A TRANSDISCIPLINARY, TRANSINSTITUTIONAL, AND TRANSNATIONAL INTEGRATIVE FRAMEWORK FOR HIGH QUALITY AND PERFORMANCE, AFFORDABLE, AND SUSTAINABLE HOUSING

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ABSTRACT

The built environment is the most critical element in any society to ensure the quality of life of its people, its growth and evolution, and ultimately, its survival. Within this context, the provision of high quality and performance, sustainable, and affordable housing for every socio-economic stratum of a society continues to be a critical need, and still remains an elusive goal. This paper offers an integrative framework to effectively face this need and achieve this goal. Envisioned as a public-private partnership among academia, industry, and government, three main cornerstones – a collaboratory, a cyberinfrastructure, and a set of new paradigms, provide a solid foundation to this framework.

Key words: Quality, Sustainable, and Affordable Housing, Collaboratory, Cyber infrastructure, Paradigms.

The Context

The built environment is the most critical element in any society to ensure the quality of life of its people, its growth and evolution, and ultimately, its survival. It is defined by civil infrastructure systems (e.g., energy, water, transportation, communications, and waste) and facilities (e.g., industrial, residential, non-residential) that symbiotically coexist at urban, suburban, and rural scales under multiple scales of

institutional governance, continuously growing, evolving, and changing over time. Within this context, the provision of high quality and performance, sustainable, and affordable housing for every socio-economic stratum of a society continues to be a critical need, and still remains an elusive goal. This paper offers an integrative framework to effectively face this need and achieve this goal. Particularly in this period of great global economic stress, economic recovery in any nation will inevitably require a vibrant, productive housing industry.

The conditions are ripe to seize this moment of disarray to intervene with a fresh, bold, disruptive, and innovative integrative framework that can potentially reconstruct the housing industry (a) to provide high quality and performance housing solutions for all socio-economic strata, at varying spatial and temporal scales; (b) to concurrently increase financial affordability for housing buyers and financial viability for housing providers; and (c) to improve productivity, maximizing social and economic value, while minimizing the depletion of natural resources, environmental impact, and waste. To do so, this integrative framework needs to transcend (a) the diverse range of individual disciplines involved in any aspect of, and at any stage of the life span of housing; (b) the broad set of specific academic, industry, and government institutions and organizations directly engaged at any of these aspects or stages; and (c) given the global nature of the challenges posed by housing, the focus on a given nation. As a result, the essence of this integrative framework is inherently transdisciplinary, transinstitutional, and transnational.

A key point of departure for this Transdisciplinary, Transinstitutional, and Transnational Integrative Framework for High Quality and Performance, Affordable, and Sustainable Housing (T3IF) is the "Montego Bay Declaration [1]." This consensus document identified four pre-requisites to the development of effective and efficient solutions to meet the challenges of the housing market in the 21st century:

- "First, the alleviation of poverty, and the provision of affordable housing are inextricably linked. Governments, and stakeholders in the public and private sectors, must acknowledge this link and, that they must work together at local, national, and international and regional levels to pursue integrated solutions both to alleviate poverty and provide affordable housing for the most disadvantaged sectors of the population.

- Second, governmental and private sector initiatives to plan, finance, develop, and deliver housing solutions need to address formally, explicitly, and proactively, in an integrated way, the three dimensions of sustainability - environmental, social, and economic; and elimination, reduction, and mitigation of risk and vulnerability to natural hazards.

- Third,. governmental and private sector housing initiatives cannot afford to continue following the same strategies, mechanisms, and processes that have been used to date. Housing initiatives for the 21st century require new approaches that are bold, innovative, systems based, and contextually sensitive given the interrelationships, interdependencies, and complexity of the external factors affecting the delivery of housing solutions

- Fourth, the challenges of the housing market in the 21st century cannot be overcome by government officials, policy makers, regulatory agencies, finance institutions, community leaders, planners, architects, engineers, suppliers, builders, or end-users alone. Rather, overcoming these challenges requires and demands that all these stakeholders link, coordinate, and integrate their efforts as a single cohesive critical mass, pooling, leveraging, and sharing their resources, within local, national, and international regional public/private partnerships, in the pursuit of housing initiatives of common interest and benefit to all."

Within this context, T3IF is envisioned as a unique public-private partnership among academia, industry, and government, with three main cornerstones providing a solid foundation. Elements of these three cornerstones exist in one form or another within other disciplines and knowledge domains, but currently they do not exist in a cohesive form within and among any of the knowledge domains involved directly with the built environment. They are:

- The first cornerstone is a <u>Collaboratory</u>, which Cogburn defined as "...more than an elaborate collection of information and communications technologies; it is a new networked organizational form that also includes social processes; collaboration techniques; formal and informal communication; and agreement on norms, principles, values, and rules. [2]"

- The second cornerstone is a <u>Cyberinfrastructure</u>, which the National Science Foundation refers to as "...the distributed computer, information and communication technologies combined with the personnel and integrating components that provide a long-term platform to empower the modern scientific research endeavor. [3]"

- The third cornerstone is a set of three <u>New Paradigms</u> that drive and guide the planning, definition, execution, delivery, and on-going deployment and implementation of the collaboratory and cyberinfrastructure: (a) a paradigm of <u>pluridisciplinary collaboration</u>; (b) a paradigm of <u>integration</u> among learning/teaching, research/creative work/scholarship, and engagement through practice, outreach, and service; and (c) a paradigm of <u>expanded scholarship</u> [4].

Finally, as shown in Figure 1, the nature of these cornerstones demands that the T³IF be driven at its core, by a continuum of (1) *imagination*, (2) *creativity*, (3) *innovation*, (4) *design*, and (5) *entrepreneurship*, continuously fueled by (a) *questions to be answered* through basic and applied research; (b) *problems to be solved* through the application of data, information, knowledge, and experience in diverse relevant disciplinary domains; (c) *needs to be satisfied* through innovative products, processes, service and business models, and experiences; (d) *opportunities to be realized* through entrepreneurship; and (e) *aspirations to be fulfilled* through empowerment, facilitation, coaching, and capacity building. The three cornerstones of the framework are presented next.
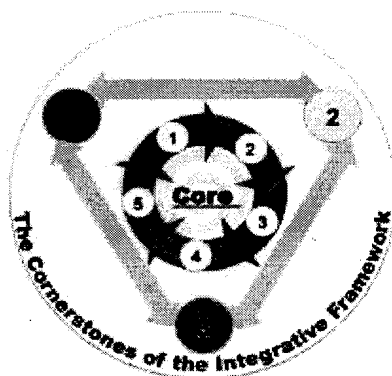

Figure 1 – Core and Cornerstones

The Collaboratory

The T³IF collaboratory has three main goals:

- Link, coordinate, and integrate the efforts of a *diverse range of stakeholders* (e.g., government officials, policy makers, regulatory agencies, finance institutions, community leaders, planners, architects, engineers, suppliers, builders, and end-users, among others) as a single cohesive critical mass, pooling, leveraging, and sharing their resources, within local and national public/private partnerships, in the pursuit of housing initiatives of common interest and benefit to all;

- Develop and implement new bold and *innovative products*, *processes*, *service and business models*, and *experiences* for housing solutions, which are systems based, contextually sensitive, and community-based, and which, in addition, are customizable, flexible, adaptable, scalable, evidence-based, outcome-pulled and value-driven, and technology-enabled; and

- Address the three dimensions of *sustainability* (environmental, social, and economic), concurrently with the elimination, reduction, and mitigation of poverty, and of risk and vulnerability to natural hazards, in an integrated, formal, explicit, systemic, systematic, and proactive way.
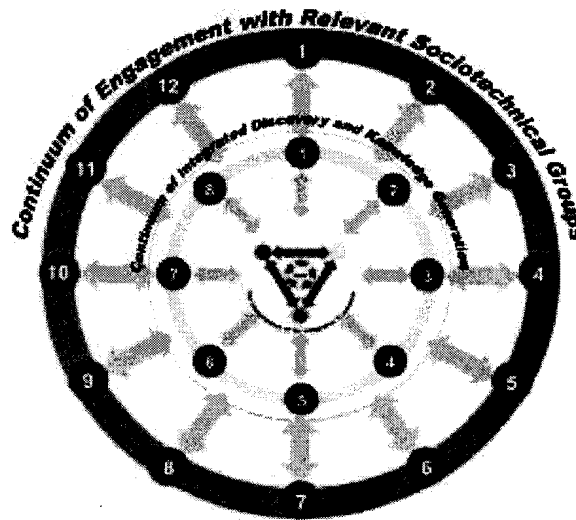

Figure 2 – Collaboratory Nested Continuums

To reach these goals, the collaboratory has the explicit intent of bringing together researchers and educators from academia, practitioners from industry, and government officials, from the knowledge domains involved directly and indirectly in the principal stages of the life span of a housing solution – from conception, planning, and financing, through design, procurement, construction, and delivery, to life span stewardship (e.g., regional and urban planning and design, land and property development, landscape architecture, architecture, engineering, construction, asset and facility management, visualization, and/or other associated relevant knowledge domains). As shown in Figure 2, the core and the three cornerstones of T³IF are nested within two other continuums, which provide an opportunity to do so. The first is a *continuum of integrated discovery and knowledge generation* with eight tasks: (1) the establishment of benchmarks and baselines; (2) research, (3) development, (4) demonstration, (5) deployment, (6) dissemination, (7) evaluation; and (8) the achievement of visions and outcomes) in housing. The second is a *continuum of engagement with relevant socio-technical groups* directly and indirectly affecting, or being affected by, housing, including twelve clusters of researchers and educators, practitioners, and government officials, who are engaged in: (1) regional and urban planning and design; (2) land, property, and real estate development; (3) design of civil infrastructure systems; (4) architecture and engineering involved in the design of

architectural, landscape, structural, mechanical, electrical, water supply and wastewater removal, and other specialty building systems; (5) general and specialty construction engineering and management; (6) facility management; (7) computing, information, and visualization technologies; (8) codes, standards, policies, and regulations; (9) utilities and services; (10) materials, products, and equipment; (11) financial mechanisms; and (12) education and workforce development.
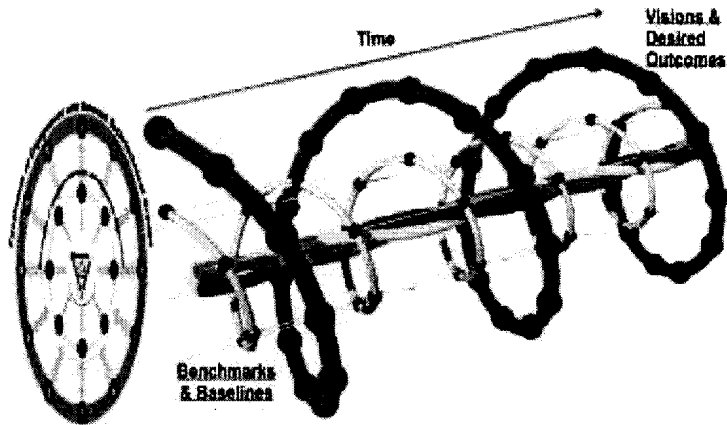

Figure 3 – Collaboratory Interactions Over Time

The result of this nested approach is a very flexible, yet highly structured, collaboratory, which can connect benchmarks and baselines with visions and desired outcomes over time by aligning any socio-technical group, with any discovery and knowledge generation task, with any cornerstone, with any element of the core, in the conception, planning, and execution of programs, projects, activities, and events related to any aspect of housing. These dynamic sets of interactions are conveyed in Figure 3.

<u>The Cyberinfrastructure</u>

The T^3IF cyberinfrastructure, which can be thought of as a virtual enterprise for the future, builds upon the *FIATECH Capital Projects Technology Roadmap* [5], and the results of an interdisciplinary charrette that set an academic research agenda centered upon the roadmap [6], customizing it to the specific context of the housing industry. The cyberinfrastructure envisions nine critical elements that act as an integrated solution set, with each element totally interoperable across the enterprise and over the life cycle of housing projects:

- Scenario-based Project Planning – This element provides a data and technology framework for the comprehensive and predictive modeling of the life cycle of a housing project, to (a) proactively optimize design, project delivery methodology, procurement and handover based on operation, use, and maintenance requirements before project delivery work stages begin, and (b) allow for direct integration to, and continuous feedback from, subsequent project delivery life cycle stages in order to enable iterative life cycle modeling, as well as comparison to initial project plans.

- Automated Design – This element provides an integrated, collaborative and automated design environment that provides a complete end-to-end design capability, which is well connected with both upstream and downstream project processes, to improve the efficiency and quality of design processes through (a) the standardization of work process and information flows, (b) interoperability of software tools, and (c) knowledgeable staff working together in a collaborative environment which enhances project planning and communication, reduces schedule and improves the quality of deliverables.

- Integrated, Automated Procurement & Supply Network – This element provides the building blocks of standard processes, classification systems, and data exchange mechanisms to (a) enable fully integrated, automated procurement and supply management systems, (b) support the seamless execution of procurement functions throughout the selection, delivery and payment processes, and (c) enable suppliers and subcontractors across the world to seamlessly "plug in" to projects, to identify business opportunities, to exchange requirements and bid information, and to monitor progress of order fulfillment

- Intelligent & Automated Construction Job Site – This element provides a forum for construction practitioners, material providers, and technology providers to make a concerted and systematic effort to identify, develop, deploy and evaluate the impact of the components, systems, standards and deployment strategies that are needed for successful Intelligent and automated construction job sites, which (a) make use of emerging information and automation technologies to minimize capital facility delivery costs (labor, material and equipment), facility delivery time, and life cycle costs, (b) and link to an asset life cycle information system, construction project management systems will continuously monitor the job site for compliance with cost, schedule, material placement and quality, technical performance, and safety.

- Intelligent Self-maintaining and Repairing Operational Facility – This element provides the mechanisms for utilization of data flow from self monitored equipment and systems to manage the actions necessary to ensure conditions and performance necessary to (a) enable safe, secure and continuously optimized

maintenance and operations, and (b) automatically and autonomously activate built-in mechanisms to perform required maintenance and/or repair functions.

- Real-time Project and Facility Management, Coordination and Control – This element provides an integrated, collaborative, and automated environment with a complete end-to-end project management coordination and control capability, which is well connected with both upstream and downstream project processes, through the standardization of work process and information flows, interoperability of software tools, and knowledgeable staff, to (a) improve the efficiency and quality of project and facility management, operations processes and regulatory interfaces, (b) enhance project and facility management and operation communication, reduce schedule, and improve the quality of deliverables, and (c) improves interface between public and private sector throughout the life cycle of the building on regulatory issues.

- New Materials, Methods, Products, and Equipment – This element provides the means to establish an initial base of existing data, information, knowledge (best practices), and experience (lessons learned) on housing, and then to grow this base by tracking, capturing, populating, periodically evaluating, and widely disseminating the expanding universe of new developments in these four areas, through the collective global intelligence and expertise embedded within academia, industry, and government.

- Technology- & Knowledge-enabled Workforce – This element focuses on the human dimension of advancing and implementing technology within the housing industry, through the development of a knowledge enabled workforce at the craft and managerial levels, which is skilled in working with advanced, user-friendly technologies that enable high levels of quality and productivity throughout the life cycle of a housing project

- Lifecycle Data Management & Information Integration – This element provides the standards, models, classifications and other mechanisms for seamless access to all data, information, knowledge, and experience needed to make optimal decisions in every phase and function of the life cycle of a housing project, which enables both data management and information exchange for the housing industry, including the foundation for, and programs to, create and maintain shared or common knowledge-bases, so organizations can accelerate the process to create and deploy an asset life cycle information systems for specific housing projects or project typologies.

The New Paradigms

Finally, the success of the collaboratory and the cyberinfrastructure for T^{3}IF presented above requires a set of new paradigms to guide their implementation:

- A *paradigm of pluridisciplinary collaboration*, which is concerned with the study of any topic associated with affordable, sustainable, and quality housing, not in only one discipline, but in, or with, several at the same time, including, as appropriate: (a) a multidisciplinary approach, which studies a topic within one discipline, with support from other disciplines, bringing together multiple perspectives, but always in the service of the driving discipline; (b) an interdisciplinary approach, which studies a topic within multiple disciplines, and with the transfer of methods from one discipline to another; (c) a crossdisciplinary approach, which studies a topic at the intersection of multiple disciplines, focusing on what is common among the disciplines involved; and (d) a transdisciplinary approach, which is concerned, at once, with what is within disciplines, between disciplines, across different disciplines, and beyond all disciplines, with the goal of understanding a topic under an imperative of unity of knowledge.

- A *paradigm of integration* in which learning and teaching, and research and creative work units within academia, interact more formally and explicitly with each other, and in addition, strong bi-directional engagement through practice, outreach, and service between academia and the industry, professional practice, government, and society at large, enable (a) learning and teaching units to maintain what they teach (curricula), how they teach (pedagogy), and the resources they use in doing so, current, relevant, and responsive to industry and societal needs; and (b) research and creative work units to do the same.

- A *paradigm of expanded scholarship*, which encompasses all five dimensions of scholarship defined by Boyer [7 & 8]: (a) *discovery* – the pursuit of inquiry and investigation in search of new knowledge; (b) *integration* – making connections across disciplines and advancing knowledge through synthesis; (c) *application* – how knowledge can be applied to the social issues of the times in a dynamic process that generates and tests new theory and knowledge; (d) *teaching* – transmitting knowledge, and transforming and extending it; and (e) *engagement*, which connects any of the previous four dimensions of scholarship to the understanding and solving of pressing social, civic, and ethical problems.

In closing, through the envisioned public-private partnership among academia, industry, and government, together with the full implementation of three main cornerstones – a collaboratory, a cyberinfrastructure, and a set of new paradigms, T^3IF offers a viable alternative to current approaches to provide high quality and performance, sustainable, and affordable housing for every socio-economic stratum of a society.

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