Emerging Technologies and Integrated Systems

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Except in the area of Information Technology applications, advances in building materials and technologies have slowed dramatically in the U.S. due to long-term underinvestments in quality building and in building research. Advances in building systems and systems integration have progressed even less, while internationally, multi-disciplinary engineering and prototyping have led to innovations in almost every multi-system dynamic (figure 5). The U.S. lags behind many nations in the development and application of emerging technologies for buildings and integrated systems. As many industrial nations export more value-added building products and systems than they import building products, the U.S. is a net importer (Almanac 1997). The HVAC industry has identified a broad range of precompetitive research that is needed as long-term drivers of energy efficiency, comfort and health, and environmental sustainability (see figure 6, ARTI 1998).

Broadening the dialogue to include all building systems, there are major pent-up needs for research in: emerging materials and technologies; systems integration and intelligent buildings; and demonstrations of advanced, multi-disciplinary design/engineering. For each of these areas it is important to stress that research must strategically address both new and retrofit construction, simple and complex buildings, identifying the building types supported from residential to commercial, educational, cultural, medical... This research needs statement will focus specifically on research needs related to the performance of integrated systems and innovations in systems interfaces and intelligent buildings.

Systems Integration & Intelligent Buildings

The best emerging technologies for buildings will not guarantee thermal, visual, acoustic, air quality, life safety, or spatial performance without appropriate systems integration. Existing building technologies may have excellent stand-alone performance but fail in the integrated setting. There is a pent-up need for multi-industry, multi-disciplinary collaborative research toward the development and prototyping of integrated, plug-and-play solutions from the hidden infrastructures in buildings to the enclosure and interior systems. "Rather than to focus on optimizing the performance of inflexible infrastructure, we should be trying to build highly agile infrastructures that make yields in quantum leaps in human performance enabling high mobility and new collective work patterns" (Dr. William Miller, VP Research and Business Development, Steelcase).

One possible approach to systems integration for performance is to reassign responsibilities of designers, manufacturers, constructors, regulators, financiers, owners, manufacturers and users away from particular building subsystems to performance agendas such as the delivery of thermal quality, visual quality, acoustic quality, life safety and resource effectiveness in the occupied setting. The next generation of roofs for example, might be required to address environmental, energy maintenance and lifespan criteria (figure 8, Roofing Specifier 1998). However, greatly improved indices of performance and "field" metrics with instrumentation (section 1.2 & 1.3) would be needed to support these goals.

A second approach that deserves strategic investment is the collaborative design and prototyping of integrated systems that take advantage of the synergies between subsystems to deliver building performance to individual occupants and organizations. This requires a transdisciplinary, concurrent engineering approach where the design team is composed of all the major manufacturers and disciplines in collaboration from the start. Some of the most needed systems integration developments, for a broad range of non-residential building types, are in the areas of:

- Researching the environmental physics, the design/engineering and the human responses to effective natural and mechanical ventilation interfaces, involving enclosure, mechanical and interior manufacturers and disciplines.

- Researching the environmental physics, the design/engineering and the human responses to effective daylight and electric lighting interfaces, involving enclosure, lighting and interior manufacturers and disciplines.

- Researching the environmental physics, the design/ engineering and the human responses to the next generation of conditioning systems; split ventilation and thermal conditioning systems (air and water); displacement ventilation; desiccant cooling; mechanical/enclosure interfaces such as load balancing; ceiling/ floor/furniture based infrastructures.

- Researching the physiological need of ongoing changes in available light, air flow, temperature and their dynamic characteristics.

- Researching the environmental physics, the design/engineering and the human responses to effective user based, dynamic controls of all environmental conditions including electric lighting, daylighting, temperature, humidity, natural ventilation and mechanical ventilation and filtration, security and egress, and fire safety. The research challenges include: unsolved communication between independent control systems; robust/common sensors, data sets, and controllers; user friendly interfaces; and reduced complexity with greater intelligence and greater control.

- Researching the physics, the design/engineering and the human responses to rapidly changing information technologies, and their corresponding impact on building infrastructures (including interiors) and design. The building industry significantly needs research into distributed, modular, reconfigurable, wireless, autonomous, and user-based systems/components to support the real needs of knowledge generation buildings. In

addition to evaluating the technical cost-effectiveness of innovations in information technology and infrastructures, there is a major need to also expand the study of organizational cost-effectiveness of IT changes and innovations.

This position paper will focus on international innovations in flexibly integrated building components and systems for improved building performance. Research needs in relation to changes in work environments, building technologies, and advanced building systems will be outlined for debate among the attendees. Emerging research agendas relating to ascending and cascading environmental conditioning strategies for environmentally sustainable buildings will also be introduced for debate.