industrialized housing

THE OPPORTUNITY AND THE PROBLEM IN DEVELOPING AREAS

IDEAS AND METHODS EXCHANGE NO. 66
PREPARED FOR THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT THROUGH THE OFFICE OF INTERNATIONAL AFFAIRS, DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, WASHINGTON, D.C. 20410

IDEAS & METHODS EXCHANGE NO. 66

industrialized housing

BY IAN DONALD TERNER
& JOHN F.C. TURNER

IN CONJUNCTION WITH OSTI,
THE ORGANIZATION FOR
SOCIAL & TECHNICAL INNOVATION,
CAMBRIDGE, MASSACHUSETTS

PREPARED FOR THE U. S. AGENCY
FOR INTERNATIONAL DEVELOPMENT

THROUGH
THE DEPARTMENT OF HOUSING
AND URBAN DEVELOPMENT
OFFICE OF INTERNATIONAL AFFAIRS
WASHINGTON, D.C. 20410

JANUARY, 1972

FOREWORD

The problem of providing suitable shelter in the world's less-developed nations is one of critical urgency. Contributing to the great demand for housing, from Peru to Pakistan to the Ivory Coast is a burgeoning population, dwindling supply of urban land, rural-to-urban migration and the ravages of natural disaster. While this problem grows more acute, the industrialized nations of North America and Europe are struggling to meet their own housing needs and are doing so through an increasingly advanced technology. It is a natural consequence of this process for housing manufacturers, technicians and public officials to seek possible applications of this advanced technology in less-developed countries. Although opportunities are readily apparent to both the "exporters" and "importers" the problems inherent in this approach are often overlooked by those unfamiliar with the political, economic, social and technical realities in those countries.

In recent years HUD's Office of International Affairs has increasingly been called upon to advise domestic housing producers and, through AID, foreign governments and developers on the appropriateness of industrialized housing techniques abroad. It has attempted to correct widely-held misconceptions, while witnessing the costly failures of many attempts to develop and export a variety of building systems.

This experience has prompted the preparation of this document, which discusses and illustrates the negative, as well as positive, merits of exporting housing technology. An attempt is made herein to develop criteria for assessing the value of existing industrialized systems abroad and at the same time to assist in the design of new systems created specifically for that market. It was prepared through the Organization for Social and Technical Innovation (OSTI) in Cambridge, Mass. by Ian Donald Terner of the MIT-Harvard Joint Center for Urban Studies, and Professor John F. C. Turner of MIT. Guidance was provided by Mr. John G. Colby, Chief, Technical Assistance Branch, Office of International Affairs, HUD.

TABLE OF CONTENTS

PHOTOGRAPHS, DIAGRAMS, AND TABLES

AUTHORS' PREFACE

A study of industrialized housing in developing economies cannot avoid confronting such basic and underlying issues as the nature of both "housing" and "development" to man and society. Although the meaning of such fundamental terms may appear to be self-evident, we wish to reflect briefly on them in order to establish a common frame of reference for much of the discussion and many of the value judgments which follow. However, in this short space all that can – and must – be done is for us to state the most basic premises which we have adopted for this discussion. Once having done so, most of the issues addressed in this report are intended to be largely pragmatic, and will hopefully respond to the day-to-day crises and decision situations in which our colleagues find themselves.

In this report the word "housing" signifies much more than houses or dwelling units – it refers to the activities of people (and their organizations and institutions) building and using houses and the directly related utilities and services. In other words, when we write the word housing, we have in mind the *actors*, their organizations, and their organized *activities* – as well as the material products or *achievements* of their actions.

Housing can be understood as an *activity* or as a *product* or set of products; the word itself can be used as a *verb* or as a *noun*. When housing is understood as a material product or as a noun, it will be evaluated quantitatively: the number and material quality of dwellings will be the measure of housing value or of the success of a housing policy. When housing is understood as an activity or as a verb, the value of material production will be qualified by the affect that it has on the people concerned and on the economy as a whole. If, as we assumed, what matters is what housing *does* for people rather than what it looks like through camera lenses or in statistics, then an observer will delay evaluation of a particular housing technique or product until he has examined the changes in the lives of the housed and in the economy or the lives of those indirectly affected.

For the purpose of this report, the word "development" means the progressive improvement of living standards with emphasis on quantity where levels are dangerously low, and with emphasis on the quality of life where levels of consumption and waste are extremely high. Thus the growth of gross product alone is *not* considered to be an adequate measure of development, for on the one hand, it can divert attention from an extreme imbalance or maldistribution of national wealth, and on the other, it may lead to potentially mortal levels of pollution. The rate at which the aggregate of all consumption grows in any particular area will only indicate genuine development if it is accompanied by a reasonable sharing of the wealth, and as long as the waste generated does not reduce the expectancy of life.

It is commonly assumed that industrialization is a key to development, and indeed that assumption is not at issue in the discussions which follow. What is at issue, however, is the *way* in which industrialization takes place, as well as its net effect on development and on the institutions and well-being of society in general.

I.D.T.
J.F.C.T.

Part I

INTRODUCTION

The Promise of Industrialization

Industrialization has led to immense increases in production and consumption of almost all material goods: clothing, vehicles, appliances, books, medicines, household goods, and even food. And since industrialization is one of the primary means by which the wealthy nations of the world have enriched themselves, it is not surprising that the poorer three-quarters of mankind now impatiently demands industrialization and the expected abundance of material wealth that flows from it.

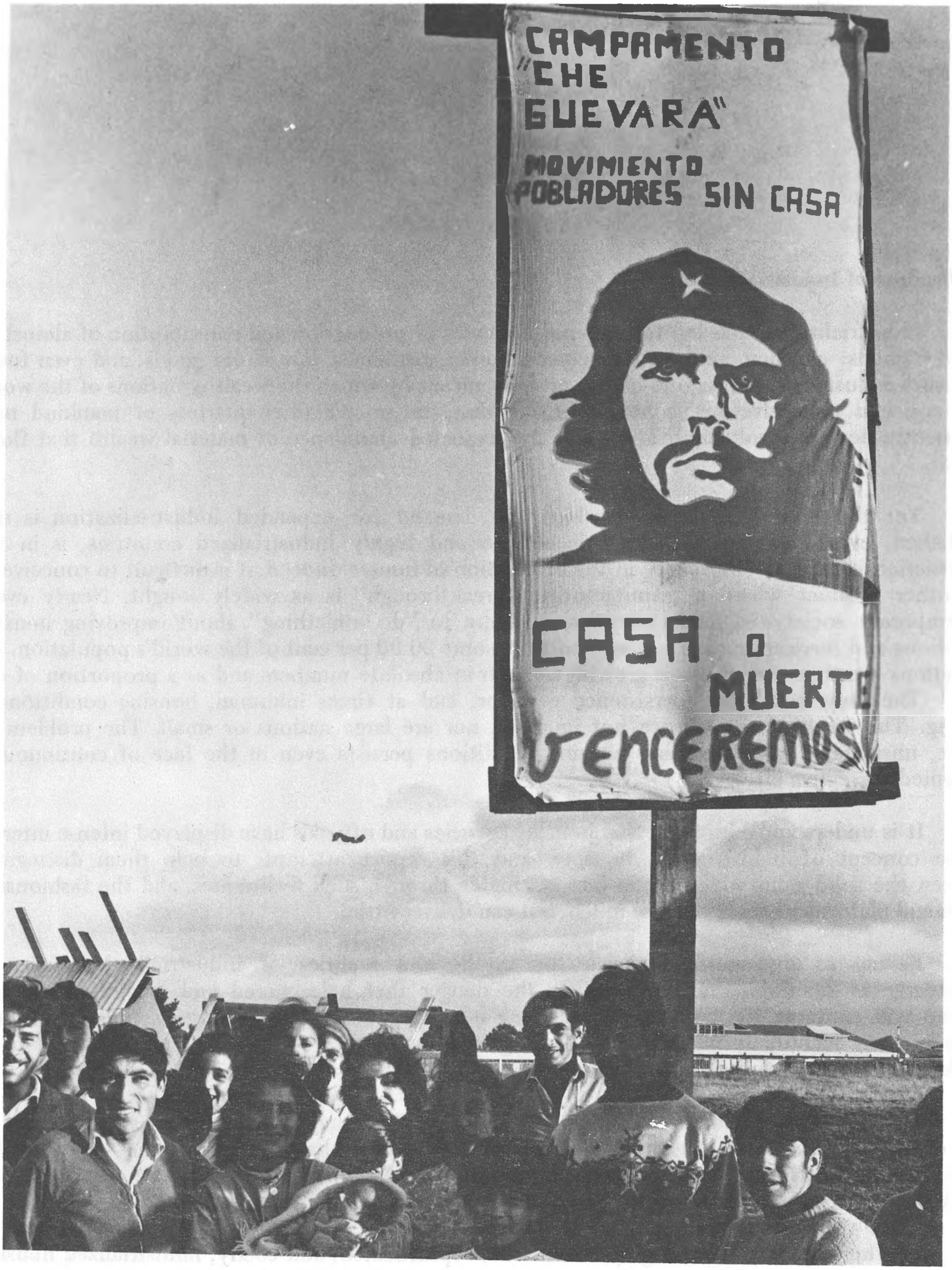
Yet the one major area in which the demand for expanded industrialization is still unsatisfied, even in many of the high income and highly industrialized countries, is in the construction industry – especially in the production of houses. Indeed, it is difficult to conceive of any other product where a manufacturing "breakthrough" is as widely sought. Nearly every contemporary society is facing relentless pressure to "do something" about improving housing conditions and services for a group now totaling some 20-30 per cent of the world's population. All indications are that that group is growing – both in absolute numbers and as a proportion of the total.[1] The universality and persistence of poor, and at times inhuman, housing conditions is striking. The wealthy nations are not immune, nor are large nations or small. The problem of unsafe, unsanitary, and degrading housing conditions persists even in the face of continuously attempted corrective efforts.

It is understandable, then, that housing agencies and officials have displayed intense interest in the concept of industrialized housing, and this report attempts to help them distinguish between the solid gains which are in fact attainable through such techniques, and the fashionable myths and platitudes which promise much, but can deliver little.

Failing to distinguish between the myths and realities of industrialized housing – particularly in developing areas – invites the danger that beleaguered and frustrated housing officials will continue the pattern of importing into their countries the large, sophisticated, and costly housing manufacturing plants of the highly industrialized countries. There are three basic problems with the continuation of this pattern:

1) The drama of importing a large new housing plant may continue to substitute for, or at least divert attention from, the need for fundamental policy changes and reforms – particularly when answers are lacking to prerequisite questions such as: who shall be housed? on what land? with what services and infrastructure? and with what forms of credit and financing?

2) The importation of highly automated, sophisticated, and costly, industrialized housing equipment may also continue to divert attention from the relatively simple, inexpensive, and highly-productive steps toward housing industrialization which may be accomplished by developing nations themselves; and which promise equal or greater housing gains than the large imported systems, but without creating adverse balance of payments situations.



A HOUSE OR DEATH – Nearly every society is facing relentless pressure to "do something" to improve housing conditions. The sign above these Chilean families reads: "The 'Che Guevara' encampment; The movement of citizens without a house; A house or death; We will win."

(Photo by James Goodsell, The Christian Science Monitor, 1971)

3) The importation of fully industrialized plants, which is often justified on the basis of exaggerated, inappropriate, or incomplete commercial and promotional claims, may continue to consume and waste vast amounts of vitally scarce material and human resources from developing economies.

This report attempts to look at the overall problems of industrialized housing, and hence should be of interest to all who maintain the reasonable hope that the quantity, quality, and economy of housing can be improved through modern industrial technology – whether those interested are citizens of the post-industrial economy of the United States, or of the least-industrialized countries of the Third World. However, the special emphasis of this discussion is on the problems faced by housing professionals and public officials in countries with low and very low per capita incomes, and the case materials presented in Chapter 3 focus on such areas.

The Questions Addressed

This report is addressed to technicians, planners, administrators, and policy makers faced with the need to take immediately effective action. Thus it moves directly to focus on two pragmatic questions:

- can the adoption of available industrial techniques contribute to the satisfaction of current housing needs for significant numbers of people in incipiently industrializing or transitional economies?

- can the industrialization of housing construction in these economies also be made to contribute to desirable forms of social and economic development?

As summarized in the following sub-section, the responses to these questions are not a simple "yes" or "no." They must be greatly qualified by the nature of industrialization and the ways in which it is employed.

The responses offered are intended for two kinds of practical use. First, while generally avoiding discussion of specific commercial systems, they begin to define a form of "consumer's guide" to industrialized housing. They suggest the kind of analysis framework that should be considered by any responsible official before deciding to commit resources to the production of industrialized housing. Secondly, this methodological framework also becomes a performace specification for designers, entrepreneurs and manufacturers of housing systems for developing areas; the same criteria which help a consumer to measure the potential effectiveness of any housing system can also be used by suppliers to tailor more appropriately their designs for particular uses and users.

Major Conclusions

The report offers nine major conclusions:

1. **Composite Process.** The study concludes that industrialization is a composite process, parts of which are immediately appropriate and useful in developing areas, and parts of which are not. Industrialization encompasses four major and independently variable aspects: 1) systemization of products; 2) specialization of labor; 3) concentration of production and marketing; and 4) the mechanization of production.

2. Increasing Risk. The implementation of each of the variables above involves respectively greater risks, ranging from virtually negligible risk for designs for product systemization, to relatively high risk for the capital investment needed to mechanize housing production.

3. Partial Industrialization. From the composite nature of industrialization, it follows that there are different degrees or types of industrialization, depending upon which aspects are included and combined in any given scheme. It also follows from Conclusion 2 (above) that different combinations will be associated with different levels of risk. Thus it is necessary to identify and recognize a spectrum of industrialization strategies ranging from certain low-risk, partial strategies (which may rely on only product systemization and labor specialization) to higher-risk, full industrialization strategies.

4. Influence of Context. The design of a particular industrialization strategy must be determined by the development level of the economic context. Specifically, the study views the progression of the overall degree of development in a society as increasingly able to mitigate the escalating risks of the higher investment aspects of industrialization. In support of this observation, the case materials reveal that building systems prematurely introduced into less-developed contexts are characteristically beset by chronic production stoppages or "down time" during which costly machines stand idle and, consequently, overhead costs rise. While such stoppages may be trivial in an industrialized society, halts for equipment repairs, for example, may take many times longer to execute in a less-developed economy because of a general lack of supporting facilities and services. Under such conditions industrialized operations are often forced to provide a costly, independent infrastructure in an attempt to create in miniature the missing services and facilities which industrialized manufacturers regularly rely on in fully developed economies. These special efforts to reduce downtime and overhead by creating an internal support structure are costly in themselves, and hence, increase overhead burdens and unit costs anyway.

5. Intermediate Technologies. The analysis draws the distinction between the industrialization of the home manufacturing *process*, and the housing output or final *product*. Thus, in addition to determining that a partially industrialized manufacturing process is desirable, the study also defines a need for *intermediate product technologies.*

These technologies lie midway between the traditional array of unrelated, uncoordinated, and often incompatible building components, and the highly systemized and sophisticated "packages" of room- and house-sized modules that typify the "heavy" building systems of industrialized nations. The intermediate technologies are principally characterized by a coordinated, simple, and non-assembled system of components. Such technology gains its greatest potential when it can be utilized not only by professional contractors, but also by self-help builders who possess no prior construction experience or skills. Furthermore, the ideally designed, intermediate technologies would allow all builders to use the components with maximum freedom and autonomy to produce a wide variety of dwelling designs and configurations according to their own perceived needs and priorities.

6. Transitional Technologies. Corollary to Conclusion Five (above) is the notion of transitional technologies which are defined as intermediate technologies possessing the additional capacity to be industrialized partially and gradually *without changes in component configuration.* Implied here are component designs which take cognizance of the fact that the same component, may be initially produced using only partially industrialized methods, but that it ultimately may be fully industrialized as lower-risk ventures succeed, and as demand and the support of the society allow. Critical is the fact that the manufacturing transition not produce incompatibilities between the earlier and later components.

7. Indirect Industrialization. The study concludes that housing should be one of the later products to be industrialized in the sequence of economic development. Whereas it is relatively easy to industrialize pins, or bricks – even in a transitional economy – it is vastly more difficult to industrialize housing, not only because of its sheer size and cost, but also because it is much more complex, and subject to a wide and changing range of user needs and requirements. Hence, *indirect* industrialization is identified as a strategy for the earlier stages of national development. Thereby, suppliers to the housing industry, rather than the overall housing sector itself industrialize such components as bricks, blocks, and fixtures.

8. Combining Strategies. Indirect industrialization (above) may take place without regard to, or any relation to, the partial industrialization of the housing industry, or to intermediate or transitional technologies. In fact, this is by far the most common approach–whether planned or spontaneous – throughout the developing world. However, when indirect and partial industrialization can be strategically *combined* to produce an intermediate building system of simple, coordinated, and compatible components–some of which may be initially mass-produced, and others not – but all of which *can* be ultimately mass produced, then the greatest potential is achieved for improving housing quality, quantity and economy in developing areas. Furthermore, this potential is achieved while minimizing investment, and hence, the risk that the attempt will be counter-productive to achieving new economies in housing–the single most important objective in economies of scarcity.

9. Social Costs. Improving housing quantity, quality and economy – by whatever strategy – does not exist in a social vacuum. For example, improving quantity and quality at the expense of cost might, under some circumstances, be politically and economically feasible, but would *not* be socially desirable, since in an economy of scarcity, such a strategy could only widen the gap between rich and poor. Other social costs which can accrue from housing industrialization include displacement of conventional construction workers in economies of already-high unemployment, reduction of housing choices, improvements in housing for only part of the population at the expense of other parts, aggravation of class differences between workers and managers, balance of payments problems, pollution, etc. Clearly these potential social costs must be kept within acceptable limits if industrially improved housing is to be of net social benefit.

Definitions

Central to the theme of this paper is a series of terms which will be used repeatedly, and to which the authors ascribe specialized definitions.

1. *SYSTEMIZATION*-the design process which gives rise to an assemblage of standardized and correlated construction components used to form a dwelling unit, whereby *ad hoc* construction methods are deliberately rationalized and regularized, usually in the interests of economy, speed, and quality control.

2. *INDUSTRIALIZATION*-the process often referred to as "mass production," whereby products, which traditionally may have been made in a hand-crafted and individualized way, are manufactured in larger quantities by a new set of processes which usually imply: 1) a standardization of the final product; 2) a specialization of labor; 3) a concentration of production, purchasing, and marketing; and 4) mechanization or automation of production processes. In addition to increased output, industrialization often implies lower costs because of economies of scale and productivity increases, and uniform and predictable (if not improved) quality of output.

3. *STANDARDIZATION*-the process whereby parts or products are manufactured in such a way as to be similar enough to be interchangeable, and so that they compare within an accepted or established range of values for size, shape, weight, quality, strength, etc.

4. *LABOR SPECIALIZATION*- the breaking down of work tasks into component operations, and their distribution among a larger number of workers implying an efficiency and expertise in performing the simplified subtasks that would not be present in performing the original, more broadly defined task. Specialization also implies the need to more thoroughly coordinate and manage the larger number of subtasks to assure that they are efficiently combined to produce the desired end product.

5. *CONCENTRATION*- the gathering of manufacturing, purchasing, and marketing aspects into a unified location in order to effect greater production control, economies of scale and agglomeration, and a more consolidated and efficient market penetration.

6. *MECHANIZATION*-the substitution of machines for human labor – whether physical or mental.

7. *COMPONENTIZATION*- the differentiation of the construction process into relatively separate or autonomous structural or functional subsystems. When these subsystems or sets of components are correlated, as in a housing system, each of the components can be modified, either without substantial changes to the others, or in such a way that a change may be predictably traced through the entire system. In this way one may understand how the initial change affects the series of companion subsystems.

8. *PREFABRICATION*- the advance production of standardized components or sections of buildings, ready for quick assembly and erection at a building site. Often this production is undertaken at a factory or work area away from the actual site itself.

9. *MODULAR COORDINATION*- the specific application of standardization in the construction industry, so that building materials and components are designed to be made more interchangeable by having their key dimensions conform to full multiples of an agreed-upon measurement (or module). In many areas the recommended module is 10 centimeters or 4 inches.

10. *'CLOSED' SYSTEM*- an industrialized building system which is internally compatible, but which cannot be combined with other functionally similar systems and does not therefore, permit the assembly of hybrid or mixed systems.

11. *'OPEN' SYSTEM*- an industrialized building system which is made up of components or subsystems which are interchangeable with those of other systems – through modular coordination and the use of compatible or standardized joining techniques.

The eleven terms, above, are used to describe the concepts of systemization and industrialization and their relationships. Figure 1-a illustrates the properties of systemization, and Figure 1-b shows the basic elements of industrialization. Figures 1-c and 1-d then show alternative ways in which these two concepts can be combined to form various industrialized housing systems.

Limitations of the Study

Although the study attempts to deal with industrialized housing in "developing countries," the authors immediately recognize the difficulty of such a sweeping generalization. Nonetheless it is sometimes helpful to group the nations of the "Third World" together, emphasizing many of their common aspects, and temporarily overlooking their differences.[2] These differences become absolutely critical, however, in attempting to use the generalizations offered by an analysis such as this in a specific situation as the basis for policy changes or recommendations. To do this without full consideration of the individual and unique qualities of an area, precludes a sound and responsible determination.

At present, the study is also limited in that any attempt to judge rigorously the applicability of industrialized construction techniques in developing countries is beset with difficulties. Construction data comparing conventional and industrialized techniques for comparable housing units is virtually non-existent. Either the data is fragmentary, or the actual end-product houses are not comparable; hence a broad quantitative analysis is virtually precluded. As the prestigious Building Research Station of the British Ministry of Public Works noted recently, "this is a field in which we have no detailed accounts of case studies of actual experiences with building systems. This is a field in which we ourselves are attempting to enter . . . ."[3] On the other hand, certain fragmentary data are available, and one may draw tentative conclusions from them. An abundance of qualitative and descriptive information is available about industrialized housing in many countries – both developing and developed, and this may be used to fill out the fragmentary quantitative picture.

The scope of this study is also limited in that it concentrates only on the construction process while avoiding detailed references to the other critical dimensions of housing policy such as the provision of land, infrastructure, and financing.

FIGURE 1:

SYSTEMIZATION AND INDUSTRIALIZATION — THE RELATIONSHIPS BETWEEN TERMS

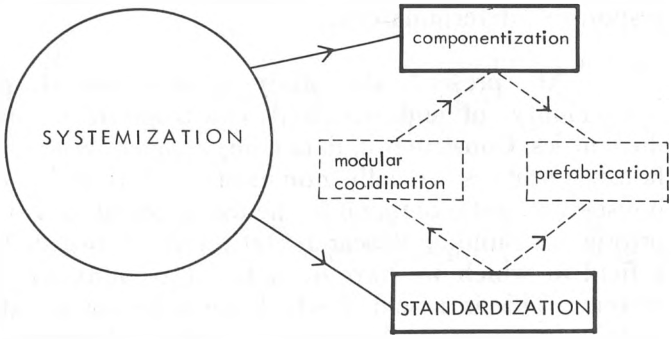
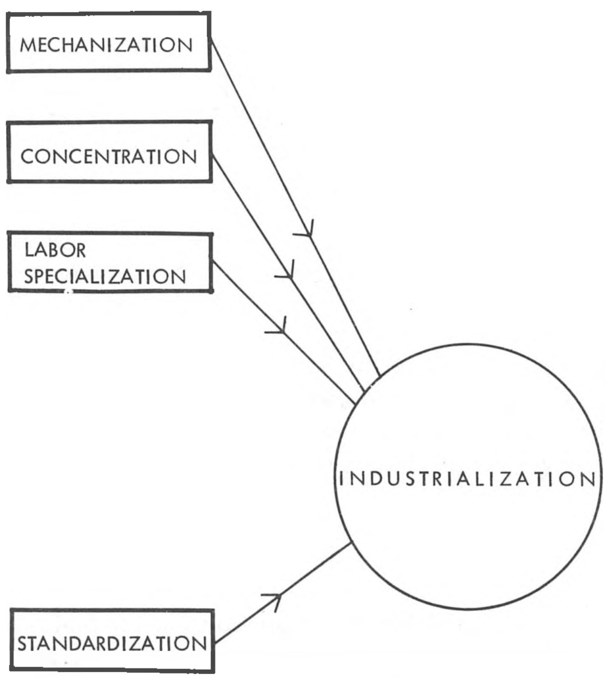


FIGURE 1-a:

Systemization leads directly to the concept of a rationalized set of *standard components* (see heavy boxes). *Modular coordination* (dotted box), a desirable but optional extension of standardization, provides for greater interchangeability among components by assuring that all key dimensions conform to full multiples of an agreed-upon measurement or module. *Prefabrication* (dotted box), an optional extension of both componentization and standardization, provides for the advance production of uniform building parts, often to gain increased production control by working away from the building site in a factory or special work area.

FIGURE 1-b:

The four prerequisites for full industrialization are shown to be standardization, concentration, and mechanization. Note that standardization is common to both figures.



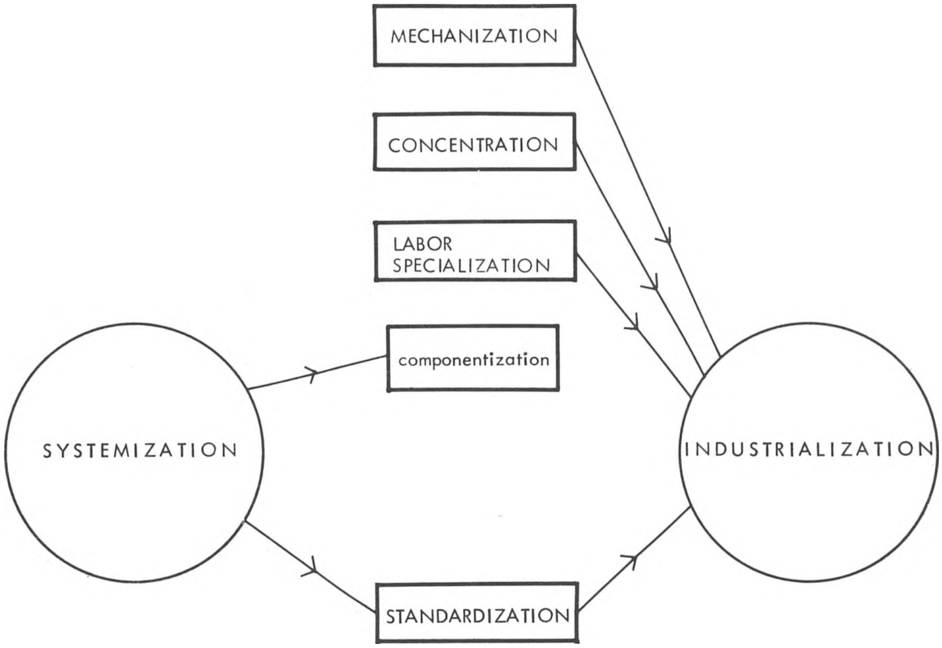


FIGURE 1-c: A fully industrialized building system combines the major elements of the preceding diagrams. Hence, a systematic or rationalized set of standardized components is produced in a labor-specialized, concentrated, and mechanized way.

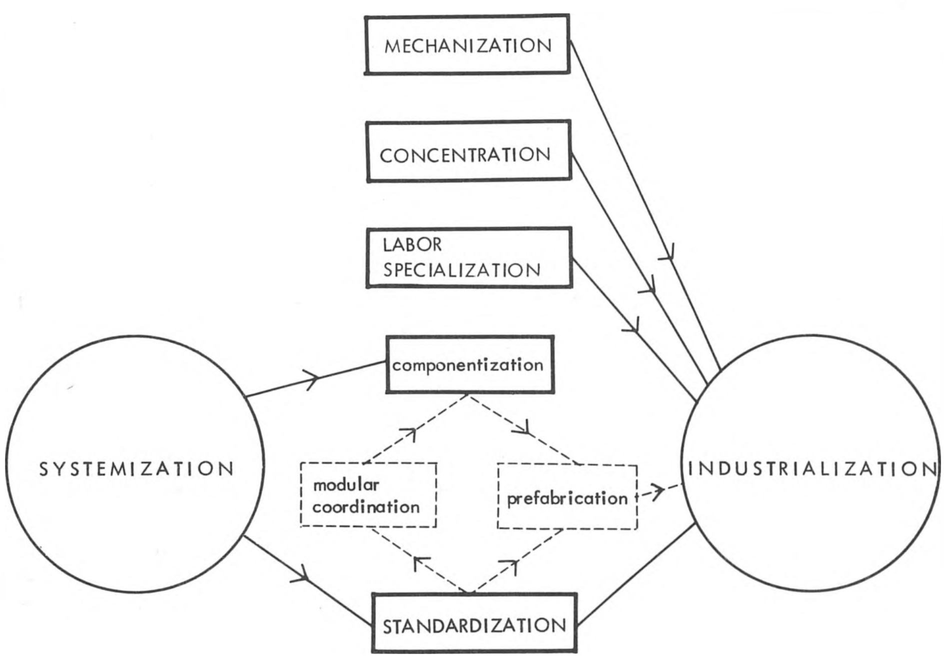


FIGURE 1-d: When modular coordination is added, the system becomes more "open," i.e. its parts become more interchangeable with those of other systems, allowing greater user flexibility and choice. This is particularly true when joining techniques are also compatible. The prefabrication option is designed to increase production efficiency and control.

Part II

INDUSTRIALIZATION: MYTHS AND REALITIES

THE DEMAND FOR INDUSTRIALIZED HOUSING –PAST, PRESENT, AND FUTURE

Past History

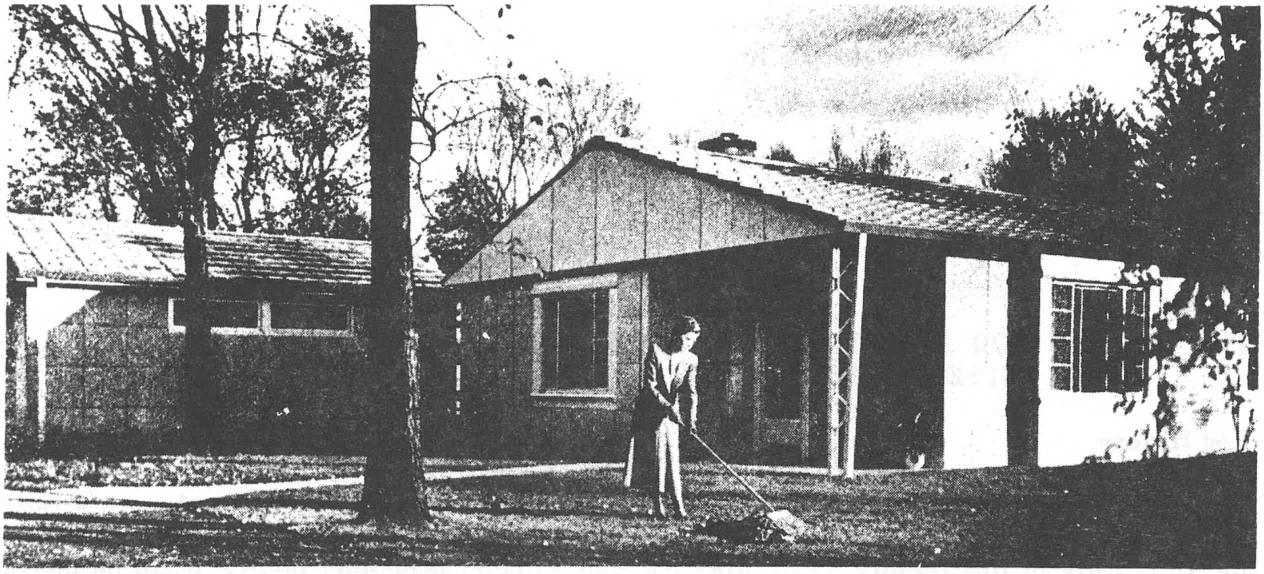
Industrialized housing concepts, particularly in the developed nations, are not new. As early as 1624, the English made use of prefabricated panelized houses for shipment to the New World. In the U.S., early in this century, Sears Roebuck sold 110,000 mail-order houses, based on precut standardized components, which pioneered many of the assembly line production techniques in use today.[1]

In 1934, Catherine Bauer reflected on the housing problems that followed World War I in Europe. She noted that " . . . in the years immediately following 1918, there was a grave shortage of all the traditional materials, particularly brick, and also a shortage of building labor skilled in the old trades. It is therefore no surprise," she wrote, "that volumes could be filled with the descriptions of structural experiments which have been carried out during the past fifteen years."[2]

She described some of the major contemporary experiments at the time: "The public authorities of Amsterdam, around 1924, erected an entire village out of concrete. Forty different systems were tested, and about ten tried out on a large scale – including poured concrete, prefabricated concrete walls or parts of walls, and concrete blocks made on the job. Small houses for thousands of families and also schools, shops, public buildings, and clubs, were put up. An enthusiastic report was published, to describe the economies thus effected."[3] Similar projects in Scandanavia and France were also described for that period, and in Germany Bauer reported that two factories were set up to manufacture large panels precast from lightweight concrete. "Houses were designed on the basis of these units, and several thousands of them were soon constructed. There were many obvious advantages. Much of the production was done in factories, thus reducing the weather gamble. And eighteen men could put up the shell of a two-story house, including cellar and floors, in a day and a half, or two hundred and thirty hours of labor all together."[4] Cost savings were officially estimated at 10%.

However, industrialized housing systems did not account for any significant proportion of residential construction until the post-World War II period. Then conditions in Europe literally demanded hundreds of thousands of new units in the war-destroyed cities on an emergency basis. Thus the stage was set for the only large scale implementation of industrialized housing in the world to date.[5] The extraordinary conditions which gave rise to this situation are important to note. Generally, six factors characterized the setting in Western Europe:

1. The greatest need was to build *large quantities* of houses in the *shortest possible time*, with *cost being subordinated* to these two major objectives.[6]



AHEAD OF ITS TIME — These post-war industrialized houses proved to be unsuccessful in penetrating the U.S. market despite heavy investment in the attempt. These types of units faced many problems—including cost, quality control, consumer resistance, inflexible building codes, and restrictive labor practices—the last two being not as often encountered in developing areas.

2. The countries committed *top national priority* to expediting the mass production of shelter.

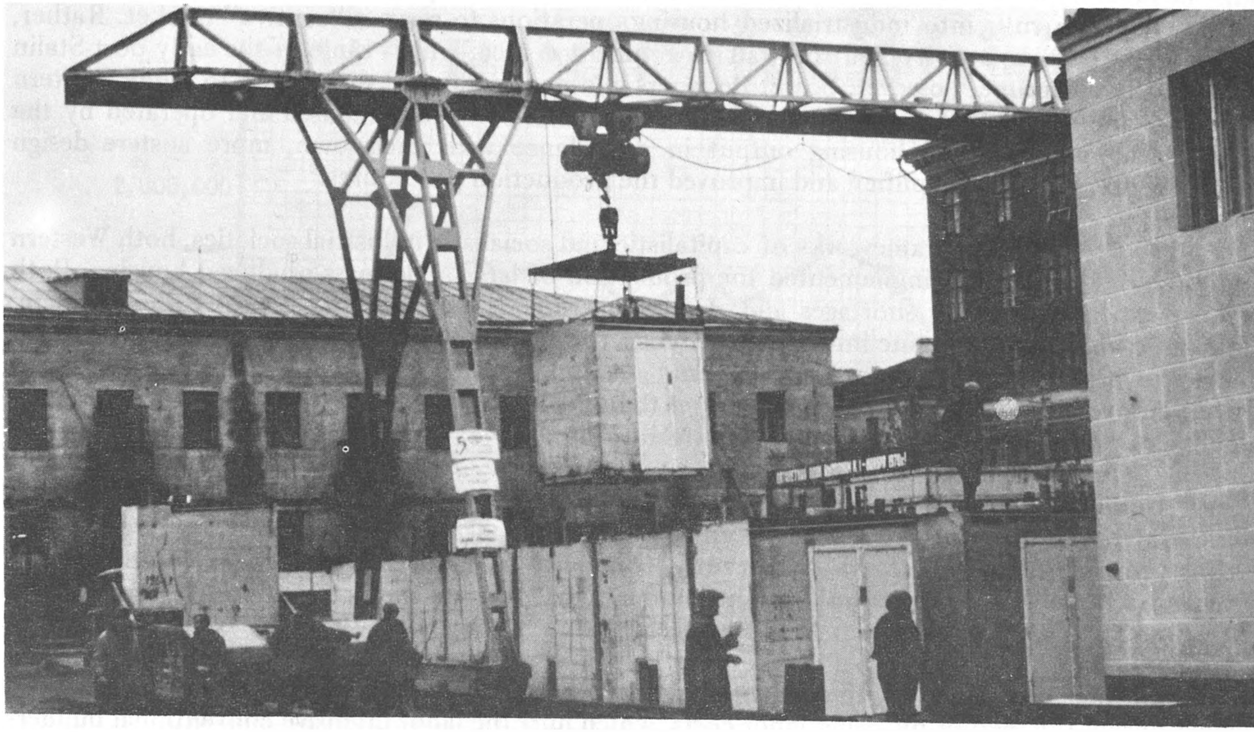
3. The countries and their traditions were *already industrialized;* labor was skilled, and investment capital was available.

4. Mass urban *markets were densely concentrated* and desperate for shelter in areas of harsh climate; customer acceptance was not critical, and all units were taken immediately. In addition, the bulk of the market was not composed of the lowest income families, for the path of war-time destruction did not discriminate by socio-economic status.

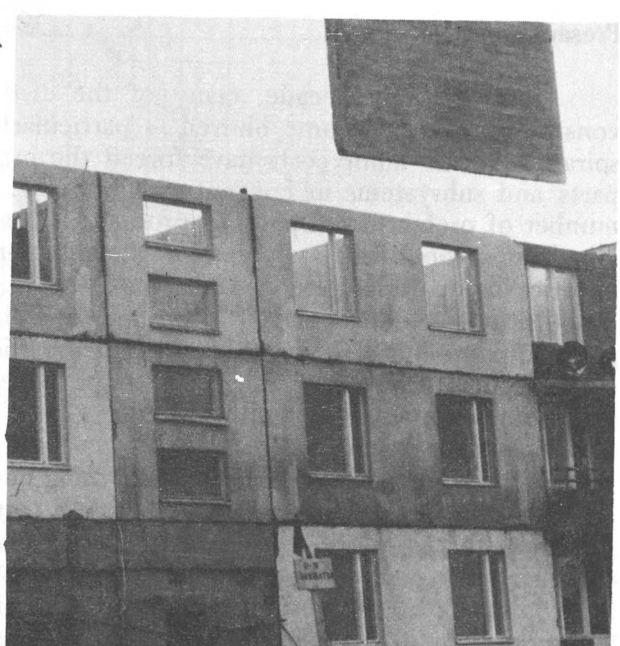
5. Land costs and development densities necessitated *high rise, apartment-type construction.*

6. An abundance of *competence and ingenuity was available in the design, engineering, and production specialties,* which mobilized themselves to solve the specific problems of a large, virtually captive market.

The conditions in the Soviet Union and other parts of Eastern Europe were similar, but with some variations. Russia "suffered more property destruction than . . . any other nation in all the wars of history. It also suffered the loss of immensely more manpower than did any other nation in World War II. The U.S.S.R. emerged then from this war in both a *need for housing* and a *deficiency of manpower* of unprecedented proportions. It was quickly and correctly determined that the necessary reconstruction could not be carried out by traditional means. Therefore, the decision was made to industrialize all building operations."[7]



SOVIET INDUSTRIALIZED HOUSING — Completed bath units are loaded from storage onto trucks (above), while wall panels arrive on site (below left) and are then lifted into place by crane (below right).



Besides the Soviets' more critical man-power shortage, which increased the pressure to implement labor-saving techniques, Russia, unlike Western Europe, did not contain or encourage entrepreneurs to rush into industrialized housing operations to serve a "captive" market. Rather, emphasis on housing activity had to await government decree, which came in the early post-Stalin era.[8] In the meantime, however, Soviet designers and engineers were dispatched to study Western Europe's commercial systems, and several complete factories were purchased and operated by the Soviets who modified the housing output in accordance with their own, more austere design requirements, and who simplified and improved the production procedures.[9]

Thus, within the frameworks of capitalistic and socialistic industrial societies, both Western and Eastern Europe each implemented the production of large-scale mass-produced housing. Both regions experienced acute shortages and strong government commitments to solve the problem. Both were able to subordinate initially higher costs to speed and volume – Western Europe through a series of producer and consumer subsidies and guarantees, and Eastern Europe by "burying" costs within an overall national development budget that ideologically viewed adequate housing for all as a public responsibility, and not a series of individual efforts.

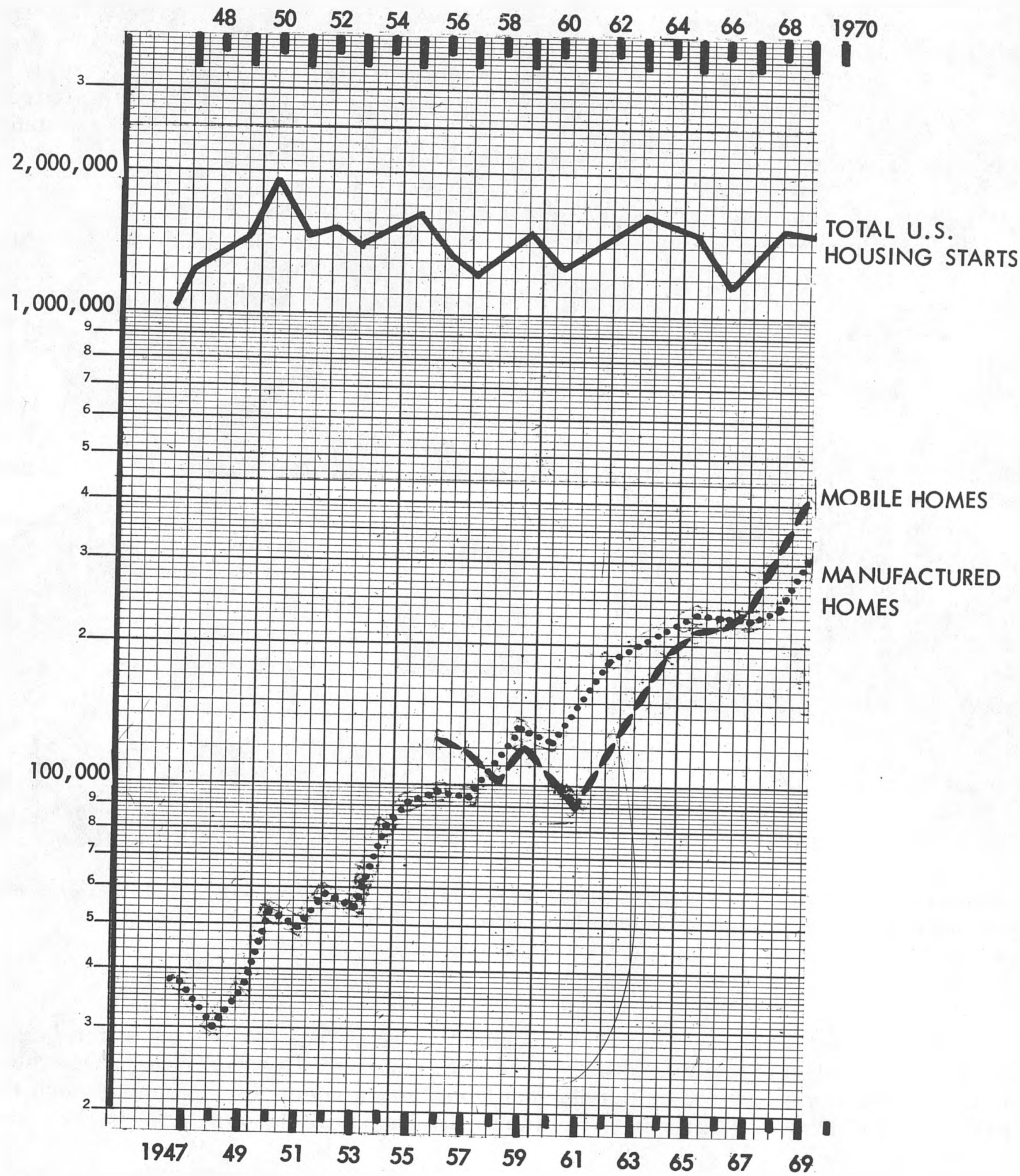
Contemporary developing nations, and indeed most industrialized nations stand today in stark contrast to many of the aspects of either portion of post-war Europe; yet these are the *only* settings to date that have been significantly conducive to industrialized housing. Both settings provided a decade of "incubation" for their industrialized producers, without which, most, if not all, would have economically perished. However, after ten years, many producers had been able to hone and refine their operations to the point of achieving unsubsidized end product costs which were more than competitive with conventional construction. Western European producers were also helped during this period by rising labor costs, which hurt the labor-intensive conventional builders more than themselves. In addition, of course, the manufacturers continued to enjoy their inherent advantage over traditional builders of a far greater output capacity.[10]

Present Demand

In the past decade, many of the distinctions between industrialized and conventional construction have become blurred – particularly in post-industrial countries like the U.S. where spiraling on-site labor costs have forced the introduction of increasing numbers of prefabricated parts and subsystems in conventional building. At present, virtually "All houses include a large number of prefabricated parts or products, mass produced by specialized firms and installed on the job. Doors, windows, hardware, appliances, cabinets, and a variety of flooring, roofing, ceiling, and partitioning materials are used in this fashion. The tendency within the industry has been to produce in the shop, under efficient and supervised conditions, as much as possible of the products going into the building, and to reduce to the minimum all on-site labor. In this fashion, the hope is that the quality of the products will be improved, that the capacity to produce will be multiplied, and that costs may be brought down."[11]

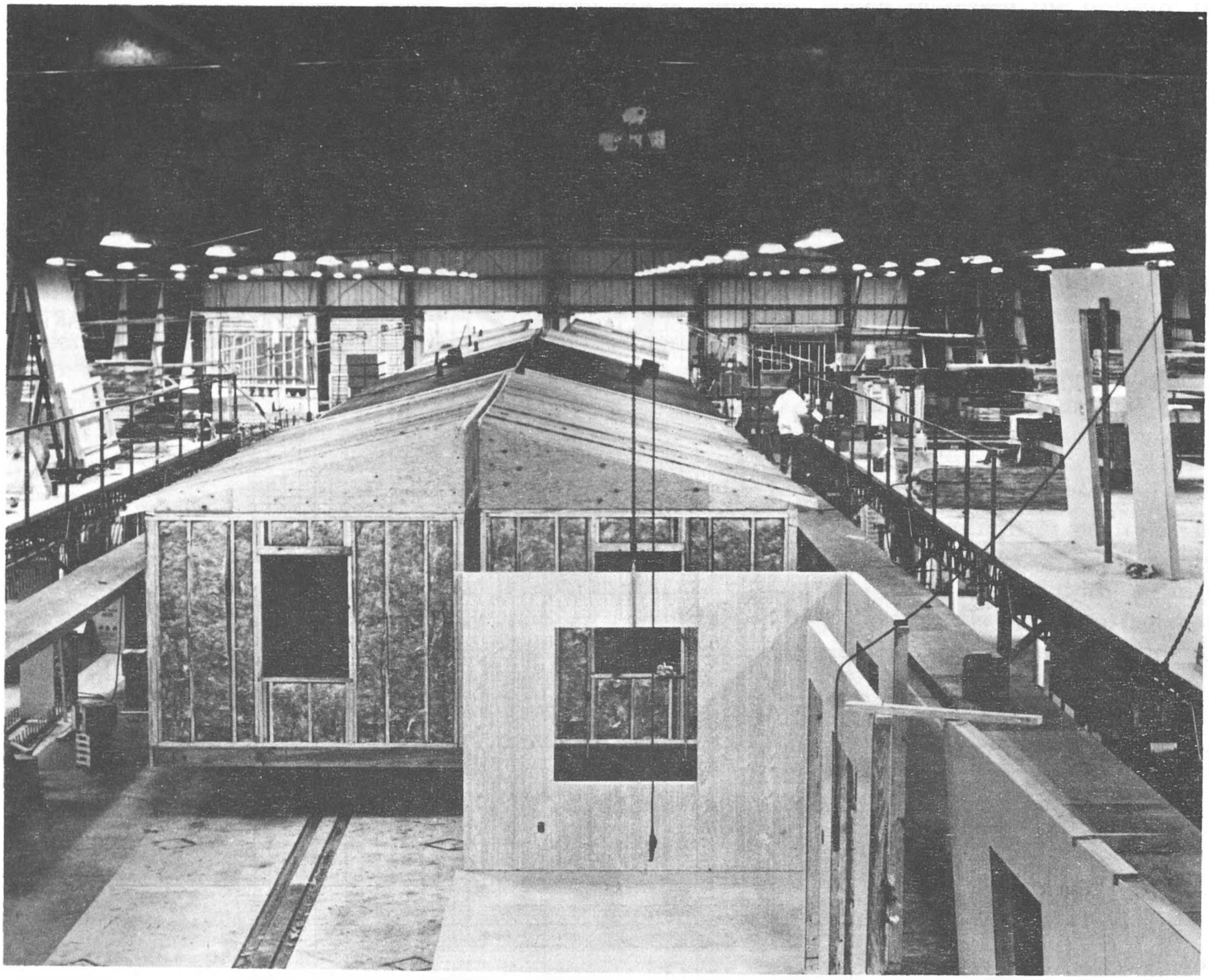
In recent years industrialized housing has come to account for an increasing proportion of housing starts in Europe, and recent growth is indicated in countries like the United Kingdom by the fact that some 40 per cent of all public sector housing starts were undertaken with industrialized methods in 1967 as compared to only 20 per cent in 1964.[12] In the U.S. approximately 16 per cent of all housing starts in 1970 were classified as "manufactured homes," and more than 20 per cent more were classified as mobile homes. Thus nearly 40 per cent of all U.S. housing was industrialized in 1970, and the growth of industrialized units far outpaced the growth of U.S. housing in general.[13] The U.S. growth of "manufactured homes," "mobile homes," and total housing starts between 1946 and 1970 is shown in Figure 2.

FIGURE 2: GROWTH TRENDS IN U.S. INDUSTRIALIZED HOUSING, 1946-1970



RAPID GROWTH — Manufactured homes (dotted line) have recently accounted for more than 20 percent of total U.S. housing starts (solid line). This total, however, does not include another form of industrialized housing — the mobile home (dashed line) — which has shown the most rapid growth, accounting for more than 400,000 units in 1969.

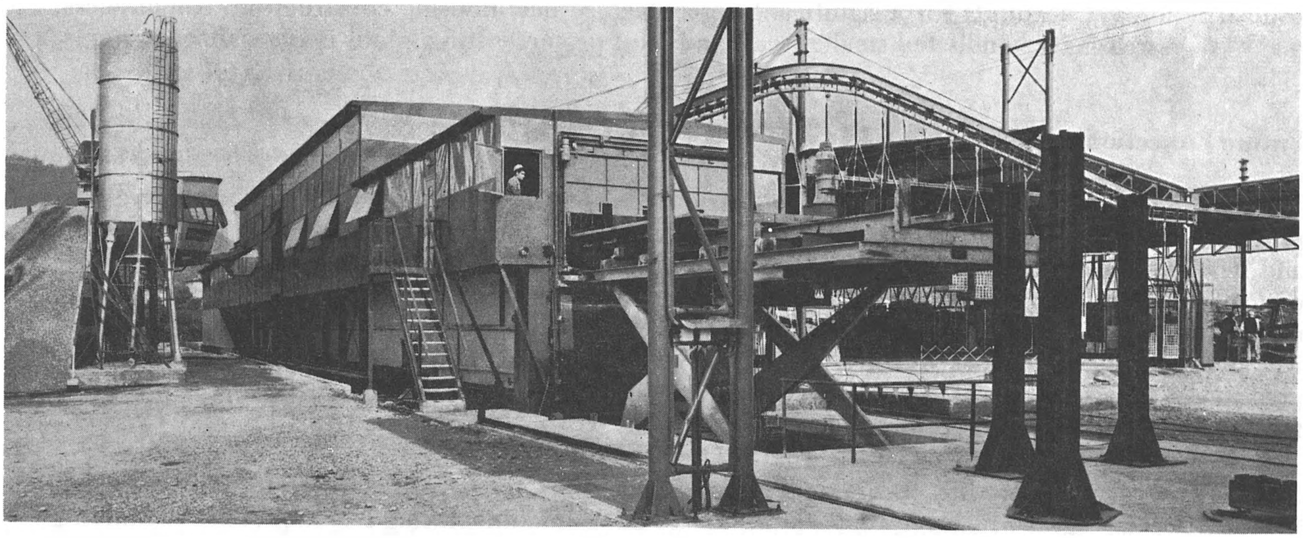
Source: Charles G. Field[13]



MOBILE HOME PRODUCTION – The fastest growing segment of the U.S. housing market is in the area of mobile homes. Significant cost savings have been achieved through complete in-factory, assembly line production.

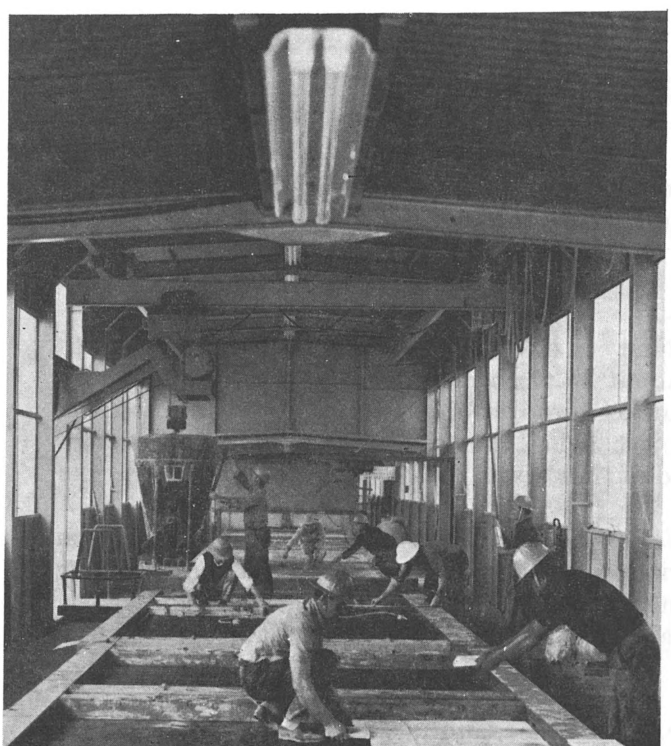
In addition, approximately 400 commercial systems are now available for licensing in Europe.[14] Generally the various European and U.S. commercial systems have proven themselves able to produce units more quickly, with less labor, and a competitive price, although they are "seldom . . . less expensive than houses produced by large scale builders using other systems of traditional construction."[15]

At present, many of these industrialized housing manufacturers are looking toward new and expanded markets in developing areas. With much of their research and development investment already amortized by construction within their own countries, the manufacturers now have the potential to reduce prices or reap greater profits in new markets. In addition, certain pieces of equipment and hardware which are considered outdated or obsolete in their own countries are still "marketable" in developing areas, which are sometimes deliberately sold hardware which is one step behind the latest level of the technology. This is done by producers in order to be able to dispose profitably of obsolete equipment.



COMPUTERIZED PLANT — This modern European housing plant (above) is designed to mass-produce high technology building systems. Components are computer-routed through an assembly line (below), and are programmed up to the hour and minute they are lifted into place (right) by an on-site crane.

(Cogefar photo)



To date, the authors have no reports from developing areas indicating that industrialized counstruction yet accounts for a significant percentage of new housing construction. Nonetheless, many such areas have conducted smaller scale and pilot projects with various industrialized systems.

Future Projections

Projections for the future of industrialized housing systems are highly tentative and primarily depend on both the absolute cost performance of the systems as they are used, refined, and developed in many contexts; and also on the costs of competing conventional techniques. The cost of labor is a critically important variable in this consideration, and if it continues to rise rapidly, labor-saving industrialized techniques will enjoy an increasing relative cost advantage, and will probably claim a more quickly growing penetration into the housing market than it does at present. In developing areas, where labor is relatively plentiful, and thus inexpensive, the prospects for industrialization are less promising.

Two trends in the U.S. underscore this point. First, construction wages exceed manufacturing wages, which reinforce the trends to adopt manufacturing techniques in the building industry. Secondly, construction labor is less productive than manufacturing labor, even though their respective wage levels suggest the opposite. The combination of these two trends, which furthermore are growing steadily over time as shown in Figures 3 and 4, provide a powerful incentive to industrialize construction practices.

Of course, cost is not the only consideration, although it remains primary unless explicitly subordinated to other aspects of industrialization such as speed and quantity, as was the case in post-war Europe. If, when and where this happens, then future projections for industrialized housing in this area would climb rapidly.

PROMISES AND PROBLEMS OF INDUSTRIALIZED HOUSING

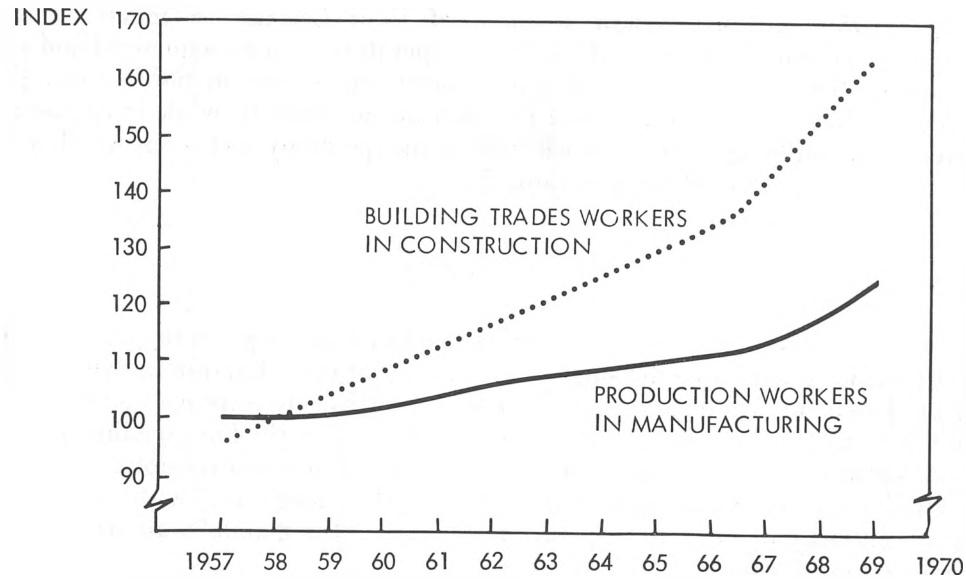
Once a governmental or private sector agency commits itself to the concept of an industrialized housing process, consideration of the risks involved tends to disappear. The following excerpt from a brochure published by the Malaysian Ministry for Local Government and Housing is an example of an outlook which notes many of the benefits and none of the costs implicit in industrialized housing.

(i) *Speed of construction.* Construction time can be reduced by as much as 40 per cent to 50 per cent for house systems and about 25 per cent to 40 per cent for multi-story flats. The saving of time allows for quicker turnover of capital employed for housing, and in the case of a housing project being financed by a loan, savings from capitalization of interest, for the period of time saved, can be achieved.

(ii) *Reduction of costs.* Costs can be reduced by 10 per cent to 25 per cent in the long run because of savings in building materials and skilled labor, the economics resulting from the repetitive process and building site. As the initial heavy investment in factory, plant and equipment is gradually amortized, construction costs can be reduced substantially.

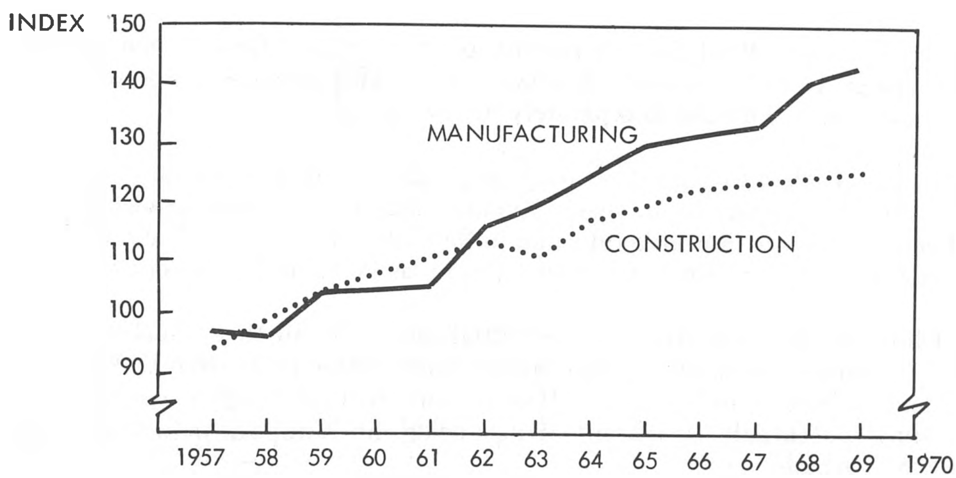
(iii) *Quality Control.* The servile machine, automatic, faithful and regular, works with a sustained exactitude, which the hand of man is incapable of, and its products are always of the same quality. Amounts of materials can be rigorously controlled, and

FIGURE 3: U.S. AVERAGE OF HOURLY EARNINGS IN MANUFACTURING AND CONSTRUCTION



WAGE DIFFERENTIAL — Wages for U.S. building trades workers in construction, when compared with those of production workers in manufacturing show an increasing tendency to be higher. (Wage index in constant dollars; 1957-59 equals 100.)

FIGURE 4: U.S. PRODUCTIVITY IN MANUFACTURING AND CONSTRUCTION



PRODUCTIVITY — From 1957 to 1962, productivity between construction and manufacturing workers was roughly comparable; however from 1962 to the present, manufacturing productivity has increased more rapidly despite lower wage levels. These trends are stimulating greater investment in the construction sector — and hence greater industrialization. (Productivity index in output per man-hour; 1957-59 equals 100)

Source: Daniel Hodes.[16]

units though complex, will be monolithic. The quality of output from the factory will therefore remain constant because of close supervision and this will ensure soundness of structure and building which in turn will reduce maintenance costs in the future.

(iv) *Organization and supervision* is more efficient because so much of the building process is carried out within the factory. Operations can be sequenced and productivity is high. Risk of accident is less since more work is done in the factory. The building sites are free of scaffoldings, and the men do not have to work in exposed situations. Above all, building operations will not be hampered by inclement weather to the same extent as in traditional construction.[17]

Cost

It is interesting to note that cost is not mentioned first in the preceding list. Yet as suggested earlier in this discussion, it remains the single most important consideration in determining whether an industrialization scheme will benefit or detract from programs to improve housing conditions for those at the lower end of the income spectrum. In fact, a between-the-lines reading of the Malaysian brochure suggests that costs are presently the same or higher than conventional construction. The promise of a 10-25 per cent savings is held out *only* for the "long run," with assurances that after "the initial heavy investment in factory, plant and equipment is gradually amortized, construction costs can be reduced substantially."

A Uniform Measure: "Development Costs". Before proceeding further with a discussion of costs, it is important to arrive at a uniform working definition, since housing costs are often measured in different ways. For purposes of this discussion, costs, unless otherwise noted, will refer to "Development Cost per Housing Unit" - which is defined as the sum of the costs of land, site development, interim financing, construction, and builder's overhead and profit.[18] Industrialization can directly affect some or all of these, depending on circumstances.

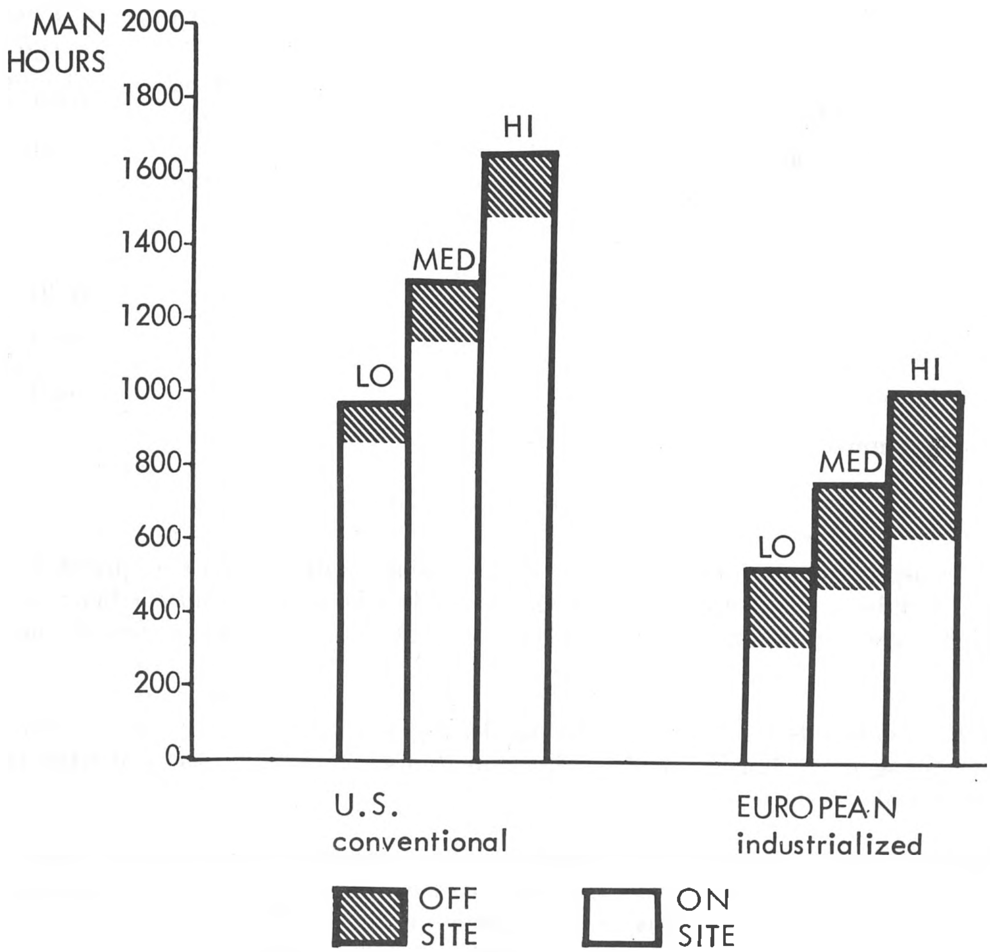
Construction Cost. Of all the components of Development Costs, construction costs are the most likely to change as a result of industrialization. The two primary components of construction cost, labor and materials are discussed separately below.

Labor: Industrialization most dramatically affects labor input due to automation and mechanization. In 1965 Soviet economists estimated that labor savings gained by "the use of the prefabricated residential building method came to 23 million man days"[19] and it has been reported that a French industrialized system can reduce labor by as much as 75 per cent.[20]

The labor saving potential of industrialization is further illustrated by comparing conventional U.S. construction with industrialized construction in Western Europe. Figure 5 graphs both on-site and off-site man-hours per 1000 square feet of roughly comparable multifamily construction, show potentially significant savings using the European industrialized methods over conventional U.S. methods.

Labor, on the other hand, like most other factors in industrialization, possesses attributes that can also raise costs; and in most cases these negative attributes appear to be potentially greatest in developing areas. Aside from the possibly crucial fact that labor savings may run counter to more general full employment goals in a society, there also may be little economic incentive to substitute capital equipment and machinery for labor. The reason is obvious. In situations of high unemployment or underemployment, or in situations of capital scarcity—both of which are common in less-developed economies—labor savings lose much of their power to reduce overall

FIGURE 5: APPROXIMATE MAN-HOURS PER THOUSAND SQUARE FEET OF MULTI-FAMILY DWELLING



INDUSTRIALIZED VERSUS CONVENTIONAL — Industrialized European construction shows savings in total man-hours over U.S. conventional construction. In addition, the high, medium, and low estimates for both types of construction consistently show a greater proportion of European construction time being spent under controlled, weather-proof, factory conditions.

Source: National Commission on Urban Problems[21]

costs, since a relatively inexpensive input is being saved, but a very costly one is substituted in its place. Typical trade-offs between capital equipment and labor are shown in Table 1.

Even the simplification of work tasks and the reduction of entry skills which result from labor specialization have their negative aspects in developing nations. With labor specialization the need for relatively high-priced management and coordinating skills increases significantly. The greater number of narrowed tasks must be adroitly balanced and orchestrated, so that lengthy operations are heavily man-loaded and brief operations lightly man-loaded. To be successful, management must establish and then maintain a smooth production rhythm, despite the inevitable contingencies and disruptions.

Table 1:
REPLACEMENT OF HUMAN LABOR BY MACHINES

Type of machine	Number of laborers replaced
Excavators, 0.15-3 m^3	20-160
Motor-scrapers, from 6 m^3	50-120
Dozers, from 80 kilograms	70-90
Motor-graders, 50-120 kilograms	30-50
Machines for earth compaction, 4-25 tons	20-50
Building cranes, 30-80 metric tons	30-40
Dump-cars, 3-5 m^3	20-30
Motor-cranes, 5 tons	10-20
Mixers, 250-750 tons	5-20
Conveyors, 4-15 meters	3-5

Source: United Nations[22]

In developing areas, however, the critical management expertise required to make the process work may be in short supply throughout the industrial sector. Thus the benefits of utilizing less skilled labor may be offset by the need for highly skilled, scarce and expensive managers and supervisors.

Increased demands for experience in purchasing, marketing, and quality control tasks also increase the management burden, and further threaten to counteract the potential labor saving aspects of industrialization.

Materials: The proponents of industrialized housing systems promise major savings in materials costs as well as in labor costs. In the best of circumstances that promise may be fulfilled through discounts on volume purchases, and often through vertical control of supply conduits which eliminate middle-man profits and the need to carry huge inventories as a hedge against scarcity.

Occasionally, industrialized operations may realize materials savings as a result of technological innovations. In a classic example, the scarcity (and thus high cost) of bricks in post-war Europe was remedied by such new technology as the refinement of *in situ* and pre-cast concrete methods, which eventually led to savings of considerable magnitudes. A contemporary instance of the same kind of savings through technological innovation is the replacement of costly copper, brass, and iron pipe by plastics and P.V.C. alternatives.

Yet savings on materials as a result of massive purchasing or innovation accrue also to large conventional builders. Furthermore, the risk of increased rather than decreased cost is inevitably greater in the context of developing areas. In a recent study of eleven partially-industrialized construction experiments in Peru, for example – all of which reduced overall costs, mainly through labor savings – only three witnessed materials savings, while eight were responsible for materials increases.[23]

There are a number of reasons why this phenomenon should be no surprise. The size of operation needed to realize significant economies of scale in materials purchases may be, in fact, so large as to induce short term or localized scarcities which, themselves, can lead to price increases of equal or greater magnitude than the original savings. This canceling effect due to price fluctuations has been observed in many developing areas as an unintended and unanticipated consequence of large-scale government housing projects.[24]

Industrialization may also imply materials cost increases if the process specifies esoteric or imported materials that are not normally produced in the local region. Advanced plastics technology, or even reinforced concrete technology, for instance, may lead to reduced materials costs in developed countries, while proving extremely expensive in less developed areas which may lack prior experience with the processes, or lack necessary supporting industries.

Interim Financing. In theory, industrialized construction is faster than conventional construction. When this is indeed the fact, shortened construction time can satisfy an important social goal (which sometimes becomes an end in itself) and simultaneously reduce the cost of interim financing, since it varies directly with construction time. For the U.S. it was estimated "that the combined savings of interest, tax, overhead, capital turnover, and earlier occupancy amount to 1% to 1½% of project cost per month saved."[25] In this case, six months saved could equal a six to nine per cent overall project saving.

Nevertheless, shortened construction time is not an advantage without risk; and, as in the cases of labor and materials savings, the risk is greater outside the world's industrially developed zones. The risk factor increases because industrialization fosters a much more critical interdependence among the specialized elements of production – management, labor, and machines. Management must assure that the pace of any subtask is predictable and is balanced with the pace of companion tasks, or bottlenecks will occur. Labor bottlenecks can arise from illness, injury, absenteeism, or strikes. And finally equipment contingencies such as breakdowns, lack of spare parts, or losses of power can also cause time-consuming delays which can trigger rising cost spirals in interim financing as well as all other cost categories.

Overhead and Profit. Reduced overhead and profit factors are traditionally expected to be a feature of industrialized mass production. For thousands of consumer goods this has been true; the profit on a single unit of production is reduced in accordance with increasing volumes sold, ultimately accounting for increased overall profits. Overhead is expected to decline to a similar degree. Even though absolute fixed overhead expenses generally mount when industrialization takes place – particularly when costly machinery must be financed and amortized – increases in production can reduce the overhead factor applied to a single unit of output.

In theory, industrialized housing should obey these rules, although operationally this potential savings is probably the most difficult to achieve. For if production bottlenecks do occur, an consequently output and sales volumes are modest, overhead costs will be shared by fewer units, and will be resultingly higher. In like manner, if fewer units are produced, profit factors cannot (and therefore probably will not) be lowered without lowering overall profits. And for the traditional private sector producer, lower overall profits are apt to be unacceptable under the circumstances of industrialization, since profit expectations are usually proportional to risks. As industrialization is generally a high risk activity, it is likely that a producer will attempt to raise profit levels (per unit) in an effort to stave off falling overall profits due to low output or sales, so that the burden of extra profit will then be passed directly to the consumer.

Thus it can be seen that while unit cost reductions remain as one of the most powerful incentives for the transition to mass production techniques, each step of the way is subject to hidden hazards which can negate or reverse presumed benefits. Cost reductions due to savings in

MASS-PRODUCED ERROR — An inherent danger of high-speed mass production techniques is that a single error may be rapidly proliferated. Such an error led to this fatal structural collapse in an industrialized building at Ronan Point, England, in 1969.

(U.P.I. photo)

labor, materials, time (interim financing), and overhead/profit are all possible, although generally the probability diminishes as the overall level of industrial development diminishes.

Land and Site Work. Land and site work are subject to savings when industrialized techniques facilitate building at increased densities. Thus a parcel of improved land at fixed cost might potentially allow more industrialized units than would be possible with conventional units. In situations where, for example, equipment such as cranes or lifting devices may be scarce or unavailable, industrialized firms often include such equipment as an integral part of their production facility, and hence may be the only producers economically capable of projects such as high rise apartments.

Yet while industrialized techniques may produce more dense development than conventional techniques, they do not necessarily do so, and in many circumstances conventional construction can achieve equivalent land and site savings.

Quantity and Quality

In addition to potential cost savings, industrialized techniques also offer increased quantity and improved quality. However, industrialization may, ironically, bring about losses in these very areas. For example, all the hazards of bottlenecks and delays discussed above as threats to cost, also persist as threats to volume – cost notwithstanding. In practice, of course, these potential negatives are inseparable and mutually exacerbating.

Industrialized production which relies on machines and specialized labor also has several implications for product quality. Optimists such as the author of the Malaysian Government brochure presume that the mechanization process itself will reduce human variability and error. Also, the repetitive nature of specialized human work is supposed to improve product quality due to the fact that each worker can focus his attention on fewer tasks and a more narrow routine.

However, industrialization can also diminish product quality. For example, when a poor or faulty design becomes finalized, hundreds of units may be produced before the flaw is detected, and possibly hundreds more before it can be corrected. In the multiple collapse at Ronan Point, England, a design error in an industrialized building component triggered a structural failure, indicating that hundreds of units previously built with the faulty components had already endangered thousands of lives. A costly modification then had to be applied to all existing units in order to reinforce them.[26] Also the thousands of automobiles periodically recalled by their manufacturers in order to correct production deficiencies offer another example of how quickly high speed manufacturing techniques can proliferate a single error.

Mirror Effect

This mirror effect, where every plus can become a minus, every desirable expectation an undesirable result, may be particularly marked in a region or country which does not have a history, economy and social system characterized by heavy commercial and industrial activity. The author of the Malaysian brochure cited at the beginning of this section sees industrialized housing in a social and economic context ideal for it; but that ideal has not been perfectly achieved in the United States, Western Europe or Japan, let alone in less developed areas of the world.

In brief, fully industrialized housing systems in the so-called "emerging areas" are almost bound to be out of phase; and to the degree that they depend on economic conditions, social goals, managerial talent and supporting services and technologies which do not exist, or exist only in nascent form, efforts in industrialized housing are apt to be difficult, if not outright failures. The case studies which follow illustrate this point.

Part III

THE IMPACT OF CONTEXT ON INDUSTRIALIZATION

CASES IN DEVELOPING AREAS

In the preceding chapter, emphasis was placed on balancing the popularly-voiced virtues of industrialized housing with the less often heralded pitfalls. Clearly, for each potential advantage, there is some risk and some potential disadvantage—regardless of social, economic, or developmental context. This chapter attempts to probe further in determining how context affects this precarious balance between advantages and disadvantages.

Candid case material dealing with how industrialized housing attempts have fared in various developing areas is rare, probably because most attempts have ended with less than complete success – and documentation of such attempts is often "embarrassing" to official agencies. Rigorous cost analyses and data are even more rare.

However, in this chapter the authors have attempted to select from the limited amount of case material available to them, three prototypical cases representing widely differing attempts to introduce industrialized building technology into developing regions.

The cases selected for this study were chosen in part because they tended to become caricatures of the actual situation, and taken together, they no doubt exaggerate some of the difficulties one can reasonably expect to encounter. However, one can be equally certain that these cases do not document or foresee *all* of the potential problems that may be met. They merely suggest the types of obstacles and difficulties that might arise, and some attempts which have been made to surmount them.

The three cases were carefully selected on the basis that they represent a wide range of experience. Geographically they span developing regions of three continents: Africa, South America, and Asia. In time, the case studies span two decades – from the early 1950's to 1970.

From an organizational point of view, the cases give insight into three completely different types of operations. The attempt at industrialization in Africa was strictly an official enterprise, in which a national government intended to own and manage the industrialized housing factories involved. The case analysis is seen from a "macro" or overall viewpoint.

The South American venture was conceived as a strictly private, profit-making enterprise. The government played no direct role, and was involved only in granting favorable taxation and import benefits to the private owners, based on the fact that the project was of "social interest" to the nation. The case is seen from a "micro" or small-scale, internal viewpoint, and includes details even of individual personalities when they exert significant or generalizable influence on the course of the program.

The Asian example is a combination of these two extremes. The government sponsored a demonstration project which was intended to prove to both its own official housing agencies, and to its private sector builders, that substantial production efficiencies could be achieved through industrialization. The case analysis also involves both macro and micro viewpoints.

All three cases ended in failure, and in substantial expenditures of scarce and valuable resources. The cases were united by other common themes as well. In each instance, the industrialized technology involved was imported from a post-industrial nation — in the cases of Africa and South America, the technology exporter was European; in the case of Asia, the technology was from the United States. There was little or no input by local designers or engineers in adapting the building system to local conditions; and when this adapting process was undertaken at all, professionals from the exporting nations were contracted to do all of the work.

In no instance did the setting for any of the three cases substantially duplicate the six conditions that so encouraged successful housing industrialization in post-war Europe (see Part II). This is not to suggest that these are the *only* conditions under which industrialization may be implemented, merely that to date, these are the only ones that have proven to be highly supportive of such attempts. Of critical importance in the following cases is that unlike Europe, cost could *not* have been subordinated to volume and speed; and that improved housing was *not* a top national priority. Had either or both of these factors held true in the cases that follow, the results might have been more positive.

But perhaps, the most serious common failing of the three cases was the fact that they (and nearly all others examined by the authors) were conceived in a virtual vacuum. None of the cases demonstrated a proper regard or concern for a total program that included land for building sites, utilities and other public services for the sites, and some form of credit mechanism in order to help finance the units. In nearly all instances, the mere application of modern technology mistakenly seemed to offer a panacea which excused discision makers from implementing the fundamental policies that must accompany new technology if it is to be positive and meaningful to society.

CASE STUDIES

Africa[1]

Public policy becomes most directly involved in the housing industrilization process in a case such as the following, in which a national government undertook to industrialize its housing industry as a fully public enterprise.

This case emphasizes the pitfalls associated with feasibility studies touting and promoting the use of highly industrialized imported systems for developing nations. The case began in 1952 when a developing nation in Africa arranged for the importation of a highly industrialized European housing system. Five years later, at the request of the government, the United Nations Technical Assistance Programme evaluated the effort and unequivocally recommended the "abandonment of the project."

Excerpts from the carefully prepared U.N. evaluation provide insight into the unfortunate chronology of events.

Background—

"After the second World War, the Governments of almost all the countries in the world found themselves faced with severe housing shortages. These were accompanied by a shortage of materials and skilled manpower. As the relief of the shortage by traditional methods of construction would have been a slow process, many Governments took an interest in attempts to produce houses by industrial mass manufacturing methods . . . .

"As the Government found itself in a position similar to most other countries, it decided in 1951 to investigate the possibility of relieving the housing shortage in the country and speeding up the development of its building industry by the introduction of non-traditional methods of construction, i.e., some form or other of prefabrication."

The Government investigated a number of industrialized building systems, and a year later negotiations were under way with a European licensor of a proprietary industrial building method employing precast concrete components.

The negotiations were culminated in a manner not atypical of such efforts – a journey to the European licensor's home works by a party of about 30 key legislators and officials headed by the Director of Housing.

Feasibility Study. The resulting agreement called only for an expensive report by the industrialized licensor. The Government agreed to pay approximately $210,000 for a seven-point feasibility study to assess:

(a) the demand over 10 years (in two 5-year increments) for the industrialized houses by both the Government and the general public;

(b) the proximity, quantity, and quality of local raw and semi-finished materials needed to produce the industrialized components;

(c) the most advantageous plant locations considering proximity to both markets and raw materials;

(d) the initial capital requirements to build the industrialized factories needed "to supply the potential demand for . . . components year by year as assessed under paragraph (a) above and advising upon the specification of the necessary factories";

(e) the cost and design specifications of a "standard house" as suggested by the market study under paragraph (a) above;

(f) the transportation cost, methods, and representative routes of distribution from housing factories to building sites;

(g) " . . . the erection costs for the standard house."

Eight months later a report was delivered to the Government by the European licensor. The U.N. was harsh in its evaluation of the report: "This document falls short by a large margin of what the Government had a right to expect." Specific criticisms included the fact that "more than half of the report is devoted to climatic, social and economic data of the country which are culled from official sources." Clearly, governments can assemble this information themselves with much greater efficiency and less cost than outside consultants. (However, this would not have been true if "official sources" were suspect or unreliable, and the consultant had been hired to generate independent data, and not merely cull official figures.)

Other U.N. criticisms of the feasibility study noted that the report said

> "nothing about the . . . process itself, the mechanical properties of concrete slabs, the size of components, the method of erection, the method of production of the components or the description of the plants producing the materials and equipment."

The U.N. continued that

> "many of the arguments of the report are irrelevant and in no way bear directly on any particular construction method, and . . . [the] conclusions concerning the exceptional suitability of . . . [the] process . . . are entirely unconvincing. The same reasoning could be applied to many other building methods, including classical methods."

Faulty Cost Analysis. The crucial cost analysis was also criticized. "Cost figures of various types of houses [were] . . . given without details whereby they might be checked and examined." When the government requested that this deficiency be remedied, the industrial licensor responded with "details concerning structural components common to *all* houses (foundations, floors, roofing, paint, electricity, joinery, etc. . . .)." but did not submit more data on the prefabricated slabs of the industrialized process itself. Furthermore, "the firm's transport estimates within a radius of 40 miles and erection estimates were completely inaccurate."

The U.N. evaluation challenges the cost comparison on two counts. First, according to the manufacturer's own estimates, in-place costs of his industrialized technology exceeded conventional construction methods by 27 to 88 percent. Secondly, the U.N. challenges even these costs as being too low, since transporting the components from factory to building site was shown to have caused "a heavy percentage of breakage and waste, a fact which is not taken into account by the . . . [manufacturer's feasibility] survey."

In addition, costs turned out to be 79 percent higher than estimated, once prototype construction was under way. In February 1952 the firm agreed to build 134 houses for $526,400, or approximately $3,900 each. Eventually, 64 were completed at a cost of more than $448,000, or some $7,000 each.

Hence, the entire argument stumbles on the cost comparison. In this case, as in most, the costs were not subordinated to other objectives, and remained a key element in determining whether the industrialization scheme would contribute to the goal of making improved housing more available to lower income families. However because the cost comparisons were ambiguously presented in the feasibility study, the project was allowed to continue for five years until the U.N. evaluation.

Conflict of Interest. The United Nations team also points out another fundamental problem with the manufacturer's preliminary study. Suggesting a conflict of interest, the U.N. observes that "while the survey was going on, two contracts were concluded between the Government and the company . . . under which [the company was] . . . to build 168 sample houses" in three of the larger cities.

The U.N. team goes on to point out that "the company thus acquired a dual role: as authors of the . . . report they were consultants and trusted advisors to the Government and as producers of the sample houses they became suppliers of the very commodity on the suitability of which they were to advise." In retrospect, the U.N. conclusion seems clear: "Had there been an independent, competent consultant advising on the . . . product, the recommendation might have been different and an enormous expenditure avoided."[2]

Capital Investment. Apart from the costs of the houses, the sheer magnitude of the required capital investment also led to serious problems. The manufacturer's feasibility study recommended building a factory capable of producing 3,000 "room-units" annually in each of three major cities, with each city being the center of a supply region having a 40-mile radius. The capital investment for each factory was estimated to be in the range of $1.1-1.2 million or $3.3-3.5 million for the three plants together. The costs for each plant were broken down as shown in Table 2.

Table 2:

BREAKDOWN OF CAPITAL INVESTMENT REQUIRED FOR ONE INDUSTRIALIZED HOUSING PLANT

	1952 Prices in U.S. Dollars
Industrial buildings and machinery	$ 608,400
Initial costs and working capital	280,000
Housing of staff	140,000
Installation and equipment of a sand quarry	140,000
TOTAL	$1,168,400

The U.N. pointed out, however, that these figures were deficient in that they failed to account for the purchase of transport equipment, mechanical handling equipment at the building site, and for land, upon which the plants and staff quarters were to be built. However, of more serious significance, the U.N. evaluators observe that

> "should the Government decide to build three . . . factories as proposed, it would commit itself to an expenditure much larger than three times [$1,168,400 since] . . . the value of the annual production of the three factories would be in the region of . . . [$6.3 million].
>
> As the price quoted for the . . . [industrialized] panels is obviously based on the assumption of continuous full production, the Government as owner of the factories would be forced to see to it that room units worth [$6.3 million] are produced and used every

year. Moreover, as the price of the . . . [industrialized] houses would be higher than that of other houses, direct sales of . . . [units] to the public would be unlikely. The Government would have to take over the whole output for a programme of subsidized housing and thus commit itself to an annual expenditure of [$6.3 million] plus a considerable sum for the acquisition and development of land, roads, drains, services, etc. This recurring expenditure would be considerably larger than the amounts earmarked . . . Yet the affect of this expenditure would be restricted . . . to circles of forty miles radius around the proposed three factories."

The industrialized manufacturer, however, attempted to claim in his feasibility study that the industrialized "components can be bought by private contractors for the erection of private houses." The U.N. challenges this assertion by stating that "as far as private builders are concerned, it is difficult to understand why they should (unless forced by severe shortages of essential materials) make use of a building method which is more expensive than the traditional methods to which they are accustomed."

The U.N. was also skeptical regarding the industrializer's claim that its factories could produce diversified concrete products other than industrialized building components.

Insensitive Design. In addition to the economic problems associated with the scheme, the U.N. criticism was sharp in other areas, particularly the design of the houses. The need for sensitive and high quality design, of course, is not only true for industrialized houses, but for conventional units as well; and there are many examples of the full range of design – from excellent to poor – for both types of construction. However, the design of industrialized houses takes on some special significance in that the units are standardized, and design features are proliferated over large volumes of output. Because of this, the U.N. criticism becomes more important than if these same defects were noted for conventionally constructed houses. The evaluation report noted that the sample industrialized "houses visited by the United Nations Mission have no special or outstanding features." Furthermore, the prefabricated slab components were evaluated as being

" . . . heavy and brittle; their manipulation, transport and storage enforces prohibitive waste; despite cost, weight and waste, the house will probably not afford the protection against moisture, rust, cracks, blisters and other disorders its cost should have assured. The bolted joints appear too frail for earthquakes, and other methods are superior. The house . . . is ill-adapted to the climatic conditions of the country (there is, for example, no ventilation beneath the ceiling; the rooms are unnecessarily high, there is no ventilation in the lower parts of the walls; there is insufficient protection of facades against solar radiation, etc.).

These mistakes can of course be corrected by a more thorough study of the question and are not peculiar to the [industrialized] . . . system; they are simply due to the inability of the firm to use the climatic, geographical and social information collected by its staff for their own report."

The U.N. evaluation led to the curtailment of the program, and the government was spared the experience of dealing with the on-going operational problems implied by the manufacturer's recommended program. Yet experience has shown that the operational problems of keeping a plant running smoothly and efficiently in a developing area are perhaps even more formidable than those typically uncovered during feasibility and demonstration phases of an industrialization program. The next case focuses on this second round of actual day-to-day operating problems once an industrialized housing feasibility study is accepted as workable.

South America[3]

In the preceding case, the U.N. evaluation team noted that "the price quoted . . . is obviously based on the *assumption of continuous full production.*"[4] The enormity of this assumption is the theme of this second case.

Background. This case involves a private sponsor, composed of a consortium of South American investment bankers, as opposed to a national government. After a lengthy and highly optimistic feasibility study conducted by the manufacturer, a study in many ways similar to that prepared for the government in the preceding case, and the ritual trip by the consortium members to the manufacturer's European headquarters, negotiations were concluded for the importation of a highly sophisticated, industrialized plant, valued at approximately $1 million. For this investment (which required considerably more than $1 million worth of local currency at the official exchange rate) plus on-going royalty payments based on volume of production, the investment consortium purchased a patent license, production equipment, and on-going technical services from the European franchiser.

The Down-Time Dilemma. From the moment of the initial payment to the franchiser, the company began a frantic race against "down-time" or periods without production. Once initial payments were made, the costs of interest and loss of liquidity on the capital investment became strictly a function of time, regardless of output quantities. The investors had to try to maximize production to offset the high fixed financial costs that accrued to the operation every minute of every day. A series of initial mistakes and bad luck, however, conspired to severely handicap the company's race against time.

Start-Up Delays. First the construction of the plant dragged beyond its scheduled nine-month period to 14 months. Bureaucratic snarls delayed import permits. Last minute problems developed with the owner of the land for the plant; and, in general, pre-start-up tasks and expenses exceeded time and cost estimates by nearly 50 per cent.

Finally when the plant was ready to begin production, the technical assistance team from the European franchiser was engaged in the opening of a plant on another continent because of the scheduling difficulties caused by the company's five-month construction delay. Thus nearly a month passed before the team arrived and test production could actually begin. When they did arrive, they could speak almost no Spanish and were unable to establish good working relationships with the plant management and personnel.

By this time, the delays were beginning to cause other problems. The construction project which was to utilize the first output of the plant had been halted after foundations had been readied; and the contractor was angrily calling the plant each day demanding components. The original plan had been to produce for a period before shipping components out to an actual job in order to assure high quality and uniform output. However, in view of the impatience of the contractor, who by this time had threatened a lawsuit, the trial production plan was abandoned and early components were shipped out, even though adequate production controls had not yet been established. The initially poor quality harmed the reputation of the company at least as much as the delay, and to this day complaints are still received from the occupants of the first buildings about leaks and unsightly joints and cracks. Within the buildings of the first project it is literally possible to see the improvement and progression of quality from the first building to the last, and even upward from the first floor of the first building.

Management Problems. Early in the process, the firm also began to develop serious management problems. In a move that is not atypical in developing nations, the investor-owners of the plant hired engineers to fill the company's three critical operating positions – general manager, plant manager, and sales/technical service manager. *None* had had previous corporate management experience, although the three were generally well-educated, and appeared to be technically competent and ambitious. Only the plant manager worked out well, and he effectively (although hesitantly – since all the engineering decisions and assumptions had been made by Europeans) applied his technical knowledge to the relatively successful operation of the plant. Nonetheless, when he became injured on the job, and was out of work for two months, the plant lapsed into chaos because the position of assistant plant manager had never been filled. This was partially due to an ill-considered economy move combined with the fact that a good candidate for the job had not been found.

The general manager, the chief operating officer of the company, proved to be a total failure. Frustrated that he was not functioning as an engineer, inept and unsuccessful in matters of business, and possibly dishonest (although this was never proven), his performance prompted the owners of the plant to begin the search for a replacement after only six months of operation. They could find no one in the country who was competent and available, and even interviewed several foreigners, all of whom demanded outrageous salaries, and none of whom seemed to be particularly suited for the job. After a year, the desperate owners considered promoting the successful plant manager, but then decided against it based on the fact that he had become too valuable at the plant. Finally, one of the younger and more daring of the banker-owners assumed the job of general manager himself. Although he personally disliked the change and knew nothing of the housing or manufacturing operations, he felt an obligation to try to save the investment. The original general manager was fired and the overall management of the company immediately improved from disastrous to mediocre.

The sales and technical service manager also felt disoriented and estranged from his traditional engineering practices, and was unable to deliver the absolutely critical volume and continuity of work needed to keep the plant producing at maximum efficiency. As a classically trained engineer, he was aloof and reserved, and found it difficult to relate to conventional builders. His cost analysis techniques were amateurish, and although the new general manager tried to school him, the sales manager resented the effort and was slow to learn, and failed to convince conventional construction companies to try to utilize the system on their projects. The new general manager, using his former banking contacts and his upper-class family and social contacts actually accounted for most project sales. In addition, he also assumed almost all public relations and advertising responsibilities.

The sales manager fared only slightly better in his technical assistance role of trouble-shooting various site and erection difficulties, and finally the owners sought to replace him also, although they were unable to recruit a better prospect, and he lingered on in his job. He soon became the only man in the company who advocated reduced prices, arguing that that was the only way to improve sales. With the company at this point losing $500 per day, there was obvious reluctance to follow his suggestion and, in fact, prices were steadily raised.

Expanded Repair Facilities. Unfortunately, other problems also beset the embattled company. Normally minor repairs were periodically causing unduly long periods of down-time. Weeks, and occasionally months were involved in ordering critical spare parts from Europe or the United States. Finally, the owners diverted quantities of their already seriously depleted working capital to invest in a complete machine and metal-working shop at the plant, so that parts could be fabricated on the spot without crippling delays. A large inventory of other parts was also ordered from Europe in advance.

A similar problem developed with regard to the company's vehicles. Normal maintenance and repair services were unsatisfactory, and after several commercial garages in the metropolitan area failed to perform adequately, and lack of vehicles began to bottleneck production, the machine shop was expanded to include an automotive shop which could accommodate and service the company's vehicles as well.

Ironically, immediately after the expanded maintenance facilities became operational, and it seemed that nearly all repairs could be made "in-house," a small fire damaged a large and important conveyor belt, and a custom-made replacement still had to be ordered from the U.S. For two months, the plant limped along until the new belt and a costly back-up belt arrived.

Public Works Deficiencies. But, gradually, the company was becoming a self-sufficient "island," attempting at great and unanticipated cost, to reproduce in miniature the supporting elements of the society around it – most of which were found to be unacceptable or unreliable. Unavoidably, these costs added to the corporate overhead and were directly reflected by increased prices.

The plant even installed emergency electric generators in order to continue production during the all-too-frequent power failures in this area. The plant also considered, but finally rejected, building its own dike along a nearby river after heavy rains and subsequent flooding closed the plant and caused serious damage necessitating major repairs.

Thus, it was impossible for the plant to completely divorce or insulate itself from its general social setting. Even as the company began to service its own trucks and cranes, it quickly realized that the ten-mile road leading to the plant, was a key problem. Filled with ruts, potholes, and cracks, the old pavement was far more of a hindrance to travel than an assist. Furthermore, the route was indirect and filled with tortuous curves. The management petitioned the metropolitan government to build a new road (which had been promised before the plant opened, and which already appeared in the metropolitan master plan); however, no response came back.

Finally, after the owners of the plant appealed to their highly-placed friends in government, it was agreed that the company would pay a "special assessment," and the road would be repaved – although not realigned. After nine more months without action, the company officials – frustrated and angry – decided to pave the road themselves, only to find that if they did not wait for the municipality to do the job, the standards they would have to meet would be absurdly high. Faced with the ruin of their new imported fleet of trucks, the company paved the road itself with the government partially compromising the paving standards after the payment of another "special assessment."

Labor Problems. Labor troubles also plagued the new plant. The workers were not unionized; and because management wanted to preserve this condition, wages paid were slightly higher than prevailing rates – partially offsetting the labor-saving features of the plant. Also, productivity appeared to be quite low and it was later learned from one of the workers that they deliberately decided to work slowly because it was rumored that sales were poor and they feared layoffs – particularly when a series of expected government housing tenders failed to materialize.

Strikes among dockworkers and other related industries also caused delays and stoppages at the plant as various suppliers failed to meet commitments.

New Office. Other major irritants caused a complex of unanticipated problems. For example, telephone service to the suburban location of the plant was so bad that it became impossible to conduct business there. Thus a suite of administrative offices was rented downtown, which facilitated many business transactions but also further burdened the company's overhead rate. Also, control over the operation was slightly diluted since the plant and the office were now separated by a 45-minute auto trip. The special radio hookup between the plant and the downtown office was only slightly better than the telephone service and both required furious shouting in order to be heard.

Deficient Franchise Service. Poor technical service from the European franchiser, who never seemed to overcome the language barrier (communication finally transpired in English which was native to neither group) led to numerous, costly cables and transatlantic phone calls—all of which added to the financial burdens of the company.

Extremely high-priced consulting fees were then paid to an American company in an attempt to acquire the services which the European franchiser failed to deliver, but for which it nonetheless received its production royalties. Further aggravating the situation was the fact that both consulting fees and royalties were payable only in U.S. dollars which had to be purchased at inflated rates with local currency. At this point the plant was losing $1,000 per day.

Devaluation and Collapse. When the nation's currency devalued, slashing the worth of the meager remaining capital reserves, the company was finally bankrupt and psychologically devastated; it painfully sold its assests at a tremendous loss. Up to this point the owners had clung to the hope that if only they could overcome the initial start-up hurdles, the plant would prove to be economically viable and could produce more and higher quality houses at competitive prices, if not absolute savings.

It is impossible to ascribe this chronicle of failures to the fact that the society around this ill-fated housing plant was not industrialized; but many of the obstacles encountered do appear to be endemic to less developed areas – particularly the management, down-time, and currency problems.

The tragedy of this failure is perhaps mitigated by the fact that a private investor – who acknowledged beforehand the risks of the venture and gambled on making a profit – bore the brunt of the financial loss. The loss of large amounts of public funds of the type which would have been committed to a government enterprise (as in the preceding case, for example) was minimized.

However even in this case, the government, the society, and particularly those in greatest need of housing also suffered – albeit indirectly. The government, in granting tax concessions to the venture, lost the potential revenues that might have been generated by an alternative investment of similar magnitude. It also had to contend with the loss of extremely scarce foreign exchange capital which, along with foregone tax revenues, limited the service options that could be provided by the public sector.

The society also suffered. Rising expectations generated by the publicity that surrounded the initial stages of the project were disappointed. Valuable resources, including raw materials, labor, management, and investment capital were consumed or diverted. Housing shortages were not only unrelieved, but were aggravated by the unproductive use of these potential inputs. And finally, the bankrupt assets of the company were purchased by a consortium of foreign investors at a small fraction of their original cost, hence delivering another element of the country's productive capacity into the hands of individuals who were generally less responsive to the national interest than native citizens.

However, the fact that this case involved a private rather than public enterprise does not mitigate its underlying theme, which is that normal, industrialized operating problems can often be exacerbated in developing areas when the economic and social supports of the society are not available to the venture. When this happens, the venture, regardless of public or private ownership or management, often must attempt at great cost and effort to become self sufficient and independent of its surroundings. To do so, it must recreate in miniature many of the supporting services and functions which industrialized producers in developed areas regularly may take for granted.

Asia[5]

The third case study is set in a developing nation in southeastern Asia in 1969-70. The case is significant not so much for what actually happened—for this program was much more modest than either of the two preceding programs—but for what was attempted in reducing the commitment and risk normally associated with industrialization attempts.

Background. In this case the national government commissioned a small-scale, pilot project from a U.S. industrialized housing manufacturer. The objective was to have the building system redesigned and reengineered so that it would be appropriate to the country's environment and consistent with and sensitive to residential construction traditions.

A demonstration program was initiated whereby a small number of prototype houses were to be built which would then be tested for potential use within non-profit government housing programs and/or private residential developments.

Performance Requirements. A series of performance features were specified for the pilot project houses; these are noteworthy since they take an important stride toward recognizing the special kinds of characteristics that industrialized construction should offer to developing regions.

1. Cost—The finished houses had to be at least competitive in price with the most austere method of construction in use in official projects. However, significant cost savings below current prices was the target objective. Cost calculations had to be all-inclusive: particularly the cost of amortizing the industrialized equipment and the cost of providing technical and training services.

2. Speed and Volume—The means of producing the housing components and finished units had to be conducive to high-speed, high-volume mass production techniques.

3. Design Quality—The designs of the components and finished housing units had to reflect traditional residential construction practices, such that room sizes, floor plans, finish materials, ventilating techniques, aesthetic detailing, etc. were generally familiar and compatible with conventional construction. In addition, the building system had to be flexible enough to embrace varying designs ranging from four-story urban walk-up apartments and row houses, to single-story rural detached homes. The designs were also required to be expandable so that initially small units could be incrementally enlarged with the system. Finally, the designs were required to meet high standards of structural safety under severe weather and seismic conditions.

4. Construction Ease—The industrially produced components had to be both easy to manufacture and easy to assemble. Dependence on skilled labor was ruled out because of severe shortages, and lack of time to conduct extended training or apprentice programs. In addition, the work tasks had to be relatively light since it was anticipated that most applications of the technology would be on a self-help basis, or that it would be done by contractors using predominantly women laborers.

5. Importation Limits—All construction materials had to be locally and readily available. The only imports allowed in the project were confined to the equipment needed to manufacture the components, and even that had to be of such a nature as to be eventually producible locally.

6. Equipment Durability—Manufacturing equipment had to be sufficiently durable for thousands of production cycles over several years. Maintenance requirements had to be simple and few in number, and equipment had to be rugged enough to withstand occasional movement. Hand-powered machines were highly favored over hydraulic or electric machines to simplify maintenance and to reduce dependence on outside utilities or services. Site machinery, including cranes or other powered lifting devices was not allowed, even for multi-story construction, and site utilities during the construction stage were assumed not to exist.

7. Equipment Cost—Capital investment in plant and equipment had to minimal. Small, transportable production kits or mini-factories were envisioned at a cost of under $50,000. In addition, it was required that there be no royalty payments, or necessity for any on-going relationship whatever with the U.S. supplier after the initial introduction of the technology.

Actual Performance. It is possible that the preconditions established in this case could have mitigated some of the failures of the preceding cases. In fact, had all of these conditions actually been achieved in this case, it is possible that it would have enjoyed a considerably greater degree of acceptance than it actually attained. As the program developed, nearly all of the performance conditions were met – except for cost. In comparison with conventional construction, final prices for the units showed an increase in the cost of materials. In self-help projects these increases were nearly offset by the savings which accrued from the use of unpaid labor—provided that self-help labor was used *both* to manufacture the industrialized components and to assemble them into homes (which was proven to be possible). Thus, in the context of a complete self-help program the costs of the units were just barely competitive with the least expensive contractor-built construction.

However, applications of the industrialized system for contractors became more expensive than conventional construction, even if labor costs were very low which, in fact, was possible since virtually no prior experience or skill was required to perform most manufacturing and assembly tasks.

Hidden Costs. Another factor also detracted from the cost comparison. The costs referred to above were not able to account for the amortization of plant and equipment. All parties concerned agreed that this was an unknown, since the equipment in the mini-factory had not been used before and its serviceable life was untested.

The U.S. manufacturer claimed that amortization would turn out to be virtually negligible, since the equipment was designed and built to last many years. Representatives of the government tested the equipment and doubted this claim, noting incipient and potentially costly failure in some of the equipment after test production of only a small number of houses.

In addition to the question of amortization, another "hidden cost" not calculated in the manufacturer's price analysis was the category of overhead. No calculations were made for management, utilities, transportation, rent, administration, etc., and indeed these costs are almost impossible to calculate within the context of government programs. Often government land is made available upon which to set up a factory without rent; or government technical advisors or managers are assigned from related agencies to assist the program without direct charge. Of course, someone must pay for these services and it might have been possible to derive "imputed" costs for governmentally assisted programs. Direct calculations also could have derived overhead factors for private entrepreneurial ventures; but no overhead calculations of any kind were performed by either the manufacturer or the evaluators, and along with amortization, operating overhead remained a hidden cost. In light of the previous South American case, it become obvious that these omissions were most serious.

Performance Evaluation. However, aside from cost, most of the other design and performance criteria were successfully met. The attitude of the government evaluators was summed up in a statement by one of them during a site inspection to the demonstration project. "We have got so many thousands of houses to build," he said, "that we can't even conceive of how to do it conventionally – much less using new technology. Given the cost uncertainties, which will only be truly revealed once we are into volume production – and then if we're wrong it'll be too late–we simply cannot take the risk. The houses themselves are excellent, and self-help combined with industrialized techniques is socially attractive; but in the final analysis we can't spend one cent more than the least-cost solution. We won't take a risk for a marginal improvement in quality; the only risk we'll take is for a quantum breakthrough of cost."

The demonstration project was thus allowed to lapse after completion of the first phase. Clearly–though this specific attempt failed–the overall program (particularly in initial performance criteria) began to recognize what kinds of performance industrialized systems will have to attain in order to be viable in developing areas.

CONCLUSIONS

In all three cases the lure of housing cost reductions through industrialized production techniques proved to be illusory. In the South American case the influence of a less-developed context was perhaps most clearly evident. There the private producer felt himself forced to replicate in miniature, and at great cost, many of the economic and social supports which industrial producers commonly rely on in more developed regions. In the African and Asian cases – neither of which progressed beyond the demonstration stage –cost comparisons were unsatisfactory even before operating problems were met. These cases took for granted the totally unrealistic assumption of full and uninterrupted production which proved so impossible to attain in South America. All the cases help to explain why a decade of subsidies and guarantees was so critically important for the European industrialized producers during their early "incubation periods," even in a context where unit cost was subordinated to volume and speed of output.

The cases also provide a stern warning against technology transfers from industrialized to less developed societies without adequate and sensitive design modifications. The African case was most notable in this respect and underscores the point that even if the cost comparison should be acceptable, poorly designed or adapted units can still undermine the viability of an economically sound industrialization effort. Although the need for quality, culturally-sensitive design applies equally to conventional construction as well, design flaws in an industrialized scheme–as shown in the African case–are necessarily subject to repetition, whereas in conventional construction they are not.

Finally, the cases show, that regardless of the degree of development, industrialized housing technology is no panacea. When economically viable and well designed, the program still must command enough priority to marshall other resources in the society which can be directed toward the provision of land and building sites, utilities and other services, and credit mechanisms which will help the lowest-income families to finance their homes.

However, if the case studies yield a pessimistic overview regarding the potentials of industrialized housing in developing areas, it is perhaps because they share the commonly false assumption that industrialization, —although a composite phenomenon—cannot be readily disaggregated. Of the three cases the Asian program went furthest in dispelling this assumption by trying to minimize reliance on the heavy, capital requirements needed for mechanization and automation, while concentrating on the lower-risk aspects of design rationalization and labor specialization. On the other hand, the Latin American and African programs viewed industrialization as a total and unified phenomenon, relying on all aspects of industrialization simultaneously.

The following chapter explores different forms of industrialization based on respective emphasis and deemphasis of the various parts of the process; it attempts to relate these forms of industrialization to various stages of economic and social development.

Part IV

TOWARD AN INDUSTRIALIZATION STRATEGY

INTRODUCTION

If the case analyses of the preceding section have presented a pessimistic overview regarding industrialized housing in developing areas, it is important to remember that the central theme of this work is that *partially* industrialized, *intermediate* technologies can mitigate and correct many of the deficiencies and failures observed in the cases.

The goal of this section of the discussion will be to define and describe the nature of these corrective and intermediate processes.

It will be remembered that *full* industrialization was described in the first part of this report as a composite process embodying four relatively independent components: systems design, skill specialization, concentration, and mechanization. These four components of full industrialization were then briefly defined, and diagrammed to show their relationships to each other (see pp. I-5, I-9 above).

In the second section of the report, these components were further discussed in terms of both their commonly assumed benefits, and their less frequently proclaimed pitfalls and risks. The third section documented the actual and unfortunate dominance of these pitfalls in two cases where full industrialization was prematurely attempted in less-developed nations in Africa and South America. The third case, in Asia, begins to approach the concept of partial industrialization; and this theme, along with the concepts of indirect industrialization and intermediate and transitional technologies, is developed more fully below.

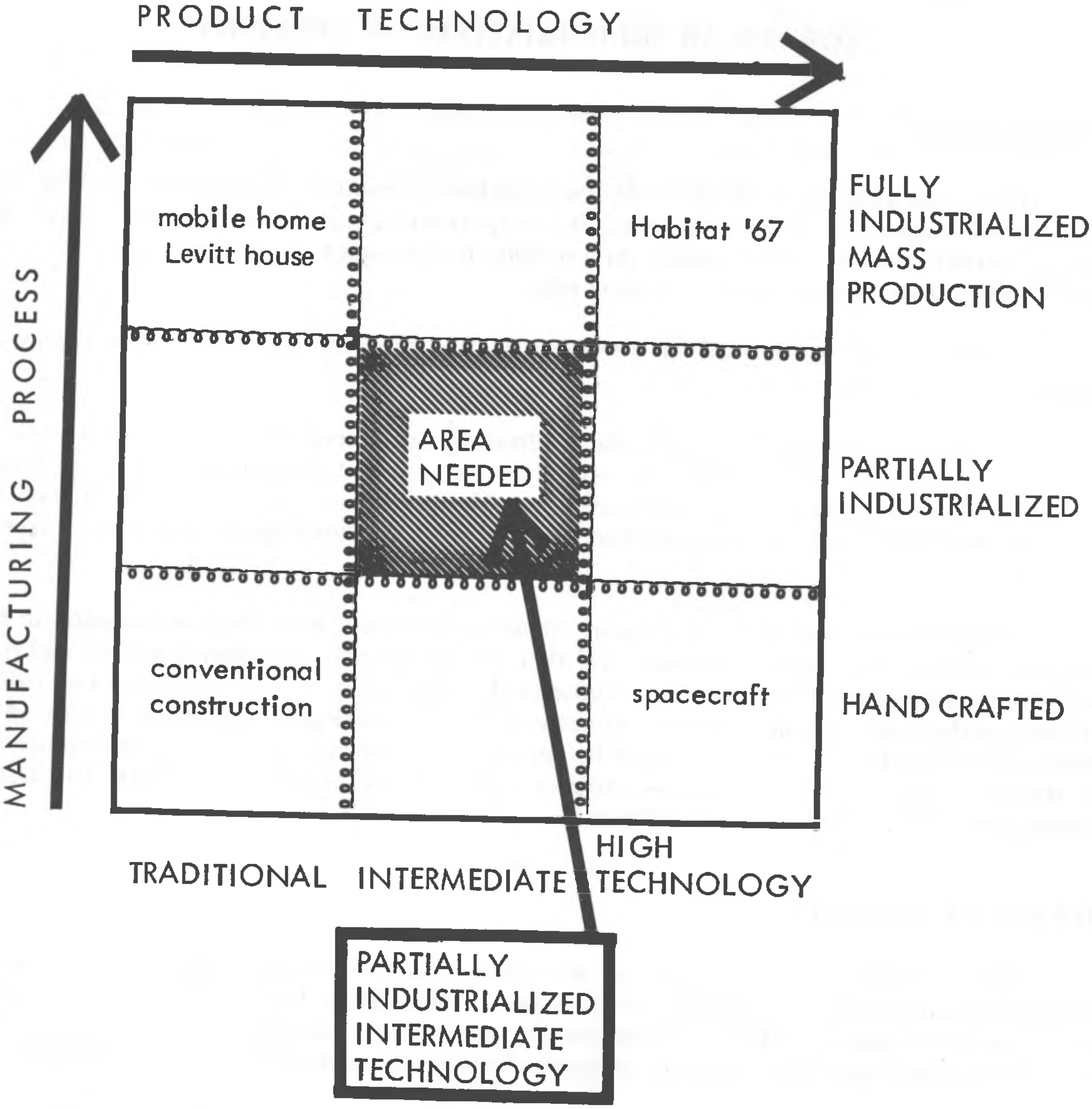
PROCESS VS. PRODUCT

First, however, it is useful to distinguish briefly between the concepts of "partial industrialization" and "intermediate technologies." The former term refers to the manufacturing *process*, and the number and kinds of industrializing techniques employed in the process. The latter term refers to the house itself, and the components which form it viewed as a end *product.*

As shown in Figure 6, the manufacturing process may be viewed as a continuum ranging from hand-crafted to fully-industrialized techniques. In like manner, the technological output or product can be viewed as a continuum ranging from traditional to advanced. The schematic 9-cell table below arbitrarily devides these continua into three segments each.

In the first cell, the fully-industrialized, yet traditional product may be typified by mobile homes or the famous mass-produced houses of William T. Levitt and Son, which was part of the U.S. response to its post-World War II housing shortage.

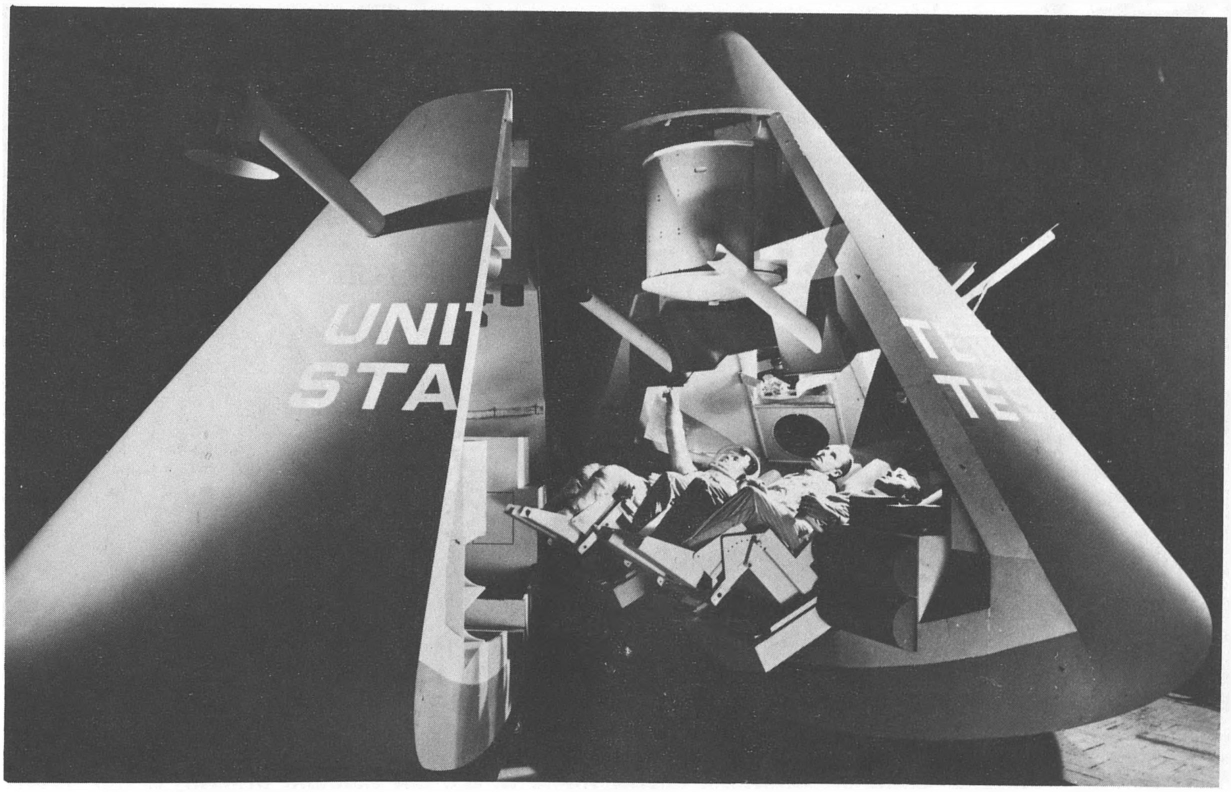
FIGURE 6: INDUSTRIALIZATION OF PROCESS COMPARED TO PRODUCT TECHNOLOGY



PROCESS VS. PRODUCT – In the schematic diagram above, the manufacturing process (vertical axis) has been divided into three production categories: handcrafted, partially industrialized, and fully industrialized. Similarly, product technology (the horizontal axis) has been subdivided into three parts: traditional, intermediate, and high technology. The center cell of the diagram indicates the product and process characteristics most needed in developing areas.

MASS-PRODUCED, CONVENTIONAL DWELLINGS – These U.S. tract-houses epitomize the industrialization of process, while holding product technology at conventional levels. These standardized, traditional houses were mass-produced at Levittown, Long Island, in 1947, utilizing highly-specialized and coordinated labor teams which moved from house to house at virtually an assembly line pace.

(Levitt and Sons photo)



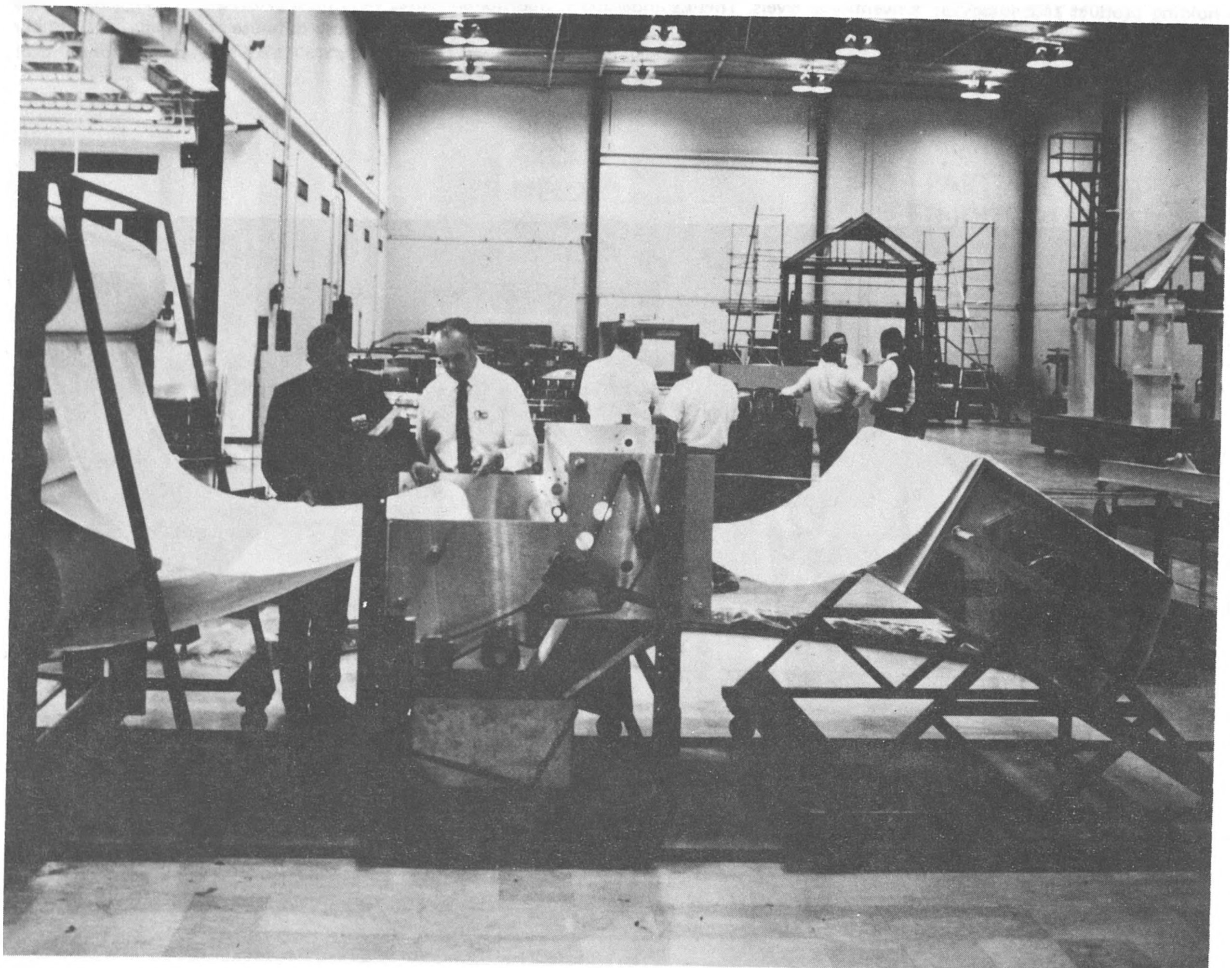
SOPHISTICATED, HAND-CRAFTED DWELLING – The space-craft, perhaps man's most sophisticated dwelling, utilizes the highest levels of product technology; however the manufacturing process is based on slow and deliberate hand-craftsmanship. These two examples represent polar opposites: the houses above focus on the industrialization of *process*, the dwelling below, on the advancement of *product*.

(NASA photo)

As a product, the Levitt house itself was extremely traditional both in appearance and construction. The architecture was traditional American "Cape Cod" and the units utilized conventional, wood-stud, balloon-frame construction. Yet the construction process was highly industrialized. The final product was a standardized mass-produced item – even to the point of using assembly line techniques. In the case of the Levitt houses though, "the line," as it was known, was composed of moving workers, not products. The workers formed well-managed and highly organized teams which moved from building to building with precise timing and coordination.

Skills were highly specialized as well, even to the point of subdividing and specializing traditional carpentry into many extremely narrowly-defined and highly-specialized subtasks.

Operations were also highly concentrated; purchasing, construction, and marketing focused on entire town-sized projects –known as Levittowns– clustering together thousands of houses. Today the individual Levitt projects are somewhat smaller, and the overall operation has grown and assumes a pattern of "dispersed concentrations."



ESOTERIC TECHNOLOGY – Space-age techniques, particularly those involving new synthetic materials, are being utilized in the manufacture of highly advanced housing modules. Here a filament winding process is used to produce an experimental dwelling.

Mechanization was perhaps the least-developed of the four aspects of industrialization in the Levitt operation. The company's style of industrialized operations shunned the large, costly machine which stamps out heavy or complex components; rather it favored a myriad of smaller, power-driven hand tools to reduce and speed the large amount of routine hand labor.

In contrast to the highly industrialized yet traditional Levitt house, the last cell of the diagram describes a hand-crafted, high-technology product, epitomized perhaps by one of the most sophisticated types of dwelling yet produced – the spacecraft.

Since the demand for spacecraft is relatively minute, and the craft are constantly changing and evolving, mass production techniques are almost totally irrelevant. Each craft is presently hand-built by master craftsmen and technicians.

The other cells in the diagram are representative of various mixes of process industrialization and product technology. The lower left cell represents conventional construction methods producing traditional houses – typifying most residential construction in most countries of the world.

The upper right cell represents both a high-technology product and a highly industrialized means of producing it. Habitat '67, the well-known industrialized housing exhibit at the 1967 Montreal World's Fair is typical of this type of solution, as are some of the high-technology experiments in the current U.S. Operation Breakthrough Program, such as the filament-wound housing module and others, (see photo at left).

This chapter postulates that the key to the reasonable and productive introduction of industrialized housing in less-developed areas resides in the central cell of Figure 6 –in the area of partially-industrialized, intermediate technologies. To better define the characteristics of this cell, both the process and the product axes will be examined in somewhat greater detail.

PROCESS–TOWARD PARTIAL INDUSTRIALIZATION

The concept of partial industrialization derives from the composite nature of full industrialization, and is used to describe a manufacturing or production strategy that selectively uses some industrializing aspects, while avoiding or postponing the use of others.

The authors view the combination of the two least-risk aspects of industrialization –systems design and labor specialization – as a starting point for a partial industrialization strategy. The somewhat higher-risk aspect of concentrated, large-scale operations is then considered as a potential adjunct to the initial strategy; and finally, the highest-risk aspect of mechanization is considered, completing the cycle back to full industrialization.

Systems Design

Systems design, the first of the industrializing aspects considered here, is a broad and general term, but it directly involves the use of standardized components which interact with one another in a regularized and compatible fashion.

In developing areas of the world, systems design is clearly the most important and relevant single aspect of industrialization, since it depends on relatively little capital investment, no imported equipment or machinery, and virtually none of the institutionalized services and facilities that are often absent or unreliable in a less-developed economy.

All that is required is a commitment of design time; and even if the higher-risk aspects of industrialization are not forthcoming or appropriate, the systems design process itself can yield significant benefits to the construction process—and may have the side effect of encouraging the other aspects of industrialization as well.

A case in point is the traditional and historic Japanese tatami house. The tatami mat itself becomes the systemized component, and because it is standardized, the means of producing it become highly repetitive in nature. This encourages labor specialization, because the repetition involved in production often gives rise to a specialized expertise which in turn may be reflected by increased production speed and quality. Historically the sustained repetition of fabricating a discrete component has also given rise to mechanization, since man has often invented ways to relieve his hands and mind of the endless monotony of highly repetitive work.

However, regardless of whether the design of standardized components ever leads to full and mechanized industrialization, it serves as a crucial first step toward partial industrialization, and is particularly appropriate to less developed regions since little investment or risk need to be involved in its execution.

Skill Specialization

As noted above, the specialization of labor can flow quite naturally from the result of a systems design effort. On the other hand, as a step toward partial industrialization it can also evolve or be encouraged independently.

A classic example of "pure" labor specialization, without the other elements of industrialization may be found in the medieval cathedral where highly skilled and specialized artisans and craftsmen were organized in guilds or trade organizations. Each in his turn contributed his specific skills to the total construction. Stone cutters, masons, sculptors, carpenters, artists, weavers, smiths, and many other specialists participated over a long period of time to complete the cathedrals. By virtue of their specialization, the work was often of notably fine and high quality, although it was seldom rapid or similar to industrialized construction in other aspects.

Since speed in the medieval context was not crucial, finely-tuned management and coordination of the various skills and trades were also relatively unimportant. The relevant increments of time were months, years, and decades – not seconds, minutes, and hours as they often are in a contemporary, industrialized setting.

Professionals vs. Operatives. However, the example of the medieval cathedral typifies only one end of the spectrum of skill specialization – the professional end. The artisans and guild members were in fact highly specialized *and* highly professionalized. Their work demanded high entry skills, often requiring many years of relatively menial apprenticeship. As skilled professionals, their work demanded the exercise of continuous judgment based on extensive experience, and there was often great professional pride (and even rivalry) expressed in the quality and excellence of the work.

At the opposite end of the skill specialization spectrum, is the operative – the man who pushes a switch, or reads a dial, or inserts a single screw in an assembly line product all day. His entry skill is low, his training or apprenticeship is negligible, but his full utilization in the production process is virtually immediate. His task is explicitly designed to minimize reliance on his judgment, and there is often little pride or satisfaction associated with his work.

Clearly, the relevance of these two extremes as purposeful models for use in the development and industrialization process is varied. On the one hand, the professionalized and skilled fabricator of a standardized housing component is a possible model for a program of partial industrialization based on skill specialization. This is particularly true if the program also encourages that the same component be fabricated and available from other competing craftsmen. Furthermore, if the component thus produced is physically and aesthetically compatible with other, related components which can also be produced by small, labor-specialized craft or cottage-type industries, then the program follows the historic and successful precedent of the tatami system rather closely.

In some ways such a skill-specialized program would also be analogous to the example of the medieval cathedral, except that in the case of the cathedral, the craftsmen were usually not involved with a component system that could be fabricated off-site and then transported to the cathedral for installation by themselves or others. Most of the skill-specialized work was done in place, although the specialized guild or union organization of the work itself may suggest contemporary analogies in currently developing societies.

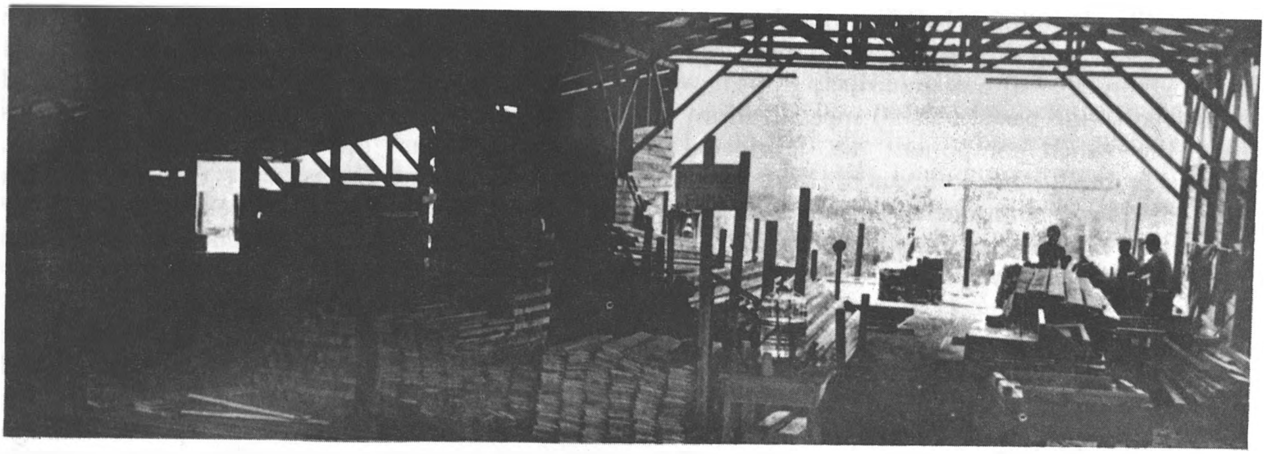
The operative model at the other extreme of the skill specialization spectrum, also may find contemporary applications in developing regions, although there are important tradeoffs between these two variations of labor specialization.

First, an operative type of labor-specialized program would have the advantage that it could be implemented rather directly and quickly without accumulated years of experience through training and apprenticeship. On the other hand, the concept of the narrowly specialized operative laborer may run counter to social goals. Such a concept, for example, might accentuate rather than mitigate the social and economic gap between laborers and managers. The job of performing a very small, simple, and specific operation does not readily lend itself to advancement toward professional or managerial status or toward increased degrees of social or economic mobility. The very real fact that operative jobs may be professional "dead-ends" may in many settings strongly militate against such a strategy — or at least public policy support for such techniques.

However, both of these labor specialization strategies are free from ties to mechanization or any other form of heavy capital commitment, although the operative strategy may imply slightly greater concentration than the professional strategy. This is because professionally oriented operations may involve only one or a few skilled workers and apprentices and be widely dispersed; whereas the operative venture would generally imply a larger and more concentrated group of narrowly-specialized workers and managers.

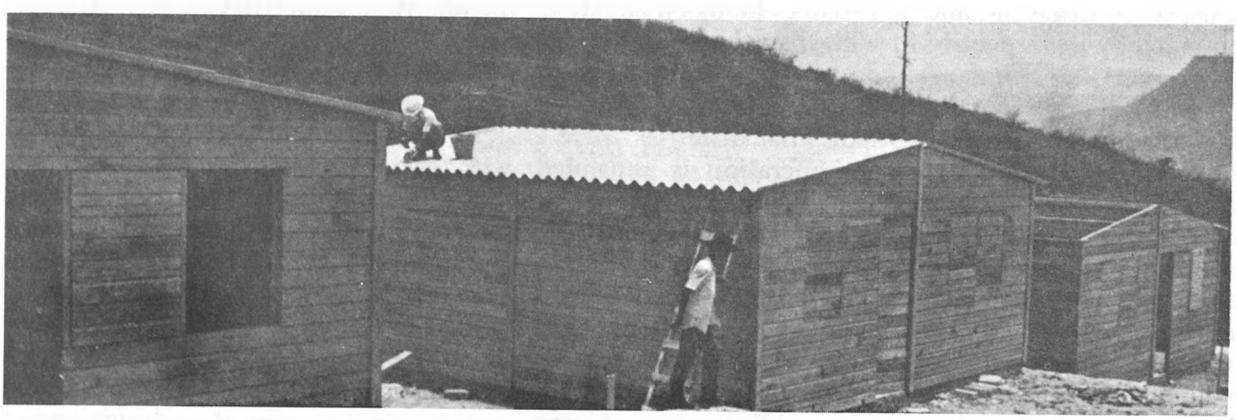
The selection of one of these strategies, or the appropriate mix of the two, will depend on the specific situation, and will have to be based largely on the relative productivity of each strategy, tempered by its respective fit with the values of the society in question.

Skill specialization, like the systems design aspect of industrialization, requires relatively little investment or risk. Most of what little risk there is stems from the fact once the number of employees and managers in an operation is expanded, with each performing a more narrowly defined and specialized task, then fixed costs in terms of salary and a physical plant or facility to accommodate the workers increase directly. Thus, unless production increases proportionally, unit costs will increase. The attraction of labor specialization, of course, is that production will increase *more* than proportionately, since it is likely that with more narrowly defined tasks, the repetitive nature of the work will lead to greater expertise and speed that will yield both quantity and quality increases, and perhaps even innovations or improvements in the product design or the manufacturing process. The risk involved follows from the ever-present threat of bottlenecks where a large number of workers might sit idle because of some contingency occurring at or during one of



PARTIAL INDUSTRIALIZATION — This small plant in Honduras produces wooden housing components which involve a high degree of standardization and labor specialization. The remaining aspects of industrialization — concentration and mechanization — are present, but in a less developed form.

COMPONENT INVENTORY — Prefabricated components are stored in the yard outside of the plant awaiting assembly at one of several nearby sites. Standardized door and window openings are visible in the panels in the immediate foreground.



ASSEMBLED HOMES — The partially-industrialized, prefabricated panels are assembled on site into simple and relatively inexpensive dwellings with a minimum of fitting and trimming. The materials used in the process respond to local availability.

(Photos by John G. Colby)

the productive steps. But these risks can be partially mitigated by maintaining a flexible work force, using part-time and overtime help to expand or contract rapidly.

Combining Techniques

The combination of both labor specialization and rationalized or systems design can become particularly powerful in developing regions in defining a partial form of industrialization. It becomes important to recognize that the rationalized design process, in order to be truly beneficial, should not stop with the mere design of the component. Production design is also important, and when a component can be specifically designed with specialized labor techniques in mind, it stands an increased chance of achieving the efficiencies and benefits desired.

Clearly in conceiving the performance requirements to be met in the Asian case study, the government and the contractor had thoughts of this combination in mind. In the African case study, the U.N. evaluation also noted the possibilities of partial industrialization based on skilled artisans and craftsmen. The report concluded that, "as *complete* prefabrication [or industrialization] of houses has not as yet yielded convincing economic results, . . . *partial* prefabrication might render very great results. In the beginning, it can be limited to certain parts of a house . . . [needing] only a small plant, it can be carried out by small contractors or even by artisans." It would be "therefore suited for popularization and use throughout the country."[1]

The report also added a note of caution, observing that the partially industrialized technology ought to be able to meet the economic test of the marketplace, and ought not be programmed to rely solely on use and consumption by official government programs. The report warns that, "If the government were to introduce a building technique that cannot be adopted by the building trade, its efforts would remain barren or might even have a negative effect."[2]

Toward Full Industrialization

The third and fourth steps on the path toward complete industrialization involve the concepts of concentrated and mechanized production. However, both of these aspects entail relatively greater investment and risk than systems design or skill specialization, and hence rely much more heavily on the full support of the institutions and facilities of an industrialized society.

Concentration. Concentrated, as opposed to dispersed, production facilities are increasingly dependent upon a society's transportation and communications networks. Raw materials must continuously and reliably reach the plant; and final product must leave the plant to reach markets.

Sheer size is another artifact of centralization. A crippling contingency such as a flood or power failure that closes one plant having a thousand-unit capacity is much more severe than if it were to shut down only one of ten dispersed plants, each having a hundred-unit capacity. Dispersion spreads the risk; concentration accumulates it. When risk and contingency factors are rooted in the facilities and services of the society in general, high risk environments commend a dispersion strategy with smaller-scale, individual operations to hedge against failure. On the other hand, lower risk environments, i.e., those rich in complete and reliable supporting services and facilities, may encourage a concentrated strategy designed to tap the potential efficiencies and economies of large-scale operations.

Mechanization. Automated and mechanized production techniques are often closely related to concentration strategies, since large volumes of production are nearly always necessary to justify the acquisition and installation of costly machinery. Accordingly, it is usually not feasible to consider the repetition of a high-investment item for each of many dispersed locations, not only because of diminished production requirements for each one, but also because the absolute magnitude of the investment escalates rapidly in doing so.

Mechanization, like the other aspects of industrialization, can occur independently of the total or composite industrialization process. Custom carpentry work in the U.S. is such an example. Traditionally the work is fabricated to order with little standardization of output. Little use is made of complex components such as prehung doors or prefabricated cabinets – the basic material is lumber in only slightly processed form, complemented by an assortment of hardware such as nails, screws, hinges, etc.

The work is typically individualized and most pieces are custom measured, fitted, and built to order. Furthermore there is almost a complete dispersion of the industry; national, regional, or even metropolitan concentrations rarely exist. The firms are small, craft-oriented, and scattered. Nonetheless, the carpentry industry is now highly mechanized. Electrically-powered tools are used for almost all tasks – sawing, drilling, sanding, planing, painting, etc. – typifying mechanization without industrialization.

Yet it is important to recognize the difference in scale between the power tools referred to above, and the large, automated machines commonly associated with industrialized housing production. Both are forms of mechanization yet there is a quantum difference in cost, and hence economic utilization factors between the two, as there are in the facilities and skills needed to maintain and service the machines. And again, the choice of the smaller, lower-risk investment, relying less on the surrounding infrastructure of the society to maintain it, is preferred for the less-developed economy.

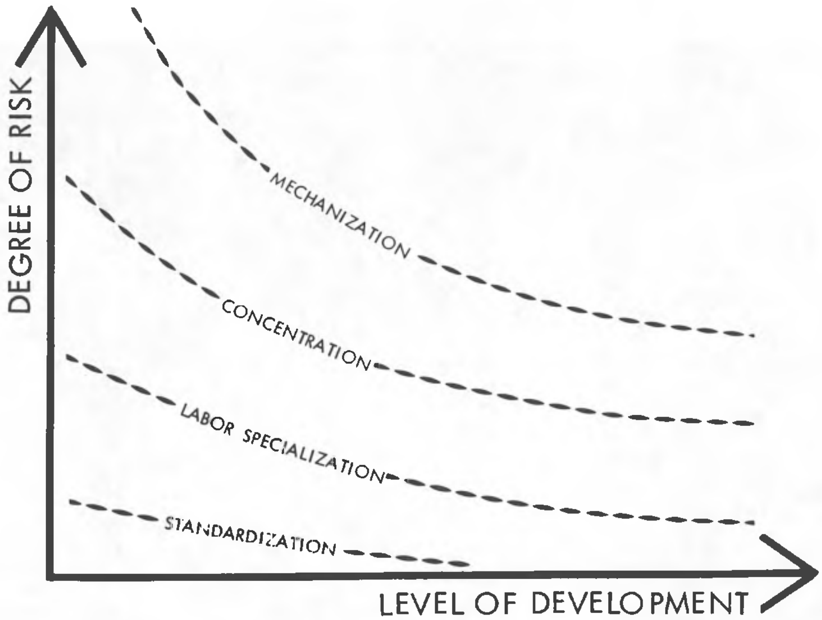
Sequencing Risk

Since mechanization generally implies the highest cost/risk factor of the four aspects of industrialization, it emerges as the final aspect of a strategic sequence ranging from partial to full industrialization. The other three aspects, particularly systems design and labor specialization – and to a lesser degree concentration – can be implemented with relatively little capital. A diagram can now be drawn schematically relating risk (which increases from bottom to top along the vertical axis), to the degree of economic development of a given region or society (which advances from left to right along the horizontal axis). Each element of industrialization can be plotted on the diagram as shown in Figure 7.

The horizontal progression from left to right is schematically indicative of increasing supportiveness in terms of the facilities and services of the economy or society. As this supporting infrastructure increases, the increasing risks of the higher-investment aspects of industrialization are mitigated.

Thus Figure 7 becomes a kind of "strategy map" for less-developed regions, showing a sequence from partial to full industrialization that is geared to the growth of the supporting infrastructure of the society, and cautions against the premature adoption of industrialization aspects that will require a simultaneous reproduction of the society in miniature for support.

FIGURE 7: THE RELATIONSHIP BETWEEN RISK AND ECONOMIC DEVELOPMENT FOR THE FOUR ELEMENTS OF INDUSTRIALIZATION



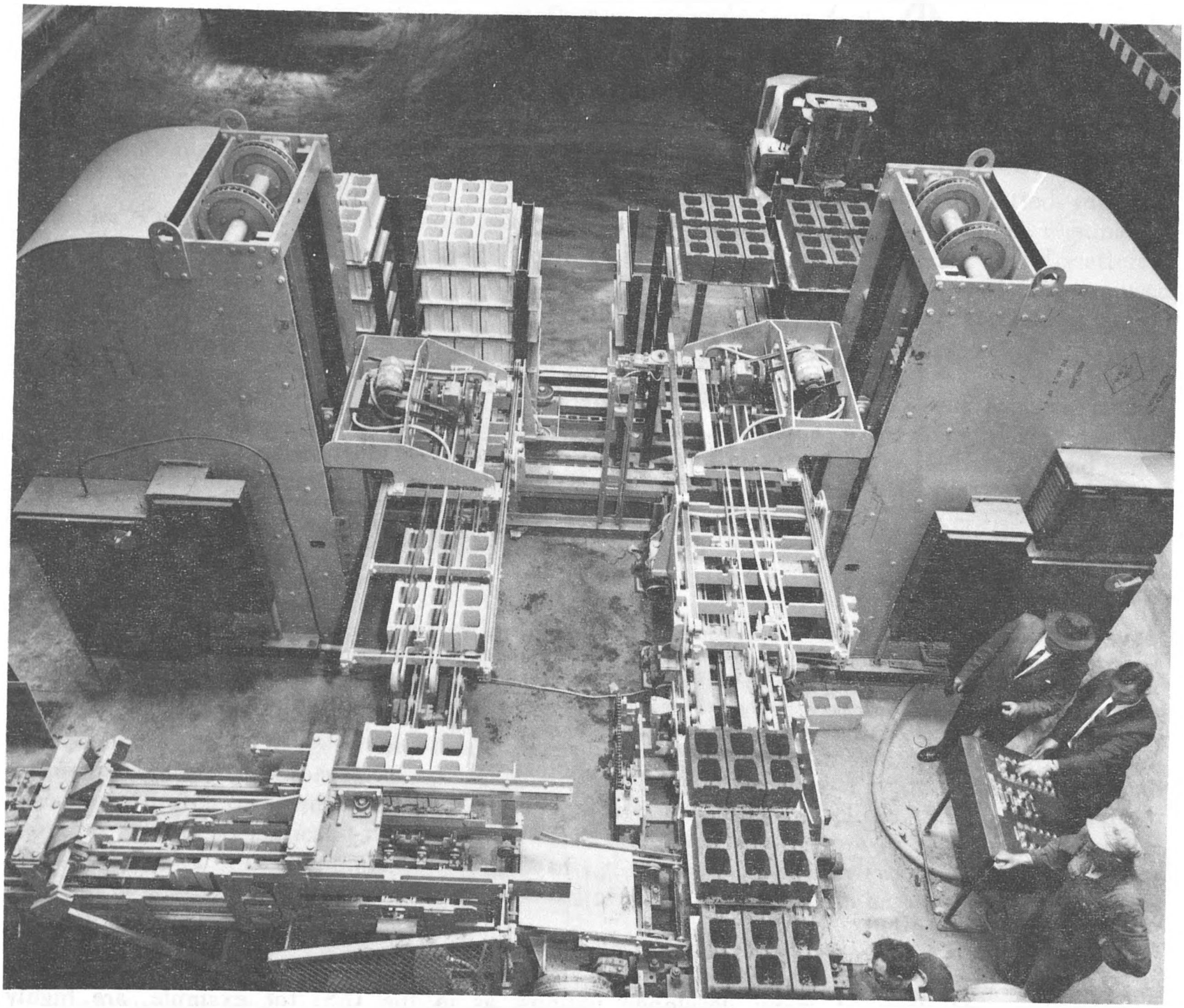
DEVELOPMENT DECREASES RISK — The diagram schematically relates risk (which increases from bottom to top along the vertical axis) to the degree of economic development (which advances from left to right along the horizontal axis) for each aspect of industrialization. Hence, the risk of counterproductivity for an investment in mechanization is greatest at all levels, although this risk drops as the supportiveness of a society grows with increasing economic development. On the other hand, the risk of standardization is always relatively low; although it too drops slightly with increasing development.

Indirect Industrialization

Like the carpentry example mentioned above, except at a larger scale, the conventional construction industries of many developed nations, as in the U.S. for example, are highly mechanized, but non-industrialized. Cranes, bulldozers, concrete mixers, and power tools of every sort are regularly utilized, yet most U.S. construction activities are non-industrialized by virtue of their individually customized and dispersed output.

However, while the U.S. construction industry is not industrializing directly, it is doing so *indirectly* by making increased use of mass-produced, industrialized components. Whereas the use of fully-industrialized techniques is a rarity among U.S. home-builders, this does not hold true for the specialized industries that supply the homebuilders. Many of these suppliers have been fully industrialized for decades, but when their mass-produced products are combined or installed by custom builders, the process often becomes *ad hoc* and asystematic.

A well-known and world-wide example of this kind of indirect industrialization of housing may be found in the concrete block industry. Millions of non-industrialized houses throughout the



AUTOMATED BLOCK PRODUCTION – Bricks and blocks are often one of the first building components to be industrialized in developing areas. Although the blocks themselves do not form a total building system, this *indirect* step toward industrialized housing is often highly successful in terms of improving the quantity, quality, and economy of materials production. A variety of well-tested machines are available embodying differing degrees of automation. Here high-speed, fully automated assembly lines are tested during installation in Auckland, New Zealand.

(Besser Company photo)

INDIRECT INDUSTRIALIZATION — Although these industrially-produced concrete stair units will be installed in conventional houses, this form of indirect industrialization of housing can be useful and productive in developing areas. Furthermore, as in this case in Honduras, the producer's investment and risk are much lower than they would be in attempting to industrialize the production of entire houses. (Photo: John G. Colby) world have utilized the mass-produced blocks since the block industry has been relatively quick and easy to industrialize. The product itself is a highly-standardized, basic component with widely accepted dimensions. The blocks may be produced initially without labor specialization, concentration, or mechanization using a single worker and a crude wooden mold. Yet the process may be partially industrialized at almost any stage. Labor specialization may be introduced to speed production with a group of workers specializing in the mixing of the concrete, others tamping the mix into the molds, and still others stripping and storing the blocks, etc. Partial industrialization may be extended to include a large, concentrated operation in an attempt to capture various economies of scale in materials procurement, market aggregation, etc. Finally mechanization may be added in the form of a proven and durable, relatively low-cost, automatic machine. This example, then, is an illustration of the partial and gradually full-industrialization of a construction supplier industry, and in turn the *indirect* industrialization of the overall housing or construction industry.

The difference is significant – indirect industrialization refers to the phenomenon whereby some parts or components of the building are industrialized, but the overall building is not; and partial industrialization refers to the process whereby the construction of the overall building makes use of some aspects of industrialization such as systems design and skill specialization, while deferring or avoiding others.

Yet many developing nations have adopted policies and allocated resources to encourage dramatically the risk-filled and complex industrialization of the overall housing industry when those same resources might have applied much more productively to an indirect form of industrialization. The money and effort could have been directed toward the manufacture of much simpler and smaller building components. As was noted earlier, it is easier to industrialize pins than houses; and hence the simpler and smaller the component, the more likely it is that it can be beneficially industrialized, and thus reflect the economies that derive from full, mass production and marketing.

And when, as will be discussed in the following section, these smaller and simpler components – unlike concrete block – are part of an overall and rationalized housing system which can be utilized by families without prior construction experience, then the strategy for the low-risk industrialization of housing in less-developed regions attains its most powerful form.

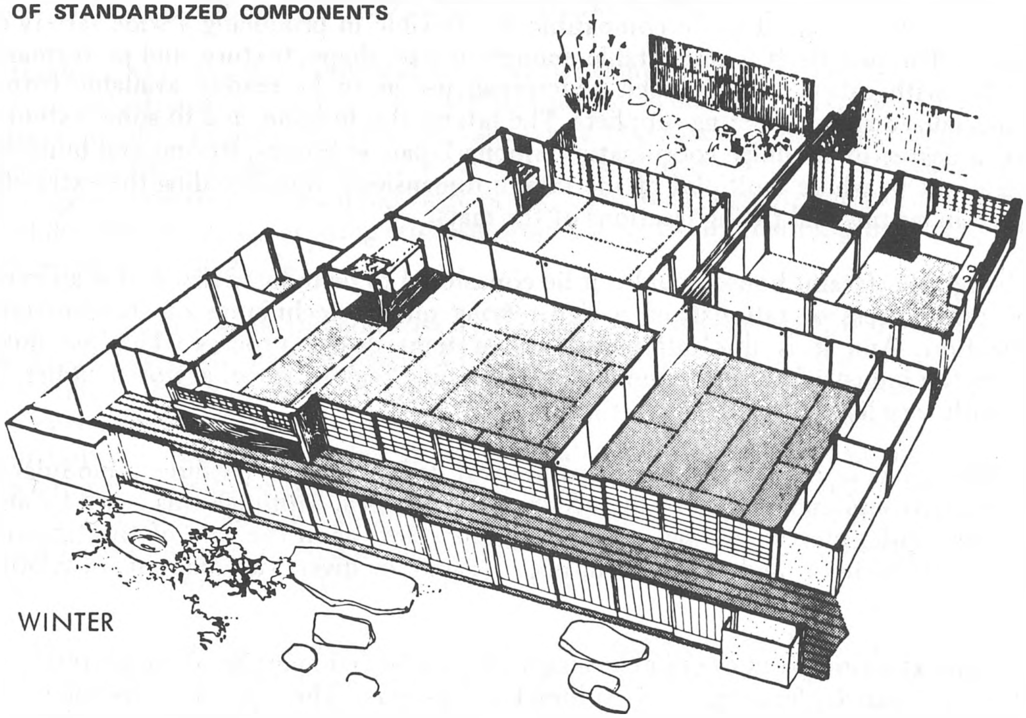
PRODUCT–TOWARD INTERMEDIATE AND TRANSITIONAL TECHNOLOGIES

In the preceding section the emphasis was on the manufacturing process, and how it might be partially or fully industrialized. In the closing portion of that discussion, the emphasis shifted in scale from the house to the smaller building component, and concentrated on how the manufacturing process for that small component might be industrialized. It was observed that the industrialization of small building components led to the indirect industrialization of the overall housing industry itself. However, while much was said about the manufacturing process, little was said about the end product. In this section greater attention will be given to the product, in an attempt to define the characteristics of intermediate technologies.

Tatami House

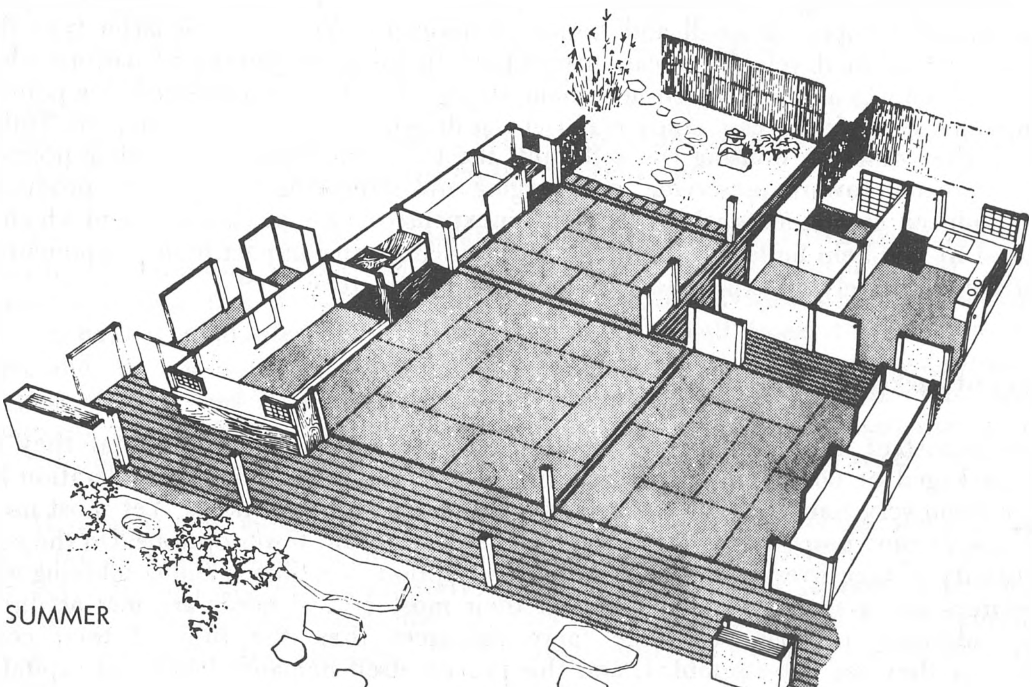
The preceding discussion on the manufacturing process placed emphasis on systems design as a means of producing standardized building components which would be amenable to a repetitive production process. However, those components must have other characteristics as well – many of which are typified by the Japanese tatami house[3] (right).

TRADITIONAL JAPANESE HOUSES BUILT UP FROM A PRE-COORDINATED SYSTEM OF STANDARDIZED COMPONENTS



WINTER

TATAMI HOUSE — The traditional Japanese house used the double-square tatami mat (approximately three feet by six feet) both as a basic planning module and building component. The use of the mats epitomize a coordinated and standardized approach toward the design of highly responsive and flexible construction systems. Wall partitions from the house, above, are removed for a summer configuration, below.



SUMMER

The tatami mat is a standardized, prefabricated component – part of a total system of components explicitly designed to be compatible yet flexible in producing a wide variety of house types and sizes. The mat itself is predictable enough in size, shape, texture, and performance to be interchangeable with others; it is in such widespread use as to be readily available from a large number of specialized and competing suppliers. The tatami also became, and to some extent remains the basis for a degree of modular coordination among Japanese houses. Rooms and buildings often have been laid out in whole multiples of the tatami dimensions, thus avoiding the extra effort and waste involved in cutting and fitting fractions of the mats.

Although the tatami house could not be considered to be industrialized, it is an exceptional example of the process of rationalized design relying on the techniques of standardization and componentization. And it is this rationalized or systems design process which assumes special significance in the industrialization sequence of developing regions since, as noted earlier, it can be undertaken with very little investment or risk.

Basically what is required is a commitment of design time to produce a modular building component sensitive and appropriate to the needs of a given area. Although this is not by any means a simple or easy task, success can be immensely important, as in the case of the tatami. Failure can be relatively innocuous, and at least will not consume or divert vast amounts of vitally needed housing resources.

Attempts at rationalized or systems design have embraced many product strategies including various types of panel, framing, and volumetric systems. The size and complexity of the components involved have ranged from relatively small, simple, and standardized brick, block, and mat components, to rather large and complex room-sized and even house-sized modules.

Trends Toward Packages

Unfortunately the trends in many less-developed areas show an increasing fascination with these larger and more complex components and packaged modules, and diminished emphasis on new or incrementally improved small and simple components. Yet it is this latter type that can often be most critical in developing areas, particularly in those less-developed nations where the traditions of self-help family construction remain strong. The U.N. emphasized this point in the report from which the African case study material was drawn in the preceding chapter. Noting that 80 percent of the country's housing was self-built, the U.N. concluded that "public policy must, therefore, be directed toward preserving, encouraging and improving this type of production."[4] Thus, mass produced components which are light, inexpensive, easy to handle – and which can be readily utilized by self-help builders potentially have much greater impact than components which must be utilized exclusively by experienced builders and contractors.

Disadvantages of Packaged Components

It is important that components remain separate and discrete, and that they not be extensively packaged or combined before reaching the user. This is a key consideration because packages, by their very nature, limit options by pre-combining components. Yet most users, and particularly low-income users in less-developed regions do not want fewer options. On the contrary, the very austerity of their lives demands a maximum of options in utilizing and combining whatever meager resources are available to them so that their most critical needs are met as directly as possible. In addition, packages consume more resources than the sum of their combined components, for they are pre-assembled, and this process itself demands labor and capital, hence increased cost to the user. Thus if components are designed so that their assembly is simple and fool-proof, packaging not only reduces options, but also increases cost.

Habitat. One of the most widely known examples of the packaged or highly-unitized approach to industrialized housing is the Habitat project which was referred to at the beginning of this chapter. In that project the basic package was a two-room, 90-ton, precast concrete module. Two or more of these modules formed a variety of dwelling units. As a prototype, Habitat was the subject of great controversy, winning high praise from many for its radically bold and dramatic design, while simultaneously drawing criticism from others for its cost (approximately $100,000 per module), social irrelevance, etc.[5]

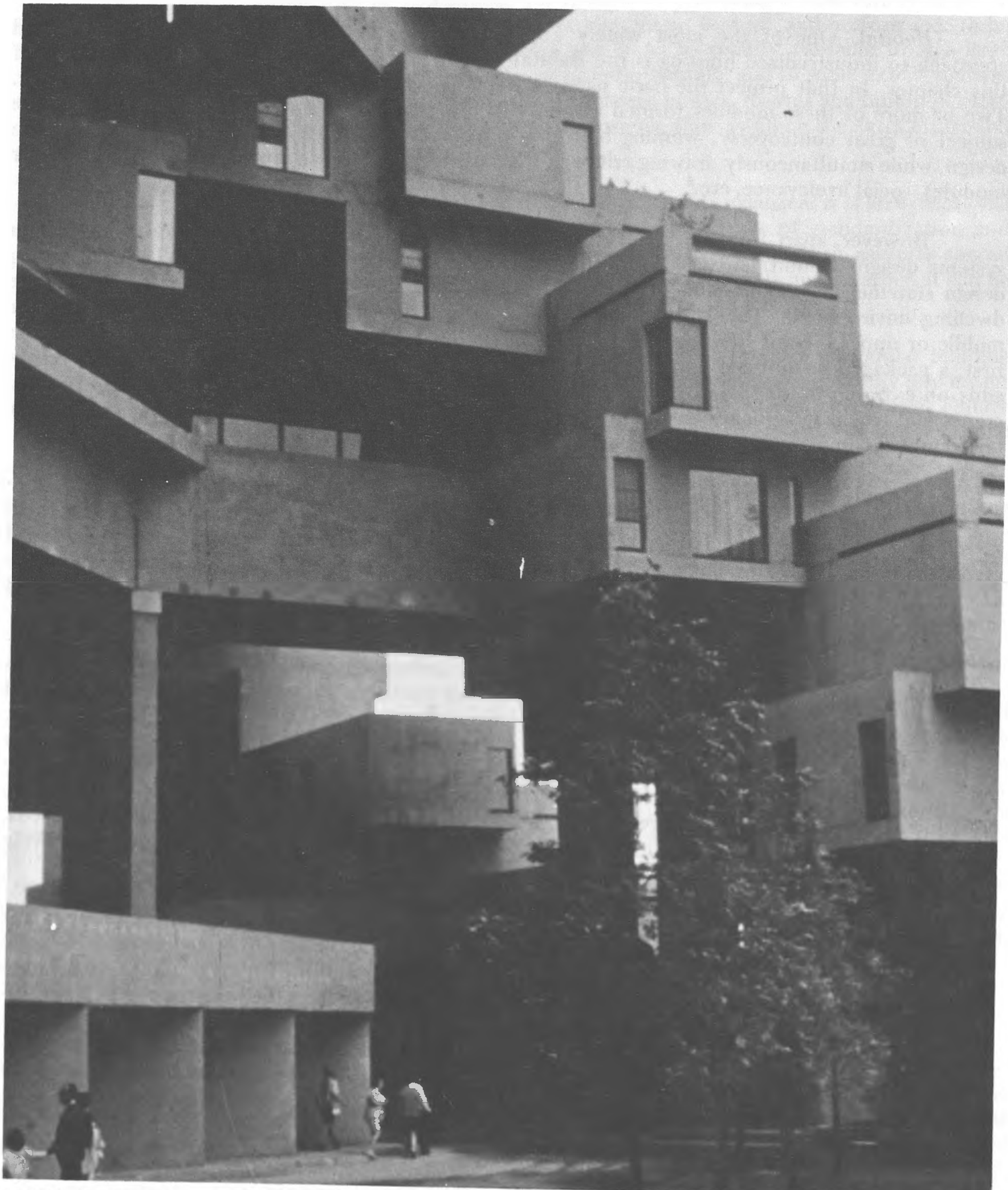
However, apart from the controversy, Habitat for purposes of this discussion, epitomizes a systems design commitment to a unitized or packaged strategy. It represents a bold and enduring design statement, but embodies little or no flexibility for change or individualized control of the dwelling environment. The authors contend that this type of design strategy may be valid for middle or upper income housing, but it loses its viability for low income families for three reasons: first, a packaged or unitized housing module is by its very nature large and heavy, which inherently adds on extra costs for special handling and transportation. Often, extremely costly high-capacity cranes and trucks must be utilized in moving the modules to the site and into place; whereas smaller unassembled components can often avoid most of this type of cost.

Second, in purchasing room or house-sized packages, the buyer needs a relatively large bundle of savings, or at least access to credit so that his payments may be made in relatively small increments over an extended time period. When purchasing small-scale components, savings and credit are certainly helpful, but without them the process does not stop—as is shown throughout the developing world where traditionally-built houses incrementally develop using conventional components over the course of decades and generations.

The third, and perhaps most important disadvantage of a packaged as opposed to component housing strategy in developing areas is that packages are by nature predetermined and inclusive. The decisions that directly affect the living environment are often made by designers, engineers, entrepreneurs, and public officials with great social and economic distance between themselves and the lives ultimately affected by their decisions. The advantage of the simple component system is that a relatively small number of standardized building elements can be combined by individuals in a large number of ways to suit a great diversity of individual needs. Using this approach, a componentized system can be manipulated to conform to the user's living patterns; with preassembled packages, often the reverse is true.

Corollary to these three considerations is the fact that a critical performance requirement for low-income housing is the ability to easily accommodate and adjust to change. In most situations it is clear that the initial house, which often barely fulfills the most urgent, immediate needs, can hardly be counted upon to fill future needs as well. Hence the houses must be based on change, and an industrialized process which is to serve the needs of low income families in developing regions must be at least as receptive to change as conventional construction, which is continuously expanded and upgraded by owner families. Thus the industrialized process must be able to provide an initially austere house yet one that can grow and improve over time.

Housing is seen most clearly in this context as a dynamic process, and no longer as a static product; the provision of incrementally additive components is crucial in order for the intermediate technology to reflect this process properly. Where change is desired, indeed where it must become a way of life, a construction system must be alterable with minimal waste. This implies not only a componentized system, but a system whereby components once joined, remain individually discrete and replaceable.



HABITAT '67 – One of the most spectacular exhibits at the Montreal World's Fair in 1967 was the block of industrialized housing known as Habitat. The project typifies a commitment to a "unitized" or "packaged" design strategy which the authors argue is less appropriate for developing areas.

Lightbulb. A typical lightbulb provides an excellent example of this principle. When the bulb needs replacement, the only part of it which is no longer serviceable is a tiny strand of tungsten filament. All the other components of the package are still perfectly usable—the glass globe, the brass screw-in base, the internal wiring, etc. Yet because the bulb is unitized or packaged, a discrete replacement is impossible, and the entire bulb must be discarded.

The packaged dwelling, like the lightbulb, implies waste when there is change; and with the world's exploding population, and the still increasing gap between rich and poor, the luxury of wasteful discarding of usable components runs counter to both improving housing conditions and narrowing the income gap among people. The days may be numbered for reducing a wall or even an entire building to a heap of rubble when change is desired. If housing conditions are to be improved under the most austere circumstances, obsolete components must be recycled and reused with minimum destruction and waste.

At a slightly enlarged scale, the lightbulb itself also provides an example and model of a marvelously discrete component. When the bulb burns out, or when a change to a different kind of light is desired, the bulb can be neatly and easily separated from the fixture and the wiring of the building. The screw-in base is standardized, and interchangeable replacements are widely and competitively available with a large variety of performance, size, shape, and design. Thus with a bulb, as with a simple componentized house, a user may start out with the most austere and lowest performance solution possible; but when he is ready, the initial component may be replaced, and if appropriate, enlarged and upgraded by the user himself, without his being "locked in" to the first, austere solution. Thus the component system can grow and evolve with the growth and evolution of the user.

The initial dwellings of low-income families in developing areas will probably continue to be extremely austere into the near future, particularly in the absence of radically new credit programs or enormous subsidies. If intermediate technologies are to make a truly significant contribution to the ability of low-income families to house themselves more adequately, they must yield easily assembled components which can be combined initially into an extremely inexpensive dwelling. But this dwelling must have the capacity to grow and improve in small increments into a fully matured home without waste and destruction of effort or materials.

Transitional Technologies

While the intermediate technologies discussed above emphasize small, simple and non-packaged components, another desirable characteristic for components in developing areas is that they lend themselves to a range of manufacturing techniques. Again the concrete block, although not part of an overall housing system, affords a good example of a component which is traditional: it can be initially manufactured by hand, and without any change in configuration, can ultimately be fully mechanized and mass-produced. Of key importance is that the machine-made blocks will be completely compatible and usable with the earlier, hand-made blocks.

Thus, if the intermediate technologies described above, are transitional as well, i.e., can be produced without change either by hand or machine, according to whichever is appropriate to the demands and capacities of the society, then the technology is additionally advantageous since it can evolve with the economy. Clearly then, the more transitional the economy the more desirable this additional characteristic of intermediate technologies becomes.

Availability of Partially-Industrialized, Intermediate Technologies

In light of the foregoing analysis, there appears to be an extreme shortage of partially-industrialized, intermediate technologies. In fact, a brief survey of 78 of the most widely used housing systems[6] indicates a virtual absence of such solutions.

There is, however, a significant amount of indirect industrialization in almost all nations. Increasingly, the suppliers of the housing sector are industrializing, and certain typical components such as concrete block and sanitary fixtures are standardized and mass produced with good quality and low prices – both of which were much more difficult to attain prior to industrialization. Yet these components exist independently of one another – and not as a part of an overall housing system which could assure not only their compatibility but also an ease of construction and replacement not presently available anywhere.

Thus the widespread trend toward indirect industrialization must be augmented by partially industrialized intermediate technologies. At present most developing nations face only the barren choice between fully-industrialized, advanced technology systems or a continuation of their slow and inadequate, hand-crafted methods of traditional building. The advanced systems are plentiful and, in desperation, many less-developed areas have imported them at great expenditures in resources for results which are highly questionable.

From the informal survey, it was found that of the techniques most in use around the world, nearly all were products of industrialized nations; and applications in less developed areas depended almost exclusively on imports. Further, the authors were able to find only a very few examples of partially-industrialized, intermediate technologies–the very ones which pose the most promising and significant challenge to professionals in the housing field. Of great additional importance to developing areas is the fact that abundant experimentation is possible in these areas at relatively low investment and risk, and without the necessity of importing professionals, technicians, machines, or materials from the industrialized nations.

Part V

SUMMARY AND CONCLUSIONS

Feasibility and Desirability

Most of the foregoing discussion has been devoted to the issues involved in ascertaining whether a specific proposal to industrialize housing in a developing economy is both feasible and desirable. In all contexts, a proposal may be viewed *feasible* if it can be expected to yield more, better, or less-costly houses than those being produced conventionally. It is desirable as well, if attendant social costs are held to within acceptable limits.

For example, in post-war Europe, industrialization was deemed feasible since it yielded a far greater volume of housing than could have been built otherwise. Yet this increase in volume was at the expense of economy – and often quality – although these and other losses were considered to be within acceptable limits: hence the program was judged to be desirable as well.

Among the three parameters of feasibility – quantity, quality, and cost of production, cost emerges as clearly the most significant in evaluating fully industrialized housing in economies of scarcity. These economies, which characterize the contemporary Third World, demand quantum cost savings in order to justify the effort, commitment, and risk associated with fully industrialized housing production. No other payoff can possibly justify such a commitment of resources in contexts of such scarcity. In other words, high risk demands high gain.

Significantly, in the course of preparing this research, the authors were unable to document a single case anywhere in the Third World where a full industrialization scheme produced the expected and crucial high-gain payoff: a quantum reduction of costs. There were, of course, cases of incremental improvements in both housing quantity and quality, but *all* were achieved at the expense of *increased* costs. The authors argue that although a scheme producing this result might be politically or even economically feasible, it is not *desirable* in an economy of scarcity since it can only serve to widen the gap between rich and poor.

In attempting to establish a meaningful and complete measure of cost, the authors have turned to the concept of "development cost" as the significant criterion for comparing the relative economies of conventional and industrialized construction. Development costs include not only construction costs, which are most obviously related to industrialization, but also interim financing, overhead, profit, and land and site work – all of which can also reflect the effects of industrialization.

By this criterion of development cost, the cases presented in this report are seen as failures – particularly since the overhead segment of development cost proves to be so sensitive to work stoppages or "down-time," which is observed to be a major problem for industrialized operations in developing economies.

In light of this, the authors recommend the abandonment of the heavy investment, high-risk notion of fully industrialized housing strategies for less-developed economies; and a refocusing on the lower-risk concepts of *partially* and *indirectly* industrialized forms of housing manufacturing, and on *intermediate* and *transitional* forms of product technology.

Once this shift takes place, the earlier emphasis on development cost as the overriding evaluative criterion also shifts since there is no longer so much to lose; and more modest payoffs in the form of small, incremental inprovements in quantity, quality, or cost are acceptable and viable.

The authors recommend to developing nations an array of low risk strategies emphasizing "partial industrialization" which is a disaggregation of the full industrialization process. Partial industrialization selects out the *systems design* and *skill specialization* techniques, which can be implemented simply and without heavy investment. The remaining higher-risk techniques of *concentration* and *mechanization* are thus postponed or avoided.

The concept and strategy of "indirect industrialization" is also recommended in this context since it similarly lowers risk, thus permitting small payoffs of quantity, quality, or cost improvements to suffice. In indirect industrialization, the suppliers to the housing sector – although *not* the housing industry itself – either fully or partially industrialize. This risk is relatively lower than in the overall housing industry because the suppliers are generally producing items such as blocks or fixtures which are much smaller and easier to industrialize than entire houses. Hence policies which encourage indirect industrialization can also help to make housing components more widely and inexpensively available (even if they are not systematically coordinated and compatible as would be the case if they were also partially industrialized).

Social Consequences

In addition to feasibility based on a reasonable expectation of more, better, or less-expensive houses, the authors also postulate that industrialization schemes must not lead to reduced housing choices, diminished individual control of dwelling environments, or increased social or economic polarization. To satisfy these social criteria, the authors turn toward intermediate technologies and systemized sets of discrete building components, designed to offer the widest possible range of choice and control to their users – and particularly to unskilled family builders.

The authors also observe that one of the prime motives for industrializing (as in post-war Europe), has been to utilize labor saving machines in the face of manpower shortages. However, with acute unemployment and underemployment, which are characteristic of the Third World, substitution of scarce capital resources for plentiful labor resources becomes highly undesirable from a social, as well as economic viewpoint. The discussion also alerts developing nations to other potential hazards of "feasible" industrialization schemes, including increased social and economic distance between operatives and managers, pollution, and outflow of foreign exchange currency.

FOOTNOTES

PART ONE – INTRODUCTION

1. United Nations, *Housing, Building, and Planning; Problems and Priorities in Human Settlements,* Report of the Secretary General (A/8037) New York: Aguust 21, 1970, p. 27 and pp. 52-54. The Report shows a 30% deficit for "Less Developed Areas" and a 21% deficit for the "World Total" in 1970. However these widely used housing "deficit" figures are not generally of major value, since they are actually surrogates for poverty on the one hand, and functions of often arbitrary and inconsistent standards on the other. In Peru for example, in 1956, a government commission found that only 11% of the nation lived in "standard" or acceptable dwellings. Such an unrealistic figure not only loses its value as a policy instrument, but it also fails to discern the actual gap between supply and effective demand. In Nairobi, annual rents for urban dwellings were recently found to exceed the full capital value of the housing unit itself – a much more important indicator of the failure of the market to respond to both actual need and ability to pay.

2. A useful study in this regard is one by M. Christine Boyer, *Comparative Development: A Quantitative Approach,* M.C.P. Thesis, Massachusetts Institute of Technology, Dept. of City and Regional Planning, Cambridge, Mass., Sept. 1968 (unpublished).

3. Letter to authors, 7 January 1971, The Building Research Station, Department of the Environment, British Government.

PART TWO – INDUSTRIALIZATION: MYTHS AND REALITIES

1. *A Fact Book on Home Manufacturing,* The Home Manufacturers Association, Washington, D.C. pp.4-5. See also *The State of the Art of Prefabrication in the Construction Industry,* A Research Report by Battelle Memorial Institute, Columbus, Ohio, 1967, pp. 14-17.

2. Catherine Bauer, *Modern Housing,* Boston: Houghton Mifflin Company, The Riverside Press, Cambridge, 1934, p.207.

3. *Ibid.*pp. 207-208.

4. *Ibid.*p. 208.

5. William Alonso *et al., Innovations in Housing Design and Construction Techniques as Applied to Low Cost Housing – A Collateral Literature Survey,* Prepared for the Department of Housing and Urban Development, In-Cities Experimental Housing Research and Development Project, March-April 1969, Reprinted by the Clearinghouse for Federal Scientific and Technical Information, (PB 184 164), U.S. Department of Commerce/National Bureau of Standards, Washington, D.C., 1969, p. 33.

6. Marian Bowley, *The British Building Industry,* Cambridge: The University Press, 1966. See also Alonso, *et al., op. cit.,*p. 33.

7. Allan Bates, "Low Cost Housing in the Soviet Union," *Industrialized Housing,* Materials compiled and prepared for the Subcommittee on Urban Affairs of the Joint Economic Committee, Congress of the United States, U.S. Government Printing Office, Washington, D.C., 1969 p. 5.

8. Leon M. Herman, "Urbanization and New Housing Construction in the U.S.S.R.," *Industrialized Housing, op. cit.,* p. 24.

9. *Ibid.,*p. 24.

10. For other historic works see:

a) Burnham Kelly, *The Prefabrication of Houses,* New York: Wiley and M.I.T., 1951.

b) Konrad Wachsmann, *The Turning Point of Building,* New York: Reinhold, 1961.

c) Tennessee Valley Authority, *Factory-built Houses,* 1944.

d) The Report of the President's Committee on Urban Housing (The "Kaiser Commission"), Technical Sutdies, Volume II, U.S. Government Printing Office, Washington, D.C., 1968, pp. 177-189.

11. Alonso, *et al., op. cit.,* pp. 30-31.

12. National Commission on Urban Problems ("Douglas Commission"), Appendix: "Selected Data of European Experience with Industrialized Building Systems," U.S. Government Printing Office, Washington, D.C., 1968.

13. Charles Gersten Field, "Home Manufacturing and Building Codes: The Confrontation Between Technology and Institutional Regulation," unpublished Ph.D. dissertation in City and Regional Planning, Harvard University, Cambridge, Mass., June 1971, p. 28.

14. Battelle Research Report, *op, cit.,* p. 17.

15. Alonso, *et al., op. cit.,* p. 36.

16. Daniel A. Hodes, "The Modular Housing Industry," *Financial Analyst's Journal,* May-June, 1970, p. 85, using the Manufacturing Index of the U.S. Bureau of Labor Statistics, and the Construction Index from the *Economics of the Construction Industry,* The Conference Board, 1969.

17. Aprodicio A. Laquian, "Housing Squatters and Slum Dwellers in Southeast Asia," Paper delivered at the 137th Meeting of the American Association for the Advancement of Science, Chicage, Ill., December, 1970, pp. 8-9; quoting from: Government of Malaysia, *Industrialized Building Techniques for Low Cost Housing,* Kuala Lumpur: Ministry for Local Government and Housing, 1970, pp. 4-5.

18. Frank de Leeuw, *et al.,* "Housing Costs and the Industrialization of Production, Working Paper 121-1, The Urban Institute, Washington, D.C., May 1969.

19. Herman, *op. cit.,* p. 26.

20. *Bibliography of Industrialized Building,* South African Council for Scientific and Industrial Research, National Building Research Institute, Pretoria, South Africa, 1966 (mimeographed), p. iv.

21. Figure adapted from Table 3, "Approximate Man Hours per Thousand Square Feet of Multifamily Dwelling, National Commission on Urban Problems, *op. cit.*

22. United Nations, Department of Economic and Social Affairs, *Trends in the Industrialization of Building,* United Nations, New York, 1970 (#ST-SOA-102), p. 27, citing: Stavební výzkum cís. 2-3, Výzkumný ústav stavební výroby, Praha, 1963.

23. Paul W. Strassmann, "Innovating and Employment in Building: The Experience of Peru," *The Oxford Economic Papers,* Volume 22, July, 1970, pp. 244-259. The eleven innovations studied included: 1) vinyl tiles, 2) integral terrazzo, 3) metal ceiling forms, 4) prestressed ceiling beams, 5) tubular scaffolding, 6) metal wall forms, 7) prefabricated external panels, 8) sand-lime bricks, 9) light-weight, machine-made, clay bricks, 10) asbestos cement pipes, and 11) plastic P.V.C. pipes. Strassman notes: "All eleven of the innovations here examined in detail reduced unit labour costs or the component in question between 20 and 90 per cent, but usually by one-third. . . .On the other hand, only three of the innovations lowered material costs [vinyl tiles, cement-asbestos pipe, and plastic P.V.C. pipe] , while eight increased them." p. 258.

24. In addition to the personal observations of the authors, similar observations have been made by Edward Brice and Paul M. Goldberg, at the Sloan School of Business Administration, Massachusetts Institute of Technology, Cambridge, Mass., 1971.

25. Guy G. Rothenstein, "European System Building." Paper presented at the Executive Office of the President – Office of Science and Technology, Interagency Discussion on Advanced Housing, Washington, D.C., March 1967, reported by Marion Schlefer, *Industrialization of Housing: Today's Potential,* U.S. Library of Congress Legislative Reference Service, Washington, D.C., 1968, Appendix IV.

26. "Systems Built Apartments Collapse," *Engineering News Record,* New York: McGraw-Hill Publishers, May 23, 1968, p. 54. Three persons were killed in the collapse and 11 were injured. As a result 6,000 people were ordered evacuated from 29 buildings constructed with the same industrialized system. See also *Engineering News Record,* August 22, 1968, p. 17; and November 21, 1968 p. 23.

PART THREE – THE IMPACT OF CONTEXT ON INDUSTRIALIZATION

1. United Nations Technical Assistance Programme, "Housing in Ghana" (ST/TAA/K/GHANA/I) New York, 1957. The quotations and materials for this case were excerpted from p. 38 and pp. 127-134. The reporting team included Charles Abrams, V. Bodiansky, and O. Koenigsberger.

2. *Ibid.,* p. 38. The opposited extreme of this point is under way in the PREVI Competition (Proyecto Experimental de Vivienda) sponsored jointly by the Peruvian Government and the United Nations Development Programme. The competition was open to all Peruvian and 13 invited foreign architects "to develop new approaches and techniques in the field of urban housing with emphasis on the needs of low-income groups of the population." The program was initiated in 1967-8 and is not yet complete.

3. The events presented in this case actually occurred, and are reported by the authors from confidential first-hand observations. However, a number of facts have been changed to conceal the identity of the individuals, the companies, and the countries involved, and to make the case read more easily and illustratively. (The primary activity of the company in this case was the manufacture of materials for construction components.)

4. United Nations Technical Assistance Programme, "Housing in Ghana," *op. cit.*, p. 133 (emphasis added).

5. The events presented in this case actually occurred, and are reported by the authors from confidential first-hand observations. However, a number of facts have been changed to conceal the identity of the individuals, the companies, and the countries involved, and to make the case read more easily and illustratively.

PART FOUR – TOWARD A STRATEGY

1. United Nations Technical Assistance Programme, "Housing in Ghana," *op. cit.*, p. 135.

2. *Ibid.*, p. 134.

3. Bruce Martin, *Standards and Building*, London, England: RIBA Publications, Limited, 1971, p. 102. Martin notes:

> Possibly the most notable example in the history of building is the planning of Japanese houses on the basis of a standard double-square size of mat measuring approximately 900 mm x 1800 mm (approximately 36 in x 72 in) which is, in effect, a unit of area, and from which are derived the sizes and shapes of all rooms and the overall plan of the house. A similar method of planning was adopted in 1946 for the Hertfordshire County Council schools [England] when a standard plan unit 2515 mm (99 in) square was chosen to determine the sizes and shapes of rooms and also to position the steel stanchions and the layout of beams. The method was further developed in 1950 with a plan unit 1016 mm (40 in) square, wall panels of a uniform thickness of 41 mm (1 5/8 in) and ceiling panels measuring 965 mm (38 in) square. . . .
>
> The use of a standard unit of space in the design of buildings often recurs throughout the history of building, but it is not an accepted discipline today, perhaps because its implications have not yet been effectively studied and fully worked out. . . .
>
> Many systems of building have been developed over the past twenty years on centre-line and tartan reference grids. But the use of such grids does not necessarily involve either the use of a repetitive unit of space or the use of related standard components such as floor mats, ceiling panels, and walling units. The reference grid may be simply a system of reference which neither determines the size and shape of components nor prescribes the rules which govern their position.

4. United Nations Technical Assistance Programme, "Housing in Ghana," *op. cit.*, p. 4.

5. For a bibliography of periodical articles on Habitat '67, see: *Habitat '67*, Ottawa, Canada, Queen's Printer, 1967. For the architect's own views see: Moshe Safdie, *Beyond Habitat*, edited by John Kettle, Cambridge, Mass, and London, England: M.I.T. Press, 1970.

6. The survey was compiled from the entries in: Thomas Schmid and Carlo Testa, *Systems Building, An International Survey of Methods,* New York-Washington, Frederick A. Praeger, 1979; and *Industrialized Building – A Comparative Analysis of European Experience,* Office of International Affairs Special Report, U.S. Department of Housing and Urban Development, Washington, D.C., April 1968; Appendix, February 1968, pp. 1-67; and David A. Crane, *et al., Technologies Study: Fort Lincoln New Town,* The Application of Technological Innovation in the Development of a New Community, District of Columbia Redevelopment Land Agency, *et al.,* Washington, D.C., December 1968, pp. 25-120, and *The New Building Blocks, A Report on the Factory-Produced Dwelling Module,* Research Report No. 8, Center for Housing and Environmental Studies, Cornell University, Ithaca, New York, 1968.

BIBLIOGRAPHY

Bibliographies

Breese, Gerald. *Modernization and Urbanization: Existing and Potential Relationships in the "Third World."* Monticello, Illinois: Council of Planning Librarians Exchange Bibliography No. 70, March 1969.

Dean, Robert D. *Urbanization, Industrialization, and the Development Process.* Monticello, Illinois: Council of Planning Librarians, Exchange Bibliographies No. 178, March 1971.

National Housing Center Library. *Industrialized Building and Related Topics.* Reference List #L-84. Washington, D.C.: January 1970.

National Swedish Institute for Building Research. *Building and Planning in Developing Countries*—a partially annotated bibliography. Report No. 28:1967. Stockholm, Sweden: 1967.

________________. *Social Aspects of Housing and Urban Development, A Bibliography.* Stockholm, Sweden: Document No. 3:1969. Compiled and published in agreement with the United Nations Centre for Housing, Building and Planning, Department of Economic and Social Affairs, 1969.

South African Council for Scientific and Industrial Research, National Building Research Institute. Bibliography of Industrialized Housing (UDC 69.057:016). Pretoria, South Africa: 1966.

United Nations. "Cumulative List of United Nations Documents and Publications in the Field of Housing, Building, and Planning." List No. 12 (70-07594). New York: February 1970.

Books

Abrams, Charles. *Man's Struggle for Shelter in an Urbanizing World.* Cambridge, Mass: M.I.T. Press. 1964.

Bauer, Catherine. Modern Housing. Boston: Houghton Mifflin Company. (The Riverside Press), 1934.

Bemis, Albert Farwell. *The Evolving House.* Vol. III of *Rational Design.* Cambridge, Mass.: Technology Press, 1933.

Bowley, Marian. The British Building Industry. Cambridge: The University Press, 1966.

Deeson, A.F.L. *The Comprehensive Industrialized Building Systems Annual 1967.* West Wickham, Kent, England: Product Journals Ltd., 1967.

Diament, R.M.E. *Industrialized Buildings.* Volumes I, II, III of *The Architect and Building News.* London, England: Ilifte Books Ltd., 1968.

Drury, Margaret J. *Mobile Homes: The Unrecognized Revolution in American Housing.* Published Master's Thesis. Ithaca, New York: Cornell University, Dept. of Housing and Design, 1967.

Hirschman, Albert O. *Development Projects Observed.* Washington, D.C.: The Brookings Institution, October 1967.

Hoffman, Hubert. *Row Houses and Cluster Houses: An International Survey.* New York: Frederick A. Praeger, 1957.

Jeanneret, Charles E. (Le Corbusier). *The Modular-A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics.* Cambridge, Mass.: Harvard University Press, 1948.

Kelly, Bumham. *The Prefabrication of Houses.* Cambridge, Mass." Technology Press of M.I.T. and New York: John Wiley and Sons, Inc., 1951.

Martin, Bruce. *Standards and Building,* London, England: RIBA Publications, Ltd., 1971.

Pawley, Martin. *Architecture Versus Housing,* New York, Washington, D.C.: Praeger Publishing, 1970.

Safdie, Moshe. *Beyond Habitat.* ed. John Kettle. Cambridge, Mass. and London, England: M.I.T. Press, 1970.

Schmid, Thomas and Testa, Carlo. *Systems Building, An International Survey of Methods.* New York-Washington: Frederick A. Praeger, 1969.

Tennessee Valley Authority. *Factory-built Houses.* 1944.

The New Building Blocks, A Report on the Factory-Produced Dwelling Module. Research Report No. 8. Center for Housing and Environmental Studies, Cornell University, Ithaca, New York, 1968.

Towards Industrialized Building. Proceedings of the Third CIB Congress, Copenhagen Denmark.

Wachsmann, Konrad. *The Turning Point of Building.* New York: Reinhold, 1961.

White, R.B. *Prefabrication: A History of its Development in Great Britain.* London, England: NBS Special Report 36.

Periodicals, Articles, Reports and Public Documents

Abrams, Charles. *Squatter Settlements: The Problem and the Opportunity.* Ideas and Methods Exchange No. 63. Washington, D.C.: Office of International Affairs, U.S. Department of Housing and Urban Development, April 1966.

A Fact Book on Home Manufacturing. The Home Manufacturers Association. Washington, D.C.

Alonso, William, *et al* *Innovations in Housing Design and Construction Techniques as Applied to Low Cost Housing – A Collateral Literature Survey.* Prepared for the Department of Housing and Urban Development, In-Cities Experimental Housing Research and

Development Project. Reprinted by the Clearinghouse for Federal Scientific and Technical Information (PB 184 164). U.S. Department of Commerce/National Bureau of Standards, Washington, D.C., March-April 1969.

Bates, Allan. "Low Cost Housing in the Soviet Union." *Industrialized Housing.* Materials compiled and prepared for the Subcommittee on Urban Affairs of the Joint Economic Committee, Congress of the United States, U.S. Government Printing Office, Washington, D.C., 1969.

Bender, Richard. *Selected Technological Aspects of the American Building Industry – The Industrialization of Building.* Prepared for the National Commission on Urban Problems, distributed by Clearinghouse for Federal Scientific and Technical Information (PB 185 211). U.S. Department of Commerce/National Bureau of Standards, Washington, D.C., 1969.

Bodapati, S. Narayan. "Component Interchangeability." *Building, The Newspaper for the Design and Construction Team.* London, England: The Builder House, 11 December 1970.

Boyer, M. Christine. *Comparative Development: A Quantitative Approach.* M.C.P. Thesis, Cambridge, Mass.: M.I.T., Department of Urban Studies and Planning, Sept. 1968 (unpublished).

Colby, John G. "Alternative Technologies for Housing Reconstruction in Tunisia." Washington, D.C.: U.S. Department of Housing and Urban Development, 1970 (xerox).

Colby, John G. and Dean, Charles. "Community Improvement Programs in Honduras," Washington, D.C.: U.S. Department of Housing and Urban Development, 1971. (forthcoming).

Crane, David A., *et.al. Technologies Study: Fort Lincoln New Town. The Application of Technological Innovation in the Development of a New Community.* District of Columbia Redevelopment Land Agency, *et. al.* Washington, D.C., December 1968.

Cudmore, Patrick J. "A Critical Analysis of the Role of International Corporations in Developing Countries." Paper presented at the Massachusetts Institute of Technology, Course II.45, under the direction of Prof. Lloyd Rodwin, Cambridge, Mass., 1970.

de Leeuw, Frank, *et al* "Housing Costs and the Industrialization of Production." Working Paper 121-1, The Urban Institute, Washington, D.C., May 1969.

Department of Housing and Urban Development. *In-Cities Experimental Housing Research and Development Project.* Phase I, Composite Report, Vol. III: Technology. Distributed by Clearinghouse for Federal Scientific and Technical Information (PB 184 123). U.S. Department of Commerce/National Bureau of Standards, Washington, D.C., March 1969.

Downs, Anthony. "Housing the Urban Poor: The Economics of Various Strategies." *The American Economic Review.* The Journal of the American Economic Association, LIX, 4, Part I, September 1969.

Field, Charles Gersten. "Home Manufacturing and Building Codes: The Confrontation Between Technology and Institutional Regulation." (Unpublished Ph.D. Thesis) Harvard University, Cambridge, Mass., June 1971.

Finger, Harold B. "Operation Breakthrough – A New Approach is Being Taken in the United States to Improve the Process of Producing and Providing Housing." United Nations Economic

Commission for Europe, Committee on Housing, Building and Planning, Third Seminar on the Building Industry, Moscow, October 1970. U.S. Department of Housing and Urban Development, Washington, D.C. 1970.

Habitat '67. Ottawa, Canada, Queen's Printer, 1967.

Herman, Leon M. "Urbanization and New Housing Construction in the U.S.S.R." *Industrialized Housing,* Materials compiled and prepared for the Subcommittee on Urban Affairs of the Joint Economic Committee, Congress of the United States, U.S. Government Printing Office, Washington, D.C. 1969.

Hodes, Daniel A. "The Modular Housing Industry." *Financial Analysts Journal,* May-June, 1970.

Illinois Institute of Technology Research Institute. *Application of Component Construction to Multi-Story, Low Income Housing.* Final Report. Research Project No. M6171, 3 volumes, Chicago, Illinois: January 1968. [Vol. III includes an annotated bibliography of industrialized building.]

Laquian, Aprodicio A. "Housing Squatters and Slum Dwellers in Southeast Asia." Paper delivered at the 137th Meeting of the American Association for the Advancement of Science, Chicago, Illinois, December 1970.

Lippe, F.H. "Serial Production in the Building Industry." *EAROPH News and Notes.* Eastern Regional Organization for Planning and Housing, New Delhi, India, December 1969.

Mangin, William P. and Turner, John F.C. "Benevides and the Barriada." *Progressive Architecture.* London, England: May 1968. Reprinted in *Shelter and Society.* ed. by Paul Oliver, London: Crescent Press, New York; Praeger, 1969.

Mitchell, Neal B. and Terner, Ian Donald. *Squatter Housing: Criteria for Development, Directions for Policy.* Paper for the United Nations Seminar on Prefabrication of Houses for Latin America, Information Document No. 19, Copenhagen, Denmark: August-September 1967.

National Commission on Urban Problems ("Douglas Commission"). Appendix: "Selected Data of European Experience with Industrialized Building systems," U.S. Government Printing Office. Washington, D.C. 1968.

Overseas Building Notes. *Plastics for Building in Developing Countries.* No. 134. Overseas Division, Building Research Station, Garston Watford Herts, England: September 1970.

Patman, Philip, *et al Industrialized Building – A Comparative Analysis of European Experience.* Prepared for the Office of International Affairs of the U.S. Department of Housing and Urban Development, distributed by Clearinghouse for Federal and Scientific Information (PB 179 069). U.S. Department of Commerce/National Bureau of Standards, Washington, D.C., April 1968.

Pawley, Martin. "Mass Housing: The Desperate Effort of Pre-Industrial Thought to Achieve the Equivalent of Machine Production" [on the work of Nikolaas Habraken]. *Architectural Design.* London, England: January 1970.

Pike, Alexander. "Failure of Industrialized Building in Housing Programme." *Architectural Design.* London, England: November 1967.

Rothenstein, Guy G. "European System Building." Paper presented at the Executive Office of the President – Office of Science and Technology.

Schlefer, Marion. *Industrialization of Housing: Today's Potential.* Interagency Discussion on Advanced Housing, Washington, D.C., March 1967. U.S. Library of Congress Legislative Reference Service, Washington, D.C., 1968.

Strassmann, Paul W. "Innovating and Employment in Building: The Experience of Peru." *The Oxford Economic Papers,* Vol. 22, July 1970.

"Systems Built Apartments Collapse." *Engineering News Record.* New York: McGraw-Hill Publishers, May 23, 1968.

Terner, Ian Donald and Herz, Robert C. "Squatter Inspired Housing." *Architectural Design.* Vol. 38, London, England: August 1968. Reprinted in *Ekistics,* 27:158, Athens, Greece: January 1969.

The Report of the President's Committee on Urban Housing (The "Kaiser Commission"). Technical Studies, Vol. II, U.S. Government Printing Office, Washington, D.C. 1968.

The State of the Art of Prefabrication in the Construction Industry. A Research Report by the Battelle Memorial Institute, Columbus, Ohio: 1967.

Turner, John F.C. "Housing Issues and the Standards Problem." Paper presented at the Rehovot Conference on Urbanization and Development in Developing Countries, Israel, August 1971.

__________. "The People Build with their Own Hands." *Environment and Change.* ed. by William R. Ewald, Jr. Indiana University Press, 1968.

United Nations. *Building Materials Industry, Industrialization of Developing Countries: Problems and Prospects.* UNIDO Monographs on Industrial Development, No. 3. (ID/40/3), New York, 1969.

__________. *Construction Industry, Industrialization of Developing Countries: Problems and Prospects.* UNIDO Monographs on Industrial Development, No. 2 (ID/40/2), New York, 1969.

__________. *Housing, Building and Planning; Problems and Priorities in Human Settlements.* Report of the Secretary General (A/8037) New York: August 21, 1970.

__________. Trends in the Industrialization of Building. (ST-SOA-102), Department of Economic and Social Affairs, New York, 1970.

United Nations Technical Assistance Programme. "Housing in Ghana." (ST/TAA/K/GHANA/1) New York, 1957.

U.S. Congress. Joint Economic Committee. *Industrialized Housing.* Hearings before the Subcommittee on Urban Affairs. Ninety-first Congress, First Session, Part I: July 9, 1969, Part 2: July 23-24, 1969. U.S. Government Printing Office, Washington, D.C., 1969.

__________. Joint Economic Committee. *Industrialized Housing.* Materials compiled and prepared for the Subcommittee on Urban Affairs. Ninety-first Congress, First Session. U.S. Government Printing Office, Washington, D.C., 1969.

Van Fleet, James A. *The Popular Housing Sector in Latin America: Its Implications for Urban Social and Economic Development.* (Ph.D. dissertation) The Maxwell School of Syracuse University, Department of Economics, 1969 (unpublished).

Young, Allan H. and Ball, Clairborne M. "Industrial Impacts of Residential Construction and Mobile Home Production." *Survey of Current Business,* 50:10, U.S. Department of Commerce, Office of Business Economics, Washington, D.C.: October 1970.

Charts and diagrams by Linda Taraborelli Smith

N.B. Federal Clearing House for Scientific and Technical Information now the National Technical Information Service (NTIS), Springfield, Va. 22151.