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OVERCOMING BARRIERS

TO INNOVATION IN THE HOME BUILDING INDUSTRY

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Overcoming Barriers to Innovation in the Homebuilding Industry

FINAL REPORT: April 2005

Prepared for the U.S. Department of Housing and Urban Development
Division of Policy Development and Research and the
Partnership for Advancing Technology in Housing

Building Technology Incorporated
1109 Spring Street, Suite 409
Silver Spring, MD 20910

Tables

Appendices

The U.S. Department of Housing and Urban Development's (HUD) Partnership for Advancing Technology in Housing (PATH) has completed the research reported in this document in response to the National Academy of Sciences' (NAS) evaluation of PATH's treatment of barriers to innovation in the housing industry. This evaluation, "Promoting Innovation: 2002 Assessment of the Partnership for Advancing Technology in Housing (2003)," found that while new technologies and production processes could help overcome serious problems for housing producers, "realizing these benefits on a broad scale is considerably hindered by characteristics of the housing industry that inhibit the development and diffusion of innovations." The objective of this investigation was to make feasible recommendations for overcoming such barriers.

The report is divided into four parts:

- A literature review
- An overview of the expert panels' methodology
- A summary of the expert panels' discussions
- Recommendations

An extensive literature search and review was undertaken on the published literature related to risk, fragmentation, education/communication, and industry participant preference barriers to the adoption of innovation in the homebuilding industry. Altogether, nearly 40 documents were read and summarized.

Panelists develop recommendations to overcome barriers to innovation.
Photo courtesy of D&R International

To develop a practical understanding of how these barriers affect technology adoption within the industry, three expert investigatory panels were convened in fall 2004—one on risk, a second on industry participant preferences, and a third on education/communication as barriers to innovation in housing. The panels were comprised of seven to 10 leading representatives of key stakeholders and decisionmakers in the housing industry.

Each panel developed recommendations for actions to overcome barriers to innovation in these three areas. While these recommendations are explicitly made in the context of PATH activities, they can apply to any initiative within industry or government to improve the rate and quality of innovation in the homebuilding industry. Therefore, the parties responsible for the findings and recommendations are left unnamed here, although PATH expects to act on them all.

The findings and recommendations are particularly revealing. Both conventional wisdom and current practice were challenged by the proceedings. Highlights from each panel's findings and the overall recommendations are summarized below.

Risk Panel Findings

- The ability to address market risk depends largely on an innovator's resources. Manufacturer size is a critical variable: large manufacturers often have the resources to vet a product before it goes to market, but start-ups probably do not.

- Building industry barriers help prevent the widespread adoption of bad ideas. However, builders are wary of assuming *additional* marginal risk with new innovations since they already assume substantial risk in this highly competitive market.

- Product liability risk is part of America's litigious society, and builders would be glad of HUD's assistance in protecting against the unforeseen consequences of adopting innovations. Manufacturers would also appreciate standards and protocols for durability testing.

- The lack of experienced installers—typically subcontractors—exacerbates the risk of innovation adoption. There is a critical shortage of qualified labor.

- To guard against the risk of unintended consequences, all builders must implement changes at the local level. Accordingly, staffing business units are built around producing 250-500 houses per year. However, large builders are not confined to incremental change; many large manufacturers and builders are in fact considering structural changes in the process.

- Market volatility is not a risk factor for housing innovation since financing innovations have dampened the variability of housing starts across the United States.

- Insurers make innovation possible by supporting those technologies that succeed in the market and eschewing those that do not. Government and industry have an important role to play in supporting the development of viable technologies and increasing builder awareness of these technologies.

Preference Panel Findings

- To influence stakeholder preferences, innovation programs need to provide additional information on innovations, such as their applicability to large and small builders; code acceptance or evaluation; and cost, time, and labor savings. Information tailored to target audiences is also needed.

- Consumers must also be made more aware of innovations so that they can become viable options in the marketplace.

Panel members representing suppliers and architects discuss preferences as barriers.
Photo courtesy of D&R International

- Energy efficiency does not ensure market penetration for an innovation. Innovation programs should steer innovators who emphasize energy conservation to the niche markets that value this feature.

- There should be some mechanism for certifying or clearing emerging innovations, which would assist small (and large) innovators in bringing technologies to market.

Education/Communication Panel Findings

- Any innovator hoping to be successful must convince production builders, developers, large-scale owners, subcontractors, and building code officials to try the innovation—and make its case powerfully and succinctly. These are the key decisionmakers innovation programs need to influence.

- Subcontractors who embrace an innovation can be allies in convincing a builder to try it. Given their extensive use among builders of all sizes, subcontractors are also key decisionmakers for innovation.

- The lack of English language skills need not be a barrier to innovation. Critical information related to safety or basic installation processes should be available in more than one language. The use of illustrations in printed material also helps overcome limited language skills.

- Existing education channels are insufficient to meet the current needs of the construction industry, let alone support new innovations. There is a shortage of young workers entering the field, since most young people do not currently perceive the construction industry as an attractive line of work.

Roundtable participants discuss education as a barrier to innovation.
Photo courtesy of D&R International

- While the Internet is a useful tool, acceptance of an innovation, closing of a sale, and training still depend largely on face-to-face contact. Many builders are "kinesthetic" learners who like to see and touch what they are buying. Innovators need to accommodate these ways of learning and buying when marketing their products

- Because the job of successfully educating so many decisionmakers is so involved, large and sophisticated organizations have a distinct advantage in bringing innovations to market. Such companies tend to focus on incremental innovations that are less risky and extend an existing market. Large groups, such as trade associations, can act like a big company in supporting innovations that are related to the mission of the association.

- Innovation programs should help innovators who are not within large companies or supported by a large trade association. Such programs could introduce innovators to key decisionmakers in the industry, provide seed funding for testing and data collection, facilitate work with code organizations, and help find demonstration sites. These programs will have greater impact by focusing on a limited number of innovations than trying to advance many innovations at once.

- The best time to advance innovation is during a housing recession when builders are looking for something to make their product distinctive. When the housing market is booming, builders are likely to be resistant to innovations that might slow down their standardized processes. To be successful, innovations must be sensitive to market timing.

Recommendations

The expert panels generated nine specific recommendations for overcoming barriers to innovation in housing. Each recommendation builds on the findings of the three panels.

1. *While continuing to support innovations that can lead to a net reduction in housing costs, the homebuilding industry should seek ways to raise consumer awareness of the importance of improved performance*. Consumers will not support a higher-cost innovation unless they recognize and realize a benefit. Innovations are currently of scant interest to new homebuyers or appraisers.

2. *Innovation programs should investigate ways to mitigate builders' risks for adopting housing innovation.* Builders generally will not adopt an innovation that entails significant additional risk.

3. *Smaller manufacturers offering housing innovations need special assistance.* The small size of many housing innovators hinders their understanding of the marketplace and their ability to communicate with the industry. Innovation by big companies such as DuPont could provide a model for these manufacturers.

4. *Innovation programs should develop and communicate a better understanding of the relationship between the supply chain and market success.* Supply chains and distribution channels are far more important and a much more significant barrier for innovation than previously thought.

5. *Innovation programs should seek partnerships with subcontractor associations.* The majority of innovations reach builders via subcontractor recommendations, and any innovation "discovered" by a builder must be accepted and implemented by the appropriate subcontractor.

6. *Innovation programs should provide stakeholders the information they need to make decisions about adopting innovations.* Much information that is crucial to the decision to adopt an innovation is not readily available.

7. *Innovation programs should help innovators understand and address the building codes and standards development and approval processes*. Every innovator needs help in understanding and addressing building codes and standards, which can help enable the acceptance of an innovation.

8. *Innovation programs should facilitate high-profile demonstrations of new technologies.* Stakeholders may be reluctant to adopt innovations without evaluating larger scale demonstrations of the technology. Large-scale procurements, especially by government agencies, the military, universities, and hospitals, are excellent venues to showcase innovations.

9. *The homebuilding industry should actively help get more students interested in housing construction in general, and in housing innovations in particular.* The lack of adequate education and training contributes to lower quality of construction labor, and less educated labor makes change in construction practices more difficult. Most high school students do not view construction as an attractive career.

Approach

The purpose of the literature search was to identify the scope, content, and conclusions from published literature related to risk, fragmentation, education/communication, and industry participant preference barriers to the adoption of innovation in the homebuilding industry. As the search progressed, a fifth area—"innovation"—was added, covering literature related to the general topic of innovation adoption and/or diffusion in the homebuilding industry. It was assumed that the study of adoption or diffusion could shed light on the topic of barriers to the adoption of innovation.

The literature search, initially conducted by a professional research librarian, resulted in a bibliography of approximately 100 separate documents. Documents were comprised primarily of articles in specialized journals, augmented by government reports and a number of academic dissertations. From the full list of 100 documents, the research team read and summarized those that seemed particularly relevant to this investigation (see Appendix A for document summaries) From that subset of references, 16 documents were selected as being most informative for the analysis requested by HUD. Highlights of many of these documents are referenced and summarized in this summary of the literature search.

Findings from this literature search were also used to inform the three panel discussions sponsored by HUD later in the project. The literature search aided in the selection of topics (three out of the four barrier categories listed above), suggested possible panel members, and suggested lines of inquiry to be followed in the panel discussions.

Literature Review Reporting Format

A summary sheet was developed in accordance with the following outline for each document fully reviewed in the search. Altogether, nearly 40 documents were read and summarized.

Table 1. Barriers to Innovation Literature Review Summary Sheet
Topic: Innovation Adoption/Diffusion, Fragmentation, Risk, Industry Participant Preferences, or Education/Communication
Reference: Specific bibliographic citation
Reviewer: Initials of research team member conducting review
1. Scope and content of the reference
2. Any theoretical model of innovation and/or barrier operation to consider based on the work
3. How the reference helps define one or more of the four relevant categories of barriers
4. How the reference better defines the extent to which consumers (builders at one level, and, ultimately, homebuyers) participate in making decisions or creating barriers
5. How the reference supports the conclusions with reliable and sufficient experiential data
6. How the reference differentiates energy and non-energy aspects of technology or system innovation
7. Potentially important references not previously cited
8. Additional comments or summaries of other important information

Findings

The following summary begins with a discussion of two general topics: diffusion of innovation in the homebuilding industry, and a brief commentary on the term "barriers." The balance of the summary presents excerpts and key findings from papers viewed as most informative in the search. As with any such review, not every paper has been found and studied.

Diffusion of Innovation in the Homebuilding Industry

Table 2. Key Innovation References
Arditi, David and Serdar Kale. 1997. Innovation in construction equipment and its flow into the construction industry. *Journal of Construction Engineering & Management* 123, no. 4: 371-78.
Slaughter, E. Sarah. 1998. Models of Construction Innovation. *Journal of Construction Engineering and Management* 124, no. 3: 226-31.
Hassell, Scott, Anny Wong, Ari Houser, Debra Knopman and Mark Bernstein. 2003. *Building Better Homes: Government Strategies for Promoting Innovation in Housing*, RAND Science and Technology Policy Institute, Arlington, VA.
Field, Charles G. and Goldberg, Burton. 2001. *Commercialization of Innovation: Lessons Learned*, NAHB Research Center, Inc., Upper Marlboro, MD.

In general, the content of the literature on diffusion falls into three broad categories:

- "Classic" models of innovation diffusion
- Analyses of empirical survey information regarding adoption of innovation
- Models of construction industry relationships and processes

Before 1985, much of the theory regarding classic models of diffusion in the homebuilding industry was based on research on diffusion for heavy manufacturing and the high-tech industries. Rogers (1983), Drucker (1985), and Shaffer (1985) are all examples of this approach. Bronwyn H. Hall's *Innovation and Diffusion* (2004) is the latest theory on diffusion of innovation. Hall proposes an economic model that views the process of diffusion of innovation as cumulative decisions made in an environment of uncertainty and limited information. Innovations change over time, and the diffusion process enhances them via the feedback of information about their operation or utility under varying conditions and across different users.

Starting in the late 1980s, researchers began to argue that the homebuilding industry was fundamentally so different that these manufacturing-based models of diffusion did not apply. "The fundamental differences first stem from unique characteristics present in most construction products: immobility, complexity, durability, costliness, and high risk of failure" (Nam and Tatum, 1989).

Building on all of this previous work, the most recent model put forth (in 2003) was the "Expanded Nonlinear Model of Housing Innovation," developed by Scott Hassell et al. at RAND Science and Technology Policy Institute, and presented in *Building Better Homes: Government*

Strategies for Promoting Innovation in Housing. As suggested by its title, this model is less linear than the familiar left-to-right progression of earlier models and is more open to the influence of market forces and invention at any point in the diffusion process (RAND, 2003). This model was judged to be one of the best current efforts found and merits attention by anyone interested in diffusion modeling as it relates to the homebuilding industry.

Regarding empirical surveys or case studies, most are narrow studies of arbitrary and small sets of innovations. Often these analyses use social science techniques, such as multiple regression and probit analysis, to establish causal relationships between demographic characteristics and attitudes toward innovation or adoption practices. Much of the analysis goes to great length to confirm generally accepted presumptions, such as the contention that uncertainty in adoption decisionmaking decreases as the overall level of innovation adoption increases. However, by inference, these empirical studies can confirm, or not, contentions made in the larger models discussed above.

Finally, concerning more general models of construction industry relationships and processes, several authors have tackled the job of trying to sort out and present in a logical or graphical form the many complex relationships that exist within the homebuilding industry. For example, Laborde and Sanvido (1994) construct a simple four-cell Innovation Model for Contractors. More recently, RAND (2003) proposed a five-cell model of the Homebuilding Process with further details that expand each cell of the model into a multiplicity of relationships. The reviewers found this model to be very useful in describing both key actors and key relationships within the homebuilding industry. As such, this model was used to assist the project team in designing the panel discussions in the subsequent phase of this project.

The following list highlights four general findings that the reviewers found compelling in the literature:

- Most homebuilding innovation, which can be either product- or process-related, is incremental in nature and initially comes from outside the industry (Arditi et al., 1997).

- Innovation can occur along a continuum from easily adopted incremental product changes to business and industry altering, radical product delivery system changes. Requirements for coordination and collaboration within and external to adopting construction firms increase exponentially along the continuum (Slaughter, 1998).

- With the exception of Finland, radical innovations in prefabrication and industrialization in housing have failed to take root to any significant degree anywhere in the world for any extended period of time (Rosenfeld, 1994).

- On balance, the literature contends that innovation in the homebuilding and broader construction industries is underestimated. Indeed, it is more prevalent, robust, and efficient than indicated by conventional wisdom (for example, by Arditi, Koebel, RAND, Slaughter, and Toole).

The Concept of Barriers to Innovation

The assignment from HUD for this project was to investigate barriers to innovation in the homebuilding industry in three of the four specified categories (fragmentation, risk, education, and cultural values). While barriers are mentioned extensively in the PATH program and the NAS reviews, virtually none of the more recent sources reviewed here discuss barriers to innovation in any specificity. Nam and Tatum (1989), and by reference Putnam (1985), mention organizational rigidity as a barrier to innovation. Some of the early diffusion modelers touch on barriers. Slaughter (2000) mentions that a technical change that is too big for the industry to adopt can be a barrier. Toole (1992) lists a series of reasons for non-adoption as barriers.

Barriers to innovation are occasionally implied by the literature, but no classification, analysis, or formal theory on this subject has been found in this search. The four categories of barriers suggested for this project seem to have been put forward with no identifiable substantiation in the NAS report mentioned above.

Analysis in the RAND report (2003) addresses this situation head-on. In the summary and in chapter two, the authors point out that the concept of identifying barriers and means to overcome them is based in large part on linear models of diffusion from the 1980s. “Although popular at one time,” they say, “the linear model is no longer held in high regard.” The RAND team goes on to support this contention by noting that the linear model does not well represent the complexity of relationships in the homebuilding industry; it does not account for the potential for innovation at many points within the industry, there is little provision for feedback from downstream participants, and there is little recognition of consumer preferences and market forces.

The following sections address literature related to each of the four categories identified by HUD as barriers to innovation. In each case, we present a hypothesis concerning the topic (reflecting current conventional wisdom), a brief summary of the most important literature reviewed about the topic, a summary of our findings, and a recommendation on how the topic might be addressed by the proposed expert panels.

Fragmentation

Table 3. Key Fragmentation References
Blackley, D. M. and E. M. Shepard. 1996. The Diffusion of Innovation in Home Building. *Journal of Housing Economics* 5, no. 4: 303-22.
Slaughter, E. Sarah. 1993. Builders as Sources of Construction Innovation. *Journal of Construction Engineering and Management* 119, no. 3: 532-49.
Slaughter, E. Sarah. 1991. "Rapid Innovation and Integration of Components: Comparison of User and Manufacturer Innovations through a Study of Residential Construction." Massachusetts Institute of Technology.

Common hypothesis: The homebuilding industry is extremely complex. Horizontally, there are many, many companies from the very small to the very large. And vertically, there are dozens—if not hundreds—of steps that a product must go through in its progress from manufacturer's research to consumer acceptance and application. Because of this complexity and the number of key players that must be addressed, fragmentation itself is a barrier to innovation.

The literature search yielded the following findings:

- Results from a study by Blackley and Shepard, (1996) do not support the hypothesis that fragmentation reduces the likelihood of adopting innovations. However, the measure for horizontal fragmentation was the percentage of work subcontracted, and the measure for vertical fragmentation was the extent of non-building business (i.e., architecture, engineering, real estate, design, and finance). These are crude or invalid proxies for fragmentation. For example, they ignore the relationship between manufacturers, suppliers, and builders, found by Slaughter (2000) to be significant. In explaining the effect of management intensity on propensity to adopt innovation, this paper seems to support Slaughter's theory that builders with workers participating in both management and construction are likely to adopt and adapt innovations.

- Builders innovate more than manufacturers in some cases (i.e., stressed skin panels). The value of builder innovations does not result in broad-based improvement to the basic innovation because the manufacturers do not adopt them for commercialization (Slaughter, 1993).

Based on these findings—and the fact that fragmentation has within it dimensions of communication, preferences, and risk—the project team recommended that "fragmentation" itself not be addressed as a unique topic. Instead, each proposed panel should address the implications of fragmentation in light of the innovation being reviewed. If a product or innovation has not done a sufficient job of addressing all of the key stages in the homebuilding industry as laid out by RAND (2003), it could be argued that it is not fragmentation that is the barrier here, but the fact that the innovation team has not done their homework. Each panel was asked to reflect on this dichotomy.

Risk

Table 4. Key Risk References
Toole, T. M. 1998. Uncertainty and Home Builders' Adoption of Technological Innovations. *Journal of Construction Engineering and Management* 124, no. 4: 323-32.
White, Nancy J. and Nancy Holland. Statutes of Repose: Protection for Manufacturers and Material Suppliers. *ASC Proceedings of the 32nd Annual Conference,* pp. 223-30.
Bevan, John P. 2002. New Standards, Procedures, Defenses Enacted for Housing Construction Defect Disputes in California, Thelen Reid & Priest LLP, San Francisco, CA.

Common hypothesis: Liability risk associated with failure of products and practices in the homebuilding industry is a barrier to innovation. Market risk associated with failure of homebuilders or homebuyers to accept new products or practices is a barrier to innovation.

The literature search yielded the following findings:

- The organizational environments of innovation consist of five sectors: technology, supplier, regulatory, competitor, and customer. Sectors individually, and as a group, influence actions needed for profitability, growth, and other organizational goals. Munificence (degree of environmental hostility), dynamism (unpredictable volatility in demand, prices, product characteristics, technologies), and complexity (measure of number of inputs, outputs, interactions, regulations) are key dimensions of the environment affecting uncertainty. Homebuyers, local building officials, and subcontractors are particularly significant sources of uncertainty for homebuilders (Toole, 1998).

- Contractors, manufacturers, and even owners may be targets for negligence suits when building components fail to perform satisfactorily. "Standard of care" may require actual testing of products to confirm performance rather than reliance on manufacturer or third-party information. "Responsibility between prime and consultant" leads to pass-through of negligence liability to the prime, even if not directly involved in decisions of a consultant, or even if defects are part of a manufacturers design. Manufacturer's potential liability exists in cases of negligent design or misrepresentation (including in free publications), even if others contribute to a failure. "Owner's (developer's) potential liability" evolves from the Spearin Doctrine, which holds that projects are built to plans and specifications prepared by the owner and that the owner is responsible for the consequences of defects in plans and specifications. "Handling of substitutions" leads to potential liabilities by all decisionmakers in the use of newer/substitute materials that have not been tested by experience (Lunch, 1994).

- Two variables that correlate with builders' propensity to adopt innovation are the size of the firm and the operation in multiple markets. Both may be indicators of risk tolerance (Blackley and Shepard, 1996, see Fragmentation).

- Builders' risk is local and limited, while manufacturers' risk is extensive and may expand to product interfaces. This may explain why builders innovate more than manufacturers (Slaughter, 1993, see Fragmentation).

It is an interesting question how the trend toward greater use of modular construction elements (and the view of homebuilding as modular assembly) may affect innovation. On the one hand, the use of sophisticated and well-tested building modules (such as window systems) can be seen as a way to reduce both manufacturer and builder risk. On the other hand, such modular systems may also reduce the ability to modify products or practices in the field. As discussed in a number of references, the ability of builders to experiment and adapt new ideas in the field is an excellent source of evolutionary improvements to innovations, as they diffuse within the industry and over time.

The literature on risk provides many examples of failures of once-promising innovations. The types of risk discussed in the literature are helpful in defining "categories" of risk. It is important that a panelist represent each of these categories during the general discussion of risk. And, finally, the potential for failure at many different points in the construction process illustrates the importance of feedback from any point to all other points in the process. The success of an innovator in monitoring and addressing feedback will be a key criterion in assessing the likelihood of adoption for each of the innovations to be reviewed.

Education/Communication

Table 5. Key Education/Communication References
Laborde, Maria and Victor Sanvido. 1994. Introducing New Process Technologies into Construction Companies. *Journal of Construction Engineering and Management* 120, no. 3: 488-508.
Mead, Stephen P. 2001. Developing Benchmarks for Construction Information Flows. *Journal of Construction Education* 6, no. 3: 155-66.
Burnett, Eric, Jr. and Robert W. Buddenbohn. 1999. *Training and Education Needs Assessment for the Home Building and Remodeling Industry in Pennsylvania*, Pennsylvania Housing Research Center, University Park, PA.

Common hypothesis: The lack of sufficient product technical information, training and instruction from product innovators, and education regarding the costs and benefits are all barriers to the acceptance of particular innovations.

Not surprisingly, there is not much literature to review on this subject. Vocational training, extension services, and on-the-job training are generally all in the backwater of educational or learning theory. The reviewers did note the existence of the PATH-supported Housing Education and Research Centers. Although the literature search found only one document (Burnett and Buddenbohn, 1999) from this group on this topic, these Centers could be a useful source of information.

The literature search yielded the following findings:

- The Pennsylvania Housing Research Center, has prepared an excellent report on the status of learning in the construction industry. After confirming the lack of useful references on the subject, the report builds a simple eight-stage model of learning in the homebuilding industry. The authors argue that this is merely the starting point for needed study to assess both knowledge and skills at each stage of proficiency in a building trade, craft, or profession. The willingness to accept innovation should be included (Burnett and Buddenbohn, 1999).

- The policy implication of the Housing Research Center research is in many ways more significant than the research impacts. If builders are responsible not only for the vast majority of innovations that improve construction technologies but are also the sole source of innovations that integrate the different systems, then policies to improve the development and implementation of new technologies in construction must explicitly recognize this fact. Policy programs could focus on providing detailed technical information and training directly to the users; these actions could more significantly improve technology development than subsidies and research programs directed at manufacturers. PATH should consider incorporating aspects of the U.S. Department of Agriculture's Extension Agent Program (Slaughter, 1993, see Fragmentation).

The project team did discuss at length the definition of this category. It has two important aspects: education and communication. Education, as a term, tends to focus on the level of education or skill of the construction industry participant and that person's willingness to take in new information or to accept innovation. Communication, however, also is important and focuses on the transfer of information and learning among participants at many places in the construction process. The project team believes it would be important to bring forth both of these aspects of education/communication for the panel discussion.

Other useful topics were identified by the project team for discussion in the Education Panel for which no literature references have been found to date: union procedures and work rules; building code modifications and dissemination; the education and training of code inspectors; and the increasing use of English as a second language on construction teams.

Findings (or lack thereof) from the literature search suggested that the leader of the Education Panel discussion must be creative in selecting both panel members and topics for discussion. It seems clear so far that it is important to discuss education as it relates to workers within the homebuilding industry, and communication, in general, among participants in the industry. As a caution, this topic needs to stay within the bounds of education and communication and should not stray into a more general discussion of "marketing" new product innovations.

Industry Participant Preferences

Table 6. Key Industry Participant References
Torbica, Zeljko M. and Robert C. Stroh. 2001. Customer Satisfaction in Home Building. *Journal of Construction Engineering and Management* 127, no. 1: 82-86.
Sirmans, G. Stacy, Kenneth G. Bacheller and David A. Mcpherson. 2003. *The Value of Housing Characteristics*, National Center for Real Estate Research, National Association of Realtors, Washington, DC.
Koebel, Theodore. 2003. *The Diffusion of Innovation in the Residential Building Industry*, Virginia Polytechnic and State University, Blacksburg, VA.

Common hypothesis: Both attitudes to change in general and personal preferences are expressed at every node in the model of the construction industry. At any point these preferences can enhance or delay acceptance of an innovation.

The literature search yielded the following findings:

- Recently, quality and customer satisfaction have been added to financial metrics as measures of homebuilding company performance. Analysis indicates that the service component has the greatest impact on overall satisfaction—about twice the influence of design factors and three times that of quality factors. Conversely, consumers are least satisfied with service, followed by quality, and most satisfied with house design factors (Torbica and Stroh, 2001).

- Property value is affected by physical characteristics and location, conditions of sale, market conditions, and financing. Hedonic regression analysis is used to explain value as well as to estimate it. (Hence, valuation of characteristics may be considered an objective measure of buyer preferences.) Innovations may rarely become buyer concerns that will affect property valuation and price (Sirmans et al., 2003).

- Industry concentration, while often described as diffuse, exhibits classic Pareto distribution, in which the largest 20% of firms produce 80% of new housing. (The trend appears to be toward increasing concentration as large firms become larger; the largest 10% produce 66% of new homes.) The diffusion of innovation study recommends extension of research and promotion targeting adoption of innovation to early adopters and early majority, even though this represents up to 50% penetration. Analysis of diffusion of construction technologies shows dramatic increases for 10 technologies tracked by the National Association of Home Builders' annual builder practices survey. Comparison of average prices shows cost above average for eight of the 10 technologies (Koebel, 2003).

Because homebuyers are at the very far end of the "old" linear model of the construction industry, and because they are often described as being represented solely by the contractor, consumer preferences have often been ignored by the innovation adoption literature. There is no doubt that the panel discussing industry participant preferences must be well represented by contractors or contractor organizations. It is important that there also be some representation for the ultimate consumer—the homebuyer—and for other industry participants whose preferences

can be critical in the acceptance or rejection of an innovation.

Summary

The literature search was helpful in preparing for the topical panel discussions that followed. It is certainly no surprise that the homebuilding industry has been defined as huge and extremely complex. It was useful to review the best of the models of diffusion of innovation; however, in the end, the project team recommended that the panel discussions not get mired down in arguing the relative merits of one model over another. The project team found the RAND model of the homebuilding process to be useful and it was used to help identify panelists to represent key participants or relationships within this model.

Of the four discussion topics proposed by HUD, based on findings from the search, fragmentation was to be addressed indirectly in all barrier discussions. Principal topics for individual panel discussions were risk, industry participant preferences, and education/communication as barriers to innovation in housing.

Approach

The fundamental purpose of convening three expert panels was to discuss the respective categories of barriers to innovation in housing, and to recommend actions that HUD could take to overcome these barriers by supporting their removal or alleviation.

The expert panel discussions were designed to build on the findings of the RAND report and other important literature identified in the literature review. Specifically, the industry participant structure of the RAND model was used to guide the selection of panel participants. The project team approached expert investigation of barriers to innovation by taking the following steps:

- Begin with the RAND model, "The Homebuilding Process."
- Make sure that each panel contains members who represent, are knowledgeable of, or are experts on each respective stage of the homebuilding process.
- Select and present currently available innovations for review by the panel of experts.
- Ask each representative or expert about the readiness of the innovation to be presented at that stage, and the likelihood that the innovation would be adopted by the group represented at that stage. (In this view, an innovation can enter the process at any point; however, it must address all stages at some point.)
- Develop recommendations on barrier removal or alleviation.

In this way, the expert panels could assess the overall readiness of an innovation and its overall likelihood of acceptance in the homebuilding industry without regard to its current level of diffusion and without unnecessary debate over whether a key stage of the homebuilding process presents a "good" or "bad" barrier to innovation.

However, as these panel discussions were planned, it became clear that the panels could serve as a broader model for HUD. The added value of the panel discussions could be to test a process for reviewing and selecting innovations that are both ready for adoption and have a good chance of being adopted by enough participants throughout the industry to assure their probable success. In this way, PATH could justify the selection of the most promising innovations for their support.

Panel Structures—Seats at the Table

The RAND model was evaluated from the presumed concerns related to each category of barriers, qualitatively identifying key stakeholders and relationships throughout the housing delivery process with particular attention to likely actions related to adoption of innovative products and technologies. Three maps of key stakeholders and relationships resulted. Please see Appendix B for further details.

Expert Participants

Each invited panel participant has had broad experience and success in the housing industry. For the purposes of each panel, however, these industry leaders were asked to narrow their focus to their personal interpretation of the perspectives of the particular role in the housing delivery process represented by their seat at the table. The following tables list the name and organizational affiliation of each panel participant invitee for each expert panel session. The remainder of this report attributes observations and comments in the panel discussions to each seat rather than its occupant.

Table 7. Risk as a Barrier to Innovation in Housing October 20-21, 2004, Washington, DC	
Risk Lead	Fred Krimgold, Virginia Tech
1. Community Advocacy Group (Architectural Review Board)	Avery Faulkner, Middleburg
2. Errors and Omissions Insurance for AEs	Joe Jones, Victor O. Schinnerer & Co.
3. Manufacturer: Legal/Insurance/Finance	Theresa Keninger, Counsel, Pella Corporation
4. Evaluation/Testing/Codes	Jim Googas, State of New York
5. Supplier/Wholesaler	George Yezbak, Thos. Somerville Co. *(absent)*
6a. National Builder	Peter Byrnes, Winchester Homes
6b. Regional Builder	Craig Havenner, The Christopher Companies
7. Inspection Services	Marvin Goldstein, Building Inspection Co.
8. Academic/Operations Research	J. Rene Van Dorp, George Washington University

Table 8. Preferences as Barriers to Innovation in Housing October 27-28, 2004, Washington, DC	
Preference Lead	David B. Hattis, Building Technology Inc.
1. Owner Advocate/Appraiser	Linda Braley, Appraisal Institute
2. Designer/AE	Carlos Gles, Architect, Lessard
3. Supplier (Shipper/Wholesaler/Retailer)	George Yezbak, Thos. Somerville Co.
4. Manufacturer: Market Research	Chris Fisher, Ducker *(absent)*
5. Trades/Unions Representative	Stuart Binstock, NECA
6. Builder	Marty Mitchell, Mitchell & Best
7. Consumer Protection (CPSC)	unavailable
8. Academic/Operations Research	Ted Koebel, Virginia Tech

Table 9. Education/Communication as a Barrier to Innovation November 3-4, 2004, Washington, DC	
Education/Communication Lead	Michael Bell, The Bell Company
1. Media: Real Estate	Unavailable
2. Specifier	Mike Pifer, Linden Contracting
3. Trades/Unions	Ted Kuczynski, ITI
4. Evaluation/Testing/Codes	Lorry Rosenfeldt, ICC
5. Supplier (Buyer)	Bill Conway, Builders First Source *(absent)*
6. Builder	Jano Cymes, VanMetre
7. Learning Specialist	Sandra Mittelsteadt, ACTE
8. Academic/Operations Research	John H. Cable, University of Maryland

Michael A. Bell (The Bell Company), David B. Hattis (Building Technology Incorporated), and Dr. Frederick Krimgold (Virginia Tech), served as leads for the Education/Communication, Preferences, and Risk panels, respectively. G. Kimball Hart (Hart, McMurphy, & Parks, Inc.) and William I. Whiddon (Building Technology Incorporated), served as facilitators/scribes for each expert panel session. The proceedings were observed by Mike Blanford, Dana Bres, David Engel, Michael Freedberg, and Carlos Martín of HUD PD&R, and Maureen McNulty and Jennifer Rivera of D&R International.

Innovations Selected as Contexts for Barriers Discussions

The project team first developed and evaluated a database of ToolBase Innovations (see Appendix D) to identify candidate technologies. The goals were to select innovation products and technologies from the HUD menu that had been successful, or had been available for a long period with only limited success, and/or had met with recent adoption success. An invited meeting of manufacturer members of ASTM Committee E06 (Performance of Buildings) was conducted to identify additional candidates. Availability and willingness to invest the necessary substantial resources to fully participate were serious considerations in inviting participation by manufacturers of innovations.

Table 10. Innovation Candidates	
Market Maturity	**Initial Candidates**
Emerging Innovation	Steel Framing: New Zealand
Mature Innovation	ICF: Eco Block, Polysteel, ICFA SIP: Premier, Fischer, SIPA Composite Decking: Trex
Graduate Innovation	Cement Siding: James Hardie Housewrap Flashing: DuPont

Six candidates' innovations were initially identified for possible presentation to the expert panels. Discussions were conducted with most of these initial candidates. Housewrap flashing, insulated concrete forms (ICFs), and structural insulated panels (SIPs) were finally selected as the three technologies, providing very different contrasts and experiences and a rich context for expert panel deliberations.

While it was initially preferable to have the same three companies presenting to all three panels, it was decided that since the expert panels would be deliberating independently of one another, the makeup of the innovation presenters could be different from one panel to the next if a given manufacturer within the technology was unable to present at all three. When an unavoidable commitment prevented DuPont from participating in the education/communication session, Solutia, manufacturers of the interlayer in laminated glass, and Pella Corporation, manufacturers of windows, were invited to participate in that panel. When neither could participate, it was decided that the extensiveness of the materials presented by DuPont in the risk and preferences sessions allowed a member of the project team to stand in and provide sufficient background information regarding housewrap flashing education and communication efforts.

The following observations were made regarding these participants:

- Because both ICFs and SIPs have been marketed for more than a decade, they were characterized as mature in the database. However, they both met the definition for emerging technology in terms of market diffusion level. Further, both ICFs and SIPs were still unsettled in terms of product positioning and standards development.

- Conversely, although housewrap flashing is only a relatively recent follow-on innovation to Tyvek wrap, it has quickly achieved low, but substantial, diffusion and has very high ultimate market potential. In addition, the flashing product had undergone extensive and rigorous testing as part of the product development process before market introduction.

The selected products/technologies met all the requirements. Each firm is commended for the serious attention they gave the task. The following manufacturers, associations, and individuals comprised the innovation presentation teams.

Risk Panel, October 20-21, 2004

Housewrap Flashing	Joseph King, Dupont
Structural Insulated Panels	Ken Hawkins, Premier Industries, and Bill Wachtler, SIPA
Insulated Concrete Forms	Sheldon Warman, Eco-Block

Preferences Panel, October 27-28, 2004

Housewrap Flashing	Jim Katsaros, DuPont
Structural Insulated Panels	Damian Pataluna, Fischer SIPs
Insulated Concrete Forms	Joe Lyman, ICFA

Education/Communication Panel, November 3-4,2004

Housewrap Flashing	G. Kimball Hart, based on DuPont materials
Structural Insulated Panels	Al Cobb, Panelwrights/SIPA, and Ken Hawkins, Premier SIPs
Insulated Concrete Forms	Pat Murphy, American Polysteel

Each invitee was briefed on the panelists and preliminary barrier hypotheses for their session. Each was asked to attend the full two-day panel session to gain the greatest benefits for their respective firms. Each also was asked to reserve comment and judgment while at the sessions in deference to the invited expert panels. In all cases, the invited innovation teams exceeded all expectations. Each firm is commended for the serious attention they gave the task. All of the innovator slide presentations given to each expert panel are archived in Appendix C.

Risk as a Barrier to Innovation in the Homebuilding Industry

Based on the literature review and discussions among the project team, six hypotheses reflecting current conventional wisdom were presented to the expert panelists and the innovation presentation teams by the risk expert panel lead. These hypotheses provided a broad contextual starting point for the panel sessions.

Market risk is a significant barrier to innovation in the housing industry.

- Venture capital is difficult to acquire for housing technology development.
- Many housing technology innovations fail in the market.
- The high failure rate of housing technology innovations inhibits the introduction of new products to the market.

Potential product liability is a barrier to innovation in the housing industry.

- Major product liability settlements discourage introduction of new products.
- Potential product liability inhibits the specification of new products by designers and use by builders.

The volatility of the housing market poses a barrier to the introduction of new homebuilding innovations.

- Markets are unpredictable and adoption rates are uncertain
- Volatile markets tend to foster conservatism in product selection

Errors and Omissions insurers encourage conservatism on the part of housing designers and specifiers.

- Insurance coverage discourages use of new or untested products and practices.
- Designer liability has inhibited innovation in the housing industry.

Consumer protection law advancement has increased the risk of innovation.

- Successful claims by homebuyers against builders, designers, and materials suppliers pose significant barriers to innovation in the housing industry.

Risk of unintended consequences, such as mold resulting from energy conservation, is a barrier to innovation.

- Complexity and fragmentation of the housing production process make limited product innovation too difficult to test and coordinate in advance of market application.

Each of these preliminary hypotheses was expected to and did undergo substantial change and revision as a result of discussion among panel members and innovation presenter teams.

Risk Panel Seat Perspectives

Following focused presentations on each of three innovations and brief Q&A to clarify key points, each expert panelist was asked to describe their seat's perspective on risk as a barrier to innovation in the context of the information they had just been presented and the hypotheses posed at the start of the session.

Seat #1: Community Advocacy Group (Architectural Review Board)—This panel member represents a local Architectural Review Board, officially known as the Historic District Review Commission, from a small town in Virginia known for its historic character. As with many such advocacy groups, they wish to protect the historic character of the town and have the power to do so. Any new building or building renovation in the pre-defined historic district of the town must receive a "certificate of appropriateness" before it can receive planning commission approval or get a building permit. Examples of other advocacy groups affecting homebuilding include town councils, zoning commissions, public health officers, conservation groups, or consumer protection advocates. These advocacy groups can be very powerful. Any proposed building project or renovation innovation runs the risk of being resisted or rejected by one of these groups. Comments concerning risk as a barrier to innovation include the following:

- *Builders should make better use of the staffs of architectural review boards before technology decisions are made.* Most petitioners seek to get around the boards from the outset, although the boards can easily recognize this approach in the way the offerings are disguised. The secret is to go to board staff early on to identify just what is needed for a particular project. Historic review is more difficult than a simple design review—often, owners and designers have not done enough research to identify acceptable options. All boards are truly local in character. National manufacturers would need to investigate state by state to find out where the boards are and what they want.

- *Standardized product testing and reporting of results is needed.* A more consistent and uniform system of product testing will reduce risks by giving manufacturers a basis for claiming that a product will work and cost a given amount. Untested aspects of products seem to become the pivot for legal questioning of product performance. The nation needs something like a federal bureau to regulate building products in much the same way that the Food and Drug Administration (FDA) protects the public regarding food and drugs. This new bureau could remove a significant portion of risks now faced by participants.

Seat #2: Errors and Omissions Insurance for AEs—This panel member is from that part of the liability insurance industry that insures both building designers and builders against liability for errors or omissions. Omissions can be for something a practitioner didn't know but should have, for something that was simply forgotten, or for something that was missed. There may be some overlap between this insurance and manufacturer warranties when there is a product or system failure in a home. The criteria used (education, certification, and experience) by these insurers to accept policy holders and the guidance these insurance companies provide to policy holders on limiting liability (e.g., office procedures, due diligence, and record keeping) all suggest that there are significant parameters on risk takers and risks to be taken. Their principal concern is to avoid losses by avoiding risks or failures. These insurers are masters at the language of defining risk and they have a significant influence on language used in contracts for design or building services, plans, and specifications. Comments concerning risk as a barrier to innovation include the following:

- *Rather than inhibiting innovation, insurance enables innovation.* "The hypothesis that insurance discourages innovation brought a roar of laughter from my colleagues," this panel member said. If a professional does not have insurance, then personal assets of principals and partners may be at risk, making them less likely to take a chance on a new or different product.

- *There is no insurance exclusion that prohibits the use of innovation.* Insurers have no knowledge of, and they have not collected data on, the amount of new products being used. Innovative products only become an issue for the insurance industry when they fail. When failure occurs, the customer usually sues the manufacturer for product liability, the builder for defects in workmanship, and the design professional for defects in recommendation. That is why testing is so important—practitioners must research the product, the details of test protocols, and test results.

- *Access to reliable, easy-to-understand information is key.* No one is going to stop claims. Frequency of claims is one thing; severity of claims is something else. Insureds must make use of available information to exercise the applicable standard of care. Satisfy that duty and a key element of negligence is avoided. Exterior insulation and finish systems (EIFS) are a good example: insureds based their assumptions and decisions on the best available information at the time; that is all that reasonably can be done.

- *Thorough testing and publication of results is a critical step for manufacturers.* Liability insureds need to exercise informed decisionmaking. Unless a product fails, insurers do not know (or care) about the decision to use it. We are not able to anticipate field performance and give credit for good decisions in advance. If innovation testing does not exist, it is simply a gamble with no basis for decisionmaking. Full awareness of testing and results is key for designers and builders.

- *Informed decisionmaking demands risk management and reduction procedures.* Insurers give credit to those firms that establish in-house risk management and reduction procedures. They track who is calling them for advice and how much the callers are accessing material that

they make available. They collect actuarial data on technologies and innovations only when there is problem, such as EIFS.

- *In general, due diligence requires addressing known problems, such as onsite language difficulties.* If you know that your crews do not speak and understand English well and construction method problems arise as a result, you have not exercised due diligence.

Seat #3: Manufacturer: Legal/Insurance/Finance—This panel member is the staff counsel of a medium-sized national manufacturer of high-end residential window systems and has responsibility for watching over legal and insurance issues. Manufacturers are always faced with a dynamic challenge when it comes to innovation. Competing successfully for market share, selling, and growing the company depend on finding new products or making product improvements to enhance sales. On the other hand, any such innovation always creates the potential for failure and related liability and cost. Within this tension, credibility is key and must be protected. Depending on the product and its purpose, there are many possibilities for failure. The product may fail to operate as designed. The product may operate as designed but fail to satisfy the proposed application as advertised. The product may be too costly for the intended application. Or the product may fail to reduce costs as advertised. How manufacturers identify targets of opportunity, acquire innovations (through in-house research and development or from others), assess potential liability, market, and protect credibility even in the face of failure are all-important issues for discussion. Comments concerning risk as a barrier to innovation include the following:

- *Manufacturing decisions are not contingent simply on capital resources.* Capacity, profitability, finding places to manufacture, human resources, and manufacturing resources all play a role. Even with enough money, they may not be able to manufacture a new product. For their newest venture, they must look at factors such as the availability of the labor force and the number of managers. These factors can be risks for the company.

- *Medium-size manufacturer risks are not much different from those of larger manufacturers.* This panel member's firm has reached a critical mass, but circumstances have changed as it has grown over the years. If this panel member were on the legal staff of a smaller firm, she would want to know if the firm had the structures in place to deal with issues, even if not the resources. She would seek to avoid catastrophic loss issues. This is not something that can be done superficially.

- *Product liability and consumer protection issues are especially important for mid-size and large manufacturers.* Unintended consequences do not matter until you know them—then it is too late. "We develop our products realizing that our product cannot damage the home or homeowner," this panel member reports. A structured approach to business and manufacturing decisions adds costs for a well-resourced manufacturer that moms-and-pops do not have. For mid-size and large manufacturers, building code requirements can level the playing field with smaller competitors and start-ups.

- *A manufacturer typically indemnifies its supply chain.* Manufacturers must indemnify big-box stores when entering an agreement with them. They also indemnify wholesalers and other distributors. The size of builders is a very real determinant in how they are treated: They indemnify big builders, but not small ones.

- *Manufacturers increasingly have an important role in the post-sale stage of housing delivery.* Warranty and service work is a significant part of their business. "We are a stakeholder in that arena," says this panel member.

Seat #4: Evaluation, Testing, and Building Codes—This panel member represents a state agency whose director is on the board of an international body responsible for one of the major U.S. model building codes, the International Code Council (ICC). Traditionally, the primary responsibility of building codes has been to protect the health and safety of building occupants. Recently, however, building codes have been recognizing some responsibility to provide affordable housing as well. Building codes are consensus standards based on both the best available technical information and the best judgment of industry representatives on the code councils. Model national or international codes must still be accepted and made into law by state or local jurisdictions. Code officials at the local level have the legal authority to accept or reject the application of any new building product or system innovation. They can be the ultimate showstopper. It is critical that any building innovation be assessed early as to whether or not it is covered under existing building codes. Local acceptance of an innovation is never guaranteed, but chances of acceptance locally are greatly increased if proper work has been done with the relevant code council or code writing body. Comments regarding building codes related to risk as a barrier to innovation include the following:

- *Codes can stimulate change that could affect the way the industry operates.* Three model codes have combined to create a single code: the International Building Code has been adopted to one degree or another in 48 states. On paper, the codes and the associated product evaluation reports that are generated for products that fall outside formal code acceptance are effective tools. However, in practice, the length of time and complexity in obtaining evaluation reports are barriers to local adoption of innovation—14 to 16 months to get a report is unacceptable. Consistency and quality of site code inspections will be difficult to achieve with uniformity across the U.S.

- *At present, National Evaluation Reports are of limited value to manufacturers.* The current evaluation process is a validation, not actual testing. National Evaluations Reports are basically a paper review of manufacturer-supplied results. They may be valuable in the sense that they validate manufacturer testing for local code officials, but they are not viewed as important to manufacturer product decisionmaking.

- *The role of the product evaluations is not well communicated or understood.* According to panel participants, the present evaluation service is perceived as less user-friendly than in the past. Manufacturers are reluctant to complain because they are afraid of retribution against their products. Manufacturers and builders also sense a tendency to continuously change and update codes "because they are there." In many jurisdictions, a builder may be subject to

inconsistent imposition of provisions in multiple layers of cross-referenced codes. It creates difficulty, delay, and costs for all involved and begs the question of why codes seem to amplify in complexity and proliferate rather than simplify.

Seat #5: Supplier/Wholesaler—This panel member is from a major, regional organization supplying materials to local homebuilders. The wholesaler buys materials in large quantities, stores them, and then distributes the materials in small lots to builders. They have all the parts and pieces needed for the job and deliver them in sequence. The wholesaler makes profit on throughput and as such, must understand what homebuilders want. The wholesaler can be the most important middleman between the manufacturer and the homebuilder. Wholesalers are critical gatekeepers in the distribution process. They are keenly sensitive to risk because, by carrying a manufacturer's product, they can be seen as endorsing or taking on some of the risk of that product in the eye of their builder customers. They also do not want to get stuck with a product that does not sell. Risks for the innovator are: 1) not being able to get the attention of the busy buyers for these organizations; 2) not being able to present enough credible data to convince buyers for the wholesale firm to take on the risk of carrying the innovation; or 3) not being able to produce the innovation in enough volume to meet the wholesaler's demands. (The invited supplier representative was unable to participate due to a last minute business conflict. To make up for the absent first-person perspective, the other panel members were asked to specifically consider their relationships and experiences with suppliers in formulating their observations and comments regarding risk barriers to innovation.) Key points made in the discussions include the following:

- *Big-box home product stores are increasingly important to manufacturers.* Big-box chains increasingly impact how mid-size and large housing product manufacturers do business and even how they innovate. Examples include exclusivity requirements, capacity demands, and even manufacturing capability. Big-boxes are also very demanding in wanting product differentiation. The ability to disseminate information and instructions through the big-store environment is also a problem. Small manufacturers cannot break into the big-box arena.

- *Big-boxes do not, as yet, respond as well to big builders as they do to manufacturers.* Big-boxes would like to deal directly with large builders, but have never made it happen in a successful way. Manufacturers go directly to big builders, some through distributor networks, rather than through the big-boxes.

Seat #6A: National Builder; Seat #6B: Regional Builder—These panel members are "production" builders of new homes. New homes present the greatest opportunity for innovation because any product or system can be replaced by a better idea at the start of a new project. The new-homes builder is the chief integrator of all building products and systems and, as such, has almost complete authority to accept or reject an innovation. He is virtually the sole interface with the majority of homebuyers who do not build custom homes. The new-homes builder faces a number of different risks concerning innovative products or processes. First, there is the business risk that the proposed innovation will not fit into the builders' existing formula for building a new home. Learning how to apply the product properly, or having problems with the building

trade workers about switching to the innovation, or simply unintended consequences of trying to fit the new product into the old tried-and-true system might not be worth it.

Next, there is the significant business risk that homebuyers will not accept the innovation. This can get very costly very quickly if it delays the sale of spec homes.

Third, there is the liability of product failure. Even if this liability is shared with the manufacturer of the innovative product, it is the builder who faces the customer and it is the builder's credibility that is most on the line. Because of these risks, instruments like contracts and warranties have been carefully developed to define these risks and to make clear how they are shared.

National builders generally are very large firms with highly structured regional subsidiary units. Regional builders generally are smaller and may be more narrowly focused, but also may compete directly with regional units of national firms in specific local homebuilding markets. Large and small firms can exhibit significant differences in the way they organize their business operations.

Comments by the Panel's National Builder of New Homes

The following diagram presents a large-builder perspective of the drivers of change and barriers and risks of adopting change for each of the innovations presented to the panel.

Table 11. Large Builder Innovation Adoption Considerations

	Criteria	**Innovation A, B, C…**
Adoption Drivers	Customer mandate	
	Customer demand: Will they pay? ▪ Style and design **Energy** ▪ Low maintenance	
	Cycle time improvement	
	Opportunity to reduce cost (risk)	
Adoption Barrier/Risks	Implementation/change over cost	
	Technical complexity, testing data, and certification	
	Market penetration and acceptance to date	
	Training of installers	
	Reliability of manufacturer and channel	
	Alternative Products	

- *A regulatory requirement is the first and foremost driver of innovation adoption decisionmaking.* Builders do whatever is asked, as fully as asked. Thankfully, the regulatory requirements are currently limited to areas of health and safety.

- *Customer demand is next, but, generally, is the adoption driver the builder would most like to pay attention to.* Design, energy, and maintenance are three areas that might be a customer focus. However, the question must be asked: will the customer pay for it? "For example, we offer an up-market window option, but it is rarely selected by our consumers," says this panel member.
- *Cycle time improvement is third in importance to the builder.* The builder is not so concerned with how much profit will be made on this house, but how many times this house can be built in a year. If an innovation will slow down the rate of building, then it will not be adopted. "If an innovation will let me build faster, I will want to look at it. If an innovation will complicate my existing process, involve additional building trades, slow me down, I will avoid it," says this panel member.

- *The opportunity to directly reduce cost or risk is the last driver for innovation adoption.* It is rare to have the time to seek an innovation that does not address the previous drivers, but it may exist.

- *Implementation or changeover cost for adoption of an innovation is the foremost risk-related barrier for builders.* To overcome the resistance to change in this area, the innovation must have a champion (with authority) within the builder firm to push it through the organization. It must be someone willing to endure the intense pain in the short run to reap benefits down the road.

- *Technical complexity, testing data, and certification are second in the hierarchy of risks.* All the scars of past failures and current difficulties come up.

- *Market penetration and acceptance to date is the third risk concern to builders.* No one wants to be on the leading edge of product innovation; it is just too risky for a builder. The builder reaction is "forget it." Until someone in the market becomes dominant, the builder will avoid the product.

- *Training of installers is fourth.* The workforce is not able to deal with change easily. Installers must know how to do it right and be able to self-inspect to achieve the benefits touted for the product.

- *Reliability of manufacture and channel is the fifth concern.* Manufacturers must be able to demonstrate that they have a complete and reliable supply chain and that they will stand behind their product.

- *An alternative product is the final risk consideration.* Alternative products typically do exist, creating confusion for the builder unless there is compelling reason to select one over another. Other aspects of builder consideration include brand confidence that enables

acceptance of follow-on products, and importance of a champion to drive change within a firm.

- *Builders are not yet able to satisfy a customer when asked for a specific thing that they do not yet offer.* Large builders listen to and use focus groups to look at changing their product over time. This is really a balancing act between the drivers and risks in the matrix. For instance, "we are only able to offer a standard window package and a single upgrade, A or B, not a range of options because of the cost of flexibility needed to offer multiple packages," says this panel member.

- *Small innovators do not have that brand link to their ultimate consumer that the larger innovators seem to insist on having before making production decisions.* For example, there are many composite deck manufacturers now, but consumers come in and request Trex decking. This shows the power of branding.

Comments by the Panel's Regional Builder of New Homes

- *Builders, large and small, have been involved in catastrophic building product failures over the years.* Product failures result in multiple manifestations for manufacturers, builders and their suppliers, customers, and others. Builders operate in the RAND model from its earliest steps and many critical product decisions are made early on, whether for market, zoning, or aesthetic considerations. Neighborhood compatibility is a current planning push.

- *"We thought we were making good decisions when we selected the products that failed,"* says this panel member. This member reports that his company did exhaustive research on EIFS before using the technology, and avoided many of the pitfalls with the product. But, they had failures too, and no longer use it no matter how the product is improved because they prefer to use brick. This firm still works with the architect; blame and finger-pointing avoid the reality that we are all after the same thing—a good product.

- *Product recall is not possible with homebuilding.* On three occasions, this regional builder offered to refund costs, twice taking houses back and reselling them. The builder would have contested, but the insurance provider would not support the effort. The settlement went entirely to the lawyer for the plaintiff. "Keep in mind, though, that we have long memories," says this panel member.

- *Logic and data rarely override emotion and belief—perception is not reality, but it is the reality that one has to deal with.* How do manufacturers build trust without one-on-one's with 50 million potential customers? Does this mean that small company innovators are doomed to fail? Why should a builder's successful formula be changed? The consumer understands and accepts the builder's current process and the attributes put in his products. Energy performance is not a current consideration. Up-market windows are also problematic—"If the curtains do not stand off the wall because of drafts and the opening mechanism works, they are acceptable to consumers. Why spend $30-$40K when an $8K package will do?" says this panel member.

- *There should be a collective interest by all innovation manufacturers in minimizing the failure of any homebuilding innovation in order to build trust with consumers.* Builders recognize that when a product is being developed, the discipline required will add cost and, therefore, further discourage innovation. Regardless, structural and water penetration issues are the areas of long-term risk for builders and need addressing.

- *A demonstration may be less trustworthy if a manufacturer or builder gets help from HUD.* It depends on the extent that HUD assumes the builder's risk. "Of course, I might be more interested in trying a particular innovation, myself, now, if HUD was going to eliminate my exposure down the road," says this panel member. "I would be relatively neutral to a fully HUD-sponsored demonstration."

- *Builders have no time or responsibility to seek a cooperative approach to resolution of issues among competing manufacturers.* If that is their approach to product improvement and quality, they are doomed to fail. It is not the builders' role to request a cooperative standard; they do not need any particular product. "I am not going to take my time to go to them to help them complete their product development," says this panel member.

- *Selection of product innovations is a market-driven decision for builders.* There are certain compromises in the specification process where you spend money where the consumer wants to see it spent. Builders must be able to justify the marketing edge they could obtain by going to the more expensive product. "Would we be competitive is the question that we must answer," says this panel member.

- *Consumers are becoming increasingly aware of quality and durability in builders' products.* There has been a huge change in consumer knowledge, predominantly as a result of the Internet. It manifests itself in all aspects of how builders must do business. For instance, consumers use big-box stores as design centers and pour over 250 faucet options where "we only offer four or five to our customers," says this panel member. "Part of the quality we offer extends to the supply chain and installation attributes we put in our product."

- *"Current quality markers are distinct for our market, but are changing," says this panel member.* Brick, granite countertops, foyer materials, fit and finish for some consumers translate to quality. "Our windows are high quality in the vinyl product space. Our market just no longer demands wood windows."

- *All homebuilders are emphasizing quality control more than in the past.* Even though it costs money, builders do it because it delivers a better product in less time.

Seat #7: Inspection Services—This panel member offers home inspection services, typically on behalf of the homebuyer, that are separate from code inspections done by the local jurisdiction. This inspection is done to protect the homebuyer from faulty or improperly performing products or systems. Lenders increasingly call for this service to be sure that the home they are helping the buyer to purchase is free of defects or previously unforeseen problems that could make the house hard to resell in the event of a foreclosure. In this case, the inspector is looking at products that are installed and operating. This is the final risk of rejection faced by the innovator, short of homebuyer rejection. It is in the interest of these inspectors to be tough on the building and installed products on behalf of the homebuyer. As this profession has been growing in recent years, it represents a somewhat new source of information for innovators about the concerns of homeowners, builders, and lenders. Comments concerning risk as a barrier to innovation include the following:

- *Lack of knowledge is a barrier to innovation and stimulates lawsuits.* Business should under-promise and over-deliver, however hyperbole is predominant in the U.S. Advertising tends to over-promise and under-deliver. Performance does not match expectation, resulting in frustration—and lawsuits follow.

- *Inspections today lack consistency and reproducibility.* Many jurisdictions inspect rigorously, but many others do "drive-by" code inspections.

- *Inspector/inspection associations would be receptive to presentation of information about innovations.* Inspectors are in a good position to reduce the risks associated with adoption by consumers (and builders) and even endorse products. They provide information about costs and durability, and opinions about the expected performance of the product.

- *The inspection industry is well positioned to deal with the changing aspects of housing over time.* For example, more and more mold problems associated with paper-faced drywall are emerging. Mold is seen as a profit opportunity for inspectors, as was asbestos, radon, and buried oil tanks.

- *While understanding that the lack of a standard inspection form results in uneven inspection quality, the industry does not push for consistent forms*. Mom-and-pop operations do not respond well to the push for consistency. A pending change of real estate laws that will allow banks to get involved at every level and stage of property transactions will result in substantial downward pressure on cost/commission (similar to what has happened in the travel industry). Many see 3% housing sale commissions within only a few years.

Seat #8: Academic/Operations Research—This panel member served as an objective observer of the intricate workings and relationships of participants in the homebuilding industry with an eye toward testing hypotheses and developing models of operation to aid industry progress. The particular seat-holder for this panel investigates the causes and effects of uncertainty of information in innovation adoption decisionmaking. The seat has no direct or indirect risk or role related to housing innovation, but can provide insights to all of those that do.

- *The role of academia is to bring organization to the discussion.* Why have products not come to market as quickly as in other industries, such as high tech? When brought to market, why does innovation not diffuse more quickly? To answer these questions, we are looking for barriers. Risk has been identified as a barrier, but it means different things to different people. The Chair may have intended traditional characterizations of risk, such as death, health impacts, or loss of money, yet around the table, we have discussed lack of skill and other aspects of market operation as barriers.

- *It may be useful to start by better defining two types of risk.* Development risk is the risk of failure of a product coming to market; production risk is the probability of failure of a product being successful after it has penetrated the marketplace. The separate definitions allow consideration of barriers separately as well. "Barriers" (termed "risk factors" or "leading indicators" in the academic fields) is a useful term because it indicates aspects of inhibition by definition.

- *Barriers for development risk and production risk can be quite different.* A development risk is not seeing production through. A production risk may be insufficient ancillary equipment, such as scaffolding. A development risk may be decisionmaking based on liability concerns. A production risk may be the inability or difficulty in integrating innovation installation with standard construction practices. Another production risk may be insufficiently skilled installation labor.

- *The RAND model may be a basis for refining development and production risks further by construction stage.* Identification and ranking of barriers at each stage could assist HUD and others in mitigating the impacts on innovation. "I am not a domain expert, but there are formal ways of ranking them that go beyond the discussion techniques being used by the panel." Taking a distributed barrier approach, responsible actors and stakeholders may be identified at each stage of the RAND process.

- *To be effective, HUD should focus on removing the most significant barriers at each stage.* Specifically, in terms of the innovations presented, large companies seem to have an

Observations from the Industrial Risk Management Academy

Housing innovation risk appears to have at least two facets. Barriers are distinctly different for each type of risk:

Development Risk: The probability of failure of an innovation coming to market.

Develop Risk Barriers:

- Insufficient investment capital to see development through
- Unsafe construction processes
- Liability associated with introduction of the product

Production Risk: The probability of failure of an innovation being successful

Production Risk Barriers:

- Inability to integrate seamlessly or easily with existing building practices
- Lack of skilled construction workers
- Difficulty in acquiring insurance (risk sharing)

Public trust is a structural problem for the housing industry.

advantage in having a portfolio of products to distribute/share risks. All innovations reinforced a notion that skilled installation labor is a prerequisite for production success. Disruption of standard practice may explain slow diffusion of more complex innovations.

- *Lack of trust may be a major issue for the homebuilding industry.* A SIPs innovator observed that consumers do not trust the building industry, and innovation claims are not trusted either. Other industries and settings have identified trust as an important factor in public acceptance of risk communication by the public at large (for example, regarding nuclear waste management). The playing field is not level; trust is difficult to achieve and easy to lose. Anything HUD can do to build trust for the homebuilding industry would be helpful, and may indirectly assist broader innovation acceptance.

- *Increased support for construction education may be an enabling strategy for HUD.* ICFs seemed less aligned with standard practice than housewrap flashing, which may explain its decades-long, low penetration. But, the recent growth spurt is apparently explained by increased public recognition of energy benefits.

- *There is no clear path to a knowledge base of how other industries build trust.* Even in other industries, the amount of resources invested in research of or development of trust is much less than that spent on questions of safety and economic loss, for example. Broadly, risk communication is the mismatch between generally understood public perception of risk and detailed evaluations of risk by subject matter experts.

Risk Panel Findings

The risk panel discussed five topic areas related to the hypotheses presented at the beginning and addressed in the innovation presentations and the prior individual observations: market risk, product liability, market volatility, insurance, and unintended consequences.

Market risk, and the capabilities needed to address it, is highly dependent on innovator resources.

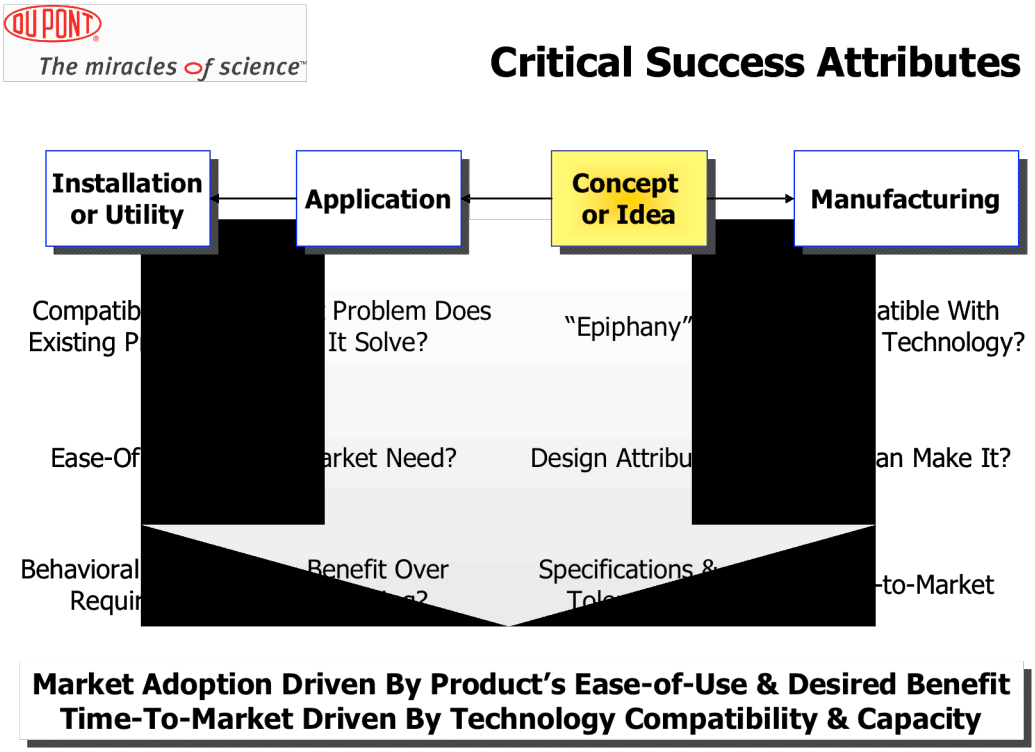
- The homebuilder is a unique producer in U.S. industry.
  - Assembler of parts (provided largely by large companies)
  - High value product (hundreds of thousands of dollars)
  - Produced by company/producer with relatively low capitalization

- There is a clear stratification by size of manufacturer.
  - Large manufacturers are very different in terms of resources and potential to instill trust.
  - Small manufacturers are missing required resources (suggesting possible options to help, such as collaboration, shared testing, supported code work, and evaluation service for code compliance).

- Manufacturer size and the innovation attribute of disruption of current/conventional construction processes are critical variables to market risk.
- Public trust is critical. Is there some way for HUD to support the building of trust for the housing industry, either through financial support or establishment of an FDA-like organization for product review and testing?

As the following figure indicates, the large manufacturer has the resources and inclination to thoroughly vet a product before it goes to market, but a start-up probably does not.

large manufacturer "line-of-sight marketing" innovation success attributes…



Source: Joseph A. King Jr., Ph.D., Global Technical Manager, DuPont Tyvek.

Building industry barriers do a good job of slowing down bad ideas, but if the question is how to reduce housing costs, it may be insoluble ("big issue getting worse"). Tyvek adds cost; testing adds cost.

- Builders' market price points are high and growing land prices preclude entry-level housing.
  - Urban infill land is valued at $17-25 per square foot (sf) locally.
  - Only rural lots can be used to provide houses in the upper $200s to lower $300s.
  - Buyers commute one to two hours each way to pay for affordable housing.

- Rather than being highly risk averse, by definition, builders already have assumed substantial risk. It is *additional* marginal risk that becomes the show-stopper in terms of assuming risk associated with innovation.

- Customers are becoming more sophisticated in getting data, but primarily concerning only finished products.

Product liability risk is a subset of America's litigious society.

- Arbitration clauses work well.

- Builders would readily accept HUD as a back-stop against long-term unforeseen consequences for highly regarded innovations. Reducing risk to the builder would make the entire process more fluid.

- Accelerated testing for durability has its own problems. There is not a lot of research, although there is some at the National Institute of Standards and Technology. Standards and protocols would be very helpful to manufacturers.

The lack of experienced installers (typically subcontractors) exacerbates the risk of innovation adoption. Until the 1990s, the work force consisted of older trained workers; today, there is a critical shortage of qualified labor.

- Is this an opportunity to use more pre-assembled subsystems?

- The trade-off is a huge cost to revise the labor system.

- Builders will pay a modest premium for a qualified installer. Is this a service opportunity for manufacturers?

In terms of the risk of unintended consequences, for any builder—even a national production builder—any change has to be managed and implemented locally!

- For a large builder, staffing business units are built around producing 250-500 houses per year. Does this mean that innovators are locked into only incremental change forever? No, large manufacturers and builders are, in fact, considering structural changes in the process.

Market volatility is not presently a risk factor for housing innovation—financing innovations have dampened the variability of housing starts across the United States.

- Local and regional swings can still occur, however, and the cost of land as a percentage of the house may have some volatility.

Contrary to the initial hypothesis, insurers do not impede innovation; they make it possible by protecting the innovator.

- Insurers can (and do) rapidly kill any innovation that fails in the marketplace.
- Generally, however, insurer response to innovation is a delayed reaction, responding to instances of innovation failures as they multiply.
- In carefully considering innovation adoption, architects, engineers, and builders are performing due diligence. In carefully considering production decisions, manufacturers also are performing due diligence. HUD could help small innovators address due diligence considerations.
- On a builder attention scale of 1 to 10, "consumer protection" rates a 1, while "frivolous" litigation rates a 7 or 8.
- HUD has the opportunity for an important role, but it needs to be selective and discriminatory.
- A way to stimulate innovation is a way to reward it (e.g., HUD review panel and/or HUD award).
- HUD needs to define (and publish) the level of complexity of innovation.
- HUD should add some differentiation to the PATH list of innovative technologies.
- HUD should support the development of viable technologies.
- HUD should establish a panel to review and give awards for best innovations. The foundation of endorsement is promoting these innovations.

Industry Participant Preferences as a Barrier

Based on the literature review and discussions among the project team, three hypotheses, reflecting current conventional wisdom, were presented to the expert panelists and the innovation presentation teams by the preferences expert panel lead to provide a broad contextual starting point for the panel sessions.

Both attitudes to change, in general, and personal preferences are expressed at every node in the operation of the construction industry. The following housing delivery process participants may exercise preferences that can either enhance or delay the acceptance of an innovation, as a function of the process phase:

- Land Development: Consumer and Community Advocacy Groups
- Design: Designers/Architects/Engineers
- Pre-Construction: Product Manufacturers/Materials Suppliers

- Construction: Homebuilders/Subcontractors/Labor
- Post-Construction: Homebuyers/Consumer Protection Groups/Agencies

When considering the preferences of these participants as either enhancing or delaying the acceptance of an innovation, it is important to realize that these preferences may derive from various sources:

- Cultural values
- Attitudes to change in general
- Perceived or real economic advantage
- Influence of peers and others
- Any combination of these

In attempting to influence or modify the preferences of any respective participant, it is important to understand both how the preferences manifest themselves, and what their sources are.

As with the risk panel, each of these preliminary hypotheses did undergo quite substantial revision as a result of discussion among panel members and innovation presenter teams.

Preference Panel Seat Perspectives

Following focused presentations on each of three innovations and brief Q&A to clarify key points, each expert panelist was asked to describe their seat perspective on preferences as barriers to innovation in the context of the information and experiences they had just been presented, as well as the hypotheses posed at the start of the session.

Seat #1: Owner Advocate, Appraiser—Who is it that can claim to know what current homebuyers want? Realtors, who represent homebuyers in home purchase transactions, certainly have a first-hand view of what buyers want. Builders, who want to sell homes, must be intimately in touch with what homebuyers want. Appraisers, who set the market values on homes (and features) for transactions, certainly have a sense of what homebuyers value and are willing to pay for.

Of the three, the panel member for this discussion represents appraisers and, specifically, the analysis processes appraisers use to identify consumer preferences nationally, regionally, and locally. How can an innovation get onto the consumer's preference/value "map?" Becoming a consumer preference is a market "pull" for an innovation. Without some level of consumer acceptance, preference is a barrier. There are several important issues: How do homebuyers get information about innovations so as to form preferences? How are preferences communicated? How do advertising and other forms of "education" shape preferences? In the end, the sale of the home—including the innovation—is the final arbiter of preference. Note that appraiser perspective occurs at both the beginning and at the end of the RAND Model.

The following list describe the appraiser views of preference as a barrier to innovation:

- *The effectiveness of appraisal in facilitating the acceptance of innovation depends on market conditions.* Appraisal and pricing are not relevant in tight urban markets. People will buy anything.

- *Documentation on the presence of an innovation in a house is needed.* An appraiser of a finished house cannot know if an innovation is present or if it was done properly. Thus, the appraiser cannot properly reflect the value of the innovation in the appraisal, thereby contributing to the education of the consumer about the innovation.
- *Competition among manufacturers in marketing an innovation is a barrier.* When several smaller companies are all involved in a given innovation, it seems difficult to get competitors to cooperate in growing their market.

- *Buyer demand has to be developed by education.* It is critical for manufacturers to understand regional markets for their innovations and to focus their educational efforts in those markets. Buyer resistance to innovations that feature improved performance over conventional construction with regard to energy consumption, acoustics, and/or structural performance could become an educational opportunity in those regions where such attributes are considered important due to physical or cultural conditions. European experience can help in this education. Market stereotyping, expressed by some innovators, will not serve them well in this regard.

- *Education is key to removing preference barriers.* HUD's role is education. However, the medium is crucial for reaching the consumer. One consumer representative stated she would never go to PATH ToolBase for information, but rather to "This Old House" or "Ask Jeeves."

- *Incremental innovations are more market-ready than systems innovations.* Cost is not a problem for them, and builders should feature them as a systems upgrade, and "charge the heck" for them. An example is flashing as a window upgrade.

Seat #2: Designer/Architect/Engineer—This panel member is a practicing architect specializing in residential buildings, both multifamily and single-family homes. Custom homes using the services of an architect are actually a relatively small percentage of annual home construction, typically less than 10%. Nonetheless, this is a situation where the homeowner wishes to be part of the decisionmaking process so that his or her personal preferences can be explicitly addressed. Architects in this situation know homeowner preferences. Homeowners can be open to innovative ideas: from reading, from peers, or from recommendations or options offered by the architect. Many design firms have staff to look for new ideas and to review and assess proposed innovative materials or products. An architect's views of preferences as barriers to innovation include the following:

- *The market is looking for assurances and consumer satisfaction*. The preservation of real estate values is a barrier to innovation in general, unless the innovation is mandated by the codes. However, if the innovation reduces risk, such as water penetration, then it has potential in the market.

- *The market is looking to European technology for energy solutions in incremental innovations, such as water heaters and toilets.* The U.S. must change from a "disposable society."

- *Some recent trends affect innovation.* An example is the emergence of a national building code and the increase in the level of sophistication of consumers over the past 20 years.

- *Innovators do not understand the market.* Innovators need roadmaps of the regulatory and market systems, and HUD could provide them.

- *Innovations, especially systems innovations, would benefit from alliances that provide opportunities of larger-scale demonstrations.* There is a need for an aggregated market to demonstrate innovations on a large scale. Procurements of military housing, several hundred units at a time, may provide such opportunities.

- Recommendations to HUD:

    - Promote consolidation of the national code.
    - Promote certification of products.
    - Promote consumer satisfaction.
    - Promote durability.
    - Consider emphasizing innovations in the multifamily market that may trickle down to single family.

Seat #3: Supplier/Wholesaler—This panel member represents a major regional supplier of building products to contractors. His customers, builders, or subcontractors, are highly price sensitive and service driven, demanding availability and on-time delivery. This business is highly competitive and profit must be made on low margins and high volume. In short, there is little patience for any product that is not sure to move through the business swiftly and painlessly.

While builders are a surrogate for homeowner preferences, wholesalers are an excellent surrogate for builder preferences. Wholesalers supply what builders want. Thus, wholesaler preferences are either a gateway or a barrier for innovations. If an item is not on the wholesaler's list of materials, it will not flow to new homes. Within this general category, there are smaller wholesalers that specialize in more innovative or hard-to-find products. Mechanical and plumbing suppliers are represented in two associations: the American Supply Association and Affiliated Distributors. A supplier's views of preferences as barriers to innovation include the following:

- *A supplier's decisionmaking process on innovation adoption is very similar to the product development process described in the DuPont "line-of-sight marketing" summary of critical success attributes.*

- *The housing supply chain is very important in terms of its value added.* It is interesting that all three innovations presented at the workshop generally bypass the suppliers. The

distributor must be convinced that the innovative technology is better than what exists, and then he can help create the market for it, recommending it to builders/customers and finding the buyers for it. However, to do so, the following conditions should apply:

- The innovation can use the distributor's added value.
- The innovation is subject to unique sales rather than parts over long periods of time.
- The innovation moves, not cluttering inventory.
- The innovation is not a commodity, so that the distributor's margin is supported.
- The innovation is characterized by a reliable source of supply.

The following graphic lists the ways in which the participant's firm seeks to offer value-added to its customers.

supplier added value…

Being a business partner with the Thos. Somerville Co. has distinct advantages. Here are some services we can provide for our customers. We are happy to have you as a part of our team!

CONTINOUS OPERATION SINCE 1861
CONVENIENT MID-ATLANTIC LOCATIONS
CONSISTENT PRICING/SERVICES
CONVENIENT HOURS OF OPERATION
EMERGENCY HOURS
CENTRAL DISTRIBUTION CENTER
"FIRST CHOICE" SERVICE FROM CDC
INTERNAL MATERIAL TRANSFERS
FRIENDLY/KNOWLEGEABLE STAFF
EASE OF PLACING ORDERS
- PHONE
- FAX
- INTERNET
- EDI
- PDA **(New)

QUICK FOLLOW UP
REAL TIME INVENTORY INFORMATION
BROAD/DEEP/FLEXIBLE INVENTORY
MARKET SPECIFIC INVENTORIES
VMI OPTIONS
PRODUCT SOURCING CAPABILITIES
DEPENDABLE ON TIME DELIVERIES
JOB SITE DELIVERIES
DRIVER UNLOADING ASSISTANCE
FREE DELIVERY AVAILABLE
EMERGENCY/RUSH DELIVERIES
NEXT DAY DELIVERY SERVICES
TAG AND HOLD OPTIONS
COMMERCIAL QUOTATION SERVICES
PROFESSIONAL SUBMITTALS
O&M PREPARATION
FAST/EFFICIENT COUNTER SERVICE
WILL CALL SERVICES
COUNTER EXPRESS SERVICE
MULTIPLE INVOICING OPTIONS
FLEXIBLE CREDIT TERMS
CONSUMER FINANCING PROGRAMS
TRAINING/EDUCATIONAL CLASSES
DIRECT ACCESS TO MANAGEMENT
COMPETITIVE RETURN PROGRAM
INCENTIVES and PROMOTIONS
OPEN HOUSES and COUNTER DAYS
CUSTOMIZED PRICE QUOTES/BOOKS
PROFESSIONAL SALES FORCE
MULTIPLE SHOWROOM LOCATIONS
CUSTOM DESIGN SERVICES
KITCHEN/BATHROOM DESIGN-LAYOUT
TECHNICAL EXPERTISE
BUILDER SPECIFICATION TRACKING
ADVERTISING/CO-OP PROGRAMS
MARKETING ASSISTANCE
HELPFUL POSITIVE ATTITUDE
CLEAN and SAFE WORK ENVIRONMENT
CULTURE OF HONESTY and INTEGRITY
QUALITY SUPPLIERS
QUALITY EMPLOYEES and
QUALITY CUSTOMERS!!!

Source: George D. E. Yezbak, Vice President - MMG, Thos. Somerville Co.
upplied the "supplier value dded" list.

- *Education is key to removing preference barriers.* Education and training are very important from the perspective of suppliers and should be provided by the manufacturers or their trade associations. They should consider the total transaction costs, including warehousing and delivery when providing education and training. ("Just-in-time inventories" are not the usual practice in the building supply chain.)

- *Innovators should consider:*

    - Supplier selection of innovation by supply channel (custom builder, tract builder, and commercial builder). HUD could classify innovations in this way, starting with small successes (incremental innovations).
    - The strength and the scope of your market reach.
    - Code and regulatory changes, through local homebuilding associations (HBAs).
    - Who controls the specification.
    - Your role in selling the product.
    - Development time (and account for it).
    - Timing of trends. Is the innovative product on the cutting edge of a new trend?
    - A key component missing in the case of many innovations—actual installers.

- *Suppliers sometimes make recommendation.* In case of failures, however, suppliers are not sued, even though they may make recommendations.

- *Communication channels in the supply chain are important.* The communication channels between builders and suppliers are not always linked, partly because standards are sometimes not enforced at the local level (e.g., hurricane windows).

- *It is necessary to build samples for the consumer.*

Seat #4: Manufacturer, Market Research—This panel member is responsible for characterizing customer preferences and presenting them to manufacturers in ways that can be acted upon, including ideas for innovations. On behalf of the manufacturer, or an industry sector, he is looking for opportunities, unsolved problems, or previous failures. This researcher is familiar with the language or taxonomy of customer preferences. He can be looking directly at homebuyer preferences or at homebuilder preferences, both of which are of paramount interest to manufacturers. These preferences, though generally similar, do differ in significant areas such as profit margin or ease of installation.

This researcher also can address the sensitive issue of how manufacturers convert consumer preferences into business decisions and innovations. Consumer preference data is highly desirable but it is costly to get, hard to interpret, potentially inaccurate, and sometimes difficult to act upon. Lack of preference information can be a barrier in itself (the idea never gets to the innovator), just as a predisposition against innovation can be a significant barrier.

A last-minute business emergency prevented the invited market research specialist from attending. The panel was asked to offer their observations, if any, regarding the role of this seat

in adoption decisionmaking. The project team also presented J.D. Power and Associates quality survey results for the nation and the DC metropolitan area to generate dialogue among panel participants regarding the influence of market-based preferences on innovation adoption decisionmaking.

Table 12. JD Power and Associates 2004 New Home Builder Customer Satisfaction Survey Nine Factors Drive Overall Satisfaction with the Home Builder	
Factor	**% Contribution to Overall Satisfaction**
1. Builder's customer service	23%
2. Home readiness	18%
3. Builder's sales staff	16%
4. Quality of workmanship/materials	14%
5. Price/value	10%
6. Physical design elements	7%
7. Design center	5%
8. Recreational facilities	4%
9. Location	3%
Total	100%

Note that in the J.D. Power study, only 21% of overall satisfaction is contributed by the physical product as represented by "quality of workmanship/materials" and "physical design elements."

Seat #5: Trades/Unions Representative—This panel member represents a contractor association (electrical) that works closely with unionized trades. The trade unions preferences typically are clear and based on worker safety, existing skills, job and benefit protection, and furtherance of unionized workforces. Any innovation that challenges the traditional way of building or installing a product, or that appears to take work away from the current trade in favor of a different trade, is likely to meet significant resistance. Innovators may not think to address the concerns of unionized installers early on, but do so at their future peril. Trade union representatives also have an important role on various code councils. In any of these capacities, the preferences of the trade unions can be a significant barrier to innovation. Training, curriculum development, good installation documentation, communications, and lobbying are all ways to address this important group. A trades/union/contractor representative's views of preferences as barriers to innovation include the following:

- *Training is key to removing preference barriers.* HUD should support training.

- *Innovations require the training of subcontractors in order to penetrate the market.* Training is necessary for subcontractors and their workforce using innovative technologies in the residential market. Only one of the three technologies presented addressed the training of the workforce.

- *All three innovations presented are in the "Stage One—Introduction (Big Gamble)" phase of the product service life cycle.* (The flashing product demonstrates "jumping the curve" in strategic management by phasing new product developments into the future.) Innovators need to be aware that contractors and subcontractors are encouraged to focus on products in the "Stage Two—Growth" phase of the service life cycle.
- *Unions' acceptance in the housing market is regional*. Innovations may have a better chance of market penetration regionally where unions are less accepted.

- *Trade associations can support market penetration of innovations.* Two of the three technologies presented should realize institutional benefits from their respective trade associations and their work.

- *Small business innovators need help in understanding the market.* HUD should establish something similar to a Small Business Innovation Research (SBIR) to support small business innovators.

Seat #6: Builder—This panel member is a volume or production homebuilder representing himself and his company staff, which typically include an architect, specifier, and cost estimator. His preferences are an amalgamation from over the years, based on personal experience, staff analysis, and extensive hands-on market analysis. His preferences get built and tested in the marketplace every year. Most larger production builders have an internal staff process for identifying and analyzing innovations, but the builder himself always has the last say. The builder's motivations are to successfully deliver homes to the market category he has chosen through a smooth building process and an expeditious sale at the end. These building organizations vary widely and it can be a tricky choice for the innovator to decide whether to contact the builder or his staff first when seeking to introduce an innovation.

This particular panel member's company was founded in 1975 and was innovative in a niche market in the DC region. They used truss-joists, roof trusses, the tightest possible envelope with air-to-air exchangers, and polybutylene pipe. As time went on, they stopped being innovative. In the 1990s, national builders entered and dominated the DC market, focusing on the "biggest, ugliest, cheapest" product. A builder's views of preferences as barriers to innovation include the following:

- *The nature of the homebuilding industry is evolving.* The current homebuilding industry is much more a business, concerned about land and capital, and less involved in the product. In the DC market, the average land component of a house is 30-40% of its cost.

- *Home sale time is limited*. Offering innovations as options in the home, thereby possibly generating consumer demand for the innovations, is constrained by the time limit. Selling options in the home requires more time than is available in the sale.

- *Recent innovations in homebuilding have been primarily in architecture and landscape design.*

- *Raw material prices may constrain market growth for some innovations.* One innovation presented is currently hampered by a shortage of cement. Additionally, he does not see an absolute decline in soft wood that could generate demand for alternative materials.

- *Innovations should focus on market niches that demand their strengths.* One innovation presented is an easy sell in the DC market for foundations, but not above ground. It should focus on fire safety, especially in three-foot separation houses where exterior wall fire rating

is a code requirement. Another innovation presented will have an easier time because it addresses moisture penetration, and builders have liability related to moisture. (It also will benefit from the corporate name of the innovator.) Energy savings possibly can be sold by energy-efficiency mortgages or by a utility company guarantee.

- *Lack of technical information is a barrier to some innovations*. For one innovation presented, there is not enough information on wiring of a home using the innovation. The recycling of innovative materials is still a problem as well. Another innovation presented should achieve consistency of product and inter-changeability of panels in order to penetrate the residential market.

- *Lack of trust in the housing market is a barrier to innovation.* In general, trust in the housing market is problematic, posing an overarching barrier to innovation.

Seat #7: Consumer Protection Advocate—This panel member is concerned with protecting the consumer in regard to health or safety of the home and products used in it, or in preventing consumer fraud. She tends to take a long view, being concerned with performance over the whole life cycle of a product or home. Her preferences are typically "black or white" in that a product either passes or fails the test of being "safe." It is critical for an innovation not to get "cross ways" with this group as they have tremendous power—through regulation or through the press—to simply stop a product, application, or process. Examples of problems they have addressed in the past or continue to address include asbestos, lead, mold, and indoor air quality. Invited representatives of either the Consumer Product Safety Commission (CPSC) or the Centers for Disease Control and Prevention (CDC) were interested in the deliberations, but both were unable to attend the session.

Seat #8: Academic/Operations Research—This panel member is an academic who has thought about consumer preferences in the homebuilding industry in an organized way for many years. His work includes leading studies of how innovations "diffuse" through the marketplace (or not). Through work with the National Association of Realtors and leaders in affordable housing, it has been his goal to look broadly while providing intellectual models to help understand the force of preferences in buying decisions, particularly in the homebuilding industry. An academic view of preference barriers to innovation adoption follows:

- *The innovations presented contrasting situations.* Two innovations were engineering-driven while one was business-driven. Both engineering-driven innovations emphasized energy conservation, but energy consumption is not an issue for a large part of the single-family market. The panel member dubbed the disconnect a "tofu doughnut"—an innovation whose combined features fail to appeal to either feature's loyalists. These innovations may find a niche market in the green market and in low-income housing, where energy may be an issue. About one-third to one-half of the multifamily market benefits from tax subsidies (tax credit properties), which may somehow provide a market niche for energy conservation. There should be more market segmentation to encourage the use of innovations (e.g., multifamily, infill housing, and budget-constrained consumers).

- *Lack of qualified labor may be a barrier.* There is a need to develop labor specialties in residential construction, such as window installation and flashing. Labor issues are important. Where is construction labor going? Training is not the solution to construction labor shortages. Labor should move off site. Look to community colleges for labor training.

- *Marketing problems may prevent the penetration of some innovations into the market.* At least one of the technologies presented displayed serious problems in understanding the marketing of their product. The industry should solve its own marketing problems.

- *Consumers cannot evaluate the risk of failure over a long time period*. Therefore, they are not an effective market force for innovation. HUD should encourage the development of a CD owner's manual for consumers on "hot spots" for purchasing housing. HUD should develop a consumer version of ToolBase.

Preference Panel Findings

Members of the Preferences Panel were asked to help develop a set of recommendations related to preference barriers to innovation in housing. These recommendations represent a consensus of the panel members and are put forward as topics the PATH program may want to investigate further in addressing the subject of barriers to innovation in the homebuilding industry.

The current classification and categorization of innovations in the PATH program does not provide information needed to influence the preferences of most stakeholders. Current preference barriers, therefore, are not addressed. Innovative technologies in the inventory are currently classified in terms of their market penetration (on the horizon, 1%; emerging, 5%; mature, 20%; and graduate, >20%) and HUD performance goals addressed (e.g., affordability, durability, and energy conservation). Additionally, the Top Ten technologies are featured. The panel recommends that PATH should drop the market penetration classification because it is of no direct importance to housing stakeholders. PATH should include information, however classified, that can influence stakeholders' decisions regarding the innovations, such as applicability to large versus small builders, code acceptance or evaluation, cost/time/labor savings, and information targeted to specific stakeholder audiences (e.g., consumers, builders, and architects).

Consumer preferences are communicated efficiently in the housing market and they do not seem to be directed at innovations. Consumers choose from what they can see, and they focus primarily on glamour and glitz. Innovation programs should explore ways to make consumers more aware of innovations so that they can at least become an option in the marketplace. Such programs should find ways to display innovations to the consumer.

The attribute of energy efficiency is not enough to overcome preference barriers for various stakeholders, and, therefore, does not ensure market penetration for innovations that feature it. Energy efficiency is one of the PATH performance goals and many innovations

on the PATH inventory feature it, including two of the three innovations presented to the panels. However, consumer demand for energy conservation is segmented. The panel agrees that at the high end of the market for new homes, consumer indifference to energy efficiency is a barrier to innovative technologies that feature it. The panel questions if PATH can find ways for energy efficiency to become a "distinctive" attribute of this part of the housing market. For example, can ENERGY STAR help? Energy efficiency is a concern at the high end of the remodeling market, but at the modest end of that market, lenders care about qualifying first-time buyers, and energy efficiency is not considered an advantage. In the multifamily market, tax credit projects, which in Virginia account for one-third to one-half of starts, may be sensitive to energy efficiency. Innovation programs should explore ways to steer innovators who feature energy conservation to these niche markets.

Regardless of the practicality of the recommendation, this panel is asking PATH to certify or clear emerging innovations. The panel questions whether PATH should be providing more assistance to small companies. HUD has no SBIR program; should PATH incorporate elements of such a program? Large, successful innovators could serve as a model for smaller companies. New information channels are needed that add value to small innovators. The panel considered whether National Evaluation Service reports could provide a threshold for PATH support.

Education/Communication as a Barrier

Based on the literature review and discussions among the project team, 10 hypotheses, reflecting current conventional wisdom, were presented to the expert panelists and the innovation presentation teams by the education/communication expert panel lead, to provide a broad contextual starting point for the panel sessions.

- "Education" as a term tends to focus on the level of education or skill of the construction industry participant and that person's willingness to take in new information or to accept innovation.

- "Communication," however, also is important and focuses on the transfer of information and learning between participants at many places in the construction process.

- There are only five minutes to educate most key decisionmakers in the construction industry.

- Production builders, developers, large-scale owners, suppliers, and building code officials are the key decisionmakers in adopting innovation. Any successful innovation must have educational materials sufficient to convince decisionmakers to try.

- Builders of all sizes are now using subcontractors extensively. Lack of language skills is a major barrier to any change in conventional processes, especially for innovations.

- There is a major lack of product and installation materials in languages other than English.

- Existing education channels (e.g., vo-tech, secondary school, trade on-the-job training, and university programs) are insufficient to meet construction industry basic needs, let alone advanced needs of introducing innovation.
- In the construction industry, successful education still depends on face-to-face contact. Internet = Technology Scanning; Face-to-Face = Acceptance/Sale

- Because successful education addresses all of the above, only large and sophisticated innovators are likely to be successful getting innovation adopted in today's market.

- The current housing boom market is not conducive to innovation education, or even communication. The best time to advance innovation may be during a housing recession when builders are open to a "teaching moment"—something to make them distinctive.

As with the prior panels, each of these preliminary hypotheses did undergo substantial change and revision as a result of discussion among panel members and innovation presenter teams.

Education/Communication Panel Seat Perspectives

Following focused presentations on each of three innovations and brief Q&A to clarify key points, each expert panelist was asked to describe their seat perspective on education/communication as a barrier to innovation in the context of the information and experiences they had just been presented and the hypotheses posed at the start of the session.

Seat #1: Media: Real Estate—This panel member communicates housing-related information to all the other participants in the housing delivery process. They also conduct surveys among their readers from time to time. An invited representative of McGraw-Hill was interested in the deliberations, but was unable to attend the session.

Seat #2: Specifier—This panel member works on the staff of a major multifamily builder and is responsible for assessing and recommending innovations to the company. He is the gatekeeper for many new ideas. He is reputed to be technical, thorough, and detail-oriented both by inclination and training, including a wealth of on-the-job experience. He has a great set of product files and a Rolodex of supplier phone numbers. Once an innovation has successfully passed his screen, he must be able to communicate effectively with others in the company so that the product is purchased and installed correctly. He communicates with a network of peers so they can help one another by readily passing information about a product or innovation success or failure. In making decisions, he needs to see credible information about a new product effectively presented or communicated. His comments concerning education/communication as a barrier to innovation include the following:

- *The initial review of an innovation is very quick.* "In the five minutes I might give for my initial scan of an innovation, I need to see three things: cost of the item; time to install (or the time you will save me over current practice); and availability (including supplier and time to deliver)," says this panel member.

- *Subcontractors are key*. Any innovation must be understandable and acceptable to the subcontractor that is likely to be used on the job. In the case of one innovation (structural insulated panels), they could not find a subcontractor who would try it. The project only proceeded, at the insistence of the owner, after the SIPs manufacturer could supply a trained subcontractor.

- *Innovations that shorten net time to build are highly desired*. An innovation that saves time in one area or trade cannot add time or make matters worse for another trade. For example, using SIPs saved several days on the building enclosure, but it took the electrician an extra two weeks to wire the building.

- *New ideas from magazines get a serious vetting*. Owners and architects often ask about a new product or system they have read about in a magazine. His first questions in response are who sells it and who installs it? If it survives these questions, they do a cost evaluation piece by piece. If the cost is too high, they can do some value engineering. "In my experience, not many structural innovations have passed this review," says this panel member.

- *Reducing callbacks has value*. Builders always are open to modestly priced innovations that can increase buyer satisfaction or reduce call-backs. For example, builders are likely to pay an extra $200-300 per house for window flashing, if it reduces call-backs. One call-back will eat up a lot more money than that.

- *Field experience is important*. "My educational path has been largely by experience," says this panel member. "I started out as a carpenter, worked as my own general contractor, and took classes in construction management at my local community college."

Seat #3: Trades/Unions—This panel member runs a training institute in collaboration between his union and contractors' association. He is responsible for seeing that members of his installing trade union are kept up to speed on new products and processes that are becoming available and to see that the installers are properly trained to work with such products or processes. He also is responsible for helping define career paths, keeping workers updated, and supplying re-training as needed. His first responsibility is to his membership. His blessing on a new product or concept can facilitate its acceptance, but he has the communication tools—newsletters, magazine, and Web sites—to kill a bad idea very quickly. He runs the educational component at the institute, which offers courses on many topics. The credibility of his sources is critical. He works with those in his trade who sit on code-writing committees. His comments concerning education/communication as a barrier to innovation include the following:

- *Building trades need not be a barrier to innovation*. The building or installing trades are ready to train their members on any new product or system that the market wants, assuming that related costs are realistic. They have worked with manufacturers before the launch of a new product to be sure that the installers were ready when the product was released.
- *Translating documents into Spanish is limited*. For labor-related training, they are using more electronic media and less printed material. "Because there are 18-20 different dialects of Spanish, we cannot successfully translate into all of them." Therefore, only safety

instructions and basic installation steps are typically translated into Spanish. All advanced teaching programs are in English. On a Hispanic crew, the person who learns English usually becomes the crew leader.

- *Training is only for union members*. Union-sponsored training is available only to union employees—those who pay into the trust fund.

Seat #4: Evaluation/Testing/Codes—This panel member runs the education and training programs of the ICC, the leading international model code organization. Other parts of the organization can render opinions on how a product or process does or does not meet code. Any innovation in the building industry faces at least two critical questions: does it fit within the existing building code and can it be installed cost effectively with current certifications? In this case, the communication barrier is the ability to correctly interpret existing code language and to get the innovation installed correctly so that both innovator and subsequent builder customers can have confidence that the innovation will be passed by local code officials. Unfortunately for innovators, this process can be costly, time-consuming, and not fully guaranteed to be successful (local code officials are always free to reject new ideas). Her attitude is neutral to innovation.

However, supporting information must have sufficient detail to be credible and to address questions about code compliance. If this required information is not communicated effectively, a negative response from this group is but a surrogate for rejection by local code officials later on. However, this group can also be very effective in supplying advice and training that can smooth the path to code inspector acceptance later on. Her comments concerning education/communication as a barrier to innovation include the following:

- *Five criteria for PATH support should be proposed*. PATH needs to establish at least five criteria for determining if an innovation is ready for their support:

  - Does the innovation provide an increased level of safety? (This can be assessed by the Evaluation Service).
  - Are there clear construction cost savings? Will these be passed on to the consumer (homebuyer)?
  - Is there a clear potential to reduce construction time?
  - Does the innovation offer significant energy savings? How much, and can these projections be confirmed?
  - Will the innovation improve the performance of the building or provide for reduced long-term maintenance?

  This panel member notes, “We will respond to any idea that can make it over at least one of the two hurdles: can it reduce construction time or can it reduce cost?”

- *Communications from Innovators should be targeted*. Communications from innovators need to be tailored to address various “audiences” or market segments:

  - Design professional: cost savings.

- Builders: cost savings and time savings.
- Subcontractors and installers: increased safety and time savings.
- Code officials: increased safety and energy savings.
- Consumers/homebuyers: energy savings, improved performance, and reduced maintenance.

The education barrier can be overcome by getting the right message to the right target. Innovators need help in determining how to focus limited resources toward these targets.

- *Code officials are open to education about innovations*. Code officials are open to education because it is mandatory to maintain certification. Currently, there is no core course on new materials or innovation in their program. However, new ideas can be presented as programs at annual meetings of code officials or the tradeshow at the ICC annual convention. A report by the Evaluation Service can also be used as an educational tool beyond the local jurisdiction affected. The training must be truly educational and not just a veiled sales pitch. To date, manufacturer-specific training has not been allowed for certification credits.

- *Innovators should participate in developing building codes*. Participation in the code-writing process is a sure way to gain code acceptance. Anyone can make a proposal to the ICC and work it through the process. However, this can be costly and time consuming and well beyond the resources of a small innovator.

- *Innovators need good publications*. Quality publications are a way to address code officials. The ICC maintains a reference with over 2,200 products. The ICC will not include specific manufacturers or products in their training courses, but they would be open to booklets or other publications generally explaining an innovation and addressing its code-related issues. This would need to be coordinated with ICC to fit into one of their existing curricula. About 20% of all code officials receive ICC training.

- *Installer certification need not be a barrier*. "We can respond with training overnight if it is needed so that someone can go to work," says this panel member.

- *Communications should occur before market introduction*. Several major manufacturers send them materials or products before their introduction into the market. "We check for code compliance and review their training curriculum," says this panel member. The idea is to have the market ready before the product is introduced.

- *Government lenders give credit for energy savings*. Freddie Mac and Fannie Mae once made a big push for energy efficiency. They would not allow a higher mortgage payment for an energy-efficient house, but they would allow up to a 2% higher debt-to-equity ratio.

Seat #5: Supplier/Wholesaler—This panel member is from a major, regional organization supplying materials to local homebuilders. He was unable to attend the session.

Seat #6: Builder—This panel member represents homebuilders, in general, but has particular experience as a high-production builder. Because most homebuyers in this market are presented with a finished building to purchase or not as they desire, the principal consumer of housing innovation is the homebuilder. Whether the builder depends on staff or not for analysis, it is the builder who makes the final decision about what innovations are going to be added to the next home built. Builders have many demands on their time, suggesting that communications to them must be compressed. They are extremely cautious about making any change to their existing product or process that might increase liability or cause delay in either constructing or marketing their product. But, they are always open to any idea that might reduce cost or construction time. Effective communication to a builder represents one of the greatest potential barriers to innovation acceptance. His comments concerning education/communication as a barrier to innovation include the following:

- *Durability is currently undervalued by the marketplace*. Morality for a builder includes being environmentally sensitive and fiscally responsible. Housing must fit within the prevailing code and fit the budget of the target market. But, it is the marketplace that sets the standard for durability. No individual builder can change that.

- *Builders are open to education about innovation*. Education is, by itself, critical to the success of any business. Builders are always open to new ideas. However, each business is an ongoing machine. It cannot be stopped to take time to learn. Unfortunately, about 80% of builders are smaller local and regional builders who do not have time to stop and retrain in order to accept an innovation. The question is how best to filter down critical information to them so they will take action. "I am open to any idea that can jump the cost savings/time savings hurdle," says this panel member. "But, frankly, few ideas are coming at me right now." Typical sources for new ideas are:

    - Builder shows
    - Salesmen
    - Trade magazines
    - Subcontractors

- *Trade associations should be a key educator about innovations*. Builders look to trade associations to train them and their subcontractors. New products are brought to their monthly sales and construction meetings for review. They are having their subcontractors trained in the NAHB Quality Control program, but the time commitment is significant and the results are as yet unclear.

- *Builders want fewer trades and less management on the job*. There is always a benefit to having fewer trades or less management required on the job. Any innovation that can quantify this in dollars will get a hearing.

- *Home-schooled students make good employees*. "As employers, we have been impressed with the home-school movement. These young people appear to do better on testing and we find it easier to get them onto the job."

- *The Market Does Not Value Energy Efficiency*. Homebuyers are not demanding energy efficiency, so builders are building to energy-efficiency levels required by code but not the most energy-efficient home possible. Any value added to a building, whether vinyl-wrapped fascia board or energy efficiency, is not passed to the consumer unless the consumer is educated about the value that benefit provides.

Seat #7: Learning Specialist—This panel member represents those who teach and, in particular, those who teach the homebuilding workforce. Educators traditionally are very open to innovation. They have the advantage of teaching to young and open minds. Vocational schools and young workers represent an excellent opportunity for introducing an innovation to a receptive audience. However, there are several potential communication barriers.

There is the challenge of getting information about the innovation to the teachers, into curricula, and into the classroom. There can be the challenge of teaching in a situation where English is a second language. Funding limitations may reduce the time available for communicating fundamentals of the innovation in depth. Then there is the challenge of transferring classroom learning to the job site. Manufacturers once had stronger ties to vocational education. Innovators may want to assess what worked in the past as an opportunity for enhancing such relationships again. This panel member's comments concerning education/communication as a barrier to innovation include the following:

- *Construction is not attracting high school students*. Construction and construction trades are not attractive or "glitzy" to current high school students. They are likely to try something else first out of high school. As a result, the average age of a construction trade apprentice is now 29.

- *It is now even harder to get teachers' attention*. Because of all the current focus on Standards of Learning (SOL) testing, teaching time or "blackboard space" is very limited for other subjects and vocational training. NAHB has been innovative in appealing to teachers by using the "Bob the Builder" CD ROM.

- *Consider career academies as an alternative education tool*. A new concept supported by the Carnegie Foundation, called Career Academies, uses team teaching and a "private school within a public school" approach to offer educational alternatives for high school students. Construction would be an excellent theme for this learning environment. The U.S. Department of Energy (DOE) is already putting some funding toward these small learning communities.

- *PATH should propose several innovative ideas for reaching students*. Here is a list of ideas PATH might try to get more students interested in construction and innovation:

    - Contact the Public Relations Society of America and ask them to consider "building innovation" as a theme for one of their upcoming "Silver Anvil" awards. This is a program where university-level students compete in developing innovative marketing

programs. Green buildings, affordable housing, and innovations, including some of the innovations reviewed at this meeting, are all possible topics.
- Work with Habitat for Humanity or other housing-related programs to devise a way that students might get actual credit toward a home for themselves and their family. Students need stable and affordable housing. They would work hard for it.
- Look at the very successful models of Fire Prevention Week and Building Safety Week as a way of getting an important message to students. Perhaps PATH could find a way to integrate with these ongoing programs.

Seat #8: Academic/Operations Research—This panel member is currently an academic and previously a government manager of a technological innovation program in energy conservation who has thought about education within the context of the homebuilding industry for many years. He has studied best practices within the industry and has developed his own findings about education delivery to the industry. Whether at the trades level or at supervisory levels, it is possible to define the knowledge and skills that are necessary to be successful at each level. Although neutral to any specific innovation, academics are well aware of their role in facilitating the acceptance of innovation by preparing a workforce to accept it. Less research has been done in this area than in many other areas of learning theory. More attention to vocational and on-the-job education could enhance the diffusion of innovation to the benefit of the homebuilding industry and, ultimately, of homebuyers. His comments concerning education/ communication as a barrier to innovation include the following:

- *Innovation takes a long time*. An early 1970s study at Berkeley for DOE looked at market penetration in the building industry. The study focused on products rather than systems. It found that, on the average, it took 20-30 years to penetrate the market (examples include low-E coatings and screw-in fluorescents). Systems innovations (such as SIPs and ICFs) will take dramatically more time to penetrate.

- *PATH can take action now*. Following are several recommendations to PATH for actions to help speed the diffusion process:

  - For each innovation to be supported, carefully analyze and identify all of the key participants who must embrace the innovation and how best to reach them.
  - Assist with research that can "feed" the voluntary standards development processes.
  - Support the presentation of technical papers at the various standards organizations.
  - Train faculty so that they can train the next generation of architects and engineers.
  - Prepare supporting documents and overtly work with code officials to gain acceptance for new technologies.

- *Focus on problem-solving innovations*. In construction, builders usually change from business-as-usual practices only to solve a problem, not because they have come upon a great engineering idea. PATH could use this rule as another criterion for sorting those innovations to support.

- *Better continuing education is badly needed*. There is a significant need to improve continuing education, especially at it relates to the construction industry. Higher education tends to focus on research as a way to support big budgets to the disregard of continuing education. Many working people want advanced learning and employers are willing to pay for it. The common use of one- to three-day seminars is not effective.

- *Student exposure to innovation is limited*. About the only exposure architecture and engineering students get to innovation is in doing special projects. Innovation is not part of the standard curriculum.

Education/Communication Panel Findings

Members of the Education/Communication panel were asked to help develop a refined set of hypotheses about how the construction industry currently views or responds to several barriers of importance concerning education or communication. These hypotheses represent a consensus of the panel members and are put forward as topics the PATH program may want to investigate further in addressing the subject of barriers to innovation in the homebuilding industry.

Production builders, developers, large-scale owners, subcontractors, and building code officials are the key decisionmakers in adopting innovation. Any innovation hoping to be successful must have educational materials sufficient to convince these decisionmakers, within a very short period of time, to try the innovation. The information presented must be "believable" and more than a "sales pitch." It must be succinct and it must address two key issues: potential cost savings or potential time savings. The more specific the message is to the target audience and the better the presentation "speaks the language" of the target audience, the better. The three best issues to "push" an innovation are a real problem to be solved, some other need felt by the decisionmaker, or a new code requirement.

Builders of all sizes are using subcontractors extensively. Innovators must identify the appropriate subcontractor and see that they are open to the innovation. Subcontractors who embrace an innovation can be allies in convincing a builder to try that innovation. If a builder is interested in an innovation, the likely subcontractor for the product or system also must be interested in trying the innovation if it is to have any success. To date, subcontractors have often been overlooked as a key decision-maker for innovation. None of the large subcontractor associations are currently members of PATH. The panel recommends that PATH look into building stronger relationships with these organizations so as to foster a more open attitude toward innovations.

Lack of English language skills need not be a barrier to innovation acceptance. Language is not a barrier but a reality on the job site that must be accommodated. Critical information related to safety or basic installation processes should be in more than one language. Spanish and French, for materials going to Canada, are currently the most common. But, it is not realistically possible to translate all-important information into all of the possible languages and dialects, spoken on the job site. To accommodate reality, job foremen are learning some Spanish and the crew chiefs for most subcontractors speak some English. The use of illustrations in printed

material also is useful in overcoming limited language skills.

Existing education channels (including secondary school, vo-tech, trade association training, on-the-job training, and university courses) are insufficient to meet current basic needs of the construction industry, let alone advanced needs to support introducing innovation. Young people do not currently perceive the construction industry as an attractive line of work. There is a shortage of young workers entering the field and many only try the construction trades after trying other lines of work. As a result, the average age of an apprenticed tradesman has increased significantly, to age 29, over the past several years. University programs that train young engineers and project managers appear to have no problem placing their graduates.

In the construction industry, successful education still relies heavily on face-to-face contact. While the Internet is a very useful tool for scanning for information, in construction, acceptance of an innovation or the closing of a sale still depends, in many cases, on face-to-face contact. In part, this is generational. Many older baby boomers are still not inclined to use the Internet a great deal. Younger "Generation X" and "millenials" seem more inclined to use electronic messages. But part of this is also temperament. Many builders are "kinesthetic" learners and like to touch what they are buying. Also, motor skills related to building in general are hard to train online. Innovators need to understand these ways of learning and buying in designing their channels to market and should be cautious about depending too much on the Internet to do the job.

Because the job of successfully educating so many decisionmakers is so involved, large and sophisticated organizations have a distinct advantage in getting innovations adopted in today's construction marketplace. Because it is costly to launch and maintain a sales force that can address and educate all of the decisionmakers in an industry as diverse as construction, large and well-funded companies have a distinct advantage—but not a monopoly—in bringing innovations to market. Because it is simpler and less risky, such large companies tend to focus on incremental innovations that extend an existing market. A "small guy" with a great idea or an innovation that requires systemwide change is much less likely to be successful. Groups of like interest, such as trade associations, can bring together resources and act like a big company in supporting innovations that are related to the mission of the association. For example, the large Portland Cement Association (PCA) has been very helpful in supporting the innovation of ICFs.

PATH could help selected, small innovators become successful. For innovators who are not within large companies or supported by a large trade association, the PATH program could use its resources to increase the probability of success of an innovation. Within the limits of what is appropriate for a government organization, PATH could: introduce the innovator to key decisionmakers in the industry; provide seed funding for testing and data collection; facilitate work with code organizations; or help find demonstration sites. The current PATH approach of presenting a large "library" of some 200 innovations without meaningful differentiation is not particularly helpful to decisionmakers interested in innovations. The members of the panel suggest that PATH consider using some effective criteria (e.g., broad possible application, potential to transform the industry, and public benefit) to select a much more limited number of

innovations to support annually. The relatively limited resources of PATH could then be more focused on providing more of the types of help discussed above to fewer innovations so as to have a greater impact.

The best time to advance innovation is during a housing recession when builders are more actively looking for something to make their product distinctive. When the housing market is booming, builders are highly motivated to produce housing quickly for sale, and they are understandably likely to be resistant to any innovation that might slow down or mess up their standardized processes. In a housing recession, however, there is more time to look for and try innovations that might stimulate the market in a builder's favor. In general, this idea suggests that innovations, like any new product introduction, must be sensitive to market timing.

Following are nine specific recommendations of actions for overcoming barriers to innovation in housing. Each recommendation represents a common theme of the panel discussions. Some of these recommendations came from all three panels, while others were discussed by one or two of the panels. Because these were discussions and not a voting or statistical process, there has been no effort to tabulate recommendations by panel. Where appropriate, these recommendations have been elaborated by findings from the literature search.

1. **Seek ways to raise the importance to consumers of improving long-term housing performance through innovations, while continuing efforts to find innovations that lead to a net reduction in the ultimate cost of the house.**

HUD's goal of increasing housing affordability through reducing housing costs or improving housing performance (e.g., quality, durability, and energy use) encounters barriers related to consumer preferences and a general inability to communicate the benefits of improved performance. Consumers will not support a higher cost innovation unless they recognize and realize a benefit. Many innovations, including all three reviewed at these panel discussions, add to the final first cost/price of the house. Innovations, in general, and energy-saving innovations, in particular, are of scant current interest to new homebuyers (or appraisers). While continuing to seek innovations that can lead to a net *reduction* in the final cost of the house, innovation programs should seek ways to raise the awareness of the importance of improved performance for consumers.

The following actions will help overcome these barriers:

- Focus innovations toward niche markets that might be interested in improved performance: affordable housing, Habitat for Humanity, renovation builders, owner-occupied or owner-managed buildings.

- Consider targeting support of innovations to geographic markets that might be more interested in improved performance.

- Wait for and increase efforts in "bad" markets when builders might be more attuned to innovations that will yield market differentiation.

- Tie innovation support to other popular concepts like green buildings.

- The real market for innovation in new homes is in improving the margin for builders, either by reducing material costs or construction time.

- If energy is not a "trigger" that gets an innovation recognized as having value, search for surrogate characteristics that will be valued by homebuyers.

It is recognized that this objective is particularly difficult to achieve in markets where the cost of land is so high that it distorts the relationship between housing prices and housing construction costs.

2. Investigate ways to mitigate builders' risks for adopting housing innovation.

Builders generally will not adopt an innovation that entails significant additional risk. Currently, builders shoulder a very high percentage of the risk for attempting innovations.

The following actions will help overcome this barrier:

- Builders would readily accept HUD as a "back stop" against future unintended consequences from innovations that were highly regarded.

- Reducing builder risk is a significant way to reduce a major barrier to innovation.

- The strength of the federal government might be used to offset a portion of risk to builders for using innovations that had been in some way tested and approved.

3. Provide special assistance to limited-resource manufacturers offering housing innovations.

The small size of many housing innovators, and their limited resources, constrain their development of an understanding of the marketplace and their ability to communicate with the industry. Small manufacturers offering housing innovations need special assistance. Innovation programs could help small companies introduce innovations so that they become successful, Innovation by big companies such as DuPont could provide a model for these manufacturers.

Key actions recommended at the panel discussions include:

- Interacting with code panels and implementing code changes
- Product testing
- Preparing marketing strategies and plans
- Preparing financial analyses and finding capitalization
- Understanding procurement processes
- Detailing methods of installation in an array of circumstances
- Doing due diligence to address insurability issues

It could be a mistake to jump ahead and try to remove barriers prematurely. The market does a good job of preventing wide acceptance of bad ideas. If innovation programs can assist in sorting out the products that are effective and help them to be certified in some way, market barriers will fall by themselves.

4. Develop and communicate a better understanding of the importance of the relationship between the homebuilding supply chain and innovation market success.

Supply chains and distribution channels are far more important and a much more significant barrier for innovation—from all sources related to risk, preferences, and lack of communication with and within the industry—than previously thought.

The panel on preference barriers offered the following observations:

- It is interesting that all three innovations presented generally bypass the suppliers.

- The distributor must be convinced that the innovative technology is better than what exists, and then he can help create the market for it, recommending it to builders/customers and finding the buyers for it.

- In order to do so, the following conditions should apply:

    - The innovation can use the distributor's added value.
    - The innovation is subject to unique sales rather than parts over long periods of time.
    - The innovation moves, not cluttering inventory.
    - The innovation is not a commodity, so that the distributor's margin is supported.
    - The innovation is characterized by a reliable source of supply.

The following actions will help overcome these barriers:

- Innovation programs must do more to understand and address building supply chains.
- Innovation programs could do more to address the need for information within the supply chains.
- Innovation programs should develop specific communication links for innovations within the supply chain.
- Innovators need help in understanding and addressing supply chains.

5. Seek industry partners among associations representing homebuilding subcontractors.

Subcontractors' preferences and their perception of risk are significant barriers to adoption of housing innovation. Subcontractors and their organizations also are key decisionmakers. The majority of innovations reach builders via subcontractor recommendations, and any innovation "discovered" by a builder must be accepted and implemented by the appropriate subcontractor.

Innovation programs should seek partners among associations representing homebuilding subcontractors.

6. All homebuilding product innovations need to be better described using more informative and discriminating attributes.

The attributes of innovations described on the PATH Web site are of limited scope. Several attributes that are crucial to the decisions to adopt an innovation are currently omitted. Superficial descriptions of innovations, in general, present a communication barrier to housing innovation.

The following actions will help overcome these barriers:

- Provide a richer set of characteristics.
- Provide more detail on what information is available.
- Any test results, case studies, or applications should be referenced.
- Identify the level of industry change that would be required to facilitate acceptance (incremental versus systemwide innovation).
- Suggest applicability by market segment (e.g., multifamily, rehabilitation, and infill housing).
- Suggest regional factors of applicability.
- Suggest applicability to large versus small builders.
- Indicate potential for cost/time/labor savings.

The risk barriers panel observed that a more consistent and uniform system of product testing will reduce risks by giving manufacturers a basis for claiming that a product will work and cost a given amount. Untested aspects of products seem to become the pivot for legal questioning of product performance. The nation needs a regulatory body, such as a federal bureau, to regulate building products in much the same way that the FDA protects the public regarding food and drugs. It could remove a significant portion of risks that participants now face.

The project team for this investigation has initiated a first step in the process by categorizing and sorting a spreadsheet database of innovation descriptions from the PATH Web site (see Appendix C).

7. Provide innovators with help in understanding and addressing the building codes and standards development and approval processes.

Designers and builders are reluctant to specify and install innovations when they are unclear about regulatory approval. In addition to this preference-related barrier to innovation, designers and builders may perceive an added risk when regulatory approval is unknown. Every innovator

needs help in understanding and addressing the building codes and standards development and approval processes.

Codes and standards can help enable the acceptance of an innovation. Builders count on codes for credibility or are driven by them, but only the largest companies supporting an innovation can afford to fully participate in the codes and standards process.

The following actions will help overcome this barrier:

- A regulatory process roadmap for innovators should be developed. Each of the following aspects should be explained in terms of its purpose, benefits, and what it takes to accomplish:

  - Specific inclusion in the building code
  - National Evaluation Service report
  - Voluntary consensus standard

- Participation in the code-writing process is a sure way to gain code acceptance. Anyone can make a proposal to the ICC and work it through the process. However, this can be costly and time-consuming and well beyond the resources of a small innovator. Innovation programs could be very helpful with resources in this regard.

- Quality publications are a way to address code officials. ICC maintains a reference with over 2,200 products. ICC won't include specific manufacturers or products in their training courses, but they would be open to booklets or other publications generally explaining an innovation and addressing its code-related issues. This would need to be coordinated with ICC to fit into one of their existing curricula. About 20% of all code officials receive ICC training.

- Specific actions could help speed the diffusion process:

  - For each innovation to be supported, carefully analyze and identify all of the key participants who must embrace the innovation and how best to reach them.
  - Assist with research that can "feed" the voluntary standards-making processes.
  - Support the presentation of technical papers at the various standards organizations.
  - Train faculty so that they can train the next generation of architects and engineers.
  - Prepare supporting documents and overtly work with code officials to gain acceptance for new technologies.

8. Facilitate linkages between housing innovators and large-scale housing procurements.

Consumers and other housing process participants may be reluctant to adopt innovations without being able to evaluate larger scale demonstrations of the technology. The relatively dispersed nature of housing innovation adoptions (one or two houses at a time) presents a preference and communication barrier to the adoption of innovations. Large-scale housing procurements,

especially by government agencies, the military, or institutions such as universities or hospitals, are excellent venues to demonstrate innovations.

The following actions will help overcome these barriers:

- Establish a clearinghouse for information about upcoming projects or requests for bids on upcoming projects.

- Contact housing project managers and help to facilitate the acceptance of innovations.

- Support housing project managers by helping prepare Requests for Proposals (RFPs) that will accept housing innovations as part of the responses.

9. Actively help get more students at all levels more interested in housing construction, in general, and in housing innovations, in particular.

The lack of adequate education and training contributes to lower quality of construction labor, which is an education-related barrier to innovation. Less educated labor makes change in construction practices more difficult. Most high school students do not view construction as an attractive career. Most young people try other careers before considering a construction trade.

The following actions will help overcome these barriers:

- Contact the Public Relations Society of America and ask them to consider "building innovation" as a theme for one of their upcoming "Silver Anvil" awards. This is a program where university-level students compete in developing innovative marketing programs. Green buildings, affordable housing, and innovations, including some of the innovations reviewed at this meeting, are all possible topics.

- Work with Habitat for Humanity or other housing-related programs to devise a way that students might get actual credit toward a home for themselves and their family. Students need stable and affordable housing. They would work hard for it.

- Look at the very successful models of Fire Prevention Week and Building Safety Week as a way of getting an important message to students. Perhaps innovation programs could find a way to integrate with these ongoing programs.

This concludes the general recommendations for reducing risk, industry participant preference, and education/communication barriers to innovation in housing derived from the expert panel sessions conducted in October and November 2004. Informal observations and recommendations from the panel discussions concerning PATH operations are presented in Appendix E.

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