

La Casa a la Carta: University-Industry Collaboration in Technology Transfer

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BACKGROUND

The interest in technology transfer has increased in recent years due to fundamental socio-economic changes in Canada. The decreasing birthrate and family size, the loss of job security and the dramatic increase in the cost of serviced land have all contributed to a steady decline in housing demand in Canada. An expansion of the housing industry during the 1980s introduced many new companies who are now willing to compensate for the lack of volume with activities abroad (Friedman 1997). In terms of past experience, the transfer of technology through traditional channels by classical suppliers has not proved effective in closing the technology gap between North and South. Instead, the process has led to a series of asymmetries. Studies on individual developing country experience have documented the indiscriminate import of technology that involved high costs, inhibited learning effects and accentuated technological dependence (Singer, et al. 1988). However, the perspective on technology transfer as a process, moving away from a product fixation, is an essential orientation which integrates the technological capacity of housing concepts and strategies and the procedure of modifying Canadian products to include a culturally sensitive indigenous component.

The use of housing technology as a resource traditionally has been perceived as an individual institution's choice and responsibility. The proposed paradigm extends the process of housing technology transfer to a consortia composed of academia, industry and government. This initiation of a multi-institutional venture is a more efficiently managed effort for a mutually beneficial economic growth and diversification that develop emerging industries, provide seed capital for start-up entrepreneurial endeavours and assure the growth of economic activity within the housing industry (Williams and Gibson 1990). In rapidly changing technological and market environments, interorganizational alliances offer a means to acquire resources, information and implement innovative strategies in order to compete successfully on the global market and expand Canada's modest international business presence.

In Mexico, despite a significant number of houses built every year, efforts are substantially far from being satisfactory and provide significant opportunity for Canada's trade-dependent economy. In order to maintain the existing housing deficit of 6 million units, 980,000 units per year will be required throughout the 1990s (CMHC 1994). This demand is greatest in the 25-50 age group which constitutes 38% of the population and is projected to mount to 48% of the population by the year 2010. In comparison with Canada, where only 21% of the population is under 14 years of age, in Mexico this figure comprises 40% which will inevitably lead to a substantially greater demand for housing (CMHC 1997). The Mexican federal and state governments offer some aid through a

variety of organizations and agencies which assist with building and financing, however these programs are increasingly insufficient. This inadequacy is exacerbated by the lack of a formal mortgage banking system in Mexico. Mortgages are granted only to middle- and upper-income earners (those earning at least five times the minimum wage) at rates in excess of 50%. The main sources of financing for a home are personal resources, government assistance, pension funds and commercial banks for the middle- and high-end housing markets (INEGI 1997). Since the recession of the 1980s and an additional, considerable devaluation of the peso in 1994, Mexico is again experiencing economic vitality. In direct correlation, middle and low-to-middle income groups are also gradually gaining economic strength and a subsequent housing need is emerging as a prime area of activity for Canadian manufacturers, universities and government to target.

Predominantly, the principal construction material in Mexico is concrete and concrete block. The traditional Mexican preference for masonry construction over wood stems from perceived advantages in resistance to hurricanes, earthquakes, termites and fire and from housing tradition in general. Building with concrete block is simple, relatively fast and eliminates the necessity for a high degree of specialized labour. Significantly, the proportion of construction costs allocate 80% to materials and a mere 20% to labour which further reflects the adequate availability of inexpensive labour (INEGI 1997). In direct contrast, the Canadian housing industry traditions are strongly rooted in the woodframe house which complements local resources. In the majority of target export countries cement-based products are the primary building material, a fact which has often eliminated the potential of Canadian building systems. A foreign building system may also offset the efficiency of prefabrication by transportation, installation and management costs. Similarly, significant climate differences have further constrained the implementation of Canadian homes and products. Evidently, in order to expand the housing industry internationally, a corporate-university initiative must modify products accordingly to accommodate specific cultural and climatic criteria.

The variety and abundance of natural resources, a high quality of workmanship for cold climate construction, relatively inexpensive hydroelectric power and efficient communication and transportation systems combine to advocate Canadian products as highly competitive on the international market. Embodying this opportunity, La Casa a la Carta illustrates a design approach oriented toward the lower-middle class market: employees with steady incomes, most likely dual-income families, who are searching for access to affordable housing. The \$13,500-\$20,000 (Cdn. \$) cost per unit is aimed specifically to accommodate this particular market profile. A

variety of products from the building system in its entirety to an assortment of wall panels, windows, doors and finishes are currently needed to alleviate the inadequacy of the Mexican market. Following is an analysis of the design principles and product modifications which facilitate the transfer of technology and ease the export of industrialized housing components.

DESIGN PRINCIPLES

Constructed in November 1997 for the Construexpo Trade Show in Guadalajara, Mexico, by Archimède 2000 of Montreal the demonstration unit was constructed with the participation of 20 Canadian product manufacturers. The unit's layout was the outcome of a fictitious scenario that was created for a housing development (Figure 1). A young family purchasing a first-time home in a low-cost, perhaps social housing project was envisioned. The family, made up of working parents and two young children aged four and two, visited a site where they saw several model houses and menus of interior and exterior components. Based on their budget and space requirements they made their selections. Several rudimentary principles are the basis of a design that extends affordability strategies to include a dynamic, built-in capacity for flexibility. The need to build for a minimal budget requires a basic reduction of space. Accordingly, an attempt was made to provide a comprehensive range of essential amenities and functions within a small area (50 sq.m [500 sq.ft.]) that will ensure the homeowners have optimal proficiency in a compact unit (Figure 2). Also, the sizing of the unit was specifically chosen in order to comply with the intended budget of \$20,000 (Cdn. \$).

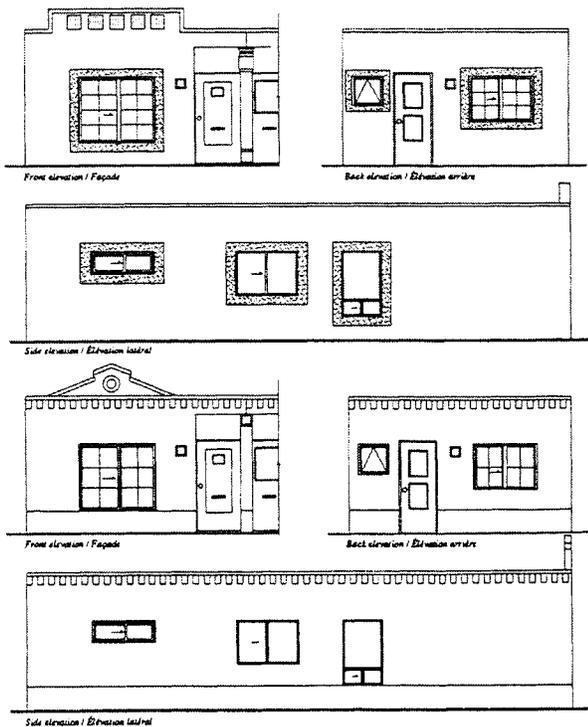


Figure 1: Elevation options

Integral to the Latin American culture is the notion of progressive building. For instance, a traditional household may initially purchase a small home and gradually expand the original perimeter employing alternative construction methods and materials. The accommodation of future expansion is implicit in the design process of La Casa a la Carta whereby factors such as light, utilities,

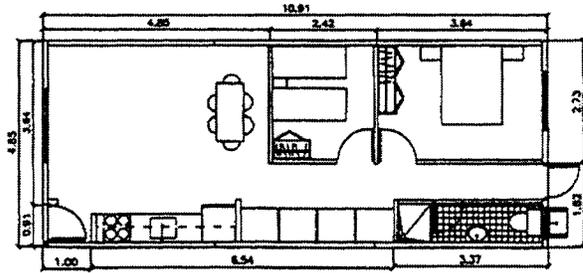


Figure 2: La Casa a la Carta plan (50 sq.m)

circulation and construction must anticipate potential modifications that may result from future expansions (Figure 3). In the demonstration unit, the longitudinal storage unit in the corridor can easily be replaced by an interior stairway and subsequent storage would be provided on the new, upper floor. Additionally, the building process is likely to be a self-help one, therefore provision for expansion by unskilled labour was an essential design criterion to facilitate flexibility with minimal complication. This instrumental flexibility affords a multitude of options to integrate the current particular requirements and financial means as well as integrating the opportunity for future modifications and elaborations with the initial conception.

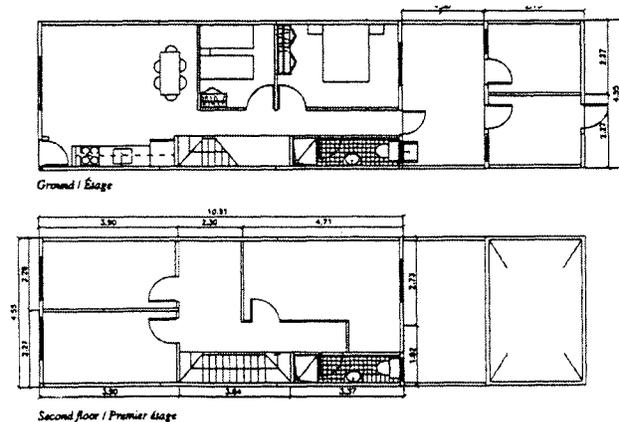


Figure 3: The growing process

In the range of available housing forms offering affordability, the narrow-front rowhouse (less than 6m [18.3 ft.] wide) is the option which best provides the prospective owner with the commonly preferred characteristics of homeownership (a single-family home with a private entrance and direct access to a yard) while at the same time extending the benefits of affordability resulting from increased density. The narrow dimension requires efficient interior space allocation and careful attention to the placement of services and natural light. The absence of interior load-bearing partitions facilitates simple adaptations fundamental to a multifaceted approach (Figure 4). The reduced structural span extends substantial savings in construction and operating costs in addition to permitting flexibility with internal partition configurations (Figure 5). The common wall between these attached units provides significant savings in building materials and energy consumption. A one-storey narrow-front rowhouse constitutes approximately one third of the exterior wall surface area and one half of the roof area in comparison with a similar freestanding home; heating and airconditioning costs are thus reduced by 25% (Friedman et al. 1993).

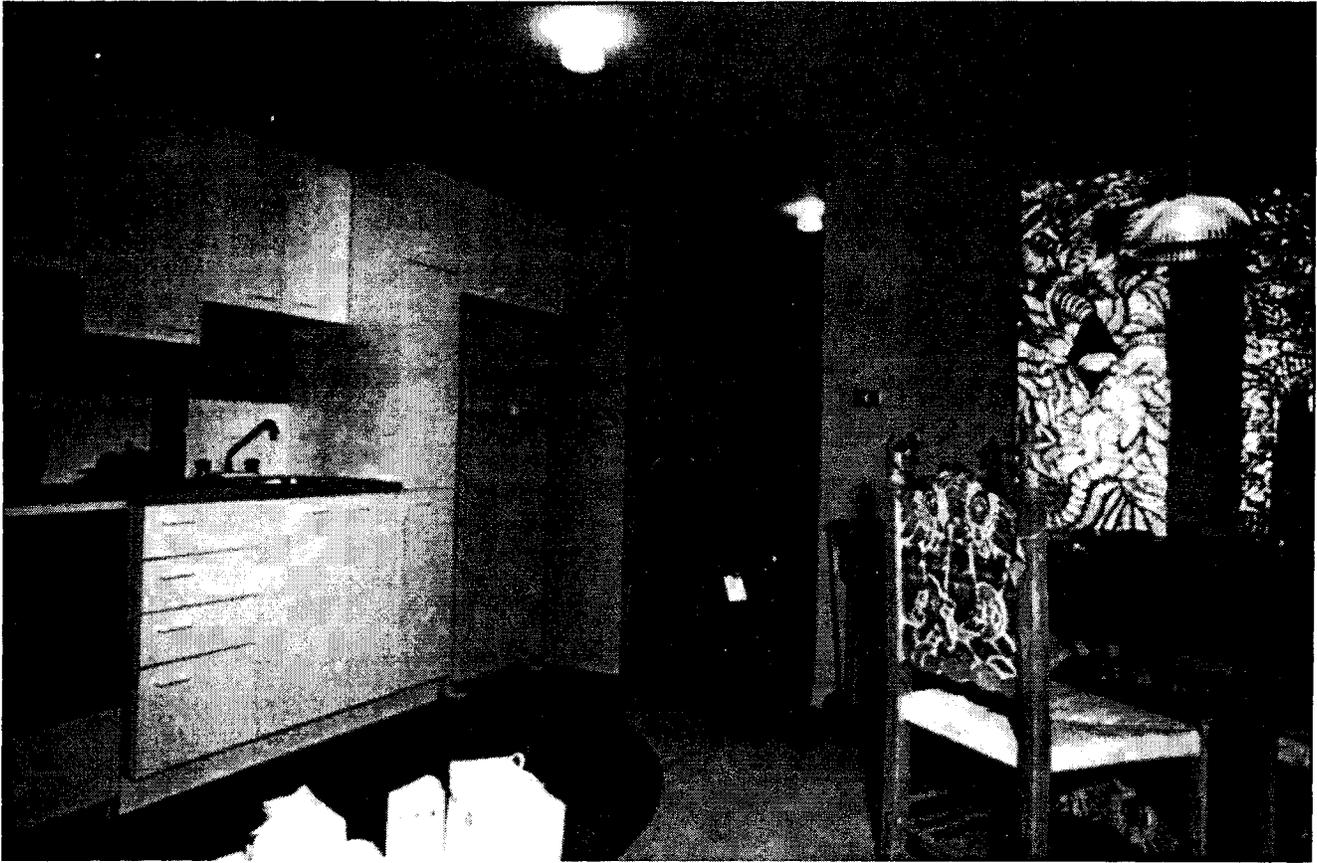


Figure 4: Dining area and kitchen of demonstration unit

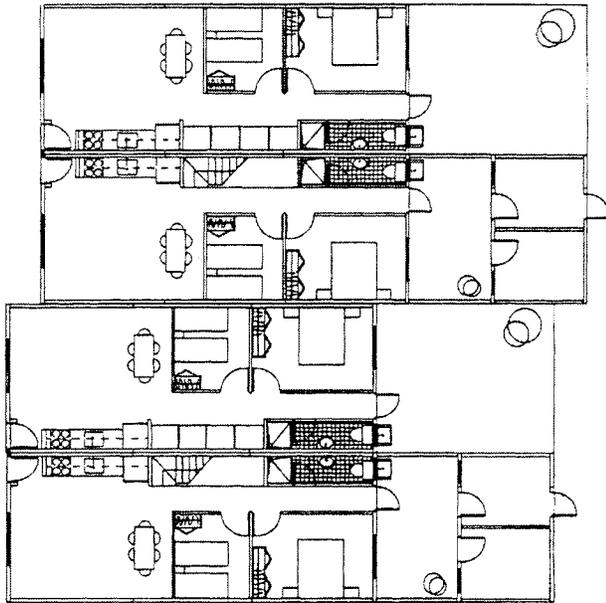


Figure 5: Rowhouse prototype

The principle underlying the facade design should incorporate the flexibility and individual identity that governs the structure and plan. A key design challenge to such high-density development is to avoid repetitive, sterile and monotonous environments. A composition strategy embodying a variety of options in terms of appearance, style, fenestration and materials enables a distinct balance between flexibility and individual unit character and a certain degree of control to unify the neighbourhood. Providing a variety of facades and design options, grouping units in small numbers and allocating appropriate parking arrangements and open spaces are fundamental elements of comfortable neighbourhood developments.

The Latin American tradition of low-cost residential construction is well-rooted in the "do-it-yourself" method of construction. The user choice will be made to suit individual lifestyles and budgets, allowing occupants to "consume" only the type and quantity of features they require or can afford. The primary design consideration incorporates a mandate to be an affordable dwelling unit whereby manipulating the personal household composition and budget is an approach that can result in significant cost savings. In order to manage such a process, a system is required. The key components of such a pertinent system are a comprehensive menu of specific components with their respective prices and a design that facilitates installation by minimizing technical construction and inconvenience (Figure 6). The extensive potential for industrialization of these components ranges in scale from the entire unit to structural systems, insulation materials, interior and exterior finishes, doors and windows, kitchen and bathroom accessories and general construction hardware. Through direct discussion with the architect or the assistance of a computer catalogue in a sales office, customers can specifically cater to their personal space requirements

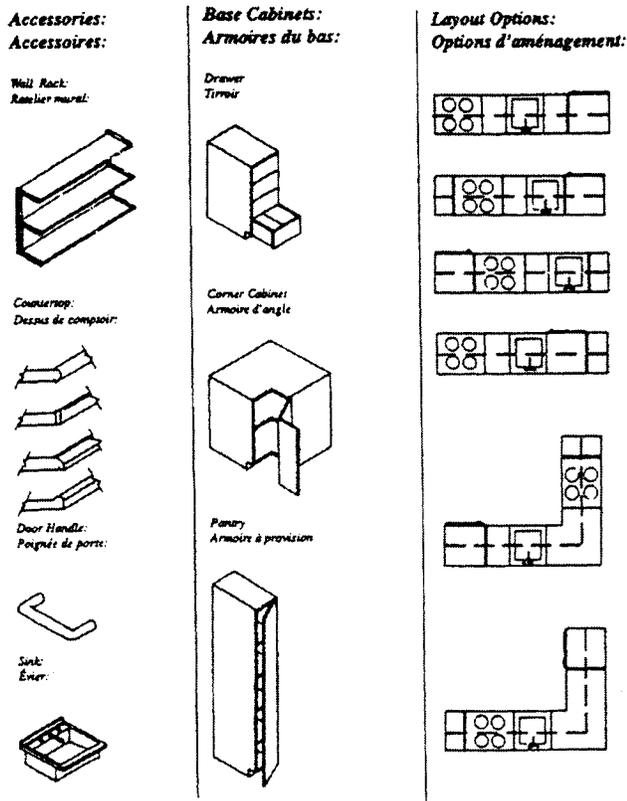


Figure 6: Menu options: kitchen elements

and individual budgets. Consequently, such an approach reinforces the affordability of each unit by providing an alternative to labour-intensive, costly infill items (e.g. closets).

PRODUCT MODIFICATION

The principle objective of the university's research in the development of La Casa a la Carta was to assist Canadian manufacturers to redirect development and production lines toward other countries' housing needs. Essentially, product modifications must integrate diverse cultural values, fundamental economics and affordability and correspondence to local codes and standards.

The development of a successful technology transfer with Mexico requires that Canadian firms become fully acquainted with the Mexican marketplace. Fundamental to this concept is an explicit sensitivity toward Mexican culture as a critical element of this alliance. In addition, a certain degree of market knowledgeability is fundamental to any progressive development. Canadians should recognize that Mexicans favour importing technologies rather than finished products. The Latin American notion of progressive development is an investment which implies durability as an essential criterion in the construction materials in addition to flexibility which enables the occupants to potentially modify and expand their units. Furthermore, a notable measure of original market research is required since statistics and available market research are scarce.

Imperative to the introduction of a new building technology is the consideration of maintaining affordability where labour costs in particular can significantly impact this factor. The advantages of using Canadian labour entail a well-organized operation where training procedures are eliminated and an efficient process with a high-quality product outcome is assured. However, these advantages can easily be countered by high labour costs which would

eliminate the affordability principle for the greater part of the Mexican market. In contrast, the cost of local labour is low but presents an alternative that must essentially be supplemented with a certain amount of training and the implementation of Canadian work organization in order to achieve adequate efficiency. The university-industry joint venture must enhance this option by simplifying the imported building system or developing a system which is familiar in principle to traditional construction techniques. In addition, transportation costs of shipping the building systems is also a factor directly affecting the affordability of the product. From a technical standpoint, potential technology transfer requires a thorough familiarity with local building code jurisdictions and climatic conditions. With dramatic disparities between Canadian and Mexican climates and seismic activity, products must be modified accordingly to be suitable to an area where earthquakes, hurricanes and high temperatures are standard elements of living conditions.

The small size, simple configuration and efficient layout of La Casa a la Carta provides an opportunity to exploit the advantages of prefabricated methods of building to their maximum potential. The simple exterior configuration and symmetry allow for quick, uncomplicated panelized construction and assembly. With respect to the variety of materials available to construct prefabricated wall panels, there are several possibilities with proven high performance in structural strength and fully satisfying the requirements of local building codes, yet the economic factor, in the sense of price and feasibility, in combination with the social factor determined by cultural acceptance must also be acknowledged. For example, despite a good load-bearing capacity, a minimal requirement for specialized tools eliminating the need for cranes and heavy mechanization, a short construction period and the availability of wood and wood products in Canada, the advantages of wood-frame construction are greatly outweighed by the high costs for specialized labour and distribution and the cultural reservations toward wood as a construction material. Similarly with metal-frame construction, the high price and need for specialized labour removes it as an option for industrialized affordable housing. It is precisely for these reasons, despite the structural capacities of wood- and steel-frame based construction, that their acceptance and application in Mexico is not a viable strategy.

It has been recognized that a single material can rarely have an equally good response to the multitude of structural and climatic requirements. Modern building science is developing new systems made of combined materials in order to find a solution which will best fulfill these requirements. In the Canadian homebuilding industry, various systems of this type have been developed and implemented. In application to the Mexican market, the sandwich panel is most likely the structural solution which is best suited to efficiently accommodate the industrialization of housing. The basis to this form of construction consists of an expanding polyurethane foam that is injected between light outer concrete layers. Each panel also has a built-in frame, made of wood or steel, which provides structural stability and through which the panels are connected to each other with screws and bolts (Friedman, Horvat & Rojano 1997). Easy implementation, low-cost materials and inexpensive labour requirements combined with the local familiarity and "trust" in concrete indicate the sandwich panel as a practical system for transfer.

Another area of interest for Canadian manufacturers is the production of insulation and various interior and exterior finishes. With the growing amount of residential air-conditioners being installed, the quality, quantity and variety of insulation materials available on the Mexican market are marginal and a valid target for technology transfer. Similarly, a lack of variety in finishes such as stucco, wallpaper, quality paints and wooden floors would also offer significant potential. In addition to protecting against physical elements, exterior finishes significantly influence the image of the house which can greatly assist the cultural acceptance in a foreign

market. For example, cement based finishes, from ordinary mortars to high quality stuccos, as well as a broad range of outside plastering materials, additives and colours would be particularly suitable to import because of superior quality and an established cultural acceptance for masonry-related products in Mexico. A similar shortage exists on the Mexican market for high quality interior and exterior paint products which are durable, environmentally friendly and non-toxic to the occupants. Floor finishes such as hardwood and vinyl tiles offer easy maintenance and installation and are further opportunities for transfer.

Modular coordination or any kind of standardization of building components is practically non-existent in the Mexican homebuilding industry. For example, windows and doors are custom made specifically for each project, whether for an individual unit or a development of several units. This method of construction is justified by the fact that labour—even skilled carpentry—is still less expensive than any type of industrialized production. However, the increasing amount of airconditioners require double-pane windows for high performance. Therefore there is a demand for good quality doors and windows in a broad range of sizes and prices to which Canada's homebuilding industry could easily cater. Additional areas of conceivable transfer are modular kitchen and bathroom components and accessories, hardware products, electrical equipment and higher quality bathroom fixtures and faucets. For example, kitchen cabinets made of quality pressed wood with durable finishing and an affordable price are merchandise that Canadian manufacturers can offer to a wide range of the Mexican market.

Careful research was needed to identify and select materials and components that offer affordability without sacrificing durability and efficiency and to modify the products accordingly to better suit the needs of the Mexican target market. For example, the supplier of the windows and doors, Bonneville Portes et Fenêtres, attempted to match Mexican price standards with high-quality Canadian windows. The aluminum window design was modified to comply with the Latin American climate which eliminates the need for thermal glass and also to correspond to the wall panels with very affordable and practical price estimates. The supplier of the closets, Gagnon and Frères, responded with a design sensitive to both the Mexican culture and the notion of flexibility incorporated within the housing unit. A melamine wall-mounted unit for the "a la carta" storage area in the corridor was designed to provide air circulation, essential due to the humidity in Mexico, and was installed such that its base was 30cm (1 ft.) above the ground to prevent damage from the volume of water Mexicans use to wash the floor. Furthermore, this wall-mounted unit acknowledges the flexibility principle by being easily adjusted to accommodate a washing machine and dryer, and is easily dismantled in order to allow for future expansion, perhaps the addition of a stairway to a second storey, or simply to change the function of this area. Similarly, free-standing closets were installed in the bedrooms also to enable greater flexibility with respect to the function of each room. The adaptation of many products and components implemented within La Casa a la Carta embodies the multitude of transfer prospects available to Canadian manufacturers (Friedman, Poirier & Krawitz 1997).

CONCLUSION

Innovative housing technology demands an integrated, holistic approach that blends technological, managerial, socioeconomic, cultural and political ramifications into an approach sensitized by a partnership between government, industry and academia. The parallel processing of the diverse range of pertinent criteria by this productive cooperation provides the infrastructure for a means of accelerating housing technology transfer, rejuvenating local economy and alleviating the housing shortage in Mexico. This high demand for housing in Mexico and the projected decline in the Canadian housing industry combine to create an intriguing balance between

supply and demand utilizing industrialized transfer as its medium. A corporate-university alliance wishing to undertake a transfer project must realize and account for the numerous challenges inherent to technology transfer which encompass cultural values, local building codes and standards, construction methods, in addition to maintaining affordability. The essential cultural, climatic and technical sensitivity required for this transfer of specialized technology dictates that Canadian products be modified to comply with Mexican demands in order to be competitive and appropriate to the targeted market segment. A systematic and organized introduction of new building systems can improve the situation in local markets and create opportunities for the development of local factories to manufacture building components and products to relieve technological dependence.

La Casa a la Carta embodies these principles and illustrates an innovative response to the Mexican housing deficit. Built in only three days in Guadalajara, Mexico, La Casa a la Carta was successfully realized for the affordable price of \$20,000 (Cdn. \$). In a network between a Mexican architect, the university and housing industry the needs of the growing middle-class were translated to 20 Canadian manufacturers who modified structural panels, kitchens, windows, light fixtures and various other products and further extended to the urban context with respect to planning parameters. Fundamentally, designing for flexibility while maintaining affordability has emerged as a mechanism that allows residents to adapt and modify their living spaces according to their evolving requirements and desires and which aligns directly with the Mexican notion of progressive development and long-term residential occupancy. With the initial unit composed of custom components, the design and configuration are tailored to the particular needs of the occupants. However, significant research remains to be carried out in a continued collaboration between the private sector, government and academics.

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