.

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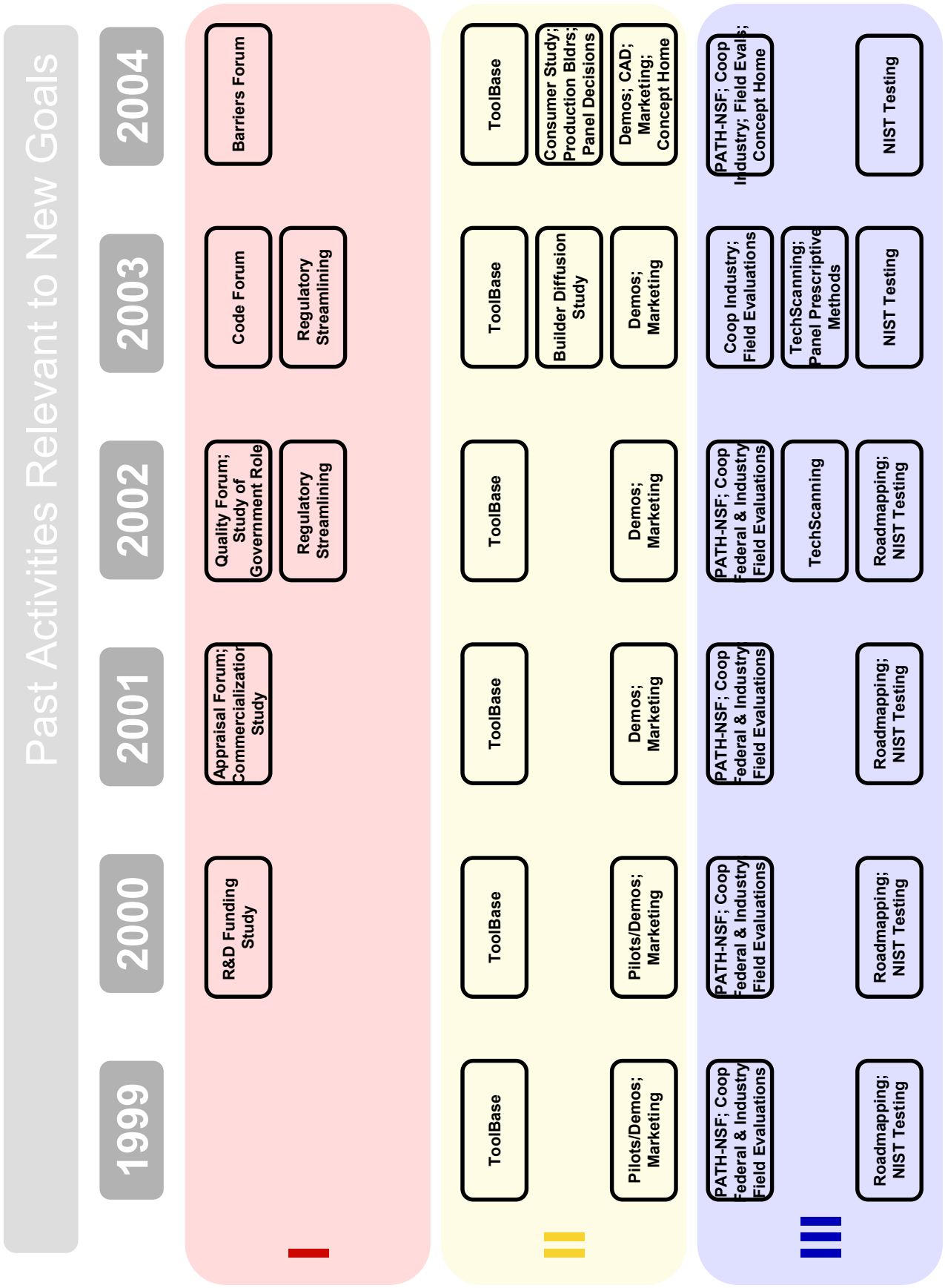

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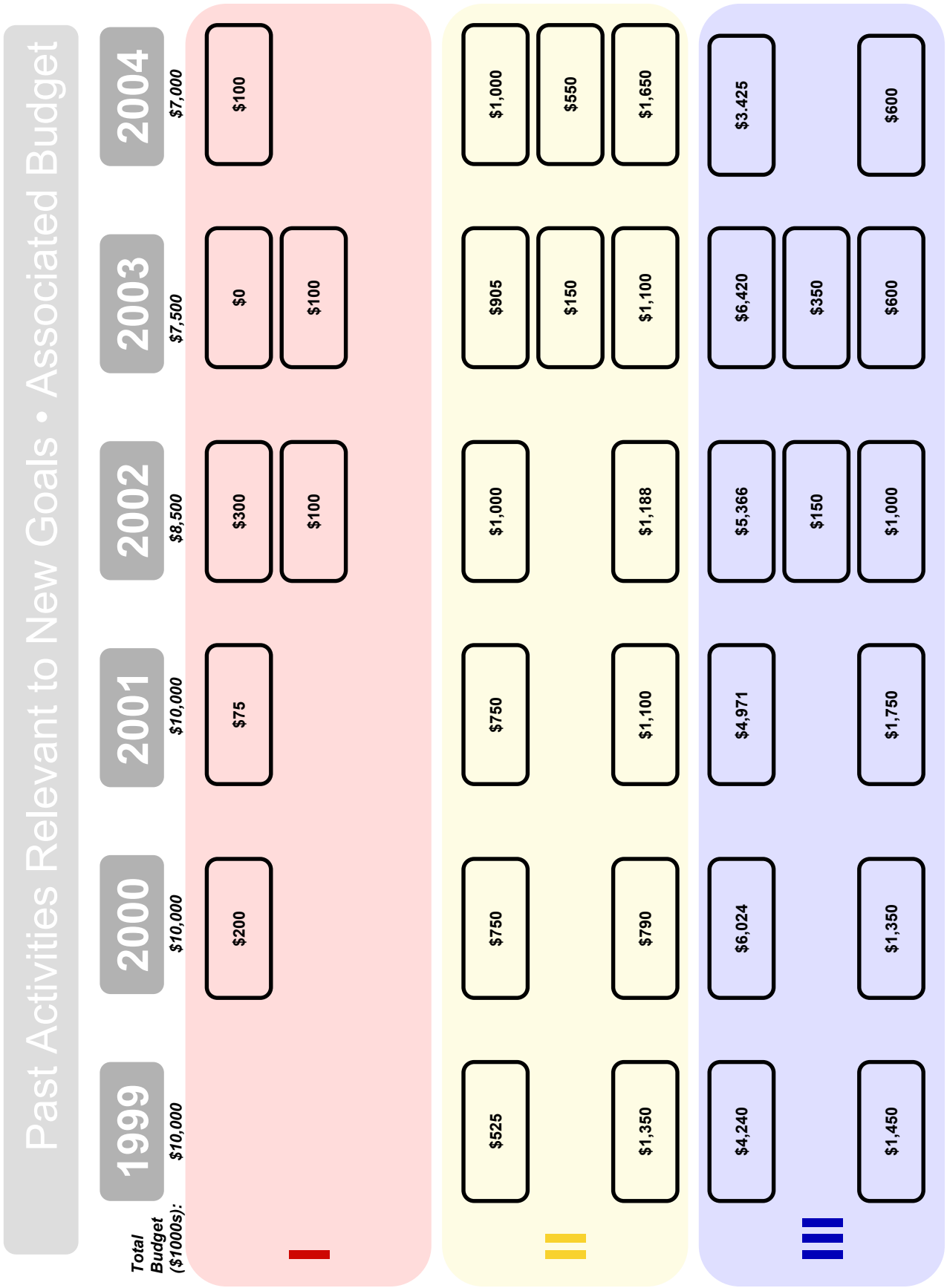

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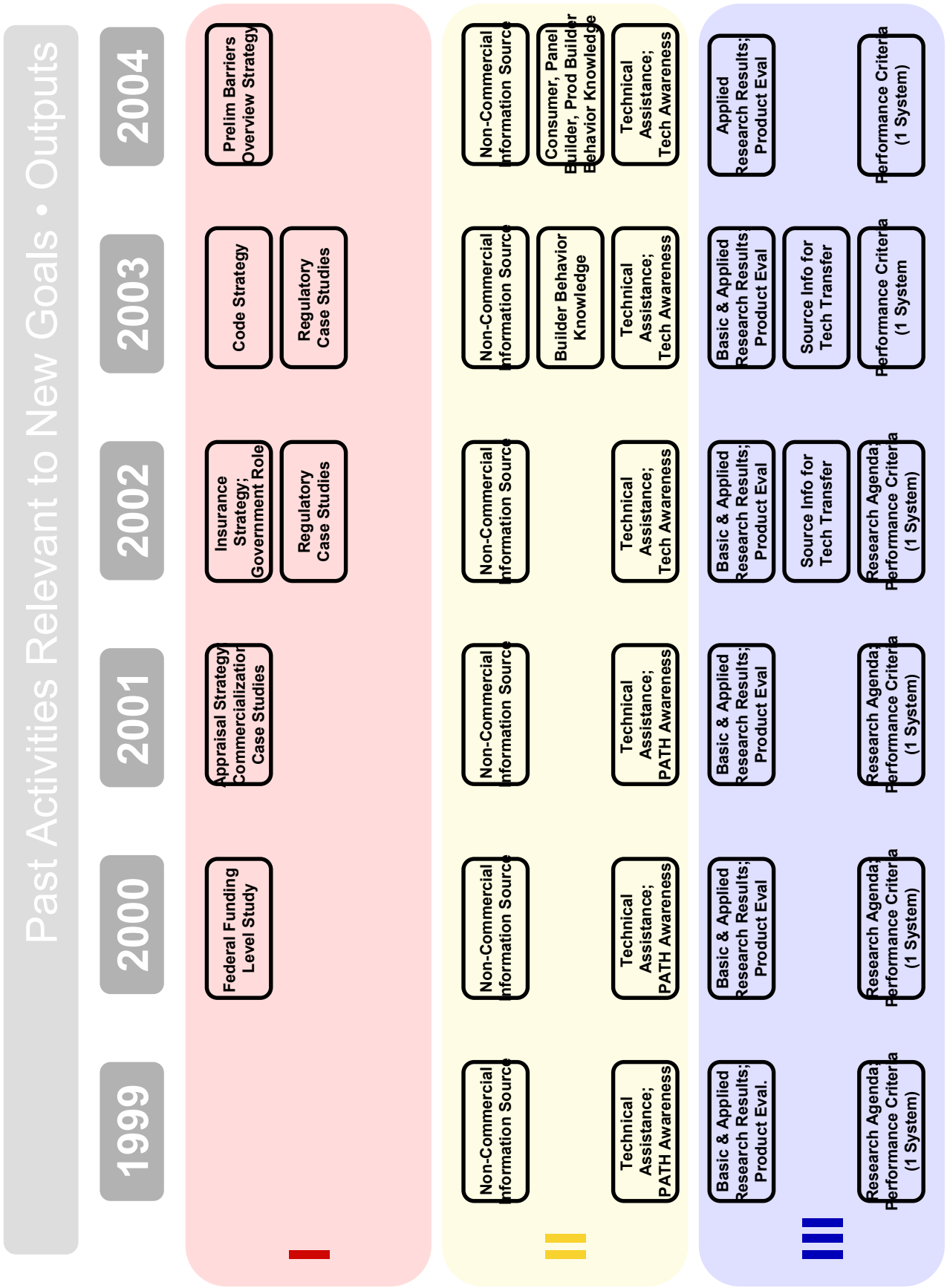

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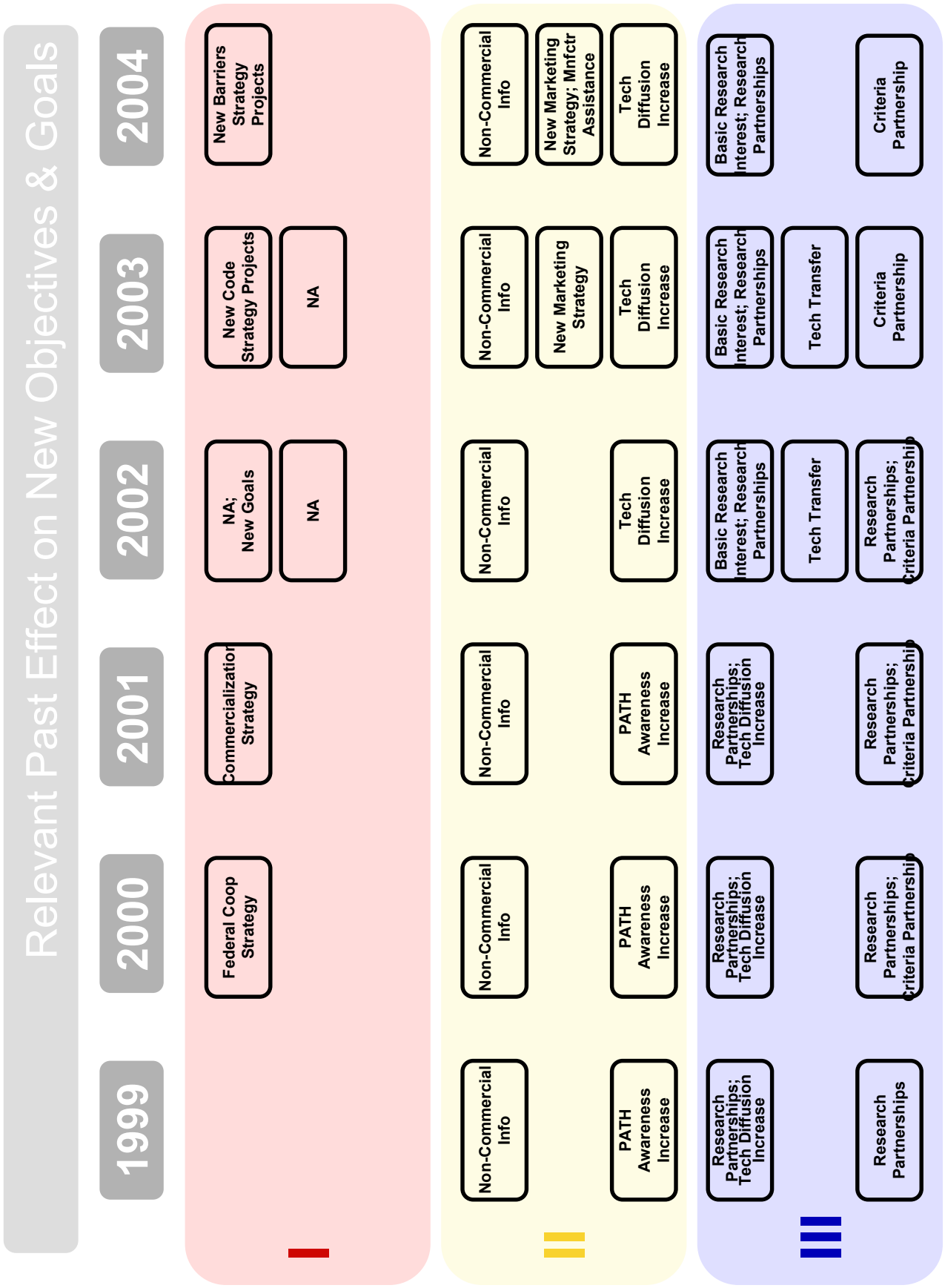

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Operating Plans: Current

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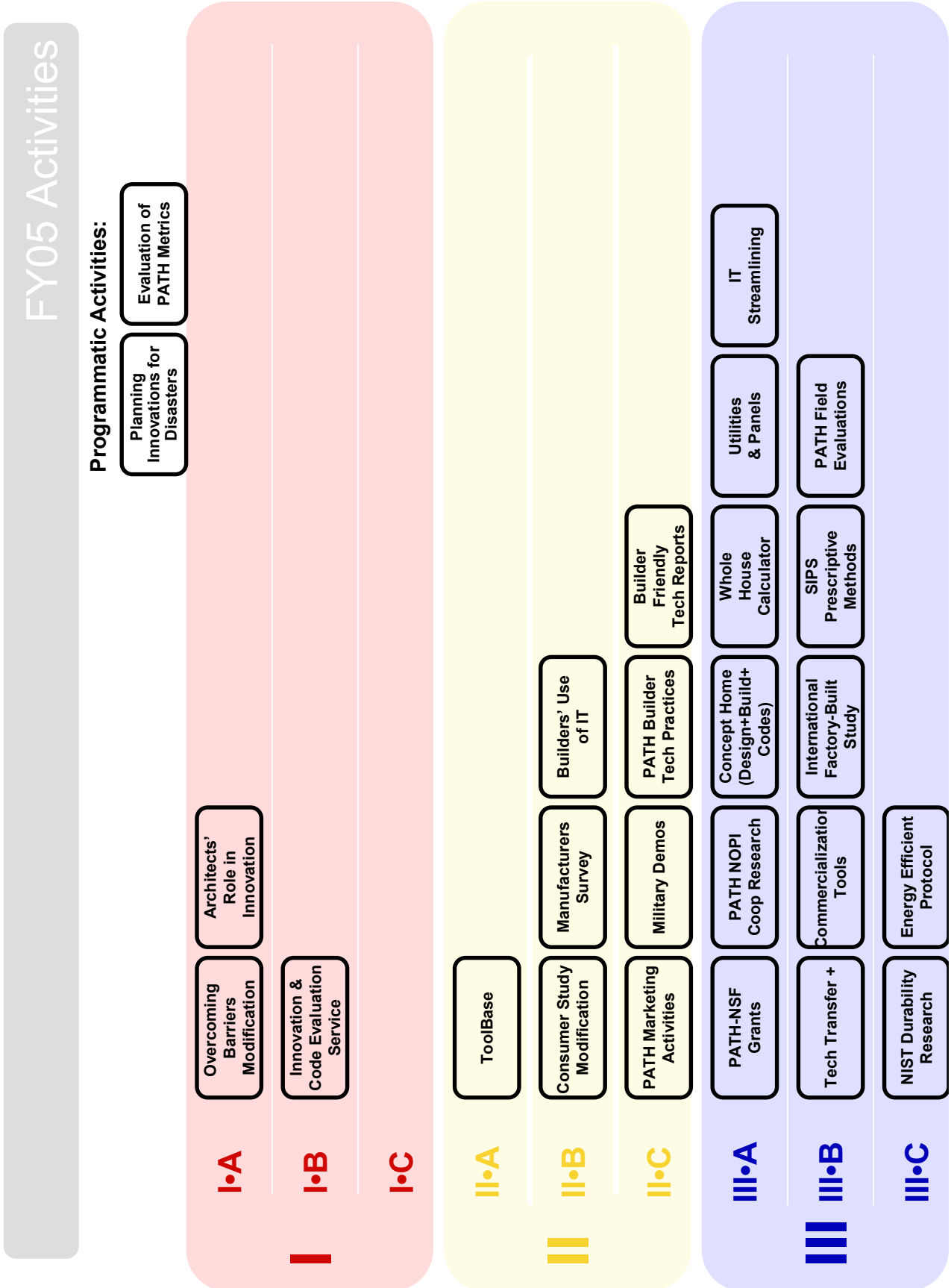

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FY05 Activities • Associated Budget

Programmatic Activities: $125,000

$100,000 | $25,000

Total Budget: $10,077,000 (including FY04 carryover)

I	I•A	$30,000	$150,000					$180,000
	I•B	$150,000						150,000
	I•C							0
II	II•A	$996,000						996,000
	II•B	$75	$425,000	$250,000				675,075
	II•C	$1,004,000	$250,000	$200,000	$71,000			1,525,000
III	III•A	$750,000	$1,143,000	$948,000	$200,000	$250,000	$50,000	3,341,000
	III•B	$280,000	$400,000	$35,000	$225,000	$1,300,000		2,240,000
	III•C	$450,000	$250,000					700,000

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Proceedings of a Workshop to Review PATH Strategy, Operating Plan, and Performance Measures
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Operating Plans: Future

Note that the following analysis of future PATH activities describes expected projects and estimated budgets for them only. As articulated in "Operations & Management: Background" (page 87), exact budgets and work scopes are subject to Congressional and Federal constraints.

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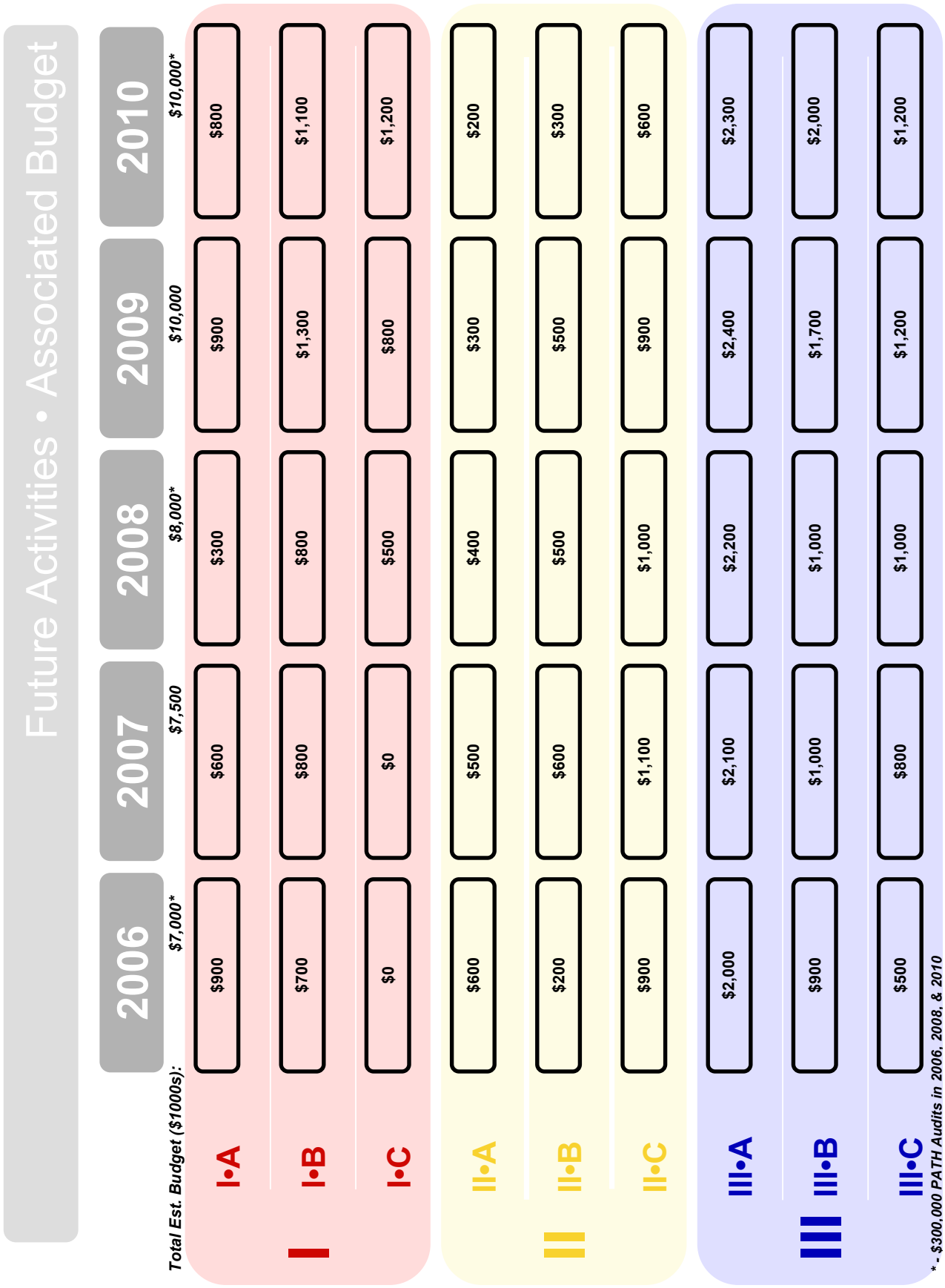

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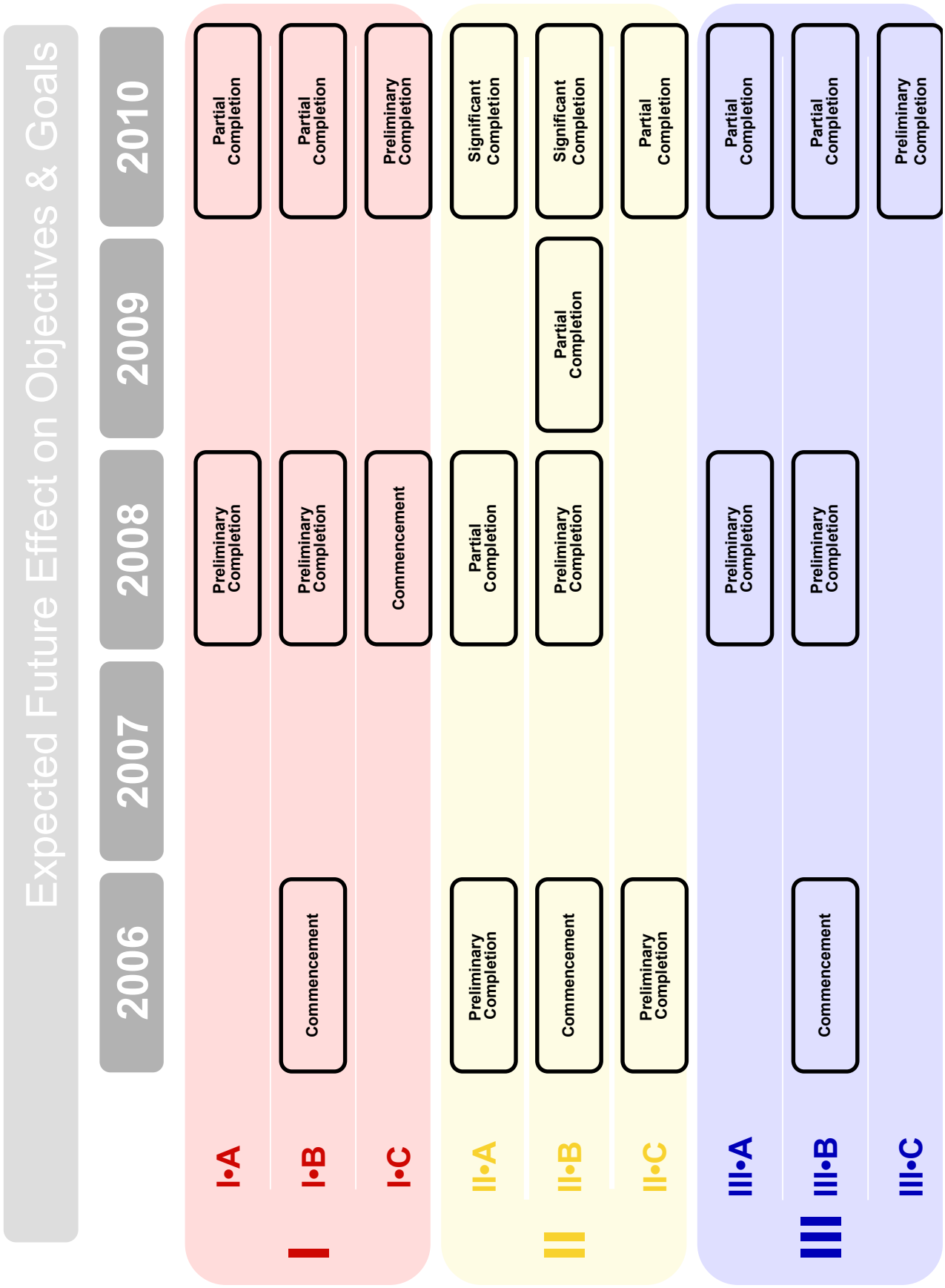

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E
Additional Comments and Observations of Workshop Participants

Presented in this appendix are the post-workshop comments of several of the participants, supplied here for the additional perspectives they provide.

COMMENTS FROM INDIVIDUALS

Manuel Gonzalez
KTGY Group, Inc.

I have summarized my observations as follows:

- Although refinements are needed, the draft PATH Review and Strategy, Performance Measures, and Operating Plan is essentially a good plan for managing the program. It responds to the findings and recommendations of earlier NRC reports and suggestions from stakeholders for improving the program. The main concern is that it contains too much relative to the program's current funding.
- The three program goals are interrelated, but this does not seem to be visible in the operating plan or measures.
- The plan has a valid logic model, but the performance measures need additional consideration to ensure that they are valid, causally connected, and practicable. Considerations should be given to incorporating performance measures into requirements for all contracts and grants. This will require care in selecting appropriate measures and validating them. Budget limitations may require acceptance of less than ideal measures. Anecdotal comments could be valid measures if their objectivity can be validated.
- The operating plan is aspirational in that it goes beyond the current level of funding. Aspirational plans are good for long-range planning but may cause unrealistic expectations if combined with short-term plans. Two separate plans may be necessary. Further, the observations that follow need to be considered and weighed in light of the need to more narrowly focus the short-term operating and evaluation plans.
- PATH needs a plan to become a sustainable program. The Construction Industry Institute and FIATECH were cited as possible models.
- PATH could be considered a virtual housing laboratory and serve as a portal to programs sponsored by PATH and others.
- The barriers to innovation are real, and a program, such as PATH, is needed to address them.
- There is a need for basic and non-proprietary applied research in housing. Undertaking this research in academic institutions leverages PATH funding and provides educational opportunities that further PATH goals.
- PATH has a better opportunity to achieve its mission by combining the forces of technology push and demand pull.

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- Dissemination of information could follow the supply chain, with outreach activities targeted to the various participants, including researchers, manufacturers, distributors, architects, engineers, builders (both large and small), code officials, consumers, financiers, insurers, and others.
- The Concept Home, Web sites, trade show participation, and magazine and newsletter articles have been effective and could be expanded especially in areas that address consumers.

David Conover
International Code Council

My observations are as follows:

- The PATH program is placing increased and significant emphasis on addressing technology acceptance and barriers to innovation—something recommended by the National Research Council in its review of the PATH program in 2002.
- The PATH program is promoting innovation that will provide for the public good as long as it can help facilitate technology acceptance and in doing so provide for better and more affordable housing for the public.
- Innovation must be considered from the standpoint of the consumer because the consumer is a key driver in technology acceptance. To support their driving innovation, ways to measure and express innovation performance need to be available to them.
- Innovation includes technology as well as processes.
- Standards and conformity assessment can foster acceptance of new technology and must be included in programs to address technology acceptance.
- The Internet and electronic means of making information available provide a formidable vehicle for communication, which in turn can support technology acceptance.
- Risk is a barrier to innovation that must be addressed, recognizing that it presents itself differently to each of the entities involved in the building process.
- The task of addressing barriers and facilitating technology acceptance is formidable and can be more easily addressed by larger participants in the process rather than smaller entities that may need assistance to create a level playing field.
- All actors in the technology supply chain need information so they can take appropriate action to address more timely acceptance in areas of the supply chain they control.
- The building regulatory system, while typically viewed as a barrier, can very effectively work as a catalyst for acceptance of innovation.
- Designers support development and implementation of systems that will facilitate electronic submittal of construction documents and their automated review and approval as a means of reducing the time for regulatory approval and increasing uniformity and reliability.
- There are limited housing technology research sources, and PATH is one of those sources and should continue to partner with industry to address research on building technology.

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Paul Emrath
National Association of Home Builders

Here are my thoughts on main issues from the workshop to emphasize:

1. As the NRC concluded in 2002, PATH's original mission was inappropriate, primarily because it was too ambitious given its resources. Nevertheless, there are many barriers to innovation in residential construction (a diffuse set of buyers who often appear more concerned about appearance than performance, unwillingness of insurers or appraisers to reward improved performance, a relatively unskilled and untrained work force, etc.), so there is an important role for PATH to play.
2. One significant role for PATH is to understand what motivates all the players in the process. For example, why do so many believe suppliers are a bottleneck to innovation? Why do architects feel they have little control? Why do none of the purchasing agents for the large publicly traded homebuilders care about innovation? Why do local governments resist proven technologies that allow homes to be built at lower cost?
3. There was widespread agreement among workshop attendees that the current, revised PATH goals—removing barriers and facilitating technology development and adoption, improving technology transfer, development, and adoption through information dissemination, and advancing housing technologies research and fostering development of new technology—are appropriate and demonstrate that the PATH staff at HUD understood the NRC's criticism and effectively implemented its recommendations. To the extent there was any dissent, it involved speculation that even the new goals may be too ambitious, given PATH's limited budget.
4. Metrics used to measure how well PATH is achieving its goals must be cost-effective. PATH could easily use up its entire, limited budget attempting to measure its own performance. This led to discussions of possible low-cost metrics, such as feedback from users of pathnet.org obtained directly through the Web site.

Bulent I. Kastarlak
AIA Emeritus
Chair, AIA Housing Network for Technology Research

Organization of the Workshop

AIA Housing Committee chair Ed Hord asked me to represent the housing committee at the subject workshop. I was honored and obliged. The following reflects my impressions and notes from the workshop.

The meeting was well organized. It has achieved its intended results through the collective efforts of many persons. I would like to mention in particular Michael Cohn (National Academies), Carlos Martin (PATH), Manny Gonzales (AIA), and John Spear (AIA). Their dedication to the cause made the workshop a success. The turnout was very good. There were about 60 participants from government, the private sector, and academia. The objective of the workshop was to review the PATH strategy, operating plan, and performance measures in light of the 2002 assessment of PATH by the National Research Council (NRC). The two subject documents were:

- *Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing (PATH)*
- *PATH Program Review & Strategy, Performance Metrics and Operating Plan for 2005-2010.*

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After proper introductions, keynote speaker Dr. Sarah Slaughter, formerly an associate professor of civil engineering at MIT, now the founder of a private consulting group MOCA Systems, spoke on the value of technological innovation in home construction and the role of government/industry partnership in promoting innovation. Her presentation was eloquent and informative.

Next, Dr. Melvin Mark, professor of psychology and senior scientist at the Institute for Policy Research and Evaluation at Pennsylvania State University, spoke on the subject of defining success and performance measures for the evaluation and management of PATH. His presentation was heavily theoretical.

Three discussion groups (A, B, C) followed. They considered the following subjects and answered the following questions pertaining to the PATH document:

- Is the goal of PATH for its actions communicated accurately?
- How important is the goal to the development and diffusion of new housing technology?
- Who is the audience and how do they define success?
- Are there performance measures to measure success?

A) John Spear led the first group. I participated as one of the four discussion leaders on the subject of removing barriers and facilitating technology development and adoption.
B) Manny Gonzales led the second group that discussed improving technology transfer and adoption through information dissemination.
C) Jorge Vanegas led the third group's discussions on the subject of advancing housing technologies research and fostering development of new technology.

Finally, the conference wrap-up session was led by four other panel members and reviewed comments on the PATH program and performance measures. The discussion focused on the feasibility of specific program items. The following topics were discussed:

- Is the draft strategy of PATH and operating plan the right paradigm?
- How do we define programmatic success?
- How are priorities established and what should they be?
- What are realistic goals given the current funding level?
- How could these goals change if the funding level changed?
- What are possible strategies for the dissemination of this information to interested parties in the homebuilding industry?

Impressions from Discussions

1. The purpose of the workshop was to assist PATH in making improvements in its operating plan that would be necessary for satisfying the requirements of the Office of Budget and Management (OMB) for continued funding of the program. If I am not mistaken, there was no one from OMB attending the workshop. The validity and relevance of OMB's evaluation standards and procedures were not discussed.

2. PATH's operating plan was prepared in response to the analysis and recommendations of the National Research Council (NRC) in *Promoting Innovation: 2002 Assessment of the PATH Program*. I read the NRC report and took extensive notes. I do not agree with everything it said about PATH's mission. However, I think that PATH was put in an intellectual straight jacket preventing it from engaging in broader, and more relevant, research for solving the housing problem in the USA. Instead the NRC assumed that "innovation in housing technology will realize social benefits" and will help solve the housing problem. By force PATH accepted this assumption. Nevertheless, doubts about pursuing innovation for innovation's sake, without resulting in "social benefits," remained. The representatives of

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the homebuilding industry strongly objected to technological innovation that would not have "cost reduction and profit enhancement" as its main objective. I shared this opinion.

3. PATH's operating plan and metrics were organized as a matrix formed by a vertical series of "Goals," "Objectives," and "Outcomes" and a horizontal series of "Inputs," "Activity," "Output," and "Outcomes" (short and long term) that would evolve from each "Objective." Because many work elements were not measurable, cause-effect associations among them were not self-evident. This presented a difficult problem for PATH in satisfying the OMB requirements. Associations were presented as three parallel series of work elements, each element derived from the higher work element. Every parallel series was independent, without connections with one another. This graphic format was misleading and simplistic.

4. The workshop was confined to PATH's strategy for promoting innovation in housing research. External issues pertaining to solving the housing problem in the USA were not on the agenda. Nevertheless, the workshop often sidetracked from the structured agenda to these external issues and brought a sense of reality to discussions. Very interesting and productive exchanges of ideas took place when discussions drifted to these external issues. In particular, representatives from the housing industry deflated the importance of certain performance standards used in evaluating the PATH operating plan. They were pragmatic. They said that innovation in housing technology is relevant to builders if it helps reduce costs and increase profits. In their opinion, all other motivations were incidental. I agreed, and advocated "cost/profit" as the principal performance standard for evaluating the PATH operating plan.

5. I reviewed both the 2002 NRC report and PATH's operating plan for 2005-2010. They are well documented and clearly written. Although I do not fully agree with all the statements included in the documents, I have not prepared a critique for either. The direction of PATH is set for the foreseeable future and commitments to the course have been made. I assumed that there is no practical benefit in criticizing the past.

6. I reviewed the "Metrics Map" for action in the PATH operating plan for 2005-2010. A total of 256 work items are listed for achieving the four goals of the plan. This corresponds to an average of 50 work items per year for five years. To implement this work program, PATH received only $5 million for FY 2006 from the federal government. Most of this money will be used by PATH for leveraging actions in the private sector for removing barriers, improving technology transfer, and advancing housing technology research. Therefore, PATH will have to operate with an average budget of $100,000 per work item during 2006. By any measure, this is a laughably (!) small amount of money for getting the job done.

7. The reality of the PATH budget dictates that considerable reduction is necessary in the operating plan. How this reduction could be achieved was the subject of more discussions. Workshop participants offered several solutions.

a. One solution was to eliminate one of the three goals altogether from consideration—(a) remove barriers and facilitate technology development and adoption; (b) improve technology transfer, development, and adoption through information dissemination; and (c) advance housing technologies' research and foster development of new technology.

b. A second solution was to apply "reverse logic" to the sequence of work elements in the plan. The sequence was to start by establishing a budget for the work item first and to work backward from "outcome" expected (short and long term), to "output"; to "activity"; to "input"; and finally to realistic achievable "Goals" and "Objectives." This approach promised to maintain all work elements by scaling them down and fitting them into the allocated budget.

c. A third solution was to prioritize work elements randomly and implement as many elements as the budget would allow.

d. A fourth solution was to eliminate the elements of technological innovation affecting the high end of the housing market altogether and dedicate the resources of PATH to innovation in "affordable housing" exclusively.

e. A fifth solution was to follow the "money trail" and eliminate work items that would not result in cost reduction and profit enhancement for the housing industry.

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8. In several presentations by speakers and in PATH's operating plan (Work Item I.A) the "Architects' role in Innovation" was presented almost as an afterthought. The plan originally allocated only $150,000 for this one work item in the budget. That role remains to be defined. Beyond that one work item in the plan, there is no other work specified for architects. This lapse of good judgment suggests that the American Institute of Architects should be more involved and assertive in promoting the importance of its members' role in the PATH operating plan.

9. Information dissemination was a recurring topic. It became apparent that PATH was assuming a "passive" role and taking the stance of "I am here; you find me." As a result, many participants have not even heard of PATH's existence until they were invited to the workshop. A large number of AIA member architects were in this category. I know for a fact that the AIA Palm Beach County chapter in Florida was not aware of PATH. Workshop participants strongly suggested that PATH should take a more active role in making its existence known to the housing industry and others by adopting the motto, "You are there; I will find you." Since government agencies, by law, cannot advertise, PATH will have to find the proper medium for communicating with its housing constituents.

10. The merits of "radical innovation," as opposed to "incremental innovation," were hotly debated. For some advocates, the "dysfunctional" (!) housing industry thrived on "incremental innovation" despite the educational and training deficiencies of its work force. Small inventions were the norm. But these did not appreciably alter the housing product, whereas, "radical innovation" advanced by others advocated major systemic changes in housing production and in its delivery methods. Manufactured housing and changes in professional practice by architects (see *Design 21* by Bulent I. Kastarlak) offered promise.

11. The consensus of the workshop participants was that there is no pressing demand for radical innovation in housing technology at this time. When the industry is making good money there is no motivation for innovation, particularly at the low end of the housing market. Everyone agreed that the high-end housing market is being well served regardless of cost factor. But the "affordable housing" market is hard-pressed for technological innovation and cost reduction. The answer for some was to strive for "attainable" housing, meaning making incremental innovations in the product and in the process of housing production provided that the cost of the product and speed of the process represent improvements over what exists now.

12. Administering innovation in housing technology could also benefit from a similar research/innovation/licensing model used by the U.S. Food and Drug Administration. Every food and drug item and medical procedure goes through an R&D process administered by the private sector and culminates with a license, or rejection, by the government before it reaches the market. This model is worth exploring for PATH.

Theodore Koebel
Virginia Polytechnic Institute and State University

Overall, I think PATH has moved in the direction that I suggested in my article quoted by the NRC report. And while I'm gratified that the committee was influenced by my work, I also want to emphasize that I was looking at technology diffusion through one particular lens in that article, that of diffusion theory and research. One of the benefits of the PATH program to me personally is that I now have a greater appreciation of the complexity of the multi-faceted processes that lead to technological advancement in this industry, as well as a greater appreciation of how little we know about that complexity. This is also true for our understanding of residential building construction, the systems complexity of which has been documented in our process modeling in the Industrializing the Construction Site projects.

PATH has ambitious goals; some might argue they have been too ambitious. But I think we know more today from facing the challenges of those goals and falling short of attaining them than we would have if PATH pursued a more modest agenda. Would PATH be better if we had clearer, surer

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models of technology development, technology testing, commercialization, and diffusion? Of course. But we don't have those models. So some stumbling and false starts should be expected. And much to its credit, PATH has learned from those and has refined its approach.

PATH and NSF-PATH are doing more to advance our understanding of technology diffusion in the residential industry than any pervious effort. PATH is helping establish the fundamental knowledge required to develop clearer, surer models to successfully introduce new technologies into housing. The PATH work plan addresses key areas where we first need to know more before we can do more. These include identifying impediments to innovation and diffusion, modeling the commercialization process and developing commercialization tools, the role of the supply chain in technology diffusion, identifying the networks that advance diffusion, and modeling the diffusion process. This work will lead to a more fundamental understanding of diffusion in this industry, an understanding based on documented research that is replacing a heavy reliance on anecdotes by industry and academic experts.

A casual review of PATH is easily confusing. There are numerous projects and reports, which are not readily ordered by an overarching model. I emphasize again that there is no single model that can (or should) determine PATH's logic. If we've learned one thing from our research, it is that the complexity of the systems involved requires multiple models rather than gross simplifications.

As PATH has matured, it is becoming increasingly necessary to clarify its contributions by providing integrative summaries and meta-analyses of its individual projects. These overviews would help crystallize what PATH has established, where knowledge gaps are persistent, and where new directions should be established. I would recommend that these overviews address the metrics of PATH's logic model, but not be constrained by them. Logic models are at best a set of working hypotheses that should be revised to reflect the ongoing learning that PATH promotes.

Matt Syal
Michigan State University

Let me make a couple of points related to research. With PATH's increasing acceptance as the voice of innovation among industry and researchers, more and more people are looking to PATH for good research—both applied and basic. As the PATH dollars reduce and other pressures start to build, we need to explore innovative ways to accomplish the research goal. Two ideas:

1. PATH should form a panel of experts and researchers to evaluate any research coming out of academia, industry, associations, PATH-supported contractors, etc. (kind of an FDA model). After the research is approved by the panel, it should be recommended by PATH.
2. PATH should serve as a catalyst in forming an industry-funded research consortium (similar to CII or FIATECH). This should be a completely independent consortium and not an add-on to any existing group.

Douglas Thomas
National Institute of Standards and Technology

The PATH goals outlined in *PATH Program Review and Strategy, Performance Metrics, and Operating Plan* are good principles that create an ideal sense of direction. All of the issues that are addressed in the draft are pertinent to increasing innovation in the residential construction industry. The primary concern that I have with the draft was touched on briefly by Dr. Slaughter at the PATH workshop and in Dr. Koebel's statement.

The goals may be ambitious for the PATH organization, and it will be difficult to measure their progress. PATH is charged with identifying and reducing barriers, disseminating information to accelerate innovation, and advancing housing technology research and development. Measuring the

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progress of PATH toward these goals is as difficult as achieving them. However, given the purpose of PATH these challenges are expected. In many respects, the residential construction industry today is similar to the agricultural industry of the early 20th century. Both industries have a slow rate of technology diffusion, have a preponderance of small firms, have workers with poor skills and training, are subject to high risk, are geographically dependent, and use sales representatives as their primary source of information. The state Agricultural Extension Services program was established in 1914 to diffuse innovations in the agricultural industry, similar to the purpose of PATH. It was not until the 1950s that the agricultural revolution took off. Measuring the progress of the Agricultural Extension Services would have been difficult until at least the 1950s. Similarly, it may take time before the efforts of PATH are clearly visible in the industry. In the meantime, PATH could have a difficult time proving its performance level and its effect on the residential construction industry.

RELATED READING

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