TRANSFERABILITY OF AEROSPACE MANAGEMENT SKILLS TO THE INDUSTRIALIZED HOUSING INDUSTRY

by

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June, 1971

Signature of Author

Alfred P. Sloan School of Management, May 14, 1971

Certified by

Accepted by

Chairman, Departmental Committee on Graduate Students
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Submitted to the Alfred P. Sloan School of Management
on May 12, 1971 in partial fulfillment of the require-
ments for the Degree of Master of Science

ABSTRACT

This study attempts to address the problem of transferability of aerospace management skills to programs in the public sector. This includes management in the government on the one hand and in the private sector on the other. In order to focus on a specific program, Operation Breakthrough, a program to introduce innovative low cost industrialized building methods and techniques into the home building process by the U.S. Department of Housing and Urban Development (HUD) was selected. It is hoped that by using a specific case, generalizations can be made with regard to the transfer of aerospace management techniques to the public sector programs in general. The research methods used in this study included interviews with persons involved in management of government and private organizations associated with home building and a review of the literature.

The approach taken in this research was to review the industrialized housing and the home building industry, investigation of innovative, low cost, industrialized home building methods and specifically Operation Breakthrough, the Aerospace Industry and attempts of these firms to diversify into the public sector, and finally the transfer process itself. By comparing existing management techniques in the home building and aerospace industries, it is possible to make tentative conclusions about the transferability of management skills. A simple model is developed to try to describe the transfer process and the major factors involved.

Several major topics have become obvious during the course of this study:
a. Problem of long range planning and strategy for R&D in government agencies such as HUD.

b. In the public sector, many of the major problems are not technological in nature but are more social, economic and political.

c. Introduction of innovation and change is difficult because of established institutions both in government and the private sector.

e. In the public sector, problems are difficult to define because of the lack of suitable boundary conditions.

The first part of this study attempts to characterize the home building industry and those factors which tend to inhibit industrialization of housing construction and the reduction in costs, market aggregation, and introduction of technical innovation. Several other related areas which could affect these critical factors are described because of their potential impact on this industry. These include the mobile home industry, military and other government construction programs, use of performance specifications in school construction, and industrialized housing construction in Europe.

A qualitative analysis is made of aerospace management techniques and these are compared with existing techniques used in the home building industries. Those programs that have been proposed for retraining or assisting unemployed aerospace engineers and scientists are reviewed and summarized. General conclusions are drawn based on the interviews and voluminous testimony given at government congressional hearings on the employment of non-utilized aerospace workers. Recommendations are made for further research.

A guide to the literature has been developed on the low cost industrialized home construction industry and the transfer of aerospace skills.

Thesis Supervisor: D.G. Marquis
Title: Professor of Management
Acknowledgements

The data for this study came from interviews and data supplied by those listed below, in appendix IV, and the literature. The quotes without direct attribution came from the literature and interviews and the assistance given by those interviewed and supplying data is greatly appreciated. The freedom and encouragement of Professors Don G. Marquis and Quintin Mills is appreciated. Special thanks is due to Dr. I. Billick, D. Stenhouse, B. Greenglass, H. Finger and the other members of the staff of the Office of the Assistant Secretary for Research and Technology at the U.S. Department of Housing and Urban Development for the assistance provided during the authors' visits to Washington. Also to be included are the innumerable people who provided information and other useful information. A particular debt of gratitude is owed to persons of the Air Force Flight Dynamics Laboratory and Air Force Systems Command whose encouragement and assistance made this year at the Sloan School such a memorable one. These include Herb Basham, Max Lipscomb, Max Davis, Phyliss Olden, Col. Joe Myers, Bill Lamar, Ruth Prost, Bill Lehmann, Frank Bordonaro, and Bob Burns.

Finally, without the continued encouragement and tolerance of my wife, Elaine, with "Philipthe Terrible" during this period, this thesis would not have been broad in its scope.

The author, however, takes full responsibility for the facts, opinions and conclusions set forth here.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Introduction</td>
<td>10</td>
</tr>
<tr>
<td>II Housing Problem</td>
<td>13</td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Nature of the Problem</td>
<td></td>
</tr>
<tr>
<td>III Building Industry</td>
<td>25</td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Management in the Home Building Industry</td>
<td></td>
</tr>
<tr>
<td>IV. Aerospace Industry</td>
<td>29</td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. The Industry</td>
<td></td>
</tr>
<tr>
<td>C. Aerospace Management</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td></td>
</tr>
<tr>
<td>D. Past Attempts of the Aerospace Industry at Diversification</td>
<td></td>
</tr>
<tr>
<td>E. Defense Companies and the Public Sector Markets</td>
<td></td>
</tr>
<tr>
<td>1. California Experiment</td>
<td></td>
</tr>
<tr>
<td>2. Successful Diversification into Consumer Products</td>
<td></td>
</tr>
<tr>
<td>3. Problems of Diversification</td>
<td></td>
</tr>
<tr>
<td>V. Department of Housing and Urban Development and Operation Breakthrough</td>
<td>58</td>
</tr>
<tr>
<td>VI Transferability of Aerospace Management Techniques to Public Sector Programs</td>
<td>61</td>
</tr>
<tr>
<td>A. Introduction</td>
<td></td>
</tr>
<tr>
<td>B. Past and Present Attempts by the Executive, the Legislative, and Other Groups at Increasing the Transfer of Aerospace Skills</td>
<td></td>
</tr>
<tr>
<td>C. Technology Transfer</td>
<td></td>
</tr>
</tbody>
</table>
**TABLE OF CONTENTS (Cont'd)**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII Conclusions</td>
<td>85</td>
</tr>
<tr>
<td>VIII Recommendations</td>
<td>94</td>
</tr>
<tr>
<td>IX References</td>
<td>97</td>
</tr>
<tr>
<td>Appendix I: The Housing Industry and Constraints to Low Cost Housing</td>
<td>102</td>
</tr>
<tr>
<td>Appendix II: HUD and Operation Breakthrough Housing Programs</td>
<td>165</td>
</tr>
<tr>
<td>Appendix III: Other Approaches and Experiences Pertinent to Industrialized Low Cost Housing</td>
<td>201</td>
</tr>
<tr>
<td>Appendix IV: Selected Survey Comments</td>
<td>249</td>
</tr>
</tbody>
</table>

References and Bibliography for the Appendices
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Estimated Housing Construction and Rehabilitation Needs to Eliminate Substandard Housing Conditions Over a Ten Year Period (1967-1977)</td>
<td>18</td>
</tr>
<tr>
<td>II</td>
<td>Geographical Housing Needs</td>
<td>20</td>
</tr>
<tr>
<td>III</td>
<td>United States Housing Programs: Cumulative Performance through 1968</td>
<td>23</td>
</tr>
<tr>
<td>IV</td>
<td>Resisted Housing Units Started 1960-1970</td>
<td>24</td>
</tr>
<tr>
<td>V</td>
<td>Major Aspects of Home Construction Management</td>
<td>30</td>
</tr>
<tr>
<td>VI</td>
<td>Approximate Number of Skills per $100 Million in Sales</td>
<td>34</td>
</tr>
<tr>
<td>VII</td>
<td>Aerospace Management Disciplines</td>
<td>41</td>
</tr>
<tr>
<td>VIII</td>
<td>Aerospace Tools and Techniques</td>
<td>45</td>
</tr>
<tr>
<td>IX</td>
<td>Market Diversification of Aerospace Companies</td>
<td>47</td>
</tr>
<tr>
<td>X</td>
<td>Diversification Efforts of Various Aerospace Firms</td>
<td>51</td>
</tr>
<tr>
<td>XI</td>
<td>Factors in the Government Transfer Process</td>
<td>78</td>
</tr>
<tr>
<td>XII</td>
<td>Factors in the Industry Transfer Process</td>
<td>79</td>
</tr>
<tr>
<td>XIII</td>
<td>Home Building Production by Size of NAHB Home Builder Operation, 1964 and 1959</td>
<td>105</td>
</tr>
<tr>
<td>XIV</td>
<td>Price of Manufactured Homes as Provided by a Leading Manufacturer, 1968</td>
<td>136</td>
</tr>
<tr>
<td>XV</td>
<td>Construction Costs and Consumer Price Indices (1950-1968)</td>
<td>139</td>
</tr>
<tr>
<td>XVI</td>
<td>FHA Financing, Typical Existing Home</td>
<td>141</td>
</tr>
<tr>
<td>XVII</td>
<td>FHA Financing Typical New Home</td>
<td>142</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>XVIII</td>
<td>Growth Rate of Selected Industries</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>1950-1960</td>
<td></td>
</tr>
<tr>
<td>XIX</td>
<td>R&amp;D Funds Spent by Selected Industries</td>
<td>145</td>
</tr>
<tr>
<td>XX</td>
<td>Number of Scientists and Engineers Employed in Selected Industries - 1967</td>
<td>146</td>
</tr>
<tr>
<td>XXI</td>
<td>Construction Costs and Consumer Price Indices</td>
<td>147</td>
</tr>
<tr>
<td>XXII</td>
<td>Estimates of Housing Property Taxes as a Percent of Income, by Income Class</td>
<td>150</td>
</tr>
<tr>
<td>XXIII</td>
<td>Development and Construction Costs</td>
<td>155</td>
</tr>
<tr>
<td>XXIV</td>
<td>Occupying Costs - Single Family Unit Built by Developer</td>
<td>157</td>
</tr>
<tr>
<td>XXV</td>
<td>Income Distribution in the U.S.</td>
<td>158</td>
</tr>
<tr>
<td>XXVI</td>
<td>Appropriations for Urban Studies and Housing Research by HUD and its Predecessor Organizations</td>
<td>172</td>
</tr>
<tr>
<td>XXVII</td>
<td>Sources of Federal R&amp;D Funds</td>
<td>173</td>
</tr>
<tr>
<td>XXVIII</td>
<td>Department of Housing and Urban Development for the Years 1969-1971</td>
<td>174</td>
</tr>
<tr>
<td>XXIX</td>
<td>Summary of Four Solicitations on Operation Breakthrough</td>
<td>180, 182</td>
</tr>
<tr>
<td>XXX</td>
<td>Operation Breakthrough: Prototype Developments</td>
<td>181</td>
</tr>
<tr>
<td>XXXI</td>
<td>Operation Breakthrough: Housing System Producers Housing and Systems Types</td>
<td>192, 193</td>
</tr>
<tr>
<td>XXXII</td>
<td>Mobile Home Shipments</td>
<td>203</td>
</tr>
<tr>
<td>XXXIII</td>
<td>Cost Comparison Between Ownership of Conventional Versus Mobile Homes</td>
<td>209</td>
</tr>
<tr>
<td>XXXIV</td>
<td>Military Housing Procurements</td>
<td>212</td>
</tr>
</tbody>
</table>
LIST OF TABLES (Cont'd)

Table                                                                                       Page

XXXV  Extent of Industrialized Home Building                                              231
XXXVI Companies Originally Involved in Utility Core Production                           238

LIST OF FIGURES

Figure                                                                                     Page

1    Evolution of Systems Analysis and Systems Management                                  37,38
2    Evolution of Systems Engineering                                                      39
3    Ansof's Diversification Classification                                                 49a
4    Simple Model of Transfer Process                                                      75
5    Four Element Transfer Model                                                           77
6    The Housing Process, Major Participants and Influences                                122
7    HUD organization for Research and Technology                                         188
8    Operation Breakthrough Program Management Line of Authority and Direction             189
Chapter I
Introduction

The main purpose of this thesis is to determine:

"How effectively can Aerospace Management techniques be used in solving problems in the public sector".

There is very little evidence that the management methods developed to manage complex space and defense programs can or cannot help to solve even more complex problems in the public sector. People can be found with views that range from complete skepticism that aerospace has any unique talent to offer, basing their arguments on costly program overruns, clear national commitments of resources and objectives (defense and space), unlimited budgets, and the lack of political or social pressures, to those that feel that all that is necessary is to give the aerospace people the necessary resources and they will solve our social problems. This study takes the position that the answer lies somewhere between these two extreme positions and tries to determine which management skills and techniques can and should be transferred, those that are not suitable because of the differences in the two sectors, and what are the barriers to the transfer of the more beneficial skills.

In order to get at this question, it has been necessary to select a specific industry which has some relevance to a social
problem and which has a complete spectrum of technological, economic, social, and political problems. The specific area selected was low cost industrialized housing and in particular "Operation Breakthrough", a research and development program of the Department of Housing and Urban Development which has as its principle aim the development of major breakthrough in low income industrialized housing. The study can be broken down into four distinct parts which are treated separately in Chapters III to VI after a short description of the housing problem in the United States in section II. These include:

1. The building industry, constraints in the building industry to low cost industrialized housing, and management in the home building industry.

2. The aerospace industry, aerospace management techniques, and past attempts of aerospace firms to diversify and their experiences in public sector markets.

3. Transferability of aerospace management skills, attempts by the government at increasing the speed of transfer, and a technology transfer model.

4. Research and Development environment at the Department of Housing and Urban Development, Management of "Operation Breakthrough" from the government side.

A great deal has been written on the aerospace industry and the management techniques used in this industry. Industry statistics
on R&D expenditures, numbers and types of persons employed, company information, etc. are readily available. One of the problems with home building is the difficulty in obtaining information on the industry (if one exists), statistics on R&D expenditures, persons, numbers and types of persons employed, company data, etc. Of particular interest to this study are the management techniques being used. Only rudimentary information is available.

The field of housing encompasses such a vast array of disciplines and touches on so many institutions that it is very difficult to obtain a clear picture of the whole area. Literature in the field covers such a broad spectrum that it is difficult for a novice just approaching the field to know where to start. It is hoped that the bibliography provided will aid others interested in doing research in this field.
Chapter II
The Housing Problem

A. Introduction

Although the need for low cost housing was recognized as far back as 1937 with the National Housing Act, it was not until the Housing Act of 1949 that a National Goal was set forth..."A decent home and suitable living environment for every American family". The drafters of this act could not foresee two major forces which would have a great impact on housing needs. The first of these was the increased migration of the non-whites to the northern urban areas after WW II. The second was the changing standards of what constitutes minimum levels of acceptable housing. The National Commission on Civil Disorders found that two thirds of the nation's non-white families located in central cities live in neighborhoods marked by substantial housing and general urban blight. (1)

It was not until the Housing and Urban Development Act of 1968, that specific goals were formulated for the limitation of sub-standard housing in ten years. This would require that the nation produce 26 million living units in the next ten years, including six million for low cost and moderate income families or 2.6 million units per year.

The Housing and Urban Development Act of 1968 is generally regarded as the most ambitious and comprehensive legislation in
the history of Federal involvement in American cities (2). Through the involvement of large and small private businesses, non profit associations, and all levels of government it seeks to redirect the physical evolution of cities and suburbs. It contemplates a wide range of subsidies, some deep and some shallow; the creation of new institutions to foster urban development and redevelopment and coordination of programs for massive healing of personal and social ills with programs for physical reconstruction.

Congress conducted extensive hearings on the legislation before it was passed into law (2). Numerous organizations and knowledgeable individuals representing the deprived, the concerned, and responsible were consulted. But a vast majority of the nation's city dwellers were not heard from; they simply stayed away. The National Association of Real Estate Boards, an organization which usually seems to take the side of the employed, property owning, middle class, confined its participation in the hearing almost entirely to the relatively minor matter of Federally assisted fire protection for riot threatened areas.

The question of why this indifference since the words such as "urban crisis", problems of segregation, property taxes, congestion, crime, pollution, rising land prices, welfare, blight, strikes by sanitation workers have become so popular. How can the majority of the population be unconcerned about the nature of Federal plans to deal with all these matters that affect the daily life in the cities of all of us?
It may be that most citizens do not really feel touched by the "urban crisis". On the other hand, perhaps the great bulk of the urban population recognizes that although problems do exist in the city life, the Federal Government is incapable of dealing effectively with them. For one thing, of course, no housing act in the United States deals with law enforcement, transportation, education, welfare, health, or garbage strikes or rising assessments. Responsibility for what are probably the urban issues of widest concern lies outside the Department of Housing and Urban Development. For another thing, "massive housing programs" such as public housing, urban renewal, or moderate income housing have proved to be neither massive nor meaningful. The people they seem directed to serve get pushed aside and programs drawn in their own directions. There is no identifiable cadre of professional housing program administrators to make the results link something like what was intended (2).

Housing is part of the urban problem in the United States but is inseparable from other aspects. It should be treated and approached as a total systems problem. In war time countries after World War II the "housing problem" was one of replacing buildings which had been destroyed. In the United States today the "housing problem" is more correctly described as the result of inadequate economic institutions and uneasy social relationships. The job is to wrestle with the fundamentally more complex social, economic, and political problems; in many ways these are more difficult than simply creating new technology or creating buildings.
Section 108 of the Housing and Urban Development Act of 1968 (3) encourages the development of new housing technologies and their testing on a large scale. The purpose of this experimentation is to find ways of providing decent housing at low cost. The cost of conventional materials and methods of construction have steadily spiraled beyond the reach of lower income families.

Under this program the Secretary of HUD could evaluate plans submitted by qualified public and private organizations for the large scale development of housing for lower income families, using new and advance technologies adaptable to mass production methods. Approved plans would be carried out with private financing, but mortgage insurance would be provided under section 233 of the National Housing Act -- the experimental housing insurance program.

To insure experimentation on an adequate scale, this section limits the number of approved plans to no more than five, but requires that each plan be capable of producing at least 1000 units a year over a five year period, so that each plan would be tested in depth. Previous projects carried out under section 233 demonstrating new technology have been of small scale involving relatively few units. As a result, no definite evaluation has been possible of the cost reductions obtainable from economies of scale or mass use of industrialized production.

Once a plan has been carried out, the Secretary would evaluate it with a view of determining:
1. the detailed cost breakdown per dwelling unit.

2. the environmental quality achieved in the units.

3. the effect which local housing codes and zone regulations have, or would have if applicable, on the cost per dwelling unit.

Upon completion of these programs, the Secretary would report his findings to the Congress, together with any recommendations for legislation to expand the supply of housing for lower income families provided through the use of the new technologies tested.

B. Nature of the Problem.

Two major Presidential Study Commissions have recently produced quantitative estimates of the housing problem. The National Commission on Urban Problems, headed by former Senator Paul Douglas (4) and the President's Commission on Urban Housing headed by Edgar K. Kaiser, and known as the Kaiser Report (5). They generally agree that six million or more housing units are substandard and should be replaced. To eliminate substandard housing conditions in one decade would mean doubling the level of housing output approximately from the present rate of about 1.3 million per year to 2.6 million per year. In effect these estimates define the housing problem by saying that the rate of housing production is too low. Table I shows the ten year needs as estimated by the Department of Housing and Urban Development, substantially similar in magnitude to estimates made by the special study commissions.
### Table I

Estimated Housing Construction and Rehabilitation Needs to Eliminate Substandard Housing Conditions Over a Ten-Year Period (1967-1977)

<table>
<thead>
<tr>
<th>Description</th>
<th>Millions of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>For net additional household formation</td>
<td>13.1</td>
</tr>
<tr>
<td>To permit an increase in vacant and seasonal units</td>
<td>4.4</td>
</tr>
<tr>
<td>To compensate for units abandoned because of population shifts</td>
<td>1.0</td>
</tr>
<tr>
<td>To compensate for demolition, casualty and other losses of non-dilapidated units</td>
<td>2.0</td>
</tr>
<tr>
<td>To permit the removal of all existing dilapidated units</td>
<td>2.0</td>
</tr>
<tr>
<td>To permit the removal of all units becoming dilapidated over the decade</td>
<td>2.0</td>
</tr>
<tr>
<td>Rehabilitation of nondilapidated, substandard units with public assistance</td>
<td>1.7</td>
</tr>
<tr>
<td>Subtotal: new units and unassisted rehabilitation</td>
<td>26.2</td>
</tr>
<tr>
<td>Rehabilitation of nondilapidated, substandard units with public assistance</td>
<td>2.0</td>
</tr>
<tr>
<td>Total need including publicly assisted rehabilitation</td>
<td>28.2</td>
</tr>
</tbody>
</table>


Note: A housing unit may be classified "substandard" for either of two reasons: it is dilapidated; or it is not dilapidated but it lacks private plumbing facilities.
The study commissions do tell us a little more, namely,-
that many are unable to afford standard housing, either because
their incomes are too low to let them pay, or because discrimi-
nation cuts them out of the market for standard housing. They
flush out the complaints, reciting restrictions imposed on builders
by the building codes across the country and by building trade
unions, the moral being that because new housing costs more than
it should, low income people remain trapped in substandard dwellings.

These points are well known and well documented in the recent
Commission studies but have not seemed to have elicited the op-
timism that housing problems are about to be solved. In fact,
the housing studies were published well after the 1968 Housing
Act became law -- that Act which was designed to correct condi-
tions identified by subsequent studies.
According to a Business Week article (7), there seems to be little debate that the demand is real. According to this article the following Geographical needs exist:

Table II  
Geographical Housing Needs

<table>
<thead>
<tr>
<th>City</th>
<th>Housing units required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicago</td>
<td>300,000</td>
</tr>
<tr>
<td>Atlanta</td>
<td>16,000</td>
</tr>
<tr>
<td>Dallas</td>
<td>46,000</td>
</tr>
<tr>
<td>Denver</td>
<td>37,000 (by 1975)</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>14,000 (in next two years)</td>
</tr>
<tr>
<td>Miami</td>
<td>14,000</td>
</tr>
<tr>
<td>Minn.-St. Paul</td>
<td>40,000</td>
</tr>
<tr>
<td>Boston</td>
<td>10,000</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>47,000 (over the next 5 years)</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>43,500</td>
</tr>
<tr>
<td>Stamford</td>
<td>3,000</td>
</tr>
<tr>
<td>New York</td>
<td>30 - 40,000 / yr.</td>
</tr>
</tbody>
</table>

The President's Committee on Urban Housing (Kaiser Committee) (4) reported that about 7.8 million American families, one in every eight, cannot afford to pay market price for standard housing.
About half of these families are living on less than $3,000 a year.

The state of the nation's housing inventory is equally distressing. Of a total supply of some 65 million units, an estimated 6.7 million occupied units are substandard -- 4 million lacking indoor plumbing, and 2.7 million in dilapidated condition. Some 6.1 million units are defined as overcrowded (more than one person per room). And only about a million of the 6 million vacant units are in standard condition and available for occupancy -- the nation's lowest available vacancy rate since 1958.

If the required rate of production is 2.6 million and the actual production rate is 1.3 million, then an additional construction capacity of 1.3 million housing units is needed. The increased production without substantial change in the building process will result in significantly increased construction costs. The introduction of innovations in both hardware and management, which could mitigate against these cost increases is impeded by constraints and uncertainties presently associated with the building process. It is necessary for the government to invest its resources to aid in overcoming these barriers to innovations and to provide the climate at which such innovations may be tried and tested if low and moderate income housing act is to be built to meet existing and anticipated material housing needs. (6)
The Federal involvement in housing is shown in Tables III and IV. This has been mainly through mortgage insurance, home supplement loans, rent supplements, and low rent public housing. Until recently, it has been limited to conventional housing construction material, methods and techniques. Government involvement in housing has been increasing at a fast rate and will probably continue to do so.
Table III
United States Federal Housing Programs:
Cumulative Performance Through 1968

<table>
<thead>
<tr>
<th>Program Description</th>
<th>Units (000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHA mortgage insurance</td>
<td></td>
</tr>
<tr>
<td>single family home sales (sec. 203)</td>
<td>8,020</td>
</tr>
<tr>
<td>rental housing projects (sec. 207)</td>
<td>229</td>
</tr>
<tr>
<td>cooperative housing (sec. 213)</td>
<td>153</td>
</tr>
<tr>
<td>urban renewal housing (sec. 220)</td>
<td>64</td>
</tr>
<tr>
<td>moderate income housing (sec. 221)</td>
<td>332</td>
</tr>
<tr>
<td>below market interest, moderate income (sec. 221 d3)</td>
<td>127</td>
</tr>
<tr>
<td>homes for families of military personnel (sec. 222)</td>
<td>212</td>
</tr>
<tr>
<td>homes in declining areas (sec. 223 e)</td>
<td>9</td>
</tr>
<tr>
<td>housing for elderly people (sec. 231 and sec. 207 elderly)</td>
<td>43</td>
</tr>
<tr>
<td>FHA home improvement loans</td>
<td></td>
</tr>
<tr>
<td>Rent supplement units</td>
<td>59</td>
</tr>
<tr>
<td>Low-rent public housing units</td>
<td>744</td>
</tr>
</tbody>
</table>

Table IV
Assisted Housing Units
Started 1960-1970

<table>
<thead>
<tr>
<th>Year</th>
<th>Units (approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>49,000</td>
</tr>
<tr>
<td>1961</td>
<td>55,000</td>
</tr>
<tr>
<td>1962</td>
<td>40,000</td>
</tr>
<tr>
<td>1963</td>
<td>55,000</td>
</tr>
<tr>
<td>1964</td>
<td>60,000</td>
</tr>
<tr>
<td>1965</td>
<td>65,000</td>
</tr>
<tr>
<td>1966</td>
<td>75,000</td>
</tr>
<tr>
<td>1967</td>
<td>108,000</td>
</tr>
<tr>
<td>1968</td>
<td>150,000</td>
</tr>
<tr>
<td>1969</td>
<td>180,000</td>
</tr>
<tr>
<td>1970</td>
<td>360,000</td>
</tr>
</tbody>
</table>

Chart shows dramatic rise of federally assisted housing starts in 1970. Volume last year hit about 380,000 units, nearly double the 1969 volume.

Source: Professional Builder, January 1971
III. Building Industry

A. Introduction

A detailed survey of the homebuilding industry, with particular emphasis on low cost industrialized housing was made as a part of this study and is included as Appendix I. This includes not only the characteristics of the industry but also many of the important constraints to low cost housing. Rather than summarize what is already in the Appendix, the following is a brief summary of some of the more important aspects of this industry.

a. The homebuilding industry is approximately a 30 billion dollar market which is closely tied to the nation's economy and is frequently used as an indicator of its health and growth.

b. The industry is large, diffuse, complex, and regional in nature. Estimates of the number of homebuilders run between 30,000 and 60,000. Of these less than 1% produce more than 500 homes a year while the average is less than 25 per year.

c. Turnover rate is high, 50 per cent greater than in other industries.

d. It is relatively easy to enter the field requiring little capital investment.

e. Low cost homebuilding is highly political.

f. Low cost industrialized housing faces a number of constraints which tend to increase housing costs. Some of these include:

availability of land

governmental red tape
Jurisdictional problems
financing
restrictive labor practices and availability of labor
building codes
industry organization
poor communications
inbred institutions
lack of standardization
zoning
taxes
social acceptance
seasonality
architectural

g. The home construction industry has been a relatively slow growth industry, characterized by low investments in research and development compared to other industries. As a result, technical innovation is introduced slowly. In essence, homes are built mainly the same today as they were twenty to thirty years ago.

h. There has not been a great deal of vertical integration in the industry. No one organization has been responsible for the total system from conception to operation and maintenance. There has been a fractionization of responsibility between the architect, engineer, builder and owner or operator.

i. House building costs have been rising due mainly to the high cost of land and secondly the rising costs of labor.
B. Management in the Home Building Industry.

In the previous sections and Appendix I, several aspects of management have already been discussed which shed some light on the whole area of management in the Home Building Industry. The nature of the industry and its markets has had a great impact on the management techniques that are used or that have come into the industry from other parts of the economy. For example, the large number of small home builders puts definite limits on the requirements for advanced management techniques such as the use of computers, management information systems, production and inventory control, etc.

If one considers the total construction industry about one third is involved in homebuilding. In the other areas of construction, large firms have been able to develop. These are firms that can afford to use and develop advanced management techniques. Further problems exist for this industry because of the lack of educational institutions which provide curricula in construction management and specifically home construction management. This results in a small number of formally trained managers entering this field. Because of the large recent wage settlements in the construction industry among major wage inflationary trends, the President in his statement of March 17, 1971 pointed out the need for improved management to combat construction inflation and meet
future construction needs:

"It is on more progressive management that we must ultimately depend to supply, efficiently and competitively, the building needs of a growing economy".

These claims are further substantiated by statements made by W.F. Dawson entitled, "The Application of New Management concepts" at the Industrialized Building Exposition and Congress, November 1970 in Louisville, Kentucky:

"Some of the problems (of the construction industry) are volume demand in excess of capacity, the dimishing number of skilled craftsmen, the industry's fragmented approach to problems, the high bankruptcy rate, spiraling construction costs, and the severe shortage of middle management. The traditional construction process of these separate entities represented by the owner, architect and the contractor, with each working for his own self-interest, leaves out government, community and industry interests when they are interacting".

He proposed three interlocking entities in the construction process, administration, production, and design. The administrative group consists of community, government, marketing, real estate, economics and financing, training and education, management systems and support sources. The design function consists of planning, architectural and engineering design, and industrial engineering while the production function is manufacturing, construction, testing and quality control.

The only major advance in the management of home construction appears to be the use of PERT and CPM. However, a recent survey by Neel (8) of 33 companies involved in industrial construction indicated that network models with both time and cost dimensions
have not been used extensively on industrial construction projects. Some of the major aspects of home construction management are listed in Table V (9).

IV. Aerospace Industry.

A. Introduction.

This section attempts to point out some of the distinctive features of the aerospace industry. This is done very briefly because this industry has been the study of several books some of them within the past few years (10-13). After this short introduction to the aerospace industry, the management disciplines and techniques developed, refined or adopted in this industry since World War II are described in some detail.

B. Aerospace Industry.

The term Aerospace Industry as used in the report includes all those firms doing business with the Department of Defense, National Aeronautics and Space Agency, and the Atomic Energy Commission. The market produced by those governmental bodies is the largest single-integrated purchasing force in the national economy. Within this market, agencies procure needed products and services under the rule of law set forth in such regulations as the Armed Services Procurement Regulations (ASPR), NASA Procurement regulations and, the Federal Procurement Regulations (FPR). The combined budgets for these agencies amount to approximately $85 billion dollars requested in FY1972. The total
Table V

Major Aspects of Home Construction Management

Land Economics

Legal (title, zoning, recording regulations, banking laws, insurance laws, contracts and subcontracts, subdivision regulations, taxes, codes, utility regulations, etc.)

Labor Economics and Relations

Organization and Control

Public Relations

Industrial and Personnel Relations

Land, Community, and Business Planning (social, economic, and political factors)

Business Analysis (Systems Analysis)

Project or Program Management

Contracting and Negotiating

Estimation and Bidding

Architecture and Engineering (techniques, methods, design)

Research and Development (materials and processes)

Systems Engineering (components, subsystems, subassemblies, etc.)

Cost Analysis and Accounting

Health and Safety

Marketing (sales, promotion, etc.)

Finance (taxes, operating funds, sales, etc.)

Purchasing and Procurement

Production, Inventory and Control

Quality Control
R&D budget requested for all agencies was 16.7 billion of which approximately 13 billion or almost 80% went to these three agencies (14). The companies engaged in this industry, which is among the largest in the nation, are highly technologically oriented. Aerodynamics, thermodynamics, mechanics, physics, chemistry, and electronics all play separate but integrated roles in creating the products of the market place. The products cover all of the tactical and strategic needs of the military agencies, the surface and space needs of NASA, as well as the technological needs of other government agencies, such as the Department of Transportation, and those industries requiring high technology products such as airlines and electronics.

The annual sales of the aerospace industry was approximately 29 billion dollars in 1969 (15). Some of the more important characteristics of this industry include:

1. High technological orientation
2. Highly capital intensive
3. Relatively few large companies but many smaller subcontractors and vendors
4. High skill level of manpower
5. Wages higher than in most other industries
6. Very high annual expenditures for R&D
7. Continuously pushing the frontiers of technology, highly innovative and subject to change
8. Markets are well defined and concentrated with mostly single customer orientation
9. Until recently social, economic and political problems were not a major concern
10. High degree of marketing expertise to select government agencies
11. Goals and objectives well defined
12. Sophisticated customer, provides good specifications knows what it wants
13. Few but large customers
14. Few but large contracts and of long duration
15. Highly specialized capabilities
16. Low capitalization, government provides funds for capital investment
17. R&D expenditures allowed as part of contracts
18. Unique reporting and control requirements of the government customer
19. Emphasis on high performance characteristics and reliability as opposed to cost considerations
20. Top management dominated by engineers
21. Military systems highly complex requiring a high degree of management sophistication
22. High quality, reliable, and close tolerance work
23. Well developed engineering design and development capability
24. Well informed on government operations
25. Low working capital requirements since government provides progress payments
26. Major skills highly specialized in sophistication fields
27. Contracts mostly cost plus fixed fee
28. Return on sales low, but return on invested capital high
29. Most R&D done under contract to the government
30. Intimate web of relations between customer and contractor
31. Large scale use of contract sales
32. Long lead time to consummate a contract
C. Aerospace Management.

1. Introducción.

In discussing management, all aspects of the management process are included from developing strategy, planning and control, research and development, design, production, evaluation, and testing operation, maintenance; to sales and marketing. It also includes all the attendant processes and techniques needed in the management of the overall processes such as management information systems, computers, systems analysis, simulation models, PERT, CPM, etc.

Most aerospace companies process unique management capabilities which have been developed because of the need to manage large, and complex aerospace type activities. This can be considered as a strong positive resource.

The work forces of these companies often approach being large aggregations of scientists, engineers, and technicians. Compared with most technically oriented industries serving commercial markets, such as drugs or chemicals, the typical defense company may have more than three times the number of scientists and engineers to support a given volume of end item sales (See Table VI).

The top management of many of the leading aerospace companies, are dominated by engineers, for example, -- McDonnell-Douglas, Boeing and Lockheed. Defense contractors possess strong capability to perform research extending the state of the art, as well
### Table VI
Approximate Numbers of Skills Per $100 Million in Sales

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Eng/Sci</th>
<th>Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defense/Space</td>
<td>3500</td>
<td>1000</td>
<td>25–40</td>
</tr>
<tr>
<td>Industrial</td>
<td>4000</td>
<td>400</td>
<td>200–250</td>
</tr>
<tr>
<td>Appliance</td>
<td>5000</td>
<td>50</td>
<td>350–500</td>
</tr>
</tbody>
</table>

**Source:** R. Peterson, Raytheon
as preparing complex engineering designs. Related to this is a management that is capable of managing the development, production and integration of large complex systems; this ability is often termed "Systems Management".

Similarly, these companies possess positive but specialized production capabilities. They are experienced at producing high value items incorporating advanced engineering and scientific design. A related manufacturing asset is the ability to work well with exotic materials and to close tolerances. In addition, in both space and defense, emphasis has been put on equipment which were lighter and smaller, with increased performance and only recently has cost been a factor.

Despite the numerous statements that have been made concerning their lack of marketing ability, these firms have been most successful in penetrating one large and rapidly growing market area - government business. In fact, they have experienced unparalleled success in selling complex systems involving advanced technology to a select government clientele. Their knowledge of defense, atomic, and space markets, customer requirements and public contracting procedures is detailed and often authoritative.

A balanced appraisal does yield some positive strengths on the part of the major military contractors - their new products and services, their systems management capability, and their knowledge of how to serve government agencies. Thus, it is not surprising that the most recent diversification efforts of these
government oriented companies have been into newly emerging, high technology markets within the public sector itself. Here there is little fear of competition from the firms entrenched in the market, nor is there need for that elaborate merchandising and distribution capability required for many commercial markets. Rather, here is where the government oriented corporation may find itself at a strong advantage.


Aerospace management technology may be thought of having its beginnings in the early fifties when the increasing dimensions of technical management of such programs as the Intercontinental Ballistics Missile required extensive modification of traditional management concepts. This is not to say that these new techniques such as project management were not already known, but were emphasized and put to use during this period. Figure 1 illustrates the evolution of certain key requirements for systems/program management technology over the last ten or more years after Borchers et al (16). Figure 2 traces the evolution of systems engineering.

The major elements of aerospace management technology can be viewed in four dimensions: disciplines, concepts, processes, and techniques. Unfortunately, terminology describing the elements employed in aerospace systems development has not evolved as a widely accepted set of definitions. In those cases where important terms are used, definitions are provided:
The Evolution of Systems Analysis

Hoover Commission Report
"Performance Budgeting" (1949)

National Security Act
Amended (1950)

Budget and Accounting
Procedure Act (1950)

Rand Reports (Novick)
"Program Budgeting" (1954)

2nd Hoover Commission
Report "Program Budgets"
(1955)

McNamara in Office (1961)
"Programming System" Initiated

DOD "Programming System"
in Operation (1963)

Executive Order 66-3
PB3S (1965)

Executive Bulletin
68-2 PPB (1967)
The Evolution of Systems Management

Ramo-Woolridge Corporation Formed 1953-54

Schriever-Ramo-Woolridge SETD Contractor

Initiated
System Management Titan 1955
Program Thor 1955

Minuteman Initiated (1958)

Project Definition - PDP
DOD Directive 3200.9

Resource Management System
DOD Directive 7000.1

Minuteman Acquisition Policies
AFSCM-1 Configuration Management
AFSCM-3 System Program Director
AFSCM-4 System Program Management
Figure 2

Evolution of Systems Engineering

MIL -S-9412

MIL -G-9412

Minuteman System Requirements Analysis BSD Exhibit 61-56

System Requirements Analysis BSD Exhibit 62-62

Systems Engineering Management AFSCM 375-5

AFSC System Engineering "Specification Approach"
a. **Disciplines.** The major disciplines in the aerospace environment are shown in Table VII. Of these, systems analysis, systems engineering, and systems management are defined:

(i) Systems Analysis is a scientific process, or methodology, which can best be described in terms of its salient problem related elements.

The Systems Analysis approach involves:

- Systematic examination and comparison of these alternative action which are related to the accomplishment of desired objectives.

- Comparison of alternatives on the basis of the resource cost and the benefit associated with each alternative.

- Explicit consideration of uncertainty.

(ii) Systems Engineering

Systems engineering is concerned with the design of the whole, as distinct from the design of the parts, and with the ensuing compatibility of machines and people that make up the total system. Systems engineering is still engineering and a good engineer is not necessarily a good manager.

(iii) Systems Management or project management consists of directing and controlling a program to completion on schedule, and at the horizontal and diagonal relationships compared to the
Table VII

Aerospace Management Discipline

<table>
<thead>
<tr>
<th>Program Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Management</td>
</tr>
<tr>
<td>Facilities Management</td>
</tr>
<tr>
<td>System Analysis</td>
</tr>
<tr>
<td>System Engineering</td>
</tr>
<tr>
<td>Program Planning/Control</td>
</tr>
<tr>
<td>Configuration Management</td>
</tr>
<tr>
<td>Data Management</td>
</tr>
<tr>
<td>Logistics Engineering</td>
</tr>
<tr>
<td>Maintainability Engineering</td>
</tr>
<tr>
<td>Reliability Engineering</td>
</tr>
<tr>
<td>Human Resource Management</td>
</tr>
<tr>
<td>Human Engineering</td>
</tr>
<tr>
<td>Test Management</td>
</tr>
<tr>
<td>Production Management</td>
</tr>
<tr>
<td>Maintenance Engineering</td>
</tr>
<tr>
<td>Contract Administration</td>
</tr>
<tr>
<td>Safety Engineering</td>
</tr>
<tr>
<td>Requirements Management</td>
</tr>
<tr>
<td>R&amp;D Management</td>
</tr>
</tbody>
</table>
vertical relationships of a hierarchical organizations. In such an arrangement, managers and technicians deal horizontally with peers and associates at different levels in the same organization and with outside organizations.

b. Concepts.

(i) The concept of systems, subsystems and interfaces.

A basic approach to the management of a complex design is the concept of the design product as a system, composed of subsystems, comprised of units which can be designed and produced as individual components. Subsequently, the units and then the subsystems are assembled, integrated, and tested as a total system. The initial overall complexity which is released by the definition of less complex subsystems is also accompanied by the establishment of interface specifications and control documentation and procedures.

(ii) The life cycle definition concept.

This concept leads to a basic technique for defining all phases of the program and provides a firm foundation for the definition of work sequence. The life cycle begins with the formulation of the concept of a system and ends with a full supported, operational system including its eventual phase out.

(iii) Concurrency.

The critical nature of the time element in the development of many large scale programs has led to the utilization of the concept of the completion of several program efforts concurrently.
The breakout of the system into subsystems permits simultaneous development efforts to proceed in each subsystem.

The above concepts established the need for effective program planning and control techniques.

c. **Process.**

The development of aerospace systems follows a general methodology which has become well established during the past decade and a half. The following are representative steps in this process:

a. Define the problem (conduct feasibility studies and perform initial systems analysis which would include war gaming to establish various alternatives to the solution of the problem taking into account the social, economic, technical and political environment).

b. Selection of a single or multiple approaches (s).

c. Specify the requirements for the system, subsystems and interfaces.

d. Define critical elements requiring further research and development, using technological forecasts, and establish resources and time scale to meet some specified performance.

e. Develop a plan for program management and for the technical and production work.

f. Develop the subsystem design, development, demonstration, and test requirements.

g. Produce and test subsystems and components.

h. Define system integration demonstration, and test requirements and conduct full scale systems tests.

i. Verify system operation and integrated logistics support activities. (This includes operation and maintenance).
d. Techniques.

The techniques or tools used by the aerospace manager includes such things as planning, budgeting, scheduling, computer simulators, etc.

Table VIII is an attempt to list disciplines and techniques used by aerospace managers in sort of an impact matrix form. These are the elements which could be applied to the management of public programs. However, one should ask, "What are concepts benefits which could be derived from the application of aerospace management technology". It grew from the early recognition of specific deficiencies in government and industry in planning, developing and acquired large, complex weapon systems. The relative advantages and disadvantages of applications of this technology to nondefense endeavors must follow a critical review of public systems planning, development and operation. It must draw out the needs of the public system manager for better management. Finally, it must critically assess the capability to meet these needs.

In a speech before the Rotary Club of Philadelphia on September 15, 1965, K.G. Hark, Jr., President of the Aerospace Industries Association, made the following comments with regard to the problems of our cities:
Table VIII

Aerospace Tools and Techniques

<table>
<thead>
<tr>
<th>Plans</th>
<th>Data Element Matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Rooms</td>
<td>Interface Specifications</td>
</tr>
<tr>
<td>Schedules</td>
<td>Critical Path</td>
</tr>
<tr>
<td>Budgets</td>
<td>Scheduling</td>
</tr>
<tr>
<td>Criteria</td>
<td>System Simulation</td>
</tr>
<tr>
<td>Trade Studies</td>
<td>Design Specification</td>
</tr>
<tr>
<td>Design Review</td>
<td>Technological</td>
</tr>
<tr>
<td>Performance Significations</td>
<td>Forecasting</td>
</tr>
<tr>
<td>Functional Analysis</td>
<td>Zero Defects</td>
</tr>
<tr>
<td>Life Cycle Costing</td>
<td>Value Engineering</td>
</tr>
<tr>
<td>Integrated Logistics Systems</td>
<td>Value Earned Reports</td>
</tr>
<tr>
<td>PPBS</td>
<td>Engineering Release</td>
</tr>
<tr>
<td>Total Package Procurement</td>
<td>Schedules</td>
</tr>
<tr>
<td>Incentive Contracting</td>
<td></td>
</tr>
<tr>
<td>PERT</td>
<td></td>
</tr>
<tr>
<td>PERT/Cost</td>
<td></td>
</tr>
<tr>
<td>PERT/Tech</td>
<td></td>
</tr>
<tr>
<td>Modeling</td>
<td></td>
</tr>
<tr>
<td>Work breakdown Structures</td>
<td></td>
</tr>
<tr>
<td>Data Requirements Lists</td>
<td></td>
</tr>
</tbody>
</table>
"The accelerating rate of scientific and technological advance has permitted the levying of national requirements of fantastic complexity. Lunar exploration, though perhaps the most dramatic of these, is but one such complex system. What has all of this to do with the future of our great cities? What has it to do with the role of a civic-minded man who is a lawyer, a banker, a teacher, or a businessman can play in his community's future? Simply this. Much of what lies ahead is no mystery. We know much of what the future will bring in terms of problems. We know they will be big complex and serious. And we know what many of them are. These problems represent the givens. We know they will be there - and we know they will overwhelm us if we do not find the means of coping with them. What we lack, thus far, is conviction that there is a means of getting hold of them. They seem so staggering in their size and complexity - so far beyond the capability of any single institutional segment of the community, public or private."

"...And they are so interrelated that to proceed to try to solve any one of them in isolation from the others is often to create more problems than are solved by the effort. The dilemma thus presented has so far frustrated most efforts to come to grips with these problems. This condition of paralysis need not remain. None of the challenges lies beyond our already existing capacity for coping with them. The tools are already at hand; and included in those tools are not only the technological capabilities but experience in systems management and systems analysis as well as proven patterns of joint public and private effort."

D. Past Attempts of the Aerospace Industry at Diversification.

Many of the large aerospace firms claim diversification attempts back to the post WW II period. Most of the experiences with commercial diversification were considered unsuccessful while diversification moves into new defense and space markets have been successful. Table IX lists the estimated percentage sales of the aerospace industry, by product since 1960 (17). There is no year when the non-aerospace sales exceeded 11% indicating a general
Table IX
Market Diversification of Aerospace Companies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DOD</td>
<td>76</td>
<td>75</td>
<td>64</td>
<td>54</td>
<td>55</td>
<td>59</td>
</tr>
<tr>
<td>NASA</td>
<td>2</td>
<td>7</td>
<td>18</td>
<td>20</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerospace</td>
<td>13</td>
<td>9</td>
<td>10</td>
<td>15</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Non Aerospace</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: Aerospace Industries Association
lack of success in diversification efforts. These generally unsuccessful diversification projects have ranged from powered wheelbarrows and canoes ("Transportation" vehicles) to wall paneling and coffins (which utilize their ability to fabricate light metals).

The typical experience with these commercial diversification efforts has been to cancel them or sell them off at a loss after several years of poor sales, below average profits or outright losses. (18)

A variety of reasons are given for the inability in commercial endeavors. It is often contended that there is a skills "mismatch", that they lack the requisite capabilities. For example, their entire administrative structure frequently is geared to the unique reporting and control requirements of military procurement. The aerospace corporations frequently have relatively low private capitalization, little, if any, civilian marketing know how, and limited experience in producing high volume at low unit cost.

Their lack of knowledge of non-defense industries is pervasive. It often includes ignorance of products, production methods, advertising and distribution, financial arrangements, funding of research and development, contracting forms, and the very nature of the civilian customer's needs.
It is not surprising that the most recent diversification efforts of these government oriented companies have been into newly emerging, high technology markets within the public sector itself. Here, there is little fear of competition from firms already entrenched in the market, nor is there need for elaborate merchandising and distribution required in many commercial markets. Rather here is where the government - oriented aerospace corporation may find itself at a strong advantage.

From a national viewpoint, the utilization of aerospace capabilities in the civilian parts of the public sector possesses considerable attraction. It would represent a useful civilian return to the nation on a military investment which already has been made. From the viewpoint of the individual aerospace company, such public sector diversification also would reduce its dependence on the aerospace government market.

One of the methods of diversification proposed by Ansoff is concentric diversification or using the existing base to expand into new markets. (See Figure 3 for Ansoff's diversification classification.) (19) This approach is used by many aerospace companies from similar resource bases and therefore tends to develop considerable overlap, or duplication of new capabilities. Conrad (10) in "Unexplored Assets for Diversification" earlier recognized a tendency for firms in any given industry to come up with the same answers when seeking diversification opportunities.
Figure 3
Ansof's Diversification Classification

<table>
<thead>
<tr>
<th>Product</th>
<th>Related Technology</th>
<th>Unrelated Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same type</td>
<td>Horizontal diversification</td>
<td></td>
</tr>
<tr>
<td>Firm its own customer</td>
<td>Vertical integration</td>
<td></td>
</tr>
<tr>
<td>Similar type</td>
<td>Concentric marketing</td>
<td></td>
</tr>
<tr>
<td>New type</td>
<td>Concentric technology</td>
<td>Conglomerate diversification</td>
</tr>
</tbody>
</table>
Table X lists in matrix form some of the diversification efforts of various aerospace firms. (21)

E. Defense Companies and the Public Sector Markets (22).

From a national point of view, the utilization of defense/space capabilities in other parts of the public sector possesses considerable attraction. It would represent a useful civilian return on this primarily security-related investment and also would be helping to meet other national objectives. From the viewpoint of the individual company, such public sector diversification would reduce its dependence on two fairly closely related government markets—defense and space. Finally, by using the by-products of the basic defense/space product lines, the nation as well as the companies would be getting an added return on an investment which already has been made and has been written off. The following are two examples of attempts of aerospace firms to enter public sector and consumer markets.

1. The California Experiment (23). One of the most ambitious efforts to utilize defense contractors and defense technology, certainly the most widely publicized program, consisted of four exploratory contracts awarded by the State of California in late 1964 and early 1965. The impetus for these contracts came from the reductions, in 1963–64, of military orders for large missile and related aerospace weapon systems, the mainstay of the state's large defense industry. The plans were ambitious, particularly
Table X
Diversification Efforts of Various Aerospace Firms

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in view of the relatively small size of each contract—$100,000.
The Lockheed Aircraft Corporation was chosen to design a state-wide
information handling system and to develop a plan for its implementa-
tions. North American Aviation was charged with developing a work
program indicating the content and specifications for a systems
approach to solving basic transportation problems. Aerojet-General
Corporation received two of the contracts. One was to explore
the feasibility of applying systems engineering and operations
analysis techniques to social problems, and to recommend a program
for prevention and control of crime and delinquency. The other
was to assess the suitability of the systems approach and related
analytical tools for solving California's waste management problems
ans was performed by Aerojet's subsidiary, Space General Corporation.

Each of the companies spent more than $100,000 on the assigned
study, thus investing some of their own funds into the effort.
Thus, they also postponed to a later date the possibility of break-
ing even in this new area of business, much less earning profit.
Inevitably, a flow of reports resulted from the four contracts.
The evaluations that have been made yield mixed results.

There were several frequently voiced criticisms of the four
studies. Some contended that they were weak of their knowledge
of the subject matter, as evidenced by incomplete or incorrect
data, as well as inadequate knowledge of the pertinent literature
or the state-of-the-art. Others maintained that the recommendations
were politically naive and impractical to implement. Another com-
plaint concerned the overemphasis on engineering and insufficient attention to social, political, and administrative aspects. (24)

The most basic criticisms related to the alleged naivete of some defense industry personnel which led them to think that they could apply the systems approach as readily to social, political, and economic questions as they had to military problems. As the president of one aerospace company was quoted as saying, "Creating a system to earn a field army the enemy has launched an attack of germ warfare is basically no different from creating a system to control juvenile deliquency". (25)

Apparently the four systems studies attempted to accomplish too much in too little time. Each of them thus wound up in recommending that the state subsequently undertake follow-on programs, costing at least $1 million a year. To date, none of these follow-on programs have been implemented. This may be explained in part by the fact that, although the four contracts were paid for by the State of California, the program was financed to a substantial degree by funds that were Federal in origin.

On the positive side, most of the publicity was favorable, if not uncritical. In his analysis of this particular aspect of the contracts, John Gilmore concludes that "...the studies were successful." (26) Harold Walt, who at the time was a senior California state official dealing with the four exploratory contracts, reported as noteworthy the fact that the state attracted
the attention of industry to its problems and that industry thus also made the state aware of its capabilities. (27) It may be indicative of this new government–industry relationship that two of the companies that received contracts established offices in the state capital, which they did not have previously.

As a result of the $440,000 expenditure by the state for the four initial studies and related consultation work, California has received about $1 million in Federal funds to support five additional systems studies. These cover a criminal justice information system, planning information for waste disposal, land-use planning data, and an examination of public assistance systems. Some of these research funds were utilized by state agencies; the great bulk was contracted out to defense companies.

In a more general way, all of the original contractors, as well as other defense firms, have expanded their civil sector systems activity since the completion of the initial California effort. Most are performing work for a variety of state, local, and Federal government agencies. Aerojet received two additional contracts from the State of California, but neither was a direct follow-on to its earlier work. (28)

The Demonstration Effect.

At least the temporary cutbacks in military procurement in 1963–1964, and the demonstration effect of the California experiment, have encouraged many other defense contractors to seek business
in the parts of the public sector they had previously ignored. Although the dollar volumes of these undertakings are still small judged by the scale of military and space programs, they do involve government agencies now doing business with high-technology private enterprises that were originally attracted to government work by the military establishment. Some nondefense firms have also begun to seek contracts in these newly emerging public sector markets.

The present appears to be a period of substantial exploration on the part of both government agencies and business enterprises in assessing the kinds of relationships through which they can successfully do business with each other.

2. **Successful Diversification into Consumer Products.** Not all attempts at diversification have been failures. Raytheon in 1970 was able to maintain its profit levels despite cut backs in defense in 1969. (29) This was made possible by successfully adopting and marketing aerospace technology developed consumer products. The first of these was the Radarange which Raytheon had developed earlier and had been marketing to hospitals, restaurants, and institutions with never any spectacular success. It was not until Raytheon acquired Amana Refrigeration, Inc. who had marketing expertise in the consumer field and aimed them at the general public did the sales of the Radarange skyrocket.

Another conversion is a highly efficient heat transfer process which they developed as a more efficient cooling process for huge
radar tubes. This device, powered by natural gas, is the size of
a two pound coffee can, and can act as the heart of a furnace
able to heat a nine room house. The product has already been test
marketed in Great Britain and the British Gas Council has ordered
70,000 units for delivery over the next three years.

A more detailed study of the diversification efforts of fifteen
aerospace firms has been made by DePasquale (1971) at the MIT Sloan
School of Management.

3. Problems of Diversification. Some of the problems often
cited in the literature as problems for diversification of aero-
space firms into either public sector or consumer markets include:

1. Lack of management motivation or support.
2. Reluctance to commit full time management and/or top
technical personnel to these diversification ventures.
3. Specialized capabilities.
4. Low capitalization.
5. Little commercial marketing capability.
6. Limited experience in producing at high volume, and low
cost.
7. Administrative structure is geared to the sometimes unique
reporting and control requirements of the governmental
customer.
8. Traditionally low price to earnings ratio limits ability
to diversify through merger.
10. Ignorance about how the private sector works (production,
financing, distribution, contracting forms, etc.).
11. High price wages.
12. Top management dominated by engineers.
13. Lack of government institutions.
14. 4-5 times number of S&E than commercial firm (i.e. drugs,
chemicals, etc.).
15. Government generally pays for R&D costs for defense work.

16. Overhead costs absorbed by defense work, particularly independent R&D costs.

17. High degree of sophistication.
V. Department of Housing and Urban Development (HUD)

A description of the U.S. Department of Housing and Urban Development and the laws which give it the statuatory authority to conduct and support urban research including housing and related activities is provided in Appendix II. HUD was formed out of the need to combine and integrate the activities of several long established housing organizations such as, FHA, HAA, etc. Prior to the establishment of HUD, little government sponsored research was done on housing. As a result, an inhouse management and technical capability was not developed.

With the recognition of the serious need for housing in the Housing Acts of 1949 and 1968, it became obvious that new and innovative management and technical skills had to be brought to bear on the housing problem. An obvious source of talent, ideas, and skills were from Defense and space activities. It is for this reason that birth was given to programs such as "In-Cities and "Operation Breakthrough". Since 1968, funds for research and development in housing have been increasing. The level is quite low but an encouraging start has been made. Despite the specific goals for housing spelled out in the Housing Act of 1968, there still is no National Commitment to provide adequate housing for all Americans.

Because of the very political nature of housing with many self made experts, established interests, and rising interest in
government involvement in the public sector, research and development activities are quite open to close scrutiny. Because of the nature of R&D, there are a great deal of uncertainties, false starts will be made and apparent inefficiencies will be visible. This is a very difficult environment for R&D to operate. The tendency will be for short term gains, low risk programs which impede the very innovative ideas that such programs hoped to encourage.

Unless long range commitments to R&D are recognized and supported, and long range commitments with specific goals and objectives are made, R&D programs in any part of the public sector can only wander aimlessly subject to the pressures of special interest groups both within and outside of government.

A. Operation Breakthrough. This is the most ambitious program to provide innovative management and technical ideas in housing to date. The management of such a program requires extreme skills and flexibility. Of particular importance are controls over program costs and schedules. The complexity of this program with twenty-two housing contractors with their subcontractors, prototype site developers, and prototype site planners at nine sites scattered throughout the country presents a control and coordinat problem of immense magnitude. Superimposed on this are the social, economic, and political factors of doing business in the public sector. All this requires extremely good management capability to consider not only the technical aspects but all the others which play an even greater role.
The problems of housing cannot be solved in a vacuum since they are so closely entangled with education, employment, social well being, and transportation. A total systems approach is required which take into account all these factors. All too often, government houses or apartments are built with little regard for the social aspects of housing, that is, are they houses that people want to live in, are they suitably located, are they adequately built, etc.

A major difficulty in the nation's whole government housing program is the fragmented responsibility for the development of housing among a number of departments and agencies, mainly in HUD but also in Agriculture, Defense, Interior, the Veterans Administration and elsewhere.
VI. Transferability of Aerospace Management Techniques to Public Sector Programs.

A. Introduction.

A great deal of interest has developed in the last year concerning the large number of scientists and engineers who have become unemployed due to cut backs in defense and space spending. Upwards of 60,000 engineers, scientists and technicians are estimated to be out of work. This problem is super-imposed on the critical inflationary spiral of the economy, unemployment in other industries such as shoes and textiles, and the unemployed soldiers who are now returning from Viet Nam. This has caused a large amount of consternation and a clamour for someone to do something about the problem. In the case of the engineers and scientists, there is a rising amount of pressure to employ these people in solving the problems of pollution, transportation, environment, housing, etc. The major question to be asked is, "Are these skills transferable?" If not why not, what are the barriers, and what must be done in order to reduce these barriers?

This section attempts to investigate the problems of transferability of aerospace skills to the public sector, what are some of the attempts being made to expedite this process, and finally a model is developed which includes most of the important factors.
involved in the transfer process.

There is a continuing controversy over whether the same skills, people and organizations, which put the man on the moon, built the ICBM systems, and built the atomic bomb can also be unleashed to attack the problems of the cities, environment, housing, transportation etc. The feelings run gamut from "provide the aerospace industry the resources and it will solve the problems" to complete skepticism as to whether the aerospace industry as a whole is uniquely qualified to attack and solve any of these problems.

The following are several quotations which indicate the wide range of views:

a. One aerospace industry president has been quoted as saying:

"Creating a system to warn a field army the enemy has launched an attack of germ warfare is basically no different from creating a system to control juvenile delinquency." or, to parody Gertrude Stein, "a system is a system, is a system". (25)

b. In statements made by the Honorable M.L. Weidenbaum, Assistant Secretary of the Treasury for Economic Policy, before the Conservation and Natural Resources Subcommittee of the House of Representatives Committee on Government Operations, November, 23, 1970, he points out "...There has been a great deal of naivete in attempting to sell systems ability of the aerospace industry as a cure all for public sector needs."

c. Karl G. Harr, Jr., President of Aerospace Industries Association in the foreword of "Aerospace Technology: Creating Social Progress, March 1970, makes the statement:
"The Apollo program centered on a clearly stated goal, lines of authority and responsibility were clear, simple, and strong. Our nation's environmental problems, however, often do not enjoy such clear delineations of authority and responsibility. They are frequently beset by limited, divided and conflicting authority among local, state and federal governments. The greatest need is for the development of innovative means to overcome such constraints so that technology's revolutionary new tools can be more affectively applied to the pressing needs of our society..."

d. In a speech made at an AIAA meeting in Houston on October 22, 1970, Dr. G. Low acting administrator of NASA, made the following statement:

"We decided to move forward to continue with the exploration of space because the need to maintain our leadership in science and technology is as strong now as it was in 1960; and because the capability that we have developed in the 1960's does not make us experts in the solution of our domestic problems.

NASA and the Aerospace Industry are not uniquely qualified to solve our domestic problems.

The domestic problems, including those of the physical environment, are largely social, economical, and political. The need for new technology, for research and development, does exist in some areas, but certainly is not the driving force in obtaining solutions. The solutions to these problems must, therefore, come from sociologists, economists, and politicians - not engineers and scientists. We in aerospace should, of course, assist wherever and whenever we can: We have developed techniques of management that may apply; there are technological problems that we are qualified to tackle; and there are areas where space technology and the applications of space technology, apply directly. We should assist, but we should not think or encourage others to believe that we can solve all of our domestic problems."

e. A U.S. Department of Labor Official wrote in the March 1971 issue of Nation's Cities suggesting, "With little or no additional training the job seeking engineers could fill city jobs in transportation, health, sanitation, air and water pollution and construction."
After five months of operating a job bank in California for matching aerospace workers with jobs in the public sector, 5000 engineers were listed but only 800 jobs. The experiment was considered a flop. The same official was quoted as saying:

"Most of the job seekers are trained for a dwindling supply of aerospace jobs, and skills learned working on a spaceship doesn't necessarily qualify a man as a sewage disposal expert."

B. Past and Present Attempts at Increasing the Transfer of Aerospace Skills

A number of proposals to encourage or speed up the transfer of aerospace skills have been made by various organizations, executive and legislative branches of government and individuals. Many of these have been of a stop gap nature with seemingly little thought given to long range solutions to meet well defined needs. This has been clearly enunciated by the Honorable M.L. Weidenbaum, Assistant Secretary of Treasury before a subcommittee of the House of Representatives, November 23, 1970:

"Personally, I believe that the focus of the present inquiry needs to be reversed. The national interest is not well served by viewing the question as how to employ the aerospace industry or any other single industry in solving pollution or other environmental problems.

Rather, we need to start with the problems to be solved then see what technology and other capabilities are needed... ."

This section summarizes some of the activities of organizations, individuals, and executive and legislative branches of government in attempting to address the problem of transferring aerospace skills into public sector programs. The term technology transfer is used not only to mean technical transfer of devices,
ideas and skills but also aerospace management methods, techniques and skills, described earlier.

(1) In August of 1964, Congress authorized the establishment of a National Commission on Technology, Automation, and Economic Progress. As spelled out in Public Law 88-444, the four primary functions of the Commission were to:

a. Identify and assess the past effects and the current and prospective role and pace of technological change.

b. Identify and describe the impact of technological and economic change on production and employment...and the social economic effects on the Nation's economy, manpower, communities, families, social structure, and human values.

c. Define those areas of unmet community needs toward which application of the new technologies might most effectively be directed; and

d. Assess the most effective means for channeling new technologies into promising directions, including civilian industries where accumulated technological advancements will yield general benefits, and assess the proper investment in the application of new technologies to large scale human and community needs.

A report was written by Lesher and Howick (31) for this commission addressing the fourth of those functions. It did not recommend any single "most effective means" since too little is known at this time about the complex mechanisms of technology transfer. It did
not consider such questions as:

a. Is there sufficient technology available, from federally supported sources to permit useful inter-sectorial transfer effort?

b. Is the transfer of technology a worthwhile national goal?

c. Can technology be transferred from one industry to another, one discipline to another, one region to another?

d. What is known about the incentives and barriers to transfer?

e. What mechanisms or channels have been employed to date, and with what success?

f. What are the essential elements, as perceived today, in the most effective methods?

(2) Numerous Senate and House Hearings have been held on proposed legislation to facilitate the transfer of aerospace skills. None of these bills has yet become law:

(a) S2662 - A bill to mobilize and utilize the scientific and engineering manpower of the nation to employ systems analysis and systems engineering to help to fully employ the nation's manpower to solve national problems. (32)

(b) S430 - A bill to mobilize and utilize the scientific and engineering manpower of the nation to employ systems analysis and system engineering to help to fully employ the nation's manpower resources to solve national problems. (33)

(c) S467 - A bill to provide for a study with respect to the utilization of systems analysis and management techniques in dealing with problems relating to unemployment, public welfare, education,
and similar problems. Also included in this bill was the creation of a National Commission on Public Management. A counterpart of this bill in the House was HR20. (34,35)

(d)McGovern Conversion Bill (S.4430) This bill was introduced in the fall of 1970 as the National Economic Conversion Act (S.4430). It was reintroduced in revised form on March 11, as The National Peacetime Transition Act or 1971 (s.1191). The bill establishes a National Commission to review conversion plans which each defense contractor would be required to submit for each of his facilities. These plans would detail how that facility would be converted to civilian activities. "In those instances when a defense contractor fails to execute a conversion plan which has been approved by the Commission, The Commission is authorized to take over, convert, or arrange for the conversion and operation of its facilities by some other organization ...." (Title II, Section 201) Defense contractors will be required to deposit 12½ percent of their pre-tax profits with the Commission to help defray the costs of additional unemployment benefits for displaced workers, and to provide loans to themselves for converting their facilities to civilian activities. Any money left in the fund may be returned to them (with nominal interest) after they successfully convert.

The McGovern bill espouses a number of fine principles, namely: (1) extensive planning is necessary to accomplish conversion effectively; (2) conversion should be achieved through a cooperative Government-industry effort and; (3) the Government
should offer incentives as well as impose constraints to assure that conversion occurs. The implementation of these principles rests on the assumption that conversion should -- and can -- occur by means of individual firms' converting each of their defense facilities to civilian activities.

(e) Kennedy Economic Conversion Loan Authorization Bill
(S.1261)

S1261 - A bill to authorize the National Science Foundation to undertake a loan guarantee and interest assistance programs to aid unemployed scientists and engineers in the conversion from defense related to civilian, socially oriented research, development, and engineering activities. This bill was introduced by Senator Kennedy of Massachusetts to provide jobless scientists and engineers with government guaranteed, low interest loans to tide them over the current unemployment crisis. Called the Conversion Loan Bill, the measure would encourage banks and private lending institutions to make long term loans to distressed scientists in amounts up to 60 percent of their former salaries or $12,000, which ever is lower. The program would be administered by the National Science Foundation (NSF), which would pick up all interest payments until a scientist has been reemployed at a job which pays him at least two thirds of his previous salary. There after, he would repay the loan over a period of 10 years, including interest payments of 3 percent. NSF would subsidize interest costs over 3 percent. (36)
(f) **Kennedy Conversion Research, Education and Assistance Bill (S.32)**

S.32 - A bill to authorize the National Science Foundation to conduct research, education, and assistance programs to prepare the country for conversion from defense to civilian, socially oriented research and development activities, and for their purposes. This bill would authorize NSF to spend $500 million over a three year period. (39)

(g) **Giaimo and Davis Reconversion Bill (36)** Bill introduced into the House similar to S.32, providing $450 million for the following purposes:

1. Establishment of local non-profit companies which would be prohibited from engaging in defense work. These organizations would give preference to hiring unemployed technical people who formerly worked in the defense field.

2. Grants to academic institutions, non-profit organizations, and private firms to develop and implement programs designed to train scientists, engineers, and technicians to work in social fields.

3. Grants distributed by the Small Business Administration to small businesses that are employed in socially oriented programs.

4. Academic fellowships awarded to scientists and technicians with priority given to those who are unemployed - to finance participation in special educational programs.

5. National Science Foundation authorization to make grants to universities, public organizations, and private firms for addi-
tional research into programs that would aid in converting technical defense oriented manpower to civilian oriented work.

(h) **Executive Authorization** President Nixon authorized the Secretary of Labor on April 2, 1971 to allot $42 million to promote jobs and help retain unemployed scientists and technicians who are victims of defense-aerospace cutbacks. These funds would be spent in the following way:

a. $5 million for a job search program to enable 20,000 job applicants to explore employment opportunities in areas away from their homes.

b. $25 million for job retraining to help expand the capability of these engineers and scientists so they can move different fields such as environmental science, urban studies, and health and safety engineering.

c. $10 million to help 10,000 families with reimbursement money so they can move their households to jobs in different areas.

d. $7 million for skill conversion fund. Small groups of professionals would explore ways to provide technological help for traditional areas of the economy.

(i) **Job Bank** The Labor Department operated a computerized clearing house for idle aerospace engineers and scientists in Sacramento. Out of 5000 listed job seeking engineers only 800 jobs were listed. It was hoped that with little or no training the job seeking engineers could fill city jobs in transportation
health, sanitation, air and water pollution, and construction. After five months of operation, the Department of Labor admitted that the system was a failure. Similar experiences appear to exist with Job Banks in Massachusetts. (41)

(j) **HUD Job Training Program (42)** HUD and the Department of Labor have proposed a pilot program to provide on-the-job training for 400 unemployed aerospace scientists and engineers in public service jobs at a cost of 1.2 million dollars. Training will be performed by city, county, and state governments. Two programs of 200 each are envisioned over at M.I.T. and the other at Berkeley. Retraining will include four weeks at one of these universities followed up by 9 months to a year of evaluation.

(k) **Tax Credits (43,44)** Several proposals have been made to spur productivity and employment by using tax credits anywhere from 5 to 7 per cent. Morrissey (1971) in an article in *Astronautics and Aeronautics* claims that within two years the level of a 7% R&D tax credit should raise non-Federally sponsored R&D from $11 to $13.6 billion annually and increase employment of engineers and scientists by 60,000 - close to the number now unemployed, while in the long term increasing treasury revenue and, more importantly, productivity across the broad spectrum of American industry.

(l) **Individual Proposals (45)** (1) Professor Baram of MIT and Barney of Rochester have proposed the establishment of "Environ-
mental Assessments Institutions" staffed by unemployed aerospace and defense industry engineers and scientists who would receive training in the broader field of environmental analysis.

(2) Similarly, Gofman and Tamplin of the University of California and Rose of MIT advocate the setting up of institutes to assess technology independent of government regulatory agencies and retraining.

Many colleges and universities are seriously considering ways to retrain aerospace scientists and engineers. (46) An example of a typical program, is that proposed by a consortium of Florida Institute of Technology, and Brevard Community College, near Cape Kennedy to retrain 3000 unemployed engineers, technicians, and scientists in environmental and related fields.

(m) WPA for Scientists and Engineers (47) W.R. Brode of the American Chemical Society has proposed a "holding pattern" to preserve an excess of technologists for this nation as a necessity. Technical programs should be established, as a holding pattern, through private, federal and state funding in such areas, as health, environmental improvement, pollution eradication, post doctoral programs, updating courses and basic research, so as to retain trained scientists and engineers and to expand their capability. He predicts a shortage of technologists in decades following the 1970's and these engineers and scientists would then be prepared to fill important and much needed demands in industry, government,
and education.

Some people have criticized this proposal as a WPA make work program. Dr. Brode hastens to point out that there are many fine compilations in our public and university libraries of national, state, and local history material with the markings, "Supported by WPA". Many scientists, especially those in physical and mathematical sciences may be surprised to look at some of the extensive numerical tables on the title page so as to note that the compilations were done under the WPA.

(n) Other Government Programs (48)

a. National Science Foundation - a few small conversion related programs.

(1) Program to gather accurate statistics on technical unemployment.

(2) Program to retrain fifteen scientists and engineers.

b. The Department of Defense's Office of Economic Adjustment has worked in several instances with community leaders to help plan community adjustments to defense cutbacks.

c. The U.S. Arms Control and Disarmament Agency has been studying since 1964 the effects of defense and disarmament on the U.S. economy. Some of this has been designed to fill gaps in statistical information on the distribution of defense-created employment and income. Other research has explored specific
adjustment problems affecting manpower, regions, and industries, or has considered broad national policies and programs relating to reallocation of resources from defense to civilian use. (49)

C. Technology Transfer
   a. Introduction.

   The transfer of knowledge or skills is a complex and not well understood process. It pervades our whole society from education to business. A great deal has been written about the transfer of technical knowledge which has been generated by massive space and defense programs to private industry and government at all levels, but little research has been performed to understand the process. According to Doctors (50), "what is needed is an applied social science program aimed at increasing knowledge of the transfer process."

   This paper does not claim to be able to provide deep insights into the transfer process, but attempts to develop a simple model of the process, identify critical elements of the transfer process for a particular transfer between the aerospace industry and the industrialized home building industry as well as the government agencies concerned in these areas, identify barriers to the transfer process, possible ways in which these barriers might be overcome, and finally to point out areas where further research might be performed.

   b. Transfer Model.

   The simple model of the transfer process is borrowed by
analogy from epidemiological research which is based on the triad concept, the relationship between host, agent, and environment. The breaking of any one of the bonds between these three allows one to isolate and investigate their interactions. In the transfer process, one can think of a transferor acting as a host, transferee as agent, and the environment as made up of barriers or aids which tend to hinder or help the transfer process.

Fig. 4 Simple model of Transfer Process.

Superimposed on this simple structure, there may be forces acting to reduce or increase the barriers to transfer. This may take the form of pressure groups, institutions, governments or people. In the case of the transferor and transferee these may be both internal and external.

For the specific case in point, the transfer of aerospace management skills to the public, and in particular, involves
four elements and the interactions between them as shown in figure 5. In order to be able to isolate some of the factors, two elements of this model will be considered, the transfer between government agencies, and the transfer between the aerospace and industrialized home building industry.

(1) Government. Significant benefits can result from the application of technology generated by one federal agency to missions of other agencies. Especially in the case of the management of such complex programs as are found in space and defense.

Management of government programs in the public sector are becoming increasingly complex requiring the latest in management skills and techniques. This was clearly pointed by Simon Ramo (51) in an article in the *Harvard Business Review*. A quote from this article is quite apropos:

"The biggest and toughest program management jobs are now clearly in the government. The government program manager has to direct the match between the requirements of the government and what science, technology, industrial know-how, and capacity make possible. The government program manager must schedule the program and arrange the allocation of resources, the system of interactions, and the coordination among the various units whose contributions are well needed for the program to move. Industry is, of course, but one of these units".

The factors affecting the transfer are classified as those that affect each of the three elements. These are listed in table XI.
Figure 5 Four Element Transfer Model
Table XI

Factors in the Government Transfer Process

<table>
<thead>
<tr>
<th>Transferor</th>
<th>Environment</th>
<th>Transferor</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need</td>
<td>Institutions</td>
<td>Attitudes</td>
<td>Educational level</td>
</tr>
<tr>
<td>Educational levels</td>
<td>Costs</td>
<td>Desires</td>
<td>Desires</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Philosophy</td>
<td>Professional background</td>
<td>Individual personal characteristics</td>
</tr>
<tr>
<td>Management Commitment</td>
<td></td>
<td></td>
<td>Experience</td>
</tr>
<tr>
<td>Receptivity to change</td>
<td></td>
<td></td>
<td>Institutions</td>
</tr>
<tr>
<td>Amount and type of communication</td>
<td></td>
<td></td>
<td>Management Commitment</td>
</tr>
<tr>
<td>Professional background</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of implementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitude toward R&amp;D</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Some of the external factors tending to promote increased transfer might include:

(a) Political resources
(b) Economic pressures
(c) Social pressures

These may take the form of legislation, unemployment, or inadequate housing as some simple examples. Some of the ways to overcome barriers might include:

<table>
<thead>
<tr>
<th>Transferor</th>
<th>Transferor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased communications</td>
<td>X</td>
</tr>
<tr>
<td>Transfer of individuals or groups</td>
<td>X</td>
</tr>
<tr>
<td>Organizational changes</td>
<td>X</td>
</tr>
<tr>
<td>Increased training (Formal and on-the-job)</td>
<td>X</td>
</tr>
</tbody>
</table>
(2) **Industry Transfer.** In the industry transfer process many of the same factors affect the transferor and transferee but the environmental barriers are significantly different. These are listed in Table XII:

<table>
<thead>
<tr>
<th>Transferee</th>
<th>Barriers</th>
<th>Transferor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need</td>
<td>Training and experience</td>
<td></td>
</tr>
<tr>
<td>Individual personality characteristics</td>
<td>Individual personality characteristics</td>
<td></td>
</tr>
<tr>
<td>Communication patterns</td>
<td>Communication patterns</td>
<td></td>
</tr>
<tr>
<td>Organizational effects</td>
<td>Organizational effects</td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>Motivation</td>
<td></td>
</tr>
<tr>
<td>Markets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovative environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architectural design</td>
<td>R&amp;D history</td>
<td>Management Commitment</td>
</tr>
<tr>
<td>Construction methods</td>
<td>Institutions</td>
<td></td>
</tr>
<tr>
<td>Zoning regulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building codes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government red tape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of finances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Political</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of institutional framework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of suitable standards</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The major factors affecting transfer in the three categories will now be discussed with reference to methods that might be used to reduce barriers. These are not by any means all inclusive but are just suggestive of things that could be done.

(3) Transferor

(i) Training and experience. In the case of the aerospace industry, a certain amount of retraining is necessary for individuals and companies if they are to do business in the markets of the public sector. This retraining has to take the form of learning how to deal with state and local governments, learn what their rules and problems are, and how to communicate with them. It was obvious from the California experiments that one of the major problems was in communications. One of the methods used to get people attuned to the problems of Space was the widespread use of study contracts which essentially helped to retrain people from aircraft thinking to spacecraft thinking. A major retraining in attitude with regards to cost and technology is also necessary. In the public sector, new technology may not be what is needed, rather existing technology at lower cost. With the unemployment of many aerospace engineers and scientists, the President and legislators have seen the need for retraining and have started to move resources in that direction even though it may be slow and late occurring.

(ii) Organization effects. It may be necessary for companies to establish new organizational elements to deal with markets in the public sector. This would have several advantages:
- It would be the primary business of that element and not just secondary element of some larger organization.

- Smaller independent organization may be able to move and communicate faster.

- It may be able to operate at a lower overhead rate rather than be saddled with the rate of the parent company.

(iii) **Motivation.** In order for the process to occur and propagate itself, there must be motivation on the part of the total organization from the top management on down. If there is not total commitment from the top in the way of resources, time and effort, then the venture into the public sector will be doomed to failure.

(4) **Transferee.**

(i) **Training and experience.** Even though a large amount of resources and effort are beginning to be funneled into retraining engineers to work in the public sector, unless something is done to upgrade the existing public sector work force, the environment, and attitudes, much of this retraining may go for naught. One of the startling results of the interviews made during this study was the concern over the lack of expertise at the state and local levels. If transfer is to take place, both parties must be able to communicate on the same level.

(ii) **Need Orientation.** All the existing research on technology (52) transfer points to the one driving force in the transfer process and that is the need orientation. Just as major
innovations arise out of some basic need, so it would appear that the transfer process would occur if there was an urgent well defined need. As an example, the complex space programs required advanced management techniques which were rapidly transferred from the defense sector because of the urgency of the need.

(iii) Perhaps the biggest barriers in the homebuilding industry are those that have built up through the years with the small builder, the way he communicates, his construction methods, his motivation, personal characteristics and organization of his business. Here is where more applied social research is required in how do you introduce change without upsetting the existing structure.

(5) Environmental Barriers.

(i) Markets. Perhaps the biggest barriers to aerospace firms entering the industrialized home building industry, bringing with them advanced technologies, is the clear evidence of suitably large markets for industrialized housing. This barrier can be overcome with the help of the Federal and state governments developing common performance specifications for military, rural, state, indian and public housing. This would be similar to the California school experiment where performance specifications were developed for components of the school and several school districts got together to produce an aggregated market. Similar actions by towns, cities, counties, and states can be taken to
aggregate markets in the crime, health, and education areas.

(ii) **Innovation.** Aerospace firms have much to offer in the area of innovation and could be quite beneficial to the home building industry. Increased expenditures for research and developments, tax credits for research and development expenditures, and R&D write offs on large government contracts could provide the necessary stimulus to give added growth to this industry.

The mobile home industry offers another area where innovation could be beneficial, especially if mobile home construction could be upgraded to meet minimum FHA standards and hence could compete with the modular home builders.

(iii) **Institutions.** Many of the problems which exist within housing on the government side are the lack of adequate institutions for handling the problems. For example, not all housing and or city problems reside within the Department of Housing and Urban Development, but aspects of housing reside in other agencies such as Agriculture, Interior, Commerce and Defense, in addition to mass transportation which is so important to city and urban development. This was recognized by the ASH Committee on Government Reorganization and all these functions were recommended for consolidation.

In other parts of the public sector, organizations wishing to enter these new markets are discouraged because of the lack of
institutional structure to aid in aggregating markets, focusing research and development, etc.

Other institution problems such as codes, zoning, political, government red tape, financing, land, labor supply, and information transfer can to some degree be affected by the Federal or state governments through control over funds. These tactics have been used in the past and have proven to be quite successful.
VII. Conclusions.

A. General.

1. The problems of low cost housing are not just technical but are mainly social, economic, and political in nature.

2. Technology together with other factors can play a small but important part in low cost industrialized housing.

3. The housing problems are not well defined but interact very strongly with transportation, education, health, employment, sociology, and technology.

4. Although there are claims and demands for "decent housing for all Americans", there is no National Commitment in the form of public agreement and resources. The goals have been defined but unlike the Appollo program the resources and direction are not and have not been adequate.

5. Some of the biggest problems in public sector programs are not technical but lie in questions of sociology, people attitudes, motivations, how can minority groups live and work together, how can people of different economic and social standing work together. There needs to be greater research into the soft science areas rather than into brick and mortar.

6. More research is required into how to introduce change into established organizations.

7. The field of housing is very complex and political, not amenable to easy solutions.
8. Research in the housing industry is quite limited and diffuse with little or no long range planning or focused research as is found in defense or space areas.

9. In any public sector program one of the biggest problems is dealing with the some 90,000 individual state and local governments.

10. At the present, the federal government's housing effort is fragmented among a number of departments and agencies, mainly in HUD but also in Agriculture, Defense, Interior, the Veterans Administration and elsewhere with little apparent coordination in integration.

B. Transferability of Aerospace Management Skills into the Public Sector.

1. Marketing. The most important skill required in the consumer market is marketing. Aerospace firms are not familiar with this type of marketing and of necessity must obtain existing marketing mechanisms in the housing industry if they are to compete. Many aerospace firms have obtained this expertise by either acquiring a company that has been working in this market or have hired individuals and teams of individuals familiar with marketing in this environment.

An important management skill that the aerospace firms bring to the homebuilding industry is the ability to work with government agencies, their procedures in contracting, methods of operating,
etc. As the government gets into bigger social programs such as demonstration programs, this will be a valuable asset.

2. **Production.** Production capabilities appear to be directly transferable since the major problems in building nose cones, aircraft, and houses involve the important aspects of materials handling, inventory control, and quality control. Their expertise has not been, however, in the area of high volume and low cost. They have developed cost control, learning curve techniques, and a discipline to improve the process through research and feedback, which should be quite useful. However, their past experiences in providing close tolerance, highly engineered products could be quite a handicap competing in a very cost conscious industry such as housing.

3. **Research and Development.** In industries such as housing, the aerospace firms are not bound by past traditions and can contribute new innovations by taking a different perspective on housing problems. They tend to be very technically oriented and must be retrained to become more cost conscious.

    Since aerospace is a knowledge industry, as opposed to an experience industry like housing, it is accustomed to dealing with risks and uncertainties. It has had to deal with increasingly complex technological problems and as a result has had to develop new and innovative solutions both from a technical and management point of view. In essence, it has become quite open to innovation and change.
4. **Systems Analysis.** It has become a way of normal business in the aerospace industry to look at problems as a whole including all the interacting factors. This starts with national policy, strategy and war games which look into all the interacting effects of the social, economic, political and technological environments. From this, results, performance specifications and cost effectiveness analyses of various approaches to the solution of complex national problems.

These same techniques can and in some cases are being applied to housing problems. It should be pointed out that this technique is not a cure-all but a tool for the decision maker to aid in allocating resources. The major problem is the development of a program and implementation which can be extremely difficult.

5. **Planning.** Although the aerospace industry has had a relatively simple planning job over the past years, it has developed an appreciation and awareness of the need for long range planning which has been conspicuously absent from the home building industry. The methods and techniques developed can be directly transferred in analyzing requirements and pointing out gaps in knowledge where further work is required.

6. **Skills Transferability.** A great deal more research is needed in the whole area of transferability of skills to determine what is the most important transfer mechanism, whether it be individuals, groups, or whole organizations, what are the barriers to transfer, and how can these barriers be overcome.

7. Aerospace management skills are transferable with
certain qualifications.

8. Retraining without specific job openings is a waste of time, money, and motion.

9. Experience has shown that scientists and engineers quickly develop needed skills on the job. Programs such as HUD's proposal to use unemployed scientists and engineers in Model Cities programs by on the job training with local officials, and the new Safety Act requirement for "Safety Engineers" should be developed.

10. If aerospace workers are to be trained to work together with local and state governments, then the skills of individuals in these organizations must be up-graded also.

B. Low Cost Industrialized Housing.

It now appears that industrialization will not immediately reduce the cost of home building substantially. Instead, the greatest short term benefits will be in home production at a faster rate and a means around the forecast shortage of skilled homebuilding tradesmen, such as plumbers, electricians, carpenters, etc.

2. Very few new building innovations are presently included in industrialized houses. It will probably take until the second or third generation of industrialized houses before major innovations in building materials and methods are introduced.

3. Market aggregation looms as the biggest stumbling block for industrialized housing. If markets of sufficient size and duration can be developed, long factory production runs will
be possible with the attendant economies.

4. The second biggest problem for industrialized housing is the proliferation of building codes and the need for some sort of national performance code.

5. Industrialized houses are presently produced for middle income rather than low income families. Additional subsidy of low income families is needed before this type of housing can be made available to this income bracket.

6. Industrialization permits more efficient use of labor and materials and greater reliance on highly mechanized and specialized equipment in factories. Management can schedule production operations with greater precision.

7. Industrialization saves money by reducing labor, but it is materials rather than labor that accounts for the bulk of housing costs.

8. Industrialization will eventually help substantially cut the weather vulnerable part of the construction process.

9. Industrialization will make it possible to more readily use new materials. Metals and plastics require heavy equipment and volume production to justify expense.

10. Present experience indicates that the labor input for a factory assembled house is 45% with a higher proportion of unskilled labor, than for a comparable conventionally-built house. With a sustained market of 3,000 - 5,000 houses a year
within a few hundred miles of factory and volume savings in materials procurement, the total construction cost of a factory assembled house could be 15% less than for a comparable conventional house. (Stockfish 1968)

11. With the spiraling wage increases in the construction industry, industrialization may help in maintaining housing costs at a reasonably stable level.

12. Although a number of constraints have been identified to low cost housing, surprisingly little quantitative information exists as to their importance. Research is required to quantify each of these factors before decisions can be made in allocating resources to remove these constraints.

D. Government Involvement in Low Income Industrialized Housing.

1. One of the major benefits of HUD's Operation Breakthrough may be as a catalyst in getting large firms into the industrialized home building industry.

2. The government can do a great deal in helping to aggregate the markets through programs such as FHA 235 and 236 subsidized housing programs, military housing construction and rural housing construction.

3. Long range plans for implementing low income housing goals are urgently needed. This would include a total systems approach including transportation, education, employment, health,
and welfare, sociology, political, and technological aspects.

4. Increased research and development is required on a long term continuous basis. This should include not only building materials and processes but also social, economic, and health aspects of housing.

E. Public Sector Markets.

1. In a number of other public sector markets besides housing, such as crime, health and welfare, education and transportation the markets are fragmented and diffuse making it difficult to aggregate themarkets. New marketing skills have to be developed to penetrate the market of some 90,000 local municipalities.

2. On the local and state levels, the governments lack the sophistication in contracting, research and development, administrative practices, and management skills, making it exceedingly difficult to do business.

3. Problems in the public sector are often not well defined mainly because the boundary conditions are not well defined. For example, it is difficult to even define the problem given the necessary resources, i.e. What would you do with Harlem or mass transportation in the cities if given enough resources?

4. Existing technologies both in engineering and management are sufficiently advanced but need to be applied to the problems of the local communities.

5. Management of programs in the public sector present greater challenges than in either space or defense.
F. **HUD's R&D in Housing.**

1. HUD has developed an impressive R&D program within the last three years compared to the previous decade. However, it lacks long term objectives and strategies.

2. Operation Breakthrough has done a great deal to encourage large corporations to enter the industrialized housing field. Whether these companies remain in the field remains to be seen, but the government can do a great deal to help by rising its leverage in its controls over housing support by aggregating the housing markets.

3. Much more research is needed into the social aspects of housing including housing preferences for the future, i.e., what do people want to live in, how will living habits change in the next decade or two, problems of maintenance and management, integration of low cost housing into the communities, effects of housing and neighborhood characteristics on health and social performance, required standards for public service, effects of housing on race relations and the ways in which racial issues constrain its programs, research into the social, economic and political processes through which its programs are assured to operate, and methods of introducing innovations and change against the housing industry, local and state governments and local communities.

4. Besides major demonstration programs, HUD should develop an inhouse research and development capability to (1) support existing housing programs both managerially and technically,
(2) develop a firm long range research and development base on the problems of housing and its interactions similar to defense and space, and (3) provide a means to develop inhouse technical and management skills for use on larger programs. This capability should include both inhouse research facilities, facilities developed for space and defense, and the use of contractor research capability. Contracted research should be used for seed money to be leveraged against construction industry resources.

5. HUD's R&D capability is presently a vigorous and healthy establishment often called an enigma within a large government organization such as HUD. It must be longer range oriented so as not to be continuously at the mercy of short term crises.

VIII. Recommendations.

The whole area of management in public sector programs and specifically housing is ripe for research in which major contributions can be made. The problems are not well defined, and many times do not tend themselves to clean quantifiable results, experiments are difficult to design and obtain meaningful data, and historical data may not be available. In the New York Rand experience Blum (53) contends that it has been their experience that 40% of the effort goes into defining the problem, 10% into developing a simulation of the problem and determining a plausible solution and 50% was spent in implementing the solution. It is
very important in evolving solutions to public problems that serious thought be given early to the implementability of a solution with emphasis on social, economic and political barriers.

In this very challenging arena, the following areas require a great deal more research:

1. Methods of introducing change into the home building industry using case studies or analogies with their industries.
2. Methods and strategies for introducing innovation and change, i.e., reducing barriers.
3. Research into the impact of social factors on housing such as poverty, race, education, welfare, safety, etc.
5. Transfer mechanisms and models for technology from the aerospace to the homebuilding industry.
6. Quantification of the cost of constraints to low cost housing.
7. Research on application of systems analysis to housing.
8. Little quantitative data is available on the home building industry. A great deal of systematic research is required in describing and analyzing this industry. Areas that would provide extremely productive would include management techniques, construction techniques and changes, research and development, and problems of entry into the market.
9. Research into dealing with political factors which tend to restrict technological innovation and entry into the market.

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APPENDIX I

THE HOUSING INDUSTRY AND CONSTRAINTS TO LOW COST HOUSING
The Building Industry

A. Introduction.

The building industry is large, diffuse, and complex, consisting of a loose conglomeration of small units. Annual sales are approximately 80-100 billion annually. Of this about one third goes into actual housing unit construction and the remaining into durable goods expenditures, service industries, schools, community facilities, etc. (2) The industry has some 900,000 contractors and 1,500,000 subcontractors employing approximately 3,000,000 people. They are supplied by a vast number of raw and finished materials producers, and equipment manufacturers employing 660,000 persons. To handle financial, insurance and real estate requires another 1,100,000 people of whom more than 600,000 are in real estate. The building design profession includes 30,000 registered architects and 75,000 engineers and specialists.

Generally three broad categories of home builders have been identified. These are contract builders, operative builders, and investment builders. The builders in contract construction include those primarily engaged in the erection of buildings for a previously determined buyer. Operative builders are those who construct on their own account for speculative sale. Investment builders are those who construct buildings for rental. The homebuilding industry covers thousands of small firms, although it is difficult to estimate the exact number because many may only build one or two units per year as an avocation while employed full-time.
elsewhere. As a result, some estimates of the number of homebuilders in the United States run as high as 60,000. Those closely associated with studies of the house building industry tend to give a more conservative estimate of approximately 30,000 home builders. In 1968, the National Association of Home Builders (NAHB) reported a membership of approximately 18,000 house builders (2).

A survey of home builders by the National Association of Home Builders (NAHB) found that the average builder produces somewhere between 5 and 25 units a year. (2) The NAHB survey showed that over 64% of its members produce less than 25 units a year and 2.3% produced over 250 single housing units. (See table XIII) One fourth had no full time employees; 61% had fewer than 4 salaried employees.

The home building trade journal "Professional Builder" recently published a report entitled "Housing Giants", which was a survey of the 120 largest homebuilders in the U.S. It reported that the average "giant" company did $28319,986 worth of business in 1968 and operated in 3 states. (3) The average giant only built 563 multi family units. The largest home builder, Levitt and Sons, produced 6000 units in 20 projects spread over 8 states, Puerto Rico, and France. The second largest produced only half as much.
## Table XIII

**Home Building Production by size of NAHB Home Builder Operation, 1964 and 1959**

<table>
<thead>
<tr>
<th>Size of Operations, units</th>
<th>Percent of NAHB Builders 1964</th>
<th>Percent of NAHB Builders 1959</th>
<th>Percent of Housing Units Produced by NAHB Builders 1964</th>
<th>Percent of Housing Units Produced by NAHB Builders 1959</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>18.5</td>
<td>13.5</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>6-10</td>
<td>18.9</td>
<td>17.1</td>
<td>3.5</td>
<td>2.2</td>
</tr>
<tr>
<td>11-25</td>
<td>27.0</td>
<td>26.9</td>
<td>11.2</td>
<td>7.5</td>
</tr>
<tr>
<td>26-50</td>
<td>16.9</td>
<td>17.6</td>
<td>14.8</td>
<td>10.6</td>
</tr>
<tr>
<td>51-75</td>
<td>6.5</td>
<td>6.6</td>
<td>9.4</td>
<td>6.9</td>
</tr>
<tr>
<td>76-100</td>
<td>4.2</td>
<td>5.6</td>
<td>8.5</td>
<td>8.2</td>
</tr>
<tr>
<td>101-250</td>
<td>5.5</td>
<td>8.1</td>
<td>22.2</td>
<td>21.8</td>
</tr>
<tr>
<td>251-500</td>
<td>1.7</td>
<td>3.1</td>
<td>14.7</td>
<td>18.4</td>
</tr>
<tr>
<td>over 500</td>
<td>0.8</td>
<td>1.5</td>
<td>14.7</td>
<td>23.9</td>
</tr>
</tbody>
</table>

The number of design-construction firms with an annual volume greater than $500 million can be counted on the fingers of one hand. Few materials and equipment producers rank among the nation's 500 largest industrial firms.

The high rate of business failures in this industry reflects its inherent weaknesses. The industry ranks second in the total number of failures exceeded only by retail trade. (4) The capability of construction contractor in the housing field is limited by low working capital, poor management, inefficient methods (sometimes because of the restrictive work practices of labor), and inadequate knowledge of new materials and processes.

Studies have pointed out that more than 80 percent of the home builders going into business for the first time have had considerable building experience. This experience had been obtained either as a manager or supervisor elsewhere, in another home building business, or as a skilled craftsman in one of the building trades. It is important to note the method used by the latter group for initiating home-building operations. They often are operating as a sub-contractor or a skilled craftsman such as a carpenter, mason, or plumber. At some point the craftsman is approached by one or two potential home buyers who request him to take the responsibility for constructing their house. If this request coincides with his belief that he has sufficient knowledge to undertake the task he will do so. In this case management is not too
difficult, land usually is provided by the client, and he has enough credit to initiate construction. The only additional major requirement is to schedule the various subcontractors. If he is already acting as a subcontractor, he will use his own skilled crew in that particular trade and subcontract other parts of the job. Once he experiences success in taking the full responsibility for constructing one or two units, it is likely he will want to expand his home building business to perhaps 4 to 6 units the following year. (5)

This type of operation does not require any more administrative staff than a part-time bookkeeper/secretary. But it appears that once the operation expands to 12 or 15 units per year additional administrative staff is needed. Because of the ease of entry, home building is an extremely competitive industry. There are few requirements for entering the business, but once in it, there is a great need to provide personal service and to develop a reputable relationship with subcontractors, material suppliers, lending institutions, and clients.

Competition in the industry is intense. Its turnover rate is 50 percent higher than in other industries. Bidding and contracting award practices increase risks and often result in quality being sacrificed to price. Smaller contractors often have difficulty in obtaining performance bonds. The inability of many contractor-developers to obtain adequate financing limits the economies they could make through quantity purchasing, higher
managerial skill, year-round operations, etc. These built-in problems of the industry together with the low profit incentives of low-cost housing work are significant barriers to the development of low-cost housing projects. Improvements are needed in contract award practices, bonding requirements (federal bonding programs are suggested) and profit incentives.

B. Marketing (6)

Many ingredients go into the marketing of a house. Land must be located which is suitable for development. This includes ready access to utilities, public services such as schools, and transportation, and unemployment opportunities. Arrangements for financing must be made to cover the cost of land acquisition and development, to finance construction, and to provide mortgage funding for the completed units. Many approvals must be secured from local governments (including zone changes, building permits and code approvals), from the Federal Government if HUD programs are utilized, and in many cases from local citizenry. Another major element of marketing is to locate the housing development where there is both a need for housing and a body of potential buyers or renters who can pay for it.

An understanding of the local market is extremely important. Housing demand and buyer preferences vary from area to area. Demand and preferences are reflected in the existing housing supply system because they are a function of the awareness, ability to
pay, and aspirations of home buyers. The home builder must be aware of these factors in each community in which he hopes to build.

Finally, another major factor is the individual client. In most cases his house is the most expensive item he will purchase in his lifetime. As a result he demands personal contact with the home builder to get his questions answered or to solve particular problems. The home builder must provide service if he is to be competitive. Because of these factors, house builders, both large and small, have found it necessary to develop close personal relationships and an identity in the community. This also results in localized and fragmented markets.

Homebuilders use one of two methods in selling houses they construct. One method is to use an outside real estate firm while the other is to use the builders own sales force.

According to the 1969 NAHB survey (2), 54 percent of all home builders use their own sales force. Those using a combination of their own sales forces and real estate firm were 12 percent. Those using a real estate firm only accounted for 34 percent. Of the majority of these firms, sales personnel worked on a commission basis. One of three techniques may also be used in promoting the sale of the home -- and unfurnished model, a furnished model, or no model at all. In 1961 the percentage of home builders using a furnished model to promote and sell homes was 26 percent while 22 percent used an unfurnished model.
One of the most important factors in industrialized housing is the problem of market aggregation so that plants can be built to produce housing on a continuous and regular basis. With large volume production, it is possible to take advantages of economies of scale and learning curves. There is little large scale production experience in the United States. In Europe where industrialized housing has been more prevalent since WW II, there is a great deal that can be learned. Although marketing is one of the most important aspects of industrialized housing, little is known or written on the subject in the housing industry.

C. Procedural and Administrative Constraints. (7)

Significant constraints on the development of lower income housing result from the regulations and processing procedures of various public agencies such as FHA, HAA, FNMA, and RAA. Managerial and administrative problems often hinder operating projects. The following are some typical constraints:

1. FHA Certification Procedures

   It presently takes from 12 to 24 months to get a typical nonprofit sponsored project off the ground. It is difficult to state how much of this time is the result of FHA processing procedures but estimates as high as 50 percent have been made.

2. Separate FHA Processing for Rehabilitation Projects and other Individual Ownership Programs

   In certain types of projects involving repetitive applications of a similar nature, FHA currently considers each
application separately (or, as in the case of 221(h), in small groups).

3. Crippling of 221 (h) program due to tenant income limitations

4. Rigid design requirements for HAA Turkey Projects

5. Rigid Rent / Income Ratio - HAA programs

6. Restrictions on land appraisal projects with small land areas

7. Restrictions on farming land for urban renewal projects

8. Inexperience of nonprofit sponsors of housing projects

9. Mistreatment of property by occupants

D. Financial Constraints (4)

The financial constraints are two fold:

1. Flow of money. A paramount issue confronting the housing industry is its extreme sensitivity to national fiscal and monetary policies. In many instances, particularly the present credit crisis and that of 1966, housing has been among the first to feel the impact of interest rate increases. Such counter-inflationary measures inevitably lead to sharp rises in financing costs for homes. Large segments of the housing market are cut off during such periods because they cannot meet the high costs. The outlook of industry, labor and management is affected and a depressed industry is not positively disposed to innovations that require risks to be taken.
The problem of maintaining a constant flow of money for housing is a vital issue to the housing industry. Dependency upon savings institutions as a primary source of mortgage funds makes home building operations particularly vulnerable when other areas of investment become more attractive. There is a sharp drop in savings deposits when bond rates and stock dividends become more attractive to investors.

As a result of credit forces, housing starts dropped from 1,450,600 in 1965 to 1,141,500 in 1966. The housing production rate did not return to the higher levels of the early 1960's until 1968, when production reached an estimated level of 1,525,000 dwelling units. The present credit squeeze has decreased housing starts in 1969 from 1.9 million estimated at the beginning of the year to the present estimate of about 1.2 million.

2. **Low rent paying capability of the user groups.** The low rent-paying capability of the user groups, combined with the high cost of new housing and limited availability of existing low-cost housing, make rent subsidies necessary if adequate housing is to be made available to those at the lowest income levels. The present 25 percent rent-to-income ratio used by the Department of Housing and Urban Development to determine rent-paying capability is unrealistic in that it makes no allowance for varying family sizes. A sliding rent-to-income scale reflecting family sizes should be used to establishing subsidy amounts. The number of families requiring rent assistance and the individual amounts of subsidy
will vary with the availability of low-cost housing and the income levels of a given area. Statistical determinations of these two factors are extremely difficult to make.

Innovations in mortgage format and requirements are required to reduce monthly debt service rates and to provide mortgage funds for "sweat equity" projects. It is necessary to induce private lenders to invest in low-cost projects by increasing the security of such investments and providing a competitive return.

E. Land Problems (8) The diminishing supply of land in urbanized areas and sharp increases in the cost of available housing sites pose serious problems to every home builder. Problems of land assembly are directly related to those resulting from the urban explosion. Such considerations as location, adequate highway access to centers of employment, and shopping and cultural activities are primary requirements for developing residential areas. But sites that meet such criteria are limited. Restrictive controls imposed by communities through regulations such as zoning ordinances and other codes have inhibited builders from using available sites for high density living units.

Existing vacant parcels in built-up sections are either too small for efficient home building operations or are unattractive terms of environmental considerations. In many instances, available sites that had been by-passed in previous periods of development contain topographical features, such as rock out-cropping, which
increases the cost of housing construction.

The diminishing supply of large tracts of land within easy access of urban centers and points of employment is of particular concern and points of employment is of particular concern to those builders who maintain large construction operations. In order to maintain satisfactory and continuous production schedules, such builders require land tracts of sufficient size and adequate roads and utilities to make their operations viable. Sites that meet these criteria and are available at reasonable cost to the builder are located at great distances from centers of employment. Often they lack adequate road access and require additional expenditures for the extension of utilities. Recent commissions have noted increased difficulties in obtaining adequate housing sites for multi-family developments within easy commuting distance from urban centers. Zoning ordinances have imposed restrictive requirements which effectively prohibit construction of such development within near urban communities. These conditions impose particular hardships on low income families who cannot afford to purchase single family homes and to whom the cost of commuting to areas far removed from their work imposes a serious financial strain.

F. Citizen resistance to low cost housing (9) User groups often resist low-cost housing projects because of relocation problems and lack of confidence in the promised benefits. Incentives should be offered to encourage the user group to assist in the relocation process, and care should be taken to ensure that people are not
forced to move to housing of appreciably lower quality or higher cost. Greater cooperation can be expected if the user groups are involved in the planning and development process and given the understanding that their needs are being actively considered.

High or middle income housing and commercial or cultural facilities should be developed on the same sites as low-cost housing to increase the attractiveness and property values of the neighborhood.

Local citizen resistance has developed over low cost housing for both real and imaginary reasons. Concerns include the low tax might arise from property on which high rise apartments may be built and increased costs for schools and services required by the inhabitants. Communities have either consciously or unconsciously excluded low income families by restrictive zone practices. Other reasons usually given are the creation of "instant slums", "those other people", and racial discrimination.

G. Government constraints. Constraints in this area include low-paid, low-skilled local housing administrators who are unable to process technical requests from developers efficiently or prepare complicated applications for federal aid; zoning regulations tending to increase the cost of housing and restrict innovative developments; and public opposition to low-cost housing projects and the resulting increased cost of municipal services; poorly coordinated housing agencies. Proposals have been made which include increasing salaries and instituting educational programs to increase the skill of housing administrators; providing
expert assistance to governmental organizations; simplifying
governmental procedures; offering inducements to local governments
to improve zoning regulations; rearranging capital improvement
priorities to benefit lower-income housing areas; consolidating
and coordinating housing authorities (including joint efforts
between local and federal government organizations).

H. Labor supply constraints. (4) If the rate of home
building is increased from 1.3 to 2.6 million units per year and
building methods remain unchanged there will be a critical shortage
of skilled construction labor. At present the labor force in the
construction industries is about 3 million, depending on the year
and the season of the year. The labor force involved in home
building is only a portion of the total construction labor force
and is estimated to contain about 1.5 million men at present.
If building methods do not change then the number of men required
in this activity will be proportional to the number of dwelling
units built annually. An increase of 66% from 1.3 million to
2.6 million dwellings per year will therefore require an additional
1.0 million men. Attracting this number of additional men into
the building industries, in addition to those required to account
for attrition, will most certainly result in increased wages
in construction as compared to other occupations. This demand
would accelerate the tendency.

Labor in the construction trades is in a strong position
to command wage increases because of its strong position in
negotiating with the comparatively weaker builders and contractors. Those representing heavy construction activities, such as bridges, roads, and large high-rise commercial and industrial buildings have dominated labor-management negotiations. Large wage rises could be absorbed by heavy construction companies because productivity could be increased through greater use of mechanization. On the other hand, these wage increases must also be accepted by the relatively weaker home builders who deal with workers from the same craft union. Another factor is seasonality* in the construction industry which leads to uncertainty of construction employment, which in turn results in perpetuation of many restrictive work practices, and works against establishment of permanent employer-employee relationships. Inefficient methods which add to labor requirements result from union rules, lack of adequate capitalization in the construction industry, and the deficiency of applied research into procedures and costs. Racial imbalance has historically developed from the formation of clannish construction trade unions and the need to control the labor supply imposed by the cyclic nature of the industry. Existing labor agreements, developed for heavy and commercial construction, frequently include work rules, wage classifications and training provisions not particularly applicable to the housing industry.

*The seasonal nature of building accounts for change of about 30 percent from February to August of any year.
Many of the building craft unions have been criticized as the slowest to throw doors open to job-hungry minorities. But it appears that this may be an exaggeration to blame it entirely on race, since there isn't a big increase in white apprentices either. Of the 3.0 million trade workers now in the building trades, many of them are of advanced age and due to leave the work force in the next few years. It is estimated by the NAHB that there will be a need for 400,000 new workers annually in the building trades between now and 1975 to fill new job requirements and replace those leaving the work force. But contractors say only about 16,000 are entering apprenticeship programs each year.

Another program is that of the union structure. Often national leaders may agree with a building program but are powerless since the locals wield the real power. It is they who negotiate with the contractors and sub-contractors with respect to wages and working conditions. They establish local rules, decide who shall be admitted to the union, determine their own dues, and in cooperation with the employers, carry on apprenticeship programs. (5)
I. Information flow constraints (1) There is a serious lack of vital information required by policy makers in all sectors of the building industry. Very little accurate information is available on the local level as to the exact numbers of people and companies engaged in each level of the industry. (7) Technical data regarding construction activities and developments as well as supply factors, such as land and marketing information, are either unavailable or inadequate. The growing complexity of building technology has made it virtually impossible for professionals to keep abreast of developments within their areas of responsibility. There are commercial enterprises such as Sweets Catalog, which publishes producers' literature regarding building materials and equipment.

Local building department officials, who must rule on new methods and materials have no single authoritative source to which they may look for technical guidance. The reports of building research activities by various institutions, companies and public agencies, are not disseminated to responsible members of the building industry in any systematic way. Each professional builder and local officials must obtain needed information on a hit-or-miss basis.

In order to plan for the most efficient use of resources, the building industry needs information relating to construction activity. Those in the building industry who rely upon the bidding process do not have sufficient data to schedule their work...
work efficiently. At peak times when new construction projects are let out for bid only a few contractors and subcontractors are willing to submit their bids because they are already working at full capacity. Those responsible for preparing the drawings and specifications for bidding do not have sufficient advance information regarding possible overloads to enable them to reschedule the bidding and contract awards to more appropriate periods, i.e., when contractors will not be working at full capacity.

In an effort to reduce housing costs by opening up opportunities to try out new materials, new construction methods, new combinations and assemblies, new system analysis, new cost control techniques, new intensive land use, and new methods of financing, basic data are needed to judge or measure the success of these efforts. Just what does housing cost? What benchmarks are there for measuring the ups or downs in this complex market? What components exert the most likely opportunities for productive cost reduction? Data to answer these questions must be collected, analyzed, stored, and retrieved. This requires commitment and investment, neither of which has been supplied by the industry or government.

J. Organization of the building process (1) The term "building process" may be defined as the chain of decisions and events by which the supply of labor, materials, financing and information are organized and assembled to construct a building,
in compliance with government rules and procedures, to meet the users requirements.

The present housing delivery process requires input from different sources, from architects to zoning officials, and each operates within constraints set up by separate and different sources for impediments and restrictions. In total, there are 23 major public and private participants (see figure 6) in the housing production process and 17 major public and private sources of laws, rules and practices that restrict and influence the process practically every step of the way.

The earlier discussion of the building industry indicated its high degree of fragmentation. Each sector of the industry, the architect, the engineer, the contractor, the subcontractor, and the manufacturer of building materials performs a specific function with specific attention to the standards, needs and problems of his own sector of the industry. But no sector is responsible for reviewing and expediting the entire building process, i.e. there is no total systems approach. The introduction and use of technological innovations depends upon their acceptance by all levels of the process. In effect each interest group has veto power over any innovation.

Government agencies constitute additional layers which assert their authority at various times during the building process. Local, state, and federal agencies impose their respective rules
Figure 6
The Housing Process Major Participants and Influences

1. PREPARATION PHASE
   A. Land Acquisitions
   B. Planning
   C. Zoning Amendments

2. PRODUCTION PHASE
   A. Site Preparation
   B. Construction
   C. Financing

3. DISTRIBUTION PHASE
   A. Sale (and subsequent resale or refinancing)

4. SERVICE PHASE
   A. Maintenance and Management
   B. Repairs
   C. Improvements and additions

Source: A Decent Home p. 115
and procedures which affect the building industry. For example, the need for multiple bidding in publicly financed construction can be justified because it protects the public against unreasonably high pricing on single item source items. However, the inventor with a patent finds it almost impossible to introduce his innovation until he convinces two or three others to go into the business of producing his invention. Federal vigilance against monopolistic alliances also protects the public against restraints of trade. This protection, however, is not provided at no cost. Companies that could cooperate to produce more efficient and cheaper building systems are deterred by the threat of anti-trust litigation.

The lack of communication and coordination among clients, the various participants in the building process and the regulation agencies make it difficult to introduce innovations or to use resources effectively. Further, there is little incentive for change. Architect's fees are usually keyed to the cost of the building and offer no specific inducement to find improved techniques and designs. Current contracting procedures offer no reward to the builder for suggesting changes which will lower the cost of the building or reduce the operating and maintenance costs of the structure. Subcontractors are not rewarded for proposing or making improvements. Building inspectors who approve innovations become vulnerable without corresponding awards. Lending and insurance agencies discourage the use of building techniques with
which they are not familiar. Clearly, the introduction of innovations is hampered by present procedures and incentives.

Few firms knit all the building operation into one organization. The general pattern in the construction industry is to draw together a team of the necessary elements to carry out one building operation. The team is then dispersed and may not be reassembled in precisely the same form for another building project. The vertical integration of the construction process, including design and construction, plus, if necessary, land development, financing, and management, is more common abroad than in the U.S. (1)

K. Supply of materials. (1) Although housing technology has provided the building industry with many choices of building products and materials, from time to time there have been severe shortages of critical materials. The recent crisis in lumber shortage illustrated the consequences to home building when its vital supplies become constricted.

The introduction of new materials, or new techniques for assembling old materials, is affected by local government regulations and local work practices. In this regard the case for plastic pipe is classic. Two-thirds of the nation's building codes still prohibit the use of plastic pipe for drainage plumbing systems in residential construction. Yet, all mobile homes use such materials without adverse affects. Throughout Europe plastic pipes are generally accepted by authorities for residential construc-
tion. The primary opposition to the use of such materials can be attributed to competitive interests, including producers of metal pipes, plumbing subcontractors and unions. The lower costs for such materials and for their assembly pose threats to these groups. The publication of new model plumbing codes and the adoption of local codes permitting the use of such materials has been successfully blocked or delayed by these interests.

The diversity of building codes in over 5,000 localities across the nation has inhibited manufacturers of building materials and equipment from introducing cost-saving, more efficient innovations. It was generally assumed that local building officials looked to the model code groups for guidance. But the census survey of codes for the National Commission on Urban Problems* (11) found that only one-sixth of the communities with populations over 5,000 followed the model codes and kept theirs up to date. The requirements of obtaining product acceptance in each jurisdiction, entailing great expenditures in money and staff time, is a strong deterrent to producers contemplating new developments.

L. Constraints on architectural design (12) The compensation offered architects for the design of low-cost housing projects often has been substandard. This is a significant constraint to the design process because it can result in unenthusiastic, superficial treatment. Increased compensation is likely to encourage improved design.

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*This study, commonly known as the Douglas Commission Report, devoted about 20 percent of its report to building codes and standards.
There are a number of other problems related to the architectural design process. These include architectural approaches stressing graphic rather than analytical or numerical design, the architect's lack of knowledge of the needs of lower-income groups, and the lack of coordination among the professions concerned with low-cost housing. These all tend to restrict effective design of large-scale, low-cost housing projects. The establishment of design teams composed of architects, social scientists, advocate planners, contractors, operations research experts, and experts in modern management and systems analysis techniques could alleviate many of these problems.

M. Restrains on innovation in the building industry. Throughout the preceding ten sections the various factors which impinge on and affect the introductions of new innovations into the building industry have been implied. These factors include highly decentralized industry, a fragmented industry, and industry characterized by thousands of small contractors, government regulation and central lack of uniformity and consistency of building codes throughout the country, lack of testing of new materials, lack of concentrated R&D, lack of institutions for carrying out the total building process, lack of communication, labor restrictions, and perhaps the most important of all, the lack of aggregated markets. In a study performed in 1963 by A.D. Little, "Patterns and Problems of Technical Innovation in American Industry", the problems of innovation are very well described. (13)
The problems of innovation in the building industry are, at least in part, the problems of continued industrialization of building activity. The building industry is now pursuing a course pretty well completed by most major U.S. industries—a course which has taken them from decentralized to centralized operation, from fragmented to more nearly unified structure, and from craft-based to technically oriented manufacture. But the building industry poses the additional problem of being necessarily a decentralized process—so that its problems of innovation are in part problems of how it is possible to bring manufacturing sophistication to an activity which is bound to take place on hundreds of thousands of decentralized sites.

This reflects itself in the fragmentation of the building task. The building industry is fragmented, even more than the textile or machine tool industry, on two levels. First, it consists of thousands of small companies (in spite of the present trend toward concentration of business in large contractors). Second, these small companies represent different segments of the building task: architectural, designers, structural engineers, contractors, manufacturers of components and materials. Each performs his function in terms of his own standards, needs, and problems. Each wishes to maximize profit to this own area. No one is responsible for the building task over-all. And yet, major innovation (such as premanufactured houses, pre-stressed concrete structures, or even curtain wall systems) cannot fail to affect all parties.
to the process. This means, as in textiles, that an innovation cannot be implemented unless all the bases are touched. Architects and contractors, alike, must be sold. The materials and component manufacturer must seek to please them all. But their interests are not always compatible (architects may favor good design and principles of sound structure, and contractors may be primarily concerned with reduction of costs and of labor problems on the site) and many of them may be, as in the textile field below critical size for innovation.

Each separate element of the building task experts its own conservative effect. The architect is wedded to certain concepts of style, which may not mesh with new material; the engineer, to structures he can analyze and understand, which may not be compatible with new reinforcing methods; the contractor, to methods he knows and trusts. The materials supplier is suspicious of any innovation which threatens to displace his material. The on-site laborer, draft-based, is suspicious of anything that threatens to reduce his importance, to present him with demands for skills he does not have, to make his skills obsolete, to eliminate him, or to change the conditions of his work. And he institutionalizes his resistance through his union.

Moreover, building activity is subject to the control of government agencies which set up performance requirements for product, but are separate from the producers and from each other.
Building codes -- federal, state, and municipal -- are an anchor to the industry. They tend to be based, not on general statements or performance requirements, but on specifications for particular materials and components. Thus the regional height of foundation grade beams or the thickness of an insulating wall is based on the performance characteristics of certain traditional products filling these functions. New materials must conform to these specifications, frequently at the price of becoming uneconomical, even though their properties would make different dimensions appropriate.

The innovator of a new material or component must fight not one but many battles for the revisions of codes, since there is considerable inconsistency in most codes over the country. (There are an estimated 5000 district codes in use in the U.S.)

Codes are naturally safety based and, as such, fulfill an essential function. But the basis for the choice of a particular code is frequently arbitrary and traditional. It is required of prefinished interior panels, for example, that they be fastened with 4-penny finishing nails 6-8 inches. This is not based on an estimate of pull-out strength required, and the pull-out strength of 4-penny nails at certain intervals in certain types of wood. It is based on a generalization of past practice, a generalization which gives no basis for evaluating the performance of a new fastener. There is, in short, a lack of general technically-based performance criteria for the various elements of construction.
In many cases -- particularly with new materials such as plastics and new combinations of steel and concrete -- there is the problem of the nature of the test required to establish the life of the structural component. What will happen to a new plastic or a new type of aggregate in 10-15 years? Can you believe the accelerated tests which have been devised for determining its performance? A few well-publicized instances of the failure of new materials or components has often been sufficient to create a climate of general scepticism, about new products, leading to requirements for life-tests which are so expensive or so expensive or so time-consuming as to make the innovation commercially unattractive.

There are a variety of additional obstacles to innovation in the building area:

--lack of trained technical people in positions of responsibility within the industry.
--lack of interest in research and development.
--lack of communication with any of the more advanced technical and managerial tools of industry.

N. Building Codes. (14) A great deal has been said about building codes and the constraints that they put on innovation and the cost of housing. Good building codes are necessary, however, to protect against fire and structural collapse, and promotion of health and the orderly development of the community. To be effective, they must also be enforced. But too often obsolete codes prevent the public from benefiting from new improved methods and materials. And though arguments are still made to the
contrary, a considerable body of evidence has developed which
points to the outdated regulations as a major contribution to the
pyramiding price of new homes, along with other factors such as
cost of money, land, labor, and materials.

Today there are about 5,000 building codes in use across the
country, with as many as 100 written within a single metropoli-
tan area. Starting out as guidelines to safe and sanitary housing,
they have grown into a crazy quilt of archaic, costly, and often
conflicting regulations.

The following are a few examples of how building codes affect
house costs (15):

1. An ordinance was prepared in Memphis, Tenn. which would
   have added an estimated $125 to the average cost of a home by
   requiring a specified type of cable for electrical wiring, barring
   an available substitute that was less costly and just as safe.

2. A manufacturer of prefabricated homes operating in six
   states had to cope with 25 building codes jurisdictions which
   called for 75 different code regulations. Had he complied with all
   of the regulations, the cost of each home would have been raised
   by an estimated $2,500.

3. A survey by HUD showed that local codes which exceed
   the model code requirements and FHA minimum property standards
   raised the cost of a prefabricated home by $25 to $640 for each
   of the items listed in the local regulations. In this survey,
   the house would cost an extra $2,000 if the builder complied with
all the requirements, including masonry chimney, extra plumbing, and the use of plaster instead of gypsum board.

Estimates that have been made indicate that housing costs can be reduced by as much as 25% if national performance codes were used. In St. Louis where performance codes have been used since 1961, reductions of 17% have been obtained. (16)

0. **Zoning regulations constraint.** (17) Zoning ordinances reflect, to a greater or lesser degree, the changing opinions of the community as to desirable land utilization and are not legal constraints in the sense that state statutes, state constitutions, and federal laws are. State statutes and constitutions and federal laws are difficult to amend, and the process is usually slow. But zoning ordinances may be changed easily and quickly, if only a few influential persons want it changed. In addition, such ordinances provide for exceptions, called zoning variances, which are opposed by a local zoning or planning agency. For specific projects zoning ordinances do not represent a constraint as long as the city government favors the project. Local cooperation is the essential requirement.

The effects of zoning ordinances upon the overall layout of a city is quite a different matter. In great part zoning ordinances determine the location and character of neighborhoods in the city. It is obvious that boundaries of land use, such as commercial, industrial and residential, are established in specific areas in the city through the operation of the zoning ordinances. Also
the quality and character of these areas are in part determined by their zoning. Zoning can determine population density, whether a neighborhood will consist of single family dwellings, small multi-family housing or high rise construction. In a more subtle manner zoning laws establish the quality of housing. For example, zoning requiring large lot, single family residential area.

In addition to controlling the quality of the neighborhoods throughout the city, zoning ordinances impose other substantial overall constraints. Among these constraints are:

1. Zoning restrictions which increase cost of constructing lower income housing.
2. Zoning boards which are composed of laymen who do not understand the complexities of urban planning.
3. Zoning ordinances which do not provide sufficient flexibility to allow for the design of cluster type development or other forms of dwelling configurations.

P. Construction methods. (18) Production methods have not changed drastically in the homebuilding industry in at least the last ten years. Although there was some indication that more homebuilders were using prefabricated components in 1968, the 1964 NAHB survey indicated that three fourths of all home builders were using the rationalized traditional methods. The rationalized traditional method of construction is defined as the method combining some use of prefabricated components, such as prefabricated roof tresses and prehung doors, with the traditional method of cutting and fitting all the pieces together on the job. Also, the percentage of builders who used factory built homes or who are fabricating their own major parts, either on-site or off-site, had not
changed significantly. To date, most prefabrication in this country had been simply a matter of moving the process of conventional on site building, as it pertains to walls, roof, and floors of the house, into the factory. Some of these factories are outfitted with a few jigs or tables for bonding together roof trusses or wall panels. Others are more sophisticated with mechanical handling, nailing, and stapling equipment. Offsite fabrication can be subdivided into four categories: prefabricated components, manufactured homes, modular homes, and mobile homes.

1. **Prefabricated Components Manufacturers.** The most significant growth in prefabrication activities during the past decade has been shown by the prefabricated component manufacturers. Some of the most important examples are: trusses, plumbing trees, prehung doors, and molded fiber glass tubs and enclosures, and precast concrete wall and floor panels. According to the National Commission on Urban Problems, there are approximately 2100 component manufacturers, consisting of retail and wholesale supplies of lumber and building materials, who operate their own fabrication facilities around the country.

2. **Manufactured Homes.** Home manufacturing came into widespread use following World War II. Home manufacturers produce a variety of housing types, including single-family housing units, row houses, and garden apartments. In 1967, 70 percent of the home manufacturing production went into single-family homes and 30 percent to low-rise
garden apartments. Most manufactured homes consist of wood frame construction. Some companies, however, are attempting to use other materials. For example, precast, load-bearing concrete panels have been used in California, Massachusetts, Arizona, New Mexico, Texas, and Florida. Other companies are experimenting with fabricated brick panels, fabricated concrete masonry panels, extruded asbestos cement panels, and aluminum sandwich panels.

There are approximately 600 home manufacturers in the United States, and they generally quote prices F.O.B. factory. The price of manufactured homes varies considerably reflecting differences in size, style, amenities, etc. The data in Table XIV show prices of various size manufactured homes as provided by a leading manufacturer.

Typically, the production of manufactured homes consists of off-site construction of almost all elements of the frame and shell. Walls, floors, and roofs are constructed as separate items; however, complete rooms and dwelling units may be constructed in the form of modules. Generally, most of the activity in this field has involved wood frame construction.

3. **Modular or Industrialized Homes.** Modular homes are essentially manufactured homes in which the walls, floors, plumbing, wiring, heating, and roofs have been assembled at the site. Each section is usually limited to a 12-foot width and a maximum length of about 60 feet. Two sections are equally placed together on a conventional foundation, such as concrete or concrete block, at the site to make a finished dwelling unit. Sections may be
Table XIV
Price of Manufactured Homes as Provided by a Leading Manufacturer, 1968

<table>
<thead>
<tr>
<th>Model</th>
<th>Size of Gross Area (ft²)</th>
<th>Factory Price to Builder, dollars</th>
<th>F.O.B. Factory Price (dollars/ft²)</th>
<th>Maximum Delivery Cost (dollars/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>960</td>
<td>9,274</td>
<td>10.13</td>
<td>0.19</td>
</tr>
<tr>
<td>B</td>
<td>1,175</td>
<td>9,867</td>
<td>8.40</td>
<td>0.17</td>
</tr>
<tr>
<td>C</td>
<td>1,435</td>
<td>10,610</td>
<td>7.39</td>
<td>0.13</td>
</tr>
<tr>
<td>D</td>
<td>1,633</td>
<td>14,526</td>
<td>8.89</td>
<td>0.11</td>
</tr>
<tr>
<td>E</td>
<td>2,199</td>
<td>17,683</td>
<td>8.07</td>
<td>0.08</td>
</tr>
</tbody>
</table>

(a) $0.60/mile, maximum economic distance 300 miles

placed by crane or may be rolled from a low-boy truck bed onto the finished foundation. Practically in all present cases the same materials are used in this type of housing unit as are used in conventional home building. Major developments in concrete and steel modules have occurred recently in Europe and this country. Factories have and are being built to produce modular homes on an assembly line basis. In 1970, 35,000 modular homes were built with 70,000 units or 4% of the 1.8 million starts expected in 1971. Secretary Romney of HUD predicts that two-thirds of homes built in 1980 will be of modular construction. (Wall Street Journal, April 8, 1971). As in the case of manufactured homes, the buyer must pay the additional cost for land, site improvements, foundation, interior furnishings, and field labor.

4. **Mobile Homes.** This unique type of production line construction will be discussed in a later section of Appendix III.

Q. **Rising home building costs.** The cost of housing depends on the cost of various inputs (labor, land, materials, credit) and on the amounts of these required. As demand increases, the unit price of the individual inputs will increase. If the building process is unchanged, then the amounts of the various inputs will remain the same and the total costs, the product of the unit costs and the amounts will rise.

The scarcity of land was one of the reasons for the cost increases of housing between 1958 and 1966. During this period the price of the average lot increased almost 3.5 times, from
138

$1,049 to $3,544. The rise was not entirely caused by inflationary trends. Site cost represented 11.7% of total FHA value of the average single family house in 1958, but they rose to 19.0% of total value in 1966. Increased production of housing and inefficient land use will intensify the scarcity of land and further increase prices.

The cost of materials rose approximately 10% from 1960 to 1968 (4). Nevertheless, there was a dramatic rise of 30% in the costs of lumber and plywood during the past year. It reached such crisis proportions that congressional investigations were conducted and the administration took steps to release more timber from federally owned lands.

The lack of industrial innovation is reflected in a dramatic rise in construction costs, disproportionate to changes in the consumer price index as shown in Table XV.
Table XV

Construction Costs and Consumer Price
Indices (20) 1950-1968

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumer Price Index</th>
<th>Construction Materials</th>
<th>Union Hourly Wage Scales</th>
<th>Construction Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>80</td>
<td>78</td>
<td>65</td>
<td>80</td>
</tr>
<tr>
<td>1955</td>
<td>90</td>
<td>90</td>
<td>85</td>
<td>95</td>
</tr>
<tr>
<td>1960</td>
<td>104</td>
<td>100</td>
<td>110</td>
<td>105</td>
</tr>
<tr>
<td>1965</td>
<td>109</td>
<td>105</td>
<td>130</td>
<td>112</td>
</tr>
<tr>
<td>1968</td>
<td>120</td>
<td>110</td>
<td>155</td>
<td>130</td>
</tr>
</tbody>
</table>
The affects of these rising costs are shown in Tables XVI and XVII for typical FHA financed new and old housing in 1960 and 1969.

R. Research in the building industry. As was pointed out earlier, home building accounts for between 4-5 percent of the Gross National Product which in 1968, was 861 billion dollars. In addition to this 35 billion dollars worth of direct construction, there are also the indirect expenditures for schools, services, durable goods, and furnishings. The National Association of Home Builders estimates these related expenditures can account for an additional 5% of the GNP. Pushing a bit further into the realm of economic speculation but claiming to use conservative estimates, the NAHB reckons the multiplier effect of the monsy spent as generating in terms of secondary jobs another 5% of the GNP.

An estimated 25% of American workers are employed in some area of its activities. But despite its size, the construction industry had been called a "slow growth" industry. A 1963 study by the Columbia University Bureau of Applied Social Research, which measures by the output per worker the growth in productivity of United States Industries, ranked a number of industries shown in Table XVIII. (21)
Table XVI
FHA Financing Typical Existing Home

<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1960</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale Price</td>
<td>$16,814</td>
<td>$13,284</td>
</tr>
<tr>
<td>Down Payment</td>
<td>893</td>
<td>1,255</td>
</tr>
<tr>
<td>Closing Costs</td>
<td>396</td>
<td>277</td>
</tr>
<tr>
<td>Monthly Payments,</td>
<td>178</td>
<td>121</td>
</tr>
<tr>
<td>Utilities,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of House</td>
<td>17,123</td>
<td>13,268</td>
</tr>
<tr>
<td>Value of Lot</td>
<td>3,696</td>
<td>2,354</td>
</tr>
<tr>
<td>Buyer's Income</td>
<td>10,694</td>
<td>6,784</td>
</tr>
<tr>
<td>Square Footage</td>
<td>1,103</td>
<td>1,057</td>
</tr>
<tr>
<td>Buyer's Age</td>
<td>33</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: HUD Challenge/November-December, 1970
<table>
<thead>
<tr>
<th></th>
<th>1969</th>
<th>1960</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale Price</td>
<td>$20,563</td>
<td>$14,662</td>
</tr>
<tr>
<td>Down Payment</td>
<td>1,239</td>
<td>1,039</td>
</tr>
<tr>
<td>Closing Costs</td>
<td>458</td>
<td>289</td>
</tr>
<tr>
<td>30-yr. Mortgage</td>
<td>19,324</td>
<td>13,611</td>
</tr>
<tr>
<td>Monthly Payments,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities, Maintenance</td>
<td>205</td>
<td>129</td>
</tr>
<tr>
<td>Value of House</td>
<td>21,030</td>
<td>14,855</td>
</tr>
<tr>
<td>Value of Lot</td>
<td>4,300</td>
<td>2,477</td>
</tr>
<tr>
<td>Buyer's Income</td>
<td>10,678</td>
<td>7,168</td>
</tr>
<tr>
<td>Square Footage</td>
<td>1,180</td>
<td>1,091</td>
</tr>
<tr>
<td>Buyer's Age</td>
<td>33</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: HUD Challenge/November-December, 1970
<table>
<thead>
<tr>
<th>Industry</th>
<th>Growth Rate per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>2.0-2.9</td>
</tr>
<tr>
<td>Chemical</td>
<td>5%</td>
</tr>
<tr>
<td>Agriculture and Forestry</td>
<td>4.0-4.9%</td>
</tr>
</tbody>
</table>
Only in service industries, was there a consistent annual growth rate of less than 2%. The rate of growth rate in the construction industry was attributed not to lack of market demand but to a "technological lag". The 1963 study by Arthur D. Little, Inc. on innovation in the use of technological resources by five mature industries asserted that during the last thirty years there has been no major technological change of major economic significance for the building industry -- technological change has been primarily evolutionary in small increments, significant only in the aggregate --- it can hardly be called "innovative."

There are several measures of the attitude of an industry toward technological innovation. One is the amount of funds it spends on R&D. During the early 1960's, the rate of R&D to value added in the construction industry was .12, in contrast with .43 in the economy as a whole. The funds actually spent for R&D by the construction industry, compared with those of several other industries for 1968 are shown in Table XIX.
<table>
<thead>
<tr>
<th>Industry</th>
<th>1968 (23)</th>
<th>1962</th>
<th>1956(22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Chemicals</td>
<td>1,640</td>
<td>1,175</td>
<td>517</td>
</tr>
<tr>
<td>Electrical</td>
<td>4,038</td>
<td>2,639</td>
<td>461</td>
</tr>
<tr>
<td>Aircraft and Missiles</td>
<td>5,651</td>
<td>4,042</td>
<td>269</td>
</tr>
<tr>
<td>Machinery</td>
<td>1,619</td>
<td>914</td>
<td>390</td>
</tr>
<tr>
<td>Textiles</td>
<td>59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In rapidly growing industries like electronics, 7-10 percent of gross sales is spent on R&D directed toward improving products. All industries in the United States were estimated to have spent 1.5 percent of their gross sales income on R&D in the early 1960's. If it were to match the average industrial practice, the building industry, with an estimated 30 billion in sales, would have had to spend 450 million on R&D.

Another measure of an industry's involvement in technological development is the number of scientists and engineers it employs. These are shown for the same selected industries for the year 1967 in Table XX.

### Table XX

**Number of Scientists and Engineers Employed in Selected Industries-1967 (24)**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Engineers</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>43,300</td>
<td>500</td>
</tr>
<tr>
<td>Chemicals</td>
<td>42,500</td>
<td>56,100</td>
</tr>
<tr>
<td>Electrical</td>
<td>41,900</td>
<td>8,700</td>
</tr>
<tr>
<td>Aircraft and Missiles</td>
<td>84,500</td>
<td>8,800</td>
</tr>
<tr>
<td>Machinery</td>
<td>81,500</td>
<td>7,000</td>
</tr>
</tbody>
</table>

As a result of limited technological research and development, the construction industry has improved little in productivity and efficiency. Increasing labor costs were not offset by technological advance either in the use of new materials or new methods of construction as they were in other countries. Although the cost of building materials increased only 18.4% from 1950 to 1962, the lack
of industrial innovation was reflected in a dramatic rise in construction costs, disproportionate to changes in the consumer price index (see Table XXI).

Table XXI

<table>
<thead>
<tr>
<th>Year</th>
<th>Construction Costs</th>
<th>Consumer Price Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>111.6</td>
<td>102.8</td>
</tr>
<tr>
<td>1954</td>
<td>132.5</td>
<td>114.8</td>
</tr>
<tr>
<td>1958</td>
<td>156.0</td>
<td>123.5</td>
</tr>
<tr>
<td>1962</td>
<td>172.1</td>
<td>129.3</td>
</tr>
</tbody>
</table>

Source: Engineering News Record, Bureau of Labor Statistics

The problem of technical innovation must be examined with respect to the organization of the industry and its methods of production. Perhaps the most important source of technological lag was the atomistic character of the industry. The industry has many and diverse segments: contractors, architects, engineering firms, craft unions, supplies, entrepreneurs of building projects, laborers and realtors. Each segment of the building industry is itself fragmented into numerous scattered firms.

For years the building industry had balked at federal proposals to develop R&D programs involving government-industry collaboration. The Public Housing Acts of 1948 and 1949 authorized a government
sponsored research program to study housing codes, technology and economics. Between 1948 and 1954, Congress appropriated $5 million for this program; but following industrial opposition appropriators were suspended in 1953. The Housing and Home Finance Agency (HHFA) was not funded for research until 1962, at which time only $375,000 was appropriated.

Not until the funding, in 1968, of the Housing and Urban Development Department, were substantial appropriations made for urban studies.

But R&D programs continue to encounter difficulties, and Harold Finger, Assistant Secretary for Urban Research and Technology in HUD, has observed that the construction industry remains unwilling to accept the idea that the necessary research cannot be handled within its present structure.

In January 1970, a report by a Department of Commerce Panel on Housing Technology (4) reviewed the obstacles to technological change in the building industry in language almost identical to that of the report on the industry that appeared in the building industry in the early 1960's. This report recommended that the Federal Government take the lead in stimulating building technology and that appropriations of $100 million annually be given HUD to improve building technology. HUD requested $55 million, but in August 1970 the Congressional appropriations for the HUD technology effort was only $30 million, low enough to require
some cutback in existing activities. All of these, however, seem to be subordinate to the fact that: 1) there is not within the industry an institution (or institutions) capable of considering the whole building process and carrying out the overall solutions that might be developed; and 2) there is not, within the group of regulating agencies, a consistent and unified set of codes, technically-based on performance requirements rather than on the actual performance of old products.

As indicated by the innovations listed above, building is in process of change. The industrialization of building is gradually occurring, and with it the concentration and integration of the building function. There are signs of effort toward the unification and rationalization of codes. But these changes are still slow and painful.

S. Taxes. (25,26) Housing must be serviced by an intricate and costly system of public services. Initially, provision must be made for the heavy capital investments in social infrastructure schools, streets, and utilities – that cost from $4,000 to $6,000 per dwelling unit; then, year after year there will be operating expenses to be paid by the locality. The present method for meeting these local costs – about two thirds from property tax and the rest from a patch work of federal and state categorical aids.

Taxes affect home owners and renters in a number of ways and especially low income families. Housing property taxes are heavily
regressive, absorbing a much higher fraction of the incomes of the poor than of the rich. This is largely because the poor get a larger part of their income for housing and the poor tend to be concentrated in the high property tax rate central cities.

Table XXII indicates how heavily the property does burden the poorer renters in the country as a whole, and for New York City. High taxes on housing, relative to taxes on other uses of the consumers dollar, are likely to discourage expenditure for housing. But they are likely to be an especially severe deterrent to the poor since they have so little leeway in family budgeting - there is little else that they can forego in order to rent better housing. This amounts to saying that the poor probably are more sensitive to price (rent) differentials than are the rich, out of necessity rather than choice.

Table XXII

Estimates of Housing Property Taxes as a Percent of Income, by Income Class

<table>
<thead>
<tr>
<th>Income Class</th>
<th>All US 1959-60</th>
<th>NYC 1960-61</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $2,000</td>
<td>8.5</td>
<td>8.6</td>
</tr>
<tr>
<td>2,000-3,000</td>
<td>3.9</td>
<td>5.6</td>
</tr>
<tr>
<td>3,000-4,000</td>
<td>3.0</td>
<td>4.1</td>
</tr>
<tr>
<td>4,000-5,000</td>
<td>2.5</td>
<td>3.4</td>
</tr>
<tr>
<td>5,000-7,000</td>
<td>2.1</td>
<td>2.8</td>
</tr>
<tr>
<td>7,000-10,000</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>10,000-15,000</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Over 15,000</td>
<td>1.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>
The general effect of these very high property taxes on the supply of housing to the low-income population has three components. First, taxes raise the cost of housing to the occupants and simply put a significant part of the existing housing stock beyond the reach of many in the low-income population. For example, take a large urban family with an income of $4,000. The maximum tolerable rent for such a family (if the rent is not paid by public assistance) might be said to be 30 percent of income, or $100 a month. Assume that the prevailing level of property taxes is 25 percent of rents in that city. Were property taxes on housing eliminated, this family could afford to rent an apartment now renting for $133 a month, without exceeding the 30 percent rent/income ratio, an apartment which is now out of reach.

Second, high property taxes discourage consumption of an investment in housing in general, by the entire population. There is ample evidence that consumers will buy more and better housing if its price is lower, just as they do with regard to most other objects of consumption. It can be and has been argued persuasively that one of the most effective ways of helping the low-income population (with respect to housing) is to rapidly increase the total supply of housing in a particular city and metropolitan area; a decrease in prices (rents), while having no immediate effect on total housing supply, does create a larger effective housing market for those who now suddenly can afford more of existing housing. The evidence from the 1950's strongly suggests that the
housing conditions of the poor improved most dramatically in those areas in which the total supply of housing rose most rapidly.

Third, property taxes cause exclusion of low cost housing from suburban communities. Such localities rely heavily on property taxes for their revenues. The taxes collected from inexpensive houses tend to fall below the costs for public services to the occupants, especially if they are families with school children.

For example, a $15,000 house may be assessed for $10,000 with a tax rate of $40 per thousand. This yields the locality $400 a year in property taxes. A family with two children occupying a house may require expenditures of $1,200 or more a year – $500 for each school child plus $200 for other services such as public protection, refuse collection, and street maintenance. The rational thing for the town to do is to exclude housing for such families.

And local zoning boards and town councils have shown great resourcefulness in doing just that. Large lot zoning is widely practiced as a means of permitting only higher priced houses and higher income residents into the locality.

T. Political constraints

Political constraints to low cost housing arise at all levels of government from the Federal to the State to the local. It is inevitable that housing becomes a political issue since it touches all sectors of our society and has a profound effect on our economy. At the Federal level, the congress gets involved in appropriations for housing
construction, R&D, etc., the desire to or not to locate low cost housing in individual constituencies, manufacturers and builders interests and labor unions only to name a few. At the executive level, major housing programs of one administration may give way to another. For example, the "In-Cities" program was started during the Johnson Administration but was substantially reduced in scope and visibility when the new administration took over. Operation Breakthrough became the present administration's new housing thrust.

At the State and local level similar political problems exist. For example, a specific case was cited in April 8, 1971 edition of the Wall Street Journal. The Erie Pennsylvania Housing Authority in November, 1968 invited bids for 76 multi-family town houses for low income housing. Two years later, after contract bid had been awarded to a builder of modular homes, the town houses had not been erected although they had been delivered to the site.

Besides zoning and labor problems, the following political problems arose:

1. A city councilman charged the development would become an "instant slum" of flimsy, overpriced crackerboxes. To refute his charges, the manufacturer had to take him and other city officials on an expense paid tour of a pleasant factory-housing development it had produced in Akron, Ohio.

2. The neighboring borough which borders on part of the development sought an injunction to stop the project, claiming it
lacked proper parking, recreational, police, and fire-protection facilities.

The chairman of the building firm was quoted by the *Wall Street Journal* as concluding, "Housing is very political".

An excellent study of the political environment and pressures that can be brought to bear against specific proposals that might affect the construction industry was done by Nelkin (28). This study traces in great detail an attempt by J. Herbert Holloman, Assistant Secretary for Science and Technology in the Department of Commerce, in August of 1962, to obtain Congressional appropriations for a Civilian Industrial Technology Program (CITP). One part of this abortive attempt to establish a federal program to encourage technological research and development in the civilian industry included a program to foster innovation in the lagging construction industry. This is a very good example of some of the complex issues involved in restructuring federal and development policy with respect to the civilian economy and evolving social needs.

U. **Housing costs** (29) The cost of housing is considered in two parts: (1) development and construction and (2) occupying cost.

Development and construction costs are shown in Table XXIII.
Table XXIII  
Development and Construction Costs

<table>
<thead>
<tr>
<th></th>
<th>Single Family Development built</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development costs</td>
<td>31%</td>
</tr>
<tr>
<td>Construction Costs</td>
<td>69%</td>
</tr>
<tr>
<td>Materials</td>
<td>37%</td>
</tr>
<tr>
<td>On site wages</td>
<td>18%</td>
</tr>
<tr>
<td>Overhead / profit</td>
<td>14%</td>
</tr>
</tbody>
</table>

Development costs include the following:

- Brokers offer land
- Interim financing
- Cost of land
- Mapping
- Survey and layout
- Preliminary design
- Building permit
- Clear and grade
- Drainage lines and water hook up
- Water hook-up
- Roads
- Curbs
- Sidewalks
- Marketing
- Utility hook-up
- Miscellaneous fees and expenses

Source: McGraw-Hill Study for Kaiser Commission
Development costs as shown in this case taken from a study done by McGraw-Hill for the Kaiser Commission accounted for 31 percent of the total project cost, the largest single item being land accounting for 9.5 percent.

The largest single item in the construction cost was framing at 12 percent of total project costs, or 1/6 of construction costs. Heating, plumbing and electrical systems account for 20% of total project costs.

The occupying costs are shown in Table XXIV.

The monthly occupancy rates of $169 for the privately financed and rehabilitated apartments and $228 for the new unit, and $174 for a single family unit are obviously well in excess of what low income families can afford to pay.

If one considers the distribution of income in the United States and assumes 25 percent of the income is available for housing, the data of Table XXV shows that for the homes described above incomes of $8,000 and above would be required.
Table XXIV

Occupying Costs - Single Family Unit
Built by Developer

<table>
<thead>
<tr>
<th></th>
<th>Dollars/month*</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt retirement</td>
<td>$92</td>
<td>53%</td>
</tr>
<tr>
<td>Taxes</td>
<td>45</td>
<td>26</td>
</tr>
<tr>
<td>Utilities</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>Maintenance and repair</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>$174</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Based on 94.3%, 30 year mortgage at 6% interest on a $16,000 home.

Data on rehabilitated and new apartments are given in the McGraw-Hill report and are repeated here for comparison.

Monthly Occupying Costs - Rehabilitated and New Apartment Unit

<table>
<thead>
<tr>
<th></th>
<th>Rehab. Unit</th>
<th>New Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative</td>
<td>$17</td>
<td>$25</td>
</tr>
<tr>
<td>Utilities</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Decorating, maintenance and repairs</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Taxes</td>
<td>24</td>
<td>31</td>
</tr>
<tr>
<td>Insurance</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Debt retirement</td>
<td>64</td>
<td>97</td>
</tr>
<tr>
<td>Vacancies and land debts</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Profits and reserves</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>$169</td>
<td>$228</td>
</tr>
</tbody>
</table>
Table XXV
Income Distribution in the U.S. (26)

<table>
<thead>
<tr>
<th>(In constant 1963 dollars)</th>
<th>1929</th>
<th>1963</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 2,000</td>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>2,000-3,999</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>4,000-5,999</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>6,000-7,999</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>8,000-9,999</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>10,000 and up</td>
<td>6</td>
<td>21</td>
</tr>
</tbody>
</table>
V. Management. The amount of information on research on management practices in the home building industry is quite sparse. Perhaps the best recent references is that of Gillies and Mittelbach.(30)

In 1944, in his classic study of the home building industry, Colean (31) characterized management in the housebuilding industry as being "as nebulous, difficult to define and lacking in identity as the industry itself". Just as housebuilding is an agglomeration of many activities, so many elements contribute to its management. These have separate and often conflicting interests and they operate with uncertain responsibility and temporary and limited control over the diverse phase of the industry, and, therefore "the industry lacks unity and integration, is localized in its operation and backward in its technology...These chaotic relationships are largely due to the weakness of management, and to the absence of managerial power necessary to weld housebuilding into a cohesive, efficient, and progressive industry...". Maisel (32) supported this contention that management in the building industry was something less than it should be..."The average firm is still not run efficiently...Perhaps the most important thing has been the failure to develop adequate record keeping and methods of production control...Related to this lack of knowledge about costs has been the failure of firms to re-examine their complete job organization and to introduce new methods and materials..."

It is generally believed that management is relatively inefficient, and that better management could well solve many of
the problems normally identified with the industry. Until the Gillies and Mittelbach study, there had never been a study of management within the industry. When measured against conventional management standards, operations within the industry, given the environment within which builders operate, maybe as effective as can be reasonably expected. If this is so, then methods besides improved management will have to be developed to advance the performance of the industry.

In the study by Gillies and Mittelbach, fifty firms in southern California were analyzed for difficulties and deficiencies of management within the construction industry. Despite the oft-stated hypothesis that management in the industry is inadequate, inept and practically non-existent, they found that managers of firms within the industry are constantly becoming aware of the management problems and of the necessity of solving them. The general feeling was that the industry in southern California was becoming more management oriented and that the revolution was not technological but rather a management one.

The following conclusions were reached in this study:

1. Increasing ability among firms to build all types of products in various markets.

2. New techniques of management are rapidly being adopted by aggressive firms which are thereby improving their competitive position and capacities for growth.

3. Changes in management are in themselves creating changes
in the environment within which building firms operate.

The following trends were also observed:

1. Increased use of subcontracting.

2. Horizontal integration combined with vertical integration in non construction processes such as mortgage financing design, property management, and real estate sales.

3. Search for new markets in urban redevelopment programs, which include construction of relocation housing, housing for special groups, commercial operations, and recreational facilities.

4. Increased reliance on specialists with knowledge and understanding of non technical problems.

5. Realization that managers must have more technical ability.
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   by Kaiser Engineers, 1969 PB 184 122

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    1965 p. 203

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    Commission on Urban Problems, U.S. GPO, Wash., D.C.
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APPENDIX II

GOVERNMENT HOUSING PROGRAMS OF THE DEPARTMENT
OF HOUSING AND URBAN DEVELOPMENT
A. Department of Housing and Urban Development (1)

The material in this Appendix is concerned only with the housing responsibilities of the U.S. Department of Housing and Urban Development. At the present, the Federal Government's housing effort is fragmented among a number of departments and agencies, mainly in HUD but also in Agriculture, Defense, Interior, The Veterens Administration and elsewhere. The housing problem is closely tied to function of other agencies such as mass transportation, education, health, commerce, and welfare.

1. Mission and Organization.

There have been twenty distinct statutory authorizations for the Department of Housing and Urban Development or its predecessor agencies to conduct and support urban research including housing and related activities, some of which date back to the late 1940's.

Title III of the Housing Act of 1948 authorized HUD's predecessors to study housing codes and the standardization of code requirements; the Housing Act of 1949 extended the authorization to housing technology and economics. In the 1950's and early 1960's appropriations were received for data collection and demonstration activities. The scope of general research changed significantly when Congress passed the Metropolitan Development Act of 1966 referred to below.

The principal legislative authorization for this department to conduct housing-related research are:
a. **Housing Act of 1961 - Section 207.** HUD provides funds under its Low-Income Housing Demonstration Program (LIHD) to help public and private bodies or agencies to develop new improved means of providing housing for low-income or handicapped people.

b. **Demonstration and Metropolitan Development Act of 1966 - Section 1010.** Encourages and assists the housing industry to continue to reduce the cost and improve the quality of housing by the application to home construction of advances in technology, and to encourage and assist the application or advances in technology to urban development activities. Specifically, the Secretary of Housing and Urban Development is directed to:

   -- conduct research and studies to test and demonstrate new and improved techniques and methods or applying advances in technology to housing construction, rehabilitation, and maintenance, and to urban development activities; and

   -- encourage and promote the acceptance and application of new and improved techniques and methods of constructing, rehabilitating, and maintaining housing, and the application of advances in technology to urban development activities, by all segments of the housing industry, communities, industries engaged in urban development activities, and the general public.

   Section 1010 also provides authority for the conduct of research and studies designed to test and demonstrated the applicability to housing construction, rehabilitation, and maintenance, and urban development.
c. Section 108. In a briefest summary, Section 108 addresses the Department as follows - as taken from the "Summary of the Housing and Urban Development Act of 1968. Committee and Currency, House of Representatives, August 1, 1968":


Subsection (a) directs the Secretary of H.U.D. to institute a program under which qualified public and private organizations will submit plans for the development of housing for lower-income families, using new and advanced technologies, on Federal land made available for that purpose or other land which is suitable.

Subsection (b) directs the Secretary to approve up to five plans utilizing new housing technologies which are submitted to him under the program, considering (among other things) the potential of the technology employed and the ability of the organization submitting the plan to produce at least 1,000 dwelling units a year utilizing that technology.

Subsection (c) directs the Secretary to seek to achieve the construction of at least 1,000 dwellings a year over a 5-year period for each of the various types of technologies proposed in the plans approved.

Subsection (d) authorizes the transfer to the Secretary of certain Federal land which is excess property for use in carrying out the program.
Subsection (e) directs the Secretary to report at the earliest practicable date with respect to projects assisted under the program, together with his recommendations.

Subsection (f) amends Section 233 of the National Housing Act to authorize F.H.A, insurance of mortgages covering projects carried out under the new program. It also makes [available] the same benefits (e.g., interest subsidies) with respect to any mortgage insured under Section 233 as would have been available under the basic section of the Act pursuant to which it is insured.

This section, then, gives a sharp and direct Congressional "guidance" to the conduct of large scale innovative low-cost housing experiments by requiring the Department to develop a program that could result in the production of at least 25,000 living units over the next five years - living units characterized by the use of new technology in their design and production, and produced under circumstances that will stimulate large-scale production methods.

d. Technical Studies. Authority for FHA's Technical Studies Program is Section I of Title I of the National Housing Act, as amended by Public Law 479, 73rd Congress. This Section provides that the FHA Commissioner may make such expenditures, including services on a contract or fee basis, as are necessary to carry out the provisions of the several titles of the Act.
e. **Experimental Housing.** Authority for FHA Experimental Housing Program is Section 233 of the Housing Act of 1961, as amended. The FHA Commissioner is authorized to insure and make commitments to insure mortgages secured by properties involving testing of advanced technology in housing design materials or construction or experimental property standards under certain specified conditions.

In May 1969, the Office of the Assistant Secretary for Research and Technology was established to serve as a focus within the Department for all of its research, development and demonstration activities. The Department's effort in housing technology is an applied research program which investigates -- through study and analysis, experiment and demonstration -- the results of current operating program and innovative operating program approaches in all areas of HUD responsibility. It is also intended to collect and disseminate information on factors affecting HUD activities and operations. The overall objective is to provide better understanding, improved methods, greater capabilities and better operating programs to deal with housing and other urban area concerns of our growing population and to deal with that population's environment.

2. **HUD Budget for Research and Technology.**

In order to understand the HUD organization for Operation Breakthrough, it is necessary to understand the research development organization of the Assistant Secretary for Research and
Technology and the particular restraints within which he must operate.
The present position of Assistant Secretary for Research and Technology was created in 1969 and its first holder is Harold Finger, former Director of NASA's Nuclear Rocket Program and top level administrator. The amount of money approved by Congress for Urban Housing and housing research has been meager to say the least. Table XXVI shows the trend in funding at HUD and its predecessor organization since 1948. (4) In the last three years, HUD's budget for R&D has increased substantially from the previous years, but is still much lower percentage wise than the R&D budgets of the Department of Defense, National Aeronautics and Space Administration and the Atomic Energy Commission. The R&D budget of these and other organizations are compared with that of HUD for the last three years in Table XXVII. A more detailed breakout is given in Table XXVIII.

3. **Major Current Projects.**

   a. **Eliminate the Deterioration of the Nation's Existing Housing Stock.** Action is being taken to prevent the further deterioration of the Nation's current inventory of housing. The focus is on the development of effective rehabilitation systems — optimum methods of preserving and modifying existing structures, and evaluation of alternative incentives, including tax incentives, for rehabilitation, modification, and maintenance.

   Much of the Nation's housing stock is old. For much of it, there is little incentive to maintain and recondition the housing.
### Table XXVI

**Appropriations for Urban Studies and Housing Research by HUD and its Predecessor Organizations (4)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Appropriated</th>
<th>Requested</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948-1953</td>
<td>$4,876,526</td>
<td></td>
<td>Housing Act of 1948</td>
</tr>
<tr>
<td>1954</td>
<td>125,000</td>
<td></td>
<td>Appropriations Act of 1954</td>
</tr>
<tr>
<td>1955</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1956</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1957</td>
<td>0</td>
<td>$175,000</td>
<td></td>
</tr>
<tr>
<td>1958</td>
<td>0</td>
<td>920,000</td>
<td></td>
</tr>
<tr>
<td>1959</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>0</td>
<td>600,000</td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>375,000</td>
<td>900,000</td>
<td>Housing Act of 1948</td>
</tr>
<tr>
<td>1963</td>
<td>375,000</td>
<td>1,450,000</td>
<td>Housing Act of 1949</td>
</tr>
<tr>
<td>1964</td>
<td>387,400</td>
<td>2,500,000</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>387,400</td>
<td>1,500,000</td>
<td></td>
</tr>
<tr>
<td>1966</td>
<td>750,000</td>
<td>1,500,000</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>500,000</td>
<td>750,000</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>10,000,000</td>
<td>20,000,000</td>
<td>Housing and Urban Development Act of 1966</td>
</tr>
<tr>
<td>1969</td>
<td>10,444,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>23,000,000</td>
<td></td>
<td>Housing and Urban Development Act of 1968</td>
</tr>
<tr>
<td>1971</td>
<td>55,000,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table XXVII:
Sources of Federal R&D Funds
(millions of dollars)

<table>
<thead>
<tr>
<th>Department or Agency</th>
<th>1970 actual</th>
<th>1971 Est.</th>
<th>1972 Est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOD-Military functions</td>
<td>7,338</td>
<td>7,400</td>
<td>8,309</td>
</tr>
<tr>
<td>NASA</td>
<td>3,825</td>
<td>3,382</td>
<td>3,215</td>
</tr>
<tr>
<td>HEW</td>
<td>1,251</td>
<td>1,506</td>
<td>1,637</td>
</tr>
<tr>
<td>AEC</td>
<td>1,346</td>
<td>1,307</td>
<td>1,251</td>
</tr>
<tr>
<td>Transportation</td>
<td>315</td>
<td>468</td>
<td>566</td>
</tr>
<tr>
<td>NSF</td>
<td>288</td>
<td>343</td>
<td>495</td>
</tr>
<tr>
<td>Agriculture</td>
<td>289</td>
<td>312</td>
<td>321</td>
</tr>
<tr>
<td>Interior</td>
<td>160</td>
<td>188</td>
<td>213</td>
</tr>
<tr>
<td>Commerce</td>
<td>124</td>
<td>157</td>
<td>181</td>
</tr>
<tr>
<td>Environmental Protection</td>
<td>75</td>
<td>118</td>
<td>132</td>
</tr>
<tr>
<td>OEO</td>
<td>101</td>
<td>116</td>
<td>100</td>
</tr>
<tr>
<td>VA</td>
<td>59</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>HUD</td>
<td>23</td>
<td>52</td>
<td>49</td>
</tr>
<tr>
<td>Smithsonian</td>
<td>20</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>Justice</td>
<td>10</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Labor</td>
<td>21</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>All other</td>
<td>79</td>
<td>87</td>
<td>125</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>15,331</strong></td>
<td><strong>15,555</strong></td>
<td><strong>16,737</strong></td>
</tr>
</tbody>
</table>

Source: Astronautics and Aeronautics, April, 1971, p. 11
# Table XXVIII

Department of Housing and Urban Development

for the years 1969-1971 (2) (Thousands)

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1971</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Housing to meet National needs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Operation Breakthrough</td>
<td>15,500</td>
<td>38,000</td>
</tr>
<tr>
<td>- Eliminate the Determination of the Nations existing Housing Stock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Self Help Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Development of Systems for Management and ownership of Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Urban Development through Considerations of Environmental Requirements for Improved Public Facilities and Services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Environmental Quality</td>
<td>3,500</td>
<td>8,000</td>
</tr>
<tr>
<td>- Communications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Energy Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Public Facility Service Installation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. Urban Development through Accumulation and Analysis of Available Data Evaluation of existing Urban Systems and Development of Operating Methods and management support.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Housing and Urban Data Series</td>
<td>3,060</td>
<td>6,700</td>
</tr>
<tr>
<td>- Applying University Resources and Discipline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Development of Improved State and local procedures and methods for dealing with Urban Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Urban Institute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Program Evaluation Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fair Housing and Equal Opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Interagency Activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4. Administration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23,000</td>
<td>55,000</td>
</tr>
</tbody>
</table>
In many cases, more housing is deteriorating and being abandoned than is being built. Improvements are needed in all elements of the repair, maintenance and rehabilitation process. The use of techniques suitable for self-help approaches must be considered as part of this process.

This activity is composed of the following elements:

1. Definition of the Rehabilitation Problem
2. Determination of the Market Profile
3. Data Gathering and Evaluation of Fifteen City Rehab Programs
4. Technological Research related to Specific Rehabilitation Problem areas.

b. **Self-Help Housing.** The Department conducted a study in 1969 in which it was concluded that self-help housing had considerable potential not now being fully realized. It also identified several problem areas as well as gaps in our knowledge of how the "sweat equity" concept might be more fully utilized.

Based on these and other related findings, the Department has undertaken in 1970 a program to develop to the fullest extent possible, the potential of self-help housing, to fill the gaps of information identified by, and to develop systems that would assist and encourage self-help.

c. **Technical Studies.** A variety of engineering studies are conducted in support of the FHA program. These studies are aimed at an immediate response to practical problems identified in the operating programs to support the issuance of technical standards.
176

d. Operation Breakthrough: Purpose and Objectives (2)

Operation Breakthrough, a major part of HUD's R&D budget, is aimed at the establishment of self-sustaining mechanisms for producing new, marketable housing in increased volumes and delivering them at controlled or reduced costs, to people of all income levels, with emphasis on those groups and individuals who have had difficulty in obtaining satisfactory housing in the past. With about half of our people unable to afford the housing that they need, this group is becoming very large and now includes middle as well as low and moderate income families. The objective is to improve the entire process by which housing is produced and provided to all people.

The program is designed to bring about improvements in housing system design, production, assembly, management, financing and marketing and to provide a high level of environmental quality, efficient land use, and low cost maintainability. To meet this objective, HUD is entering into a collaborative effort, a partnership with state and local government, with industry, with labor, and the consumer to encourage advances in the construction industry, to aggregate the market and land available for housing. An effort is being made in Operation Breakthrough to overcome the constraints that have presented the utilization of advanced existing technology that have discouraged the development of new, improved housing technology. These constraints include obsolete and varied building
codes, problems in administering these codes, extensively restrictive zoning and exclusionary land use practices.

It is hoped that through the impetus of Operation Breakthrough, a self sustaining mechanism will be established for rapid, volume production of marketable housing at costs that will make them available to people of all income levels, with particular emphasis on those groups and individuals which have had difficulty in obtaining satisfactory housing in the past. Progress toward the program's primary objective includes the production of at least 1,000 dwellings a year for five years, utilizing up to five different technologies, as called for by section 108 of the Housing and Urban Development Act of 1968.

To assist in meeting this hard objective the program addresses the following secondary objectives:

(a) Stimulate the modernization and broadening of the housing industry through increased emphasis on better design and greater utilization of improved production and management techniques within the current housing industry and through increased participation by other organizations that possess the necessary talents, interest and capability for such a commitment.

(b) Increase participation and leadership by state and local governments in providing on-going planning and market and site aggregation for housing, its environment and the community.

(c) Waive or remove constraints to the introduction and use of tested and proven innovations in design, construction, land acquisition and use, financing, labor utilization, materials, components and systems, sponsorship, consumer participation, management and maintenance.

(d) Introduce new organizational concepts and management techniques for market and site aggregation, and for design, production and marketing of living units.
(e) Coordinate the application of all available government resources appropriate to a given site or sites for housing, environment, community services and facilities.

(f) Encourage identification and development of performance standards for evaluation of innovations, working with authorities in this area.

(g) Develop an on-going testing and evaluation mechanism and technique for judging the effectiveness of innovations.

(h) Develop techniques for increased effective participation by consumers and community groups in developing the total housing environment.


Operation Breakthrough involves two types of programs. The first, and major portion, provides for the design, development and application of complete housing systems, including plans for effective use of land. The second provides for research development and design of innovative concepts for elements of the housing system, materials and techniques, land use concepts and business considerations, including legal, financing, processing and management techniques.

(a) Total Housing Systems. This portion of Operation Breakthrough consists of three phases:

Phase I - Research and Development of Innovative Housing Systems

Phase II - Prototype Construction, Demonstration and Evaluation

Phase III - Research and Development of Innovative Housing Systems.

(1) Phase I - Research and Development of Innovative Housing Systems.
The aim of Phase I was to solicit and select proposals from industry for the following three functions:

i. Housing System Producer (HSP)

ii. Prototype Site Planners (PSP)

iii. Prototype Site Developer (PSD)

The activity of each of these functions will be described more fully under the next section on organizations. Contracts were written with each of the contractors in each function. At the same time, sites were selected from proposals made by mayors and governors who were contacted by letter and questionnaire. The results of these four requests are shown in Table XXIX which is a modified form of one appearing in an article by Warburton. (3)

Because of budget cutbacks as well as community opposition, two of the prototype sites were dropped. Only eight prototype site developers are shown since one of the contractors will be developing on two sites. A listing of the Housing System Producers, Prototype Site Planners, Prototype Sites are listed in Table XXX. It is interesting to note that for these three functions 39 separate contracts were written.

In order to assure local governments of the safety and quality of Breakthrough building systems, the system concepts selected will be thoroughly tested. These tests will be conducted by both private and Federal organizations such as the National Bureau of Standards. Test methods and results will be validated by a group established by the National Academies of Science and Engineering under contract with HUD.
Table XXIX

Summary of the Four Solicitations (3)

<table>
<thead>
<tr>
<th>Prototype Sites</th>
<th>Prototype Site Planners</th>
<th>Housing Systems</th>
<th>Prototype Site Developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of requests issued</td>
<td>700</td>
<td>300</td>
<td>7500</td>
</tr>
<tr>
<td>Responses</td>
<td>218</td>
<td>82</td>
<td>236</td>
</tr>
<tr>
<td>Selections</td>
<td>10</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>(11 parcels)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### Table XXX

**Operation Breakthrough Prototype Site, Planners, Developers and Producers**

<table>
<thead>
<tr>
<th>Prototype Sites (Approximate Acreage and Addresses)</th>
<th>Site Planners (for Sites Listed at Left)</th>
<th>Site Developers (for Sites Listed at Left)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macon, Ga. 50 acres including a 6-acre lake (4215 Chambers Rd.)</td>
<td>Reynolds, Smith and Hills Jacksonville, Fla.</td>
<td>Macon Breakthrough Housing Venture (Fickling &amp; Walker, Inc. &amp; National Corporation for Housing Partnerships) Macon, Ga.</td>
</tr>
<tr>
<td>Memphis, Tenn. 10 acres in Court Avenue urban renewal area (Court Ave.)</td>
<td>Miller, Whry &amp; Brooks Louisville, Ky.</td>
<td>Alodex Corporation Memphis, Tenn.</td>
</tr>
<tr>
<td>St. Louis, Mo. 2 parcels in Mill Creek urban renewal area, totaling 15.5 acres (3331 Laclede Ave.) (2001 Market St.)</td>
<td>Hallmuth, Obata &amp; Kasabaum, Inc. St. Louis, Mo.</td>
<td>Millstone Construction Co. &amp; Millstone Assoc., Inc. &amp; Univ. Hts. Village St. Louis, Mo.</td>
</tr>
<tr>
<td>Sacramento, Calif. 60 acres in old state fairgrounds (Broadway, west of 57th St.)</td>
<td>Wurster, Bernardi &amp; Emmons, Inc. San Francisco, Calif.</td>
<td>Sacramento Breakthrough Housing Venture (Campbell Construction Co. and National Corp. for Housing Partnerships) Sacramento, Calif.</td>
</tr>
<tr>
<td>King County, Wash. 30 acres in suburban Seattle (124th Ave. N.E. &amp; N.E. 144th St.)</td>
<td>Eckbo, Dean, Austin &amp; Williams San Francisco, Calif.</td>
<td>The Boeing Co. Seattle, Wash.</td>
</tr>
<tr>
<td>VOLUME HOUSING PRODUCERS (site assignments)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAMCI, Inc.; Descon/Concordia; Townland, Inc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALCOA; Boise-Cascade; Building Systems Int.; Hercules; Material Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAMCI, Inc.; General Electric; Material Systems; Sholley; Stirling-Homex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCE-Dillon; Home Building; Material Systems; National Homes; Pantek; Pentom; Republic Steel; Scholz Homes; TRW Systems Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hercules; Levitt; Material Systems; Pentom; Republic Steel; Scholz; Stirling-Homex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Descon/Concordia; Home Building; Material Systems; Rouse-Wates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALCOA; Boise-Cascade; Christiana-Western; FCE-Dillon; Material Systems; Pantek; TRW Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALCOA; Boise-Cascade; Christiana-Western; Levitt Technology Material Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Townland</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table XXX (Cont'd)**
If the performance test indicates that the concept is acceptable, and if the Academies validate the results and test methods, HUD will then approve those concepts for use in any application for HUD program funds or mortgage insurance that may be made by sponsors, developers, housing authorities or other groups. In addition, HUD will request local communities to accept the housing system testing, evaluation, validation, and approval in lieu of existing building code requirements which have in the past tended to inhibit the application of improved housing technology.

HUD is also suggesting that State and local registration be considered to provide for acceptance of these concepts within State code requirements. It is anticipated that the portion of the testing effort which involves components and subsystems would be completed prior to September 1970. Full systems tests and consumer evaluation, maintenance and durability checks will continue well beyond that time.

(2) Phase II - Prototype Construction, demonstration and Evaluation.

The prototype sites selected in Phase I represent a wide geographical distribution. This was considered important to test consumer and community acceptance and marketability of the housing systems. It was considered essential that prototypes be constructed in representative locations throughout the nation in sufficient quantity to evaluate and demonstrate land use patterns and housing system variety. These sites are to serve as models of effective residential community design in which various housing types,
including single and multi-family units, and various economic level or price levels of housing can be arranged with good land use concepts into attractive and satisfying living environments.

On the basis of these demonstrations, and the evaluation of the sites and system made by the consumer and local groups that examine the concepts displayed, it is hoped that local communities will be encouraged to forego restrictive zoning and land use requirements that have been built up over the years, but that have become barriers to multi-family construction, to housing for low and moderate income families, to innovative and effective land use.

Approximately 3000 dwelling units will be placed on these sites (arranging between 150 and 300 units per site), depending on costs, characteristics of the housing systems selected, and the site and community characteristics.

To test consumer and community acceptance and marketability of the selected housing systems, it is important that prototypes be constructed in representative locations as mentioned earlier throughout the nation in sufficient quantity to evaluate and demonstrate land use patterns and housing system variety. Sites located in inner city urban renewal areas, at the periphery of cities and in the suburbs have been selected in the following locations for these purposes:

Indianapolis, Indiana
Jersey City, New Jersey
Kalamazoo, Michigan
Macon, Georgia
Memphis, Tennessee
Sacramento, California
Seattle King County, Washington
St. Louis, Missouri
These sites are to serve as models of effective residential community design in which various housing types, including single and multi-family units, and various economic level or price levels of housing can be arranged with good land use concepts into attractive and satisfying living environments.

These prototypes sites will be experimental in many ways. They will permit evaluation of advanced building systems, advanced service systems, mixed price level, mix of housing types, various social living patterns, and improved overall community design and planning.

(3) Phase III - Market Aggregation and Volume Production

A major deterrent to successful high volume housing production has been the various housing development and local regulatory practices which maintain fragmented markets, restrict land use and availability and increase development costs. Through this phase of Operation Breakthrough, HUD plans to help develop a process for aggregating the market, finances, and land sources, and to encourage increased volume production and delivery of housing to those that need it.

Local and State governments are being asked to work with local developers, authorities and other groups to assist in developing an inventory of the housing need and demand; to identify the land available for housing; to remove or relax the unnecessarily restrictive features of building, housing and zoning codes, and
sources of construction financing; and to encourage the construction industry to improve productivity and production methods.

In addition, each of the Housing System Procedures are being tasked to produce their own marketing plans.
3. **Organization of Operation Breakthrough.**

The organizational structure for a program such as Operation Breakthrough must of necessity be flexible in order to meet the changes that are bound to occur in such an experimental program. The amount of coordination, direction and communication is great both on the government and contractor side when you consider that twenty-two contractors are building different housing concepts on nine sites. There are a number of key elements in this network such as the Government Technical Representatives (GTR), Housing System Producers (HSP), Prototype Site Planners (PSP), Prototype Site Developers (PSD), and Site Technical Representatives (STR).

Each of these plays a key role in the overall program and will be described in detail.

The organization for Operation Breakthrough is shown in Figure 7. Figure 8 shows in greater detail the lines of authority, lines of communication, and contract management between the various participants both government and contractor.

(a) **Government Technical Representative (GTR)**

Government technical manager at HUD is responsible for the direction of the contractors work in accordance with the contract terms.

(b) **Housing System Producer (HSP)**

A housing system manufacturer is responsible for producing and erecting its housing system on a prototype site.
Figure 7

HUD Organization for Research and Technology

Assistant Secretary
Deputy Assistant Secretary

Staff
- Business Participation Division
- Program Technical Staff
- Office of Planning and Program Control
- Office of Administration and Operations

Divisions
- Environmental Factors and Public Utilities
- Building Technology and Certification
- Housing Management and Maintenance
- Urban Renewal Demonstration
- Urban Systems Operations
- Research on Planning for Urban Growth

Operation Breakthrough
- Technical Operations Division
- Market Aggregation Division
- Site and Land Development Division
- Site Relations and Negotiations Division
- Special Projects Division
Figure 8

Operation Breakthrough
Program Management Line of Authority and Direction
(c) Prototype Site Planner (PSP)

A Prototype Site Planner (PSP) has been selected for each prototype site, with responsibility to develop a total site plan incorporating the various housing systems assigned to that site; to review, accept, modify, or request changes in the specific plans and housing system designs of each of the assigned Housing System Producers (HSP) as may be required to meet the total site concept in order to provide a viable community; and to design and supervise construction of general site facilities and services. The PSP will obtain or review general sub-surface investigation data and provide this information to the contractor for his use in design of his foundations and services; the contractor shall obtain additional information as required and as noted in Article V-C of this attachment. The PSP will participate with all HSP's and the Prototype Site Developer (PSD) in community contact activities. The contractor shall cooperate with the PSP in his planning and design activities. Where directed by HUD the contractor will modify his designs in accordance with the changes requested by the PSP.

(d) Prototype Site Developer (PSD)

A Prototype Site Developer (PSD) has been selected for each prototype site, with broad responsibility for implementing the prototype site plan, and manageing and disposing of the prototype development, including responsibility for obtaining all necessary legal approvals, variances, permits, and waivers; establishing
community relationships and obtaining community participation. During Phase I, the contractor shall cooperate with the PSD for each assigned prototype site as required in obtaining community participation and in coordination of production and on-site erection plans. If selected to proceed to Phase II, the contractor shall be responsive to the requirements of the PSD to the extent defined in the contract relationship between the two parties and HUD.

(e) Prototype Site Developer Subcontractor

The contracting organization(s) which provides the grading, utilities, access roads, and sidewalks and other general prototype site construction under contract with the Prototype Site Developer.

(f) Program Control

Management Information and Program Control System - the HUD Central Office has the responsibility for management reporting system. and overall planning of time schedules.

(g) Regional Manager

HUD Regional Manager located in a HUD regional office has liaison responsibility for all Breakthrough Operations in that region, including establishing contact with HUD field personnel, governmental officials where appropriate, liaison between site planners, housing system producers, and prototype site developers.

(h) Contracting Officers

Official at HUD responsible for negotiation and administration of department contracts. A listing of the twenty-two Housing System Producers, housing and systems types are shown in Table XXXI.
**Table XXXI**

**SUMMARY DESCRIPTIONS OF THE BREAKTHROUGH HOUSING SYSTEMS**

**ALCOA CONSTRUCTION SYSTEMS, INC.**

**Housing Types:** townhouses, walk-up apartments

**System Type:** combination of steel-framed service core modules and panels

Steel-framed service-core modules including mechanical, kitchen and bathroom elements, are produced in a factory and transported to the building site. They are then joined with factory-produced panels which define the living and sleeping spaces. Aluminum or wood framed panel walls can be employed.

**BOISE-CASCADE HOUSING DEVELOPMENT**

**Housing Types:** single-family detached, single-family attached

**System Type:** light gauge steel-framed modules

The basic structural design employs light steel members and non-combustible plywood decking. Room-length gypsum board is used for interior finishing.

**BUILDING SYSTEMS INTERNATIONAL, INC.**

**Housing Types:** single-family detached, single-family attached, low, medium and high-rise apartments

**System Type:** precast concrete load-bearing panels

The Balency precast concrete system of factory-produced panels is utilized. Load-bearing interior and exterior walls and floor slabs provide flexibility in design arrangements.

**CAMEL, INC.**

**Housing Types:** single-family attached, garden apartments, medium rise apartments (4-10 stories)

**System Type:** precast reinforced concrete panels

The Tracoba system of precast concrete load-bearing cross-walls, floor panels, and facade panels is employed. The joints between walls and slabs and between adjoining slabs are cast in place, insuring continuity between elements and a rigid structure.

**CHRISTIANA WESTERN STRUCTURES, INC.**

**Housing Types:** single-family detached, townhouses, two-story garden apartments

**System Type:** wood-framed panels

Shop-fabricated wood frame panels are used for walls, partitions and roof construction, with the panel walls being produced without joints for the required lengths. A polyester resin finish, reinforced with glass fibers, is furnished as an interior and exterior wall finish in lieu of paint.

**DECON/CONCORDIA SYSTEMS, LTD.**

**Housing Types:** single-family attached, multifamily low-rise and high-rise

**System Type:** reinforced concrete panels

The structural components consist of precast concrete walls, floors and beams, which can be produced in existing pre-casting facilities. All-weather assembly of the panels at the site is accomplished by utilizing dry mechanical joints.

**F.C.E.-DILLON, INC.**

**Housing Types:** single-family attached, multifamily low, medium and high-rise

**System Type:** combination of pre-cast and site-cast concrete structural and exterior elements with wood-framed interior panels

The concrete structural system consists of precast wall and floor panels and cast-in-place concrete elements using steel "tunnel" and other re-usable forms. Interior partitions and non-load-bearing facade panels can be of pre-fabricated wood frame construction, with a wide variety of possible finishes.

**SUMMARY**

A variety of housing systems, producers, housing types, system types, building systems, and materials are discussed in the text. Each system is described in terms of its structural components, materials used, and design features. The text highlights the versatility and adaptability of these systems in creating diverse housing options.

**APPLICATION**

The text provides a comprehensive overview of the range of housing system types available, from single-family attached and detached to multifamily low, medium and high-rise. Each system is characterized by its unique structural components and design features, allowing for a wide range of applications in different building environments.

**Table XXXI**

<table>
<thead>
<tr>
<th>Housing Types</th>
<th>System Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Townhouses, Walk-up Apartments</td>
<td>Combination of Steel-Framed Service Core Modules and Panels</td>
</tr>
<tr>
<td>Single-Family Detached, Single-Family Attached, Low, Medium and High-Rise Apartments</td>
<td>Light Gauge Steel-Framed Modules</td>
</tr>
<tr>
<td>Single-Family Attached, Garden Apartments, Medium Rise Apartments (4-10 Stories)</td>
<td>Precast Reinforced Concrete Panels</td>
</tr>
<tr>
<td>Single-Family Attached, Multifamily Low-Rise and High-Rise</td>
<td>Reinforced Concrete Panels</td>
</tr>
<tr>
<td>Single-Family Attached, Multifamily Low, Medium and High-Rise</td>
<td>Combination of Pre-Cast and Site-Cast Concrete Structural and Exterior Elements with Wood-Framed Interior Panels</td>
</tr>
</tbody>
</table>

The table provides a comparison of housing types and system types, allowing for a clearer understanding of the range of options available. This table is an essential tool for architects, developers, and other professionals involved in the planning and construction of housing systems.
<table>
<thead>
<tr>
<th>Company</th>
<th>Housing Types</th>
<th>System Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEMTOM, INC.</td>
<td>single-family detached</td>
<td>stressed-skin plywood modules</td>
</tr>
<tr>
<td></td>
<td>single-family attached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily low-rise (up to 3 stories)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily high-rise (with separate structural frame)</td>
<td></td>
</tr>
<tr>
<td>Housing Types:</td>
<td>single-family detached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>single-family attached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily low-rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily high-rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: stressed-skin plywood modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>panels, comprised of plywood interior and exterior facings separated by a polyurethane foam core, are joined together by means of a polymer bond to form modular units. There is considerable flexibility in the arrangement of the modules to create various housing types.</td>
<td></td>
</tr>
<tr>
<td>Republic Steel Corporation</td>
<td>single-family detached</td>
<td>steel framed panels</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>single-family detached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: steel framed panels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>structural wall, floor and roof panels have a steel facing on both sides of a foam and insulated paper honeycomb core. Interior surfaces may be added. The foundation consists of concrete piers to which are attached steel rectangular box beams. The wall and floor panels are attached to the steel box beams, and the roof panels are added to form the complete structure. Bathrooms and kitchens are preassembled modular components.</td>
<td></td>
</tr>
<tr>
<td>Rouse-Wates, Inc.</td>
<td>multifamily low, medium and high-rise</td>
<td></td>
</tr>
<tr>
<td>Housing Types:</td>
<td>precast reinforced concrete panels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: precast reinforced concrete panels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the Wates Building System of England employs precast reinforced concrete panels as the basic structural elements. They are produced at the site in movable facilities.</td>
<td></td>
</tr>
<tr>
<td>Scholz Homes, Inc.</td>
<td>single-family detached</td>
<td>wood-framed modules</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>single-family attached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily low-rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: wood-framed modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wood framed modular units are produced in a factory, where they are completely wired and plumbed and exterior and interior finishes applied. The modules are transported to the site and erected on previously prepared foundations.</td>
<td></td>
</tr>
<tr>
<td>Shelley Systems, Inc.</td>
<td>single-family attached</td>
<td>reinforced concrete modules</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>multifamily low-rise and high-rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: reinforced concrete modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the structural system employs factory cast and finished reinforced lightweight concrete modular units. Load-bearing columns are an integral part of the modules so that, when the modules are stacked, the columns match vertically to carry all gravity loads. The modules are stacked in an alternating, checkerboard manner, and the resulting open spaces are then closed in.</td>
<td></td>
</tr>
<tr>
<td>Stirling-HomeX Corporation</td>
<td>multifamily high-rise</td>
<td>steel framed modules</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>system type: steel framed modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the structural system utilizes steel columns and steel floor beams which form an integral part of the factory-produced modules. Interior finishing is applied at the factory including vinyl covered gypsum board for walls and ceiling. The modules are erected by means of a hydraulic jacking system. The top-floor modules are placed on the first-floor level, bolted together, and raised by a hydraulic lifting device to the second story level. The next story of modules are then inserted underneath on the first-floor level, bolted together, and then hydraulically jacked up, moving the top-floor modules to a third-story level, and so on until the structure is completed.</td>
<td></td>
</tr>
<tr>
<td>Townland Marketing and Development Corp.</td>
<td>multifamily high-rise</td>
<td>reinforced concrete &quot;megastructure,&quot; with lightgauge steel framed in-fill modular cores and panels</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>system type: reinforced concrete &quot;megastructure,&quot; with lightgauge steel framed in-fill modular cores and panels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the structural system employs pre-cast, prestressed concrete columns, spandrel beams, and deck slabs to create a frame with the deck slabs running across between the spandrel beams at two or three story intervals, up to a maximum height of 15 stories. The result is the creating of concrete grids enclosing multi-story spaces. Two and three storied housing units are constructed on the separate deck slabs, utilizing lightgauge steel framed panels and mechanical core modules.</td>
<td></td>
</tr>
<tr>
<td>TRW Systems Group</td>
<td>single-family detached</td>
<td>glass fiber reinforced plastic and paper honeycomb modules</td>
</tr>
<tr>
<td>Housing Types:</td>
<td>single-family attached</td>
<td></td>
</tr>
<tr>
<td></td>
<td>multifamily low-rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>system type: glass fiber reinforced plastic and paper honeycomb modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>load-bearing walls, ceiling and floor are made with a sandwich structure, consisting of glass fiber reinforced polyester resin plastic on both sides of a Kraft paper honeycomb core. The sandwich is manufactured in an on-site factory by wrapping the various layers on a rotatable mandrel. Panels for the and walls and interior partitions are made in flat molds. The completed modules can then be arranged in various architectural arrangements.</td>
<td></td>
</tr>
</tbody>
</table>
4. **Program and Management Control.**

A management reporting system with three monthly reports is utilized for the management information and program control system. These reports are distinct from work product reports submitted on completion of specific tasks performed pursuant to the contract. The reports are:

a. Financial Management Report (HUD form 533)

b. Schedule Performance Report (HUD form 534)

c. Narrative Progress Report (includes description of scope of work planned for the reporting period, technical progress, current problems if any, and description of work to be performed during the next period.)

These three reports are submitted by the contractors simultaneously on the 10th day of each month. Data from these reports are graphically presented on boards in a project control room. This room is used by the program management to assess and review the progress of each contractor and the program as a whole. The major control parameters are contract funds and manhours expended.

5. **Contractual Arrangements.**

Separate contracts are written by the Central Breakthrough office with each HSP, PSP, and PSD. These contracts are administered by a HUD contracting officer and a government technical representative. Each contract has definite products to be developed and submitted to HUD such as site plans, production plans, market plans, etc. In Phase I, over 1000 individual reports were required, each
necessitating a review by three persons. These reports were controlled and scheduled on a manual basis.

The contracted arrangements for costs incurred by the contractors in Phase II include the overcost between the cost of construction of the home and the market value as determined from FHA and contractor estimates for the houses produced. Since this is an experimental program in which innovative methods, materials, and techniques are being tried and tested, costs will be much greater than for a conventionally built house. It is expected that if markets can be aggregated so that volume production is possible, the costs will decrease based on a learning curve.

6. Operating Environment.

The environment in which Project Breakthrough must operate can be considered as internal and external. Internally the program has to work within the structure of HUD which up to the last few years did little R&D and building of any sort. It has little or no internal capability for analysis of complete systems or any in-house R&D or support capability. As a result, it must wither develop its own inhouse R&D and analysis capability or contract for these services which it has done in the major areas of housing criteria development, materials evaluation and testing data collection, and housing inspection and certification.

HUD as an organization is relatively new having been formed in 1968 by the Housing and Urban Development Act. This Act
consolidated several independent housing activities and as Federal Housing Agency (FHA), HHA, FNMA, etc. Some of these independent agencies were quite old and inbred such as FHA which was established by the Housing Act of 1934.

The external environment is characterized by a number of influencing factors such as the Congress, the building industry, professional groups, over 400 trade associations, labor, other government agencies, 90,000 local and state governments, zoning, 5,000 different building codes, etc.

This environment presents a number of problems which must be factored into Operation Breakthrough and hence the program can not be considered as only technical oriented but includes social, economic, and political aspects. It has been pointed out by several people, that the real problems of housing are not technical but social, political, and economic in nature. It is felt that these factors significantly distinguish problems in the public sector from problems in space or defense. The problem is made all the more difficult since none of these factors are quantifiable, they are difficult to approach and define, and little applicable research is being done to better understand them.

As an indication of how these factors interact with the program, a few examples might be instructive.

a. **Building Industry.** As was pointed out in the section on the building industry, it is a fragmented industry, which is well
inbred in building houses by conventional methods. Any introduction of change thru innovation is bound to upset the equilibrium and cause resistance. This has been manifested in policy statements by the National Association of Homebuilders and House and Home Magazine (5). Further evidence of this can be seen in the resistance to the proposal made by the former Assistant Secretary of Commerce for Research and Technology, H. Holloman when he tried to institute the Civilian Industrial Technology Program (CITP) (6).

b. The Congress and Local Interests. Operation Breakthrough was originally scheduled for eleven sites but was cut back to nine because of both budget cuts and local opposition.

c. Labor Unions. Although general acceptance of industrialized housing has been recognized at the national labor levels, local labor problems have not yet been encountered. These will occur when houses start to be put up on sites in the various locales.

d. Building Codes. With over 5,000 building codes throughout the country with as many as 100 within a single metropolitan area, the problem of market aggregation will be very difficult unless some sort of standardization is obtained.

e. Social Acceptance. Because housing is being subsidized by the federal government for low and middle income families of all colors, and ethnic origin, it quickly becomes stigmatized by the local community. Work is required to break down social barriers to obtain acceptance.
7. **Results.**

As of this writing it is too soon to evaluate the effectiveness of the program. The real evaluation will come after the houses have been built and occupied and data built up on costs, community acceptance, operation, maintenance, etc. Since it is an experimental program, cost increases and delays are to be expected, and have already been reported (7). The housing units were originally scheduled for completion by March 1971, and have now been delayed until the summer of 1971 due to delays resulting from negotiations over the price per unit of the 2850 prototype units. Several beneficial results have already been accrued to the program.

a. Operation Breakthrough has stimulated considerable interest in industrialized housing and factory produced components. Such industrial giants as International Telephone and Telegraph Co., American Standard, Inc., General Electric, Westinghouse, Boeing Co., U.S., Bethlehem, Inland and Republic Steel Corporation, Hercules, Alcoa, TRW, and BoiseCascade, have entered the industrialized housing business.

b. Some of the Breakthrough companies are going ahead on their own using similar technology such as Camci Inc. of New York City which has begun building a 20 story building using a concrete panel design.

c. Other government agencies have become interested similar approaches to standardized modular construction for government buildings and housing.
d. Operation Breakthrough has developed performance criteria which could be used as basis for national home building performance codes.

e. The program has identified many impediments to the use of new materials and methods.

f. The program has recognized the major problem of marketing and is taking steps together with state and local agencies to aggregate the markets.

g. It has been instrumental in introducing advanced management techniques into HUD and the Breakthrough contractors.
REFERENCES


3. Warburton, R. "Evaluation of Proposals for Operation Breakthrough" Industrial Forum


APPENDIX III

OTHER APPROACHES AND EXPERIENCES PERTINENT TO LOW COST INDUSTRIALIZED HOUSING
A. Mobile Home Industry

1. Introduction. The mobile home industry has the potential of becoming an important factor in the production of low cost industrialized housing because of its unique experience in building mobile homes at low cost and on a somewhat production line basis. They also have acquired valuable experience in the transport and marketing of mobile homes. However, due to the stigma that has built up over the years with regards to mobile homes, the industry must develop a better image it it is to compete in the industrialized housing market. The major source of information for this section has been drawn from three sources (1-3). The work of Bernhardt is an excellent review of the literature on mobile homes containing over twelve hundred references (1). This section attempts to point out those aspects of the mobile home industry from which the industrialized housing builder could learn and also the role of this industry in aiding to solve the low and middle income housing crisis.

2. Industry. The mobile home industry has never won widespread recognition as a glamour industry, yet its annual growth rate has been 20 percent from 1962-1969 and 30 percent in the last two years. Manufacturers shipments in 1969 amounted to 412,000 units with an estimated value of about 2.5 billion dollars. The growth rate of this industry is best shown by the number of units shipped and the retail sales value as shown in Table XXXII.
Table XXXII

Mobile Homes Shipments (4)

<table>
<thead>
<tr>
<th>Year</th>
<th>Manufacturers' Shipment to dealers in U.S.</th>
<th>Retail Sales (Estimated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>412,690</td>
<td>$2,496,774,500</td>
</tr>
<tr>
<td>1968</td>
<td>317,950</td>
<td>$1,907,700,000</td>
</tr>
<tr>
<td>1967</td>
<td>240,360</td>
<td>1,370,052,000</td>
</tr>
<tr>
<td>1966</td>
<td>217,300</td>
<td>1,238,610,000</td>
</tr>
<tr>
<td>1965</td>
<td>216,470</td>
<td>1,212,232,000</td>
</tr>
<tr>
<td>1964</td>
<td>191,320</td>
<td>1,071,392,000</td>
</tr>
<tr>
<td>1963</td>
<td>150,840</td>
<td>862,064,000</td>
</tr>
<tr>
<td>1962</td>
<td>118,000</td>
<td>661,000,000</td>
</tr>
<tr>
<td>1961</td>
<td>90,200</td>
<td>505,000,000</td>
</tr>
<tr>
<td>1960</td>
<td>103,700</td>
<td>518,000,000</td>
</tr>
<tr>
<td>1959</td>
<td>120,500</td>
<td>602,000,000</td>
</tr>
<tr>
<td>1958</td>
<td>102,000</td>
<td>510,000,000</td>
</tr>
<tr>
<td>1957</td>
<td>119,300</td>
<td>596,000,000</td>
</tr>
<tr>
<td>1956</td>
<td>124,330</td>
<td>622,000,000</td>
</tr>
<tr>
<td>1955</td>
<td>111,900</td>
<td>462,000,000</td>
</tr>
<tr>
<td>1954</td>
<td>76,000</td>
<td>325,000,000</td>
</tr>
<tr>
<td>1953</td>
<td>76,900</td>
<td>322,000,000</td>
</tr>
<tr>
<td>1952</td>
<td>85,000</td>
<td>320,000,000</td>
</tr>
<tr>
<td>1951</td>
<td>67,300</td>
<td>248,000,000</td>
</tr>
<tr>
<td>1950</td>
<td>63,100</td>
<td>216,000,000</td>
</tr>
<tr>
<td>1949</td>
<td>46,200</td>
<td>122,000,000</td>
</tr>
<tr>
<td>1948</td>
<td>85,500</td>
<td>204,000,000</td>
</tr>
<tr>
<td>1947</td>
<td>60,000</td>
<td>146,000,000</td>
</tr>
</tbody>
</table>

Prior to 1947, production varied from 1,300 in 1930 upward to 60,000 in 1947.

10-wide homes came into mass production in 1955.

12-wide homes came into mass production in 1962.

14-wide homes came into mass production in 1969.

Source: Mobile Home Manufacturers Institute
No one single company dominates the industry. Skyline, the largest, accounts for 10 percent of total output, the ten top companies account for 50 percent, and the rest of the industry is fragmented among several hundred companies.

3. Nature of the Mobile Home. In some ways the mobile home resembles and is treated like an automobile. It is built on an assembly line like an auto and sold, and financed and depreciated much like an auto. It is generally taxed as personal rather than as real property.

Once placed on their sites, however, the overwhelming majority of mobile homes remain immobile and take on the appearance of a house. A mobile home has the appurtenances of a house; separate rooms, available in a variety layouts; modern kitchen, and at least one bathroom. At least 90 percent of mobile home production consists of units twelve feet wide and frequently between 55-60 feet long.

The average mobile home retails for $6,000, which includes all furnishings. This amounts to about $75 per square foot compared to the estimated conventional construction of a minimal 1,000 square foot home of $15-17 per square foot (see table XXXIII). If an owner wants more room, he can buy a "double wide", two units units that fit together, a triple wide, a combination of long and short units, units which telescope vertically or horizontally, and units which contain one or more sections that can be flipped,
unfolded, or slid out from the main structure.

4. **Community Objections to Mobile Homes.** Aesthetic, social and political factors all create community antipathy to mobile homes. On aesthetic grounds because they are not as attractive as or look like most of the new homes being built in the suburbs. It has been pointed out by Bernhardt, that there is a lack of architectural innovation on the industry.

Towns may wish to exclude mobile homes on social grounds since they may feel that the "quality" of their town will decline if the lower income residents live there. Economic segregation is as dangerous as racial segregation.

In addition to the aesthetic and social reasons for excluding mobile homes, towns often are motivated by financial difficulties. Mobile homes pay less taxes than do more expensive housing units. Having mobile homes in a town may raise the tax burden on other families to provide mobile home dwellers with town services, especially schooling for children. This undoubtedly is one motivation behind restrictive zoning and subdivision regulations.

5. **Who Lives in Mobile Homes?** There are now approximately seven million Americans living in mobile homes. Many have moved into mobile homes in the last seven years, when more than half of all the 3,100,000 mobile homes built since 1947 were manufactured. An important reason for this growth is that states classify the mobile as a vehicle, not as a structure. It is therefore by and large exempt from the building codes, the union restrictions, and the real estate taxes that apply to conventional housing.
According to a study performed by HUD, one half of the heads of households occupying new mobile homes were under thirty-five. Only 21 percent of the heads of mobile home households were fifty-five or older and a mere 12 percent retired. Mobile home families are smaller than most average U.S. families; only 27 percent of them have two or more children under eighteen, compared to 38 percent of all families.

6. **Manufacturing.** The mobile home industry until just recently was the only large scale producer of factory assembled housing in the U.S. and the resulting low cost of production is the fundamental reason for the success of the product. A modern factory contains between 60,000 and 100,000 square feet of space, and is capable of turning out 2,000 to 3,000 units per year, or eight to twelve per working day in a single shift operation. With all production inside, weather is eliminated as a construction problem. The cost of labor runs about 10 percent of total costs, compared to 25 percent for conventional single family house, excluding land. Many companies pay on an incentive basis, and some let their workers go home once the day's output schedule has been met. One of the industry's real advantages is that it pays on the basis of an industrial wage rather than a building craft wage. Labor is not only relatively inexpensive but also efficiently used.

Nevertheless the manufacturer of mobile homes is not mass production; the number of mobile homes made a day is too small, and the work is not mechanized so much as organized. But the process
does resemble assembly line production in that the home is moved to successive stations at each of which workmen perform a particular set of tasks. The mobile home starts out as a welded steel undercarriage on top of which everything is built, step by step. The sequence of operations has a great deal to do with the cost savings compared to conventional building. In a conventional house, workmen do a lot of cutting, sawing, and drilling to install heating ducts, plumbing and wiring. In a mobile home, the heating lines are put in before any walls go up. And instead of being pulled or drawn through the structure of the house, the main electrical wiring is simply fastened around the exterior wall before the siding goes up.

When the structure is completed, the furniture and drapes are added at the last station of the factory. The mobile home is typically outfitted with a refrigerator, a range, furniture, carpeting, bedspreads, curtains, mirrors, etc.

By the use of factory techniques, the industry has been able to drive the price down. The price per unit has increased only modestly during the 1960's, and since mobile homes have been getting larger, the interior of the typical unit was 520 square feet in 1961 compared to 684 square feet in 1970. The price per square foot has declined from $10.75 in 1961 to $8.75 in 1970 (including furnishings). Meanwhile, the cost per square foot of a regular single family home has climbed steeply from $13 a square foot in 1960 to $17 in 1969 (see Table XVII).
7. **Financing.** The great attraction of mobile homes is their low price and small dollar down payment. In 1969, the average price of a 12 x 60 foot mobile home with furnishings was $6,300. Smaller units, with less expensive furnishings are available at prices as low as $4,000. Down payments on a new mobile home generally average between 15 and 25 percent of the purchase price, i.e. between $700 and $1500, considerably less than that required to purchase a conventional house.

To the purchase, one must add the price of land or rent for space in a mobile home park. A comparison made by Greenwald (3) of mobile homes and conventional housing costs in New England (Table XXXIII) clearly indicates why the demand for mobile homes has been growing among moderate income families. While the monthly costs of owning a new mobile home are not very low, they are less than rents for apartments with comparable space and for medium priced older homes available in the northeast (see Tables XXIII and XXIV). When one considers only the loan and interest payments and the park rental cost, a mobile home is only slightly less costly then the older home financed with a conventional mortgage ($120 compared to $132). Taxes and other homeowner costs, however, are considerably higher on the conventional house. The larger down payment required is another important factor which may price some households, especially young marrieds, out of the older home markets.
Table XXXIII
A Comparison of the Average Monthly Costs of Owning a Mobile Home and a Conventional House (First 5 Years of Ownership)

<table>
<thead>
<tr>
<th></th>
<th>$6,000 Mobile Home</th>
<th>$24,000 Conventional House¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financing Terms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of loan</td>
<td>Consumer instalment</td>
<td>FHA mortgage</td>
</tr>
<tr>
<td>Maturity</td>
<td>7 years</td>
<td>30 years</td>
</tr>
<tr>
<td>Interest rate</td>
<td>12 percent</td>
<td>8 1/2 percent</td>
</tr>
<tr>
<td>Downpayment</td>
<td>$1,200</td>
<td>$2,400</td>
</tr>
<tr>
<td><strong>Monthly Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan repayment and interest</td>
<td>$84.74</td>
<td>$165.32</td>
</tr>
<tr>
<td>Park rent</td>
<td>36.00</td>
<td>--</td>
</tr>
<tr>
<td>Taxes</td>
<td>9.20</td>
<td>50.00</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Heating and utilities</td>
<td>30.00</td>
<td>50.00</td>
</tr>
<tr>
<td>Insurance</td>
<td>5.00</td>
<td>10.00</td>
</tr>
<tr>
<td><strong>Total Monthly Cost</strong></td>
<td>$167.79</td>
<td>$290.32</td>
</tr>
<tr>
<td><strong>Income Tax savings</strong></td>
<td>-8.79</td>
<td>-42.20</td>
</tr>
<tr>
<td><em>(20 percent marginal tax rate)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$159.15</td>
<td>$248.12</td>
</tr>
</tbody>
</table>

¹ A $24,000 home was used in this example because this was the median price of an older home in the Northeast in early 1970. The median price of a new home was $31,600.

NOTE: Obviously, the homeowner costs for taxes, heating, etc. are only crude estimates of average expenses.

8. **Transportation.** Mobile homes, when they leave the factory, start a trip of up to 300 miles and sometimes to 500 miles. Generally, transportation costs run between 50 cents and $1 a mile. Most states limit the mobile homes to twelve foot widths but eleven states are now allowing fourteen foot widths. Many single unit mobile homes are kept below sixty-five feet in length because the state laws requiring vehicles over this length to have a front and rear escort, thus increasing the transportation costs. Because the mobile home in a sense is glued and stapled together, the structure can withstand highway speeds of fifty-five miles per hour and other vigors of the road when it rides on its own chassis.

9. **Future Prospects.** The day of the modular housing is swiftly approaching with 35,000 modular structures produced in 1970. With their experience in the manufacture of housing, makers of mobile homes should have an advantage in producing modular houses. The mobile home is itself a form of a modular housing—one that consists of a single module. Up to now, mobile home companies have been slow to get into advance modular housing. People like Bernhardt at MIT are looking into ways to take advantage of this capability.

In addition, a number of obstacles have to be overcome if mobile home construction is to meet part of the housing needs of the future. These include:

a. Improvement in quality of construction

b. Increased use of architectural form in the design of the mobile home park
c. Building codes

d. Zoning and restrictive ordinances to mobile homes

e. Increase in the number of mobile home parks

f. Increased living space

B. Military Construction.

A little known fact that people sometimes do not realize is that there is a great deal of home building done annually for the Department of Defense to house the families of military personnel. An indication of the size of this market is shown in Table XXXIV which shows the trend in military housing procurements over the years. These houses are usually built on military reservations and hence are usually exempt from local zoning, building codes, social and economic pressures, and labor requirements. Also with the government buying and operating these houses, it would appear to be an ideal situation to introduce innovation into housing. As an example of this, ten years ago the Air Force developed houses for its bases in Crete and Turkey which could be called relocatable (15). In 1970, it let contracts for 200 industrialized housing units to be built at George Air Force Base in California by a combined team of the General Electric Company and Del Webb a California builder. In fiscal year '72, it will be contracting for relocatable industrialized houses at eleven bases within the U.S. The advantage of the transportable home is that if the base is closed, the homes can be moved to another site.
Table XXXIV

Total Military Housing Construction

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Construction</td>
<td>8500</td>
<td>0</td>
<td>6,700</td>
<td>2,000</td>
<td>4,800</td>
</tr>
<tr>
<td>Rental Guarantee</td>
<td>0</td>
<td>250</td>
<td>0</td>
<td>494</td>
<td>2,070</td>
</tr>
<tr>
<td>Section 809</td>
<td>860</td>
<td>70</td>
<td>600</td>
<td>325</td>
<td>500</td>
</tr>
<tr>
<td>Excess Foreign Currency</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>Relocations</td>
<td>(200)</td>
<td>0</td>
<td>0</td>
<td>(000)</td>
<td>(444)</td>
</tr>
<tr>
<td>Totals:</td>
<td>9,360</td>
<td>320</td>
<td>7,300</td>
<td>2,830</td>
<td>7,398</td>
</tr>
</tbody>
</table>

1. George Air Force Base. The 200 unit project at George Air Force Base is the first factory built housing for the military. The units are similar to those G.E. will be building for Operation Breakthrough.

The military has an average statutory limit on the costs of family quarters of 21,000 per unit in the U.S. But because of the experimental nature of the George Project this was waived. The total contract was for 5.4 million dollars, resulting in a cost of each unit of approximately 30,000. However, the Department of Defense expects to put them up for 15 percent to 20 percent less than conventional housing, if they build 1,000 units per year (6).

The completed project will comprise 16 two bedroom garden apartments, 90 three bedroom townhouses, and four single family houses. Area ranges from 1095 square feet in the apartments to 1490 square feet in the larger town houses and single family units.

Features include fully equipped kitchens, heating and air conditioning, vinyl floors, patios and balconies, and carpets. Technological innovations include one piece cast plaster walls and ceilings, stressed skin floor panels utilizing plywood and resin impregnated honeycomb a one piece utility chase with a single pipe plumbing vent of plastic pipe, and factory assembled electrical harnesses.
The cast plaster wall is perhaps one of the most important innovatives in the building industry in a number of years. General Electric undertook to develop the process even though manufacturers of gypsum board said it couldn't be done. The process was developed and has unlimited possibilities for both inside and outside walls with different finishings, mouldings, textures, etc. This is a good example of the use of aerospace technology and a new fresh approach to a problem which the existing industry said could not be done.

Another innovation was the fabrication of a plant near the building site which can be dismantled and moved to another site. Workers employed in the factory are paid industrial rather than construction wage rates. This was made possible by a decision of the Department of Labor to waive the Davis-Bacon Act which requires contractors on federally aided construction projects to match the highest wages paid on any job in a given area.

Based on preliminary discussions with Air Force and General Electric personnel, the following preliminary results to date indicate:

1. Transportation of cast plaster modules is not a problem.

2. The factory built homes are aesthetically equal to a conventionally built home.

3. A factory built home does not have the stigma of a mobile home, it looks like a conventionally built house.

4. The industrialized home is stronger and has better acoustical attenuation characteristics than a conventionally built home.
5. It takes approximately 400 manhours to fabricate the house in the factory and a crew of eight men four hours to assemble a house on site.

2. **Modular Construction.** The Department of Defense together with other government agencies through the Federal Construction Council is investigating the use of modular construction for government buildings. This will allow standard performance criteria to be written for all types of construction thus allowing greater market aggregation possibilities (7).

C. **School Construction Systems Program.**

A new and innovative method of school construction has been developed in California in the early sixties in order to overcome problems of increased construction costs and changing education needs. This was the application of the systems method to school construction which has since been adopted by other school districts. The methods used have far reaching implications for the housing industry since systems analysis techniques were used to determine performance specifications and markets were aggregated to take advantage of economies of scale (8).

The initial question that finally provided the basis for action was, "why couldn't some school districts get together, detail their educational facility needs, and then get manufacturers to provide groups of building components which would respond to educational innovation in both a flexible and compatible way, and at the same time enable schools to be built faster and at a reasonable cost?" A feasibility study was launched and it was concluded
that pooling of projects by a number of districts would be required to provide sufficient market and stimulate the kind of response that was desired. As a result, the School Construction Systems Development (SCSD) Project was launched in 1961. A legal mechanism to bind participating districts together was established, and ultimately 13 districts having immediate need for 20 to 40 million dollars in buildings were included. Thus, a market was established.

Educational needs were studied so that industrial response could be sought.

Four basic subsystems were selected:

1. Structural roof
2. Lighting ceiling
3. Air conditioning
4. Interior panels

Performance specifications indicating what a product or component should do rather than what it should be were written. In addition to certain broad requirements (such as fitting together specific horizontal and vertical planning modules), the performance specification indicated how the product must act in response to structural loads, wind, noise, fire, light, etc. An important part of the SCSD performance specification was compatibility between the subsystems.

The objectives of the performance specifications were (8):

1. Freedom in overall planning from the single large-loft building to the multi unit, campus style school.
2. The simple and economical arrangements of a variety of spaces in a variety of ways for a variety of purposes.

3. Altering and rearranging these spaces as the need arises, it was estimated that 10% of the interior partitions would be changed yearly.

From the standpoint of production, the objectives of the performance specifications were:

1. Develop new products specifically for schools.

2. Encourage manufacturers to work together so that their products would constitute a system.

3. Guarantee a sufficiently large market for the products.

4. Finding a satisfactory way to bring products, producers and purchasers together.

While the bidders were busily working out the details of the SCSD subsystems, some of the bidders were busy marketing and developing their proposals outside SCSD. The first three buildings using SCSD components included two schools and a 300,000 square foot physical science research laboratory were built in 1964 before the California program buildings were completed.

Based on the SCSD program, the school house systems project was originated in Florida in 1966. This program developed by the State Department of Education was not a one shot program, but as soon as groups of school districts organized, specifications were written and bids sought. When another group of districts were ready the process was repeated.

Another SCSD spinoff, was the University Residential Building System (URBS). In response to a need for 4500 units of student housing, an approach similar to SCSD was used. A linked compatible
subsystems approach was established, using five subsystems: (1) structure; (2) partitions; (3) bathrooms; (4) furnishings; and (5) heating ventilation and air conditioning. It has been claimed that the URBS indicated that systems building had potential application for housing, motels, hotels, nursing homes, and many other building types with special requirements, and repetitive results.

The three projects discussed so far have used the "linked-compatible" subsystems approach. The subsystems were developed and bid by individual manufacturers, with some coordination of effort during bidding but with many of the detailed problems worked out after bidding in mark-up and pilot structures. The Montreal School Commission in a program called Research in Educational Facilities (RAS) went a step further by producing specifications for five compatible subsystems and solicited consortium bids. Manufacturers were encouraged to get together and submit already integrated package of compatible subsystems.

Another program undertaken in Toronto called the Study of Educational Facilities (SEF) went even further. The SEF felt that the project had both short and long range objectives: Short range - to provide school buildings in metropolitan Toronto with the usual objectives of quality, flexibility, cost, time, and compatibility; and the long range - to develop many components and combinations of components which could serve as a great "catalog" of subsystems to be used all over North America. SEF started
by considering a broader range of subsystems:

1. Structure
2. Atmosphere
3. Lighting/ceiling
4. Interior space
5. Vertical skin
6. Plumbing
7. Electric/electronic
8. Casework
9. Roofing
10. Interior finishing

In its performance specifications, SEF developed a concept called the "mandatory interface" in which the subsystem developed by the manufacturer had to be compatible with at least two other subsystems bids in each category with which a mandatory interface was stated.

In summary, these programs addressed rather successfully the problem of incentive for initiative and innovation in school building design by use of:

1. Systems Analysis
2. Performance specifications
3. Market aggregation
4. Uniform production
5. Flexibility in design

D. Previous Government Activities in Low Cost Housing. (9)

The Office of Urban Technology and Research of the Department of Housing and Urban Development (HUD) embarked in 1968 on a pioneering program to apply professional research and development talent in a comprehensive manner to the experimental investigation
of the constraints encountered in the provision of innovative housing for low income families. This program was called the "In-Cities" program with the following purpose:

The In-Cities Research and Development project of the Office of Urban Technology and Research in the Department of Housing and Urban Development was initiated to develop an objective, and, where possible, quantitative understanding of the constraints that inhibit the introduction of innovations into the provision of housing for lower income urban families. This assumption underlying the rationale for the project is that many innovative techniques and practices exist which could substantially increase the housing supply available to these families by reducing housing costs, increasing the volume of new construction and rehabilitation, and improving the acceptability of housing to its users. For instance, new techniques or practices have been identified in the areas of housing design and construction methods, labor practices, administrative procedures, legal and financing approaches, and strategies of tenure and ownership. Few, if any, of these innovations are wholly new in the sense that they have never been considered for use before. Most of these have been thoroughly explored in principle. Some of them have been tried before and failed for reasons not fully understood. Some have succeeded on a small scale but have not been adopted for large scale use. Preliminary studies were funded with three contractor teams, Westinghouse Electric Corp., ABT Associates, and Building Systems Development, Inc. (with Kaiser Engineers).
In June of 1968, HUD consulted with Kaiser Engineers, Division of Kaiser Industries, Inc., to develop and implement a nation wide integrated experiment to be conducted in ten to twenty cities. Kaiser included as subcontractors on their multidisciplinary team, Building Systems Development, Inc., Turner Construction Corp., Real Estate Research Corp., Battelle Memorial Institute, and the Organization for Social and Technological Innovation.

Eighty-two cities were investigated for hosting one or more experiments. From those proposals submitted, an experimental plan was developed which consisted of six subexperiments, each comprising one or more housing projects to be constructed in a city. Total cost of the program was estimated to be five million over two years and ten million over four years. It is interesting to note that this program was initiated during the Johnson Administration and President Nixon took office in January of 1969.

A decision was made by HUD in May of 1969 to continue effort on only one subexperiment in Miami, Florida. The main purpose of this experiment was to be in financing using sections 23, 23g, and 235 of the 1968 Housing Act for new construction of leased housing. Other innovations being implemented involved land availability and acquisition, coordination of non profit sponsors, a general plan for obtaining labor agreements, and consideration of user needs and community acceptance. The primary reason for this reduction were given as:
a. First, the length of time required to develop a coherent overall experimental plan stretched from one month to nine months. This delay was due to conceptual difficulties inherent in the nature of the experiment, to communication problems among the participants, and to the vast number of innovations which appeared reasonable to include in the experiment but which were not readily winnowed or combined. The delay naturally caused extensive impact on project planning and implementation.

b. Second, the magnitude of the effort required to conduct a dozen or more innovative construction projects within cities was found to be much greater than originally estimated. At the end of nine months, estimates of the cost and time to conduct twelve subexperiments were roughly triple the initial proposed amounts. The errors in the original estimates were basically due to lack of hard knowledge about the effort required to obtain sufficient city-specific information, to locate and obtain land, and to negotiate with the cities, sponsors, investors, and builders to construct the housing.

c. Third, the pressure in urban centers and at HUD for a more direct attack on national housing needs on the basis of the information gathered and lessons learned to date forced consideration of a high volume program rather than continuation of the five or more planned subexperiments.

Some preliminary information is available from the Phase I effort by the three contractor teams as assembled by Kaiser in a
The program as originally conceived is thus considered by the originators to be the forerunners of "Operation Breakthrough".
The present reduced programs calls for construction of 230 units at six sites within Dade County at a total program cost of $5.5 million.

E. European Industrialized Housing.

1. **Introduction.** A great deal of experience has been gained in Europe in the field of industrialized housing which could be useful in developing industrialized housing in the United States. Since WWII, the Europeans have had to rely on industrialized housing construction because of the critical shortage of skilled workers and the need to replace rapidly housing destroyed in the war. The housing shortage in Europe developed for a number of reasons:

   a. Destruction that occurred during World War II.
   b. Population explosion
   c. Changing age structure of the population
   d. Movement of people to areas of industrial concentration
   e. Lack of incentive to invest in residential construction in some countries because of rigid rent control practices.
   f. High living standards set by the government
In 1967, the level of building per year in France, England, and Italy was between 350,000 and 400,000 units while West Germany was the only major country to produce over 500,000 units annually.

The highest annual level of home building in relation to population was in Sweden with 12.6 dwelling unit per 1,000 inhabitants. The Netherlands and Germany follow with 10.3 and 9.7 respectively. Belgium is reported to be at the low end of the scale with about 5.0.

Because of this need for housing, industrialization of housing has become widely used and accepted as compared to the U.S.

2. Construction Techniques. In Europe, the most prevalent building material used in concrete and clay products. In contrast to the U.S. where wood is usually used in low rise structures, the Europeans have developed standardized concrete components and have concentrated on high rise building.

To date, the European building systems are used for publicly financed apartments, schools and industrialized buildings. In a study conducted by Battelle (11), it is claimed that only 25 percent of the structures currently built in Europe utilize systems building. In order to obtain industrialization of building, European companies have developed building systems that can be automated, mechanized and can use fairly standard components.

The building system as used in Europe encompasses the entire process. It starts with the home design and concludes with the finished structure. All the inherent operations such as site preparation, manufacturing of components, materials handling, and
assembly are included in the system. Also, the responsibility for the building system as well as the entire construction process is usually concentrated in one organization. The end result of a building systems is excellent control over the whole construction process. The advantages of the system become apparent when one compares this method with the fragmented construction process in the United States.

Although there are many hundreds of building systems available throughout Europe, only a few appear to be successful. The key to success seems to be a company's ability to manage, organize, and market its systems. Of the building system people interviewed by Battelle in their study, many felt that the organization of the company was more important than the technical aspects of its system. For example, a technically competent system in the hands of a weak organization is doomed to failure, as the company will not have the ability to market its products.

The advantages that Europeans appear to have gained by using industrialized building methods rather than traditional methods are listed below (10-14).

**Advantages to Owner**

-savings in total cost of structure - 5 to 15 percent.
-reduction in time of actual construction -30 to 50 percent. (in many cases the rate of building could not have been maintained without using industrialized techniques.)
-good quality relative to actual cost
-more certainty as to final cost
-reduction in labor input by 30-50 percent
Advantages to Architect/Engineer

- less design and drawing time
- more certainty as to availability of components
- more certainty as to unit costs
- easier and less costly procedures in the event that changes or subsequent alterations are necessary

Advantages to Builder

- reduction in on-site labour man hours, particularly skilled labour, by 25 to 55 percent
- less uncertainty due to inclement weather
- more accurate costing due to higher content of factory labour
- less fitting or adjustment on site because of greater dimensional control of factory-made components

Advantages to Manufacturer

- better opportunity for production planning and control and use of computerized control system
- reduction in inventory and inventory control through use of standard components
- reduction of drawing office costs
- better quality control

3. Reasons for Success of the Building Systems Approach in Europe. There are a few very essential factors necessary to support the systems building approach. Probably the most important factors are volume, concentration of demand, and continuity of production, which is a function of demand. The system sponsors must have a large number of units to produce and a flow that will last for 3 years or longer in order to amortize the cost of the plant and equipment and to gain an efficient flow of production through the plant. It is interesting to note that the
factors necessary for a successful industrialized building system are almost identical with those applying to any industrialized process regardless of the end product.

In Europe, these factors are attained because (1) the majority of the buildings being erected by systems building are large, concentrated public-housing projects are sponsored by the government, (2) in many countries it is quite common for the potential occupant to wait up to 5 years for a unit (therefore, the demand far exceeds the supply), and (3) most of the system sponsors do not bid competitively on the projects. Contracts are usually negotiated or simply awarded to a contractor because the overall cost of bidding procedure is felt to be expensive for the losing companies. Naturally, the concentrated volume and continuity of flow would be difficult to achieve in the United States because of the small number of public housing units built per year, the relatively small number of housing projects exceeding 5,000 units in a given area, and our system of competitive bidding.

Throughout most of Europe, systems building was introduced because of government action or other incentives provided by the government. Without the government's support, the system sponsors would not have been able to survive in most of the countries.

Based on European experience, there are certain conditions that appear to be necessary for the successful and economic use of building systems. These are:
a. The existence of a substantial housing program either under the direct control of or financed by government

b. The major portion of the housing program consists of apartments rather than single-family units

c. An annual production volume of at least 1,000 units, varying by type of production facility used—with continuity up to five years

d. A minimum site size of 200 units, the average being near 500, providing both continuity of work for particular systems and repetition of individual components

e. The major sites being restricted to a few areas, probably the outer suburbs of major metropolitan areas, and within 25 miles of the producing facility

f. A readiness on the part of architects to work within the limits of the selected system without trying to change the system to meet their individual requirements

g. A positive attitude of encouragement by the government which may be expressed in terms of special financial conditions or technical help

h. The existence of a shortage in supply of both dwelling units and skilled labor

4. Government Involvement. As was mentioned in the previous section, systems building could not have survived without government involvement through either direct investment or providing incentives. Involvement by government in home building varies throughout Europe. The following are observations made by the Battelle Study Team (11):

a. France. The French Government has probably taken more positive action to encourage systems building than any other government, through alleviating a number of major sites for experimental purposes. Their first building system experiment, which was initiated shortly after WW II, proved to be premature as there was still an ample supply of skilled building labor. About 1955, the
experiment was repeated on a larger scale; success was achieved in this attempt because of a shortage of skilled labor had materialized. This shortage increased the cost of traditional building and allowed system building to be competitive on a cost basis. Since that time, system building has made rapid progress in France, largely because much of the building program has been controlled by the central government. This has enabled the government to provide systems sponsors with the two essentials for their economic operation—concentration of demand and continuity. Furthermore there is a basic guarantee of quality, since all the systems used for government financed housing projects must have obtained the CSTB (French Building Research Station) Agreement Certificate.

The French Government is continuing to lead the way in the development of new building techniques. A recent statement of government policy has declared that its aim is to create a sufficiently large market for standardized components so that substantial economies of scale can be achieved. The government (through CSTP) has established performance specifications for a number of components, and these are being used for a program of 50,000 dwellings to be built over 3 years, in lots of 300 at a time. It is claimed that significant cost reduction has already been obtained.

In the Netherlands strict control has been exercised over construction activity, which has been used as a basic economic regulator and as a control of the demand for skilled labor.
Each contractor is allocated an annual quota, but this may be increased by up to 50 percent if system building is used because of the reduced skilled labor content. Moreover, every building requires a building permit and this is easy to obtain if an industrialized method of construction is used. It appears that systems will be used in the Netherlands even if it costs up to 10 percent more than traditional building.

In Denmark and Sweden, industrialized building has been encouraged by the governments for two reasons: (1) to attempt to stabilize the cost of construction because of the high cost of on-site labor, and (2) to enable construction to be carried on during the winter months. The Swedish government has also declared its intention of allocating a fixed quota of the total housing program to industrialized methods of construction.

While the Ministry of Housing has taken definitive steps to encourage the use of industrialized building through the creation of the National Building Agency, the use of such methods cannot be imposed unless they are demonstrably cheaper than traditional forms of construction. The extent of industrialized home building in the U.S. and Europe is shown in Table XXXV.

It appears that the principal factor affecting the use of building systems is demand. When the demand is great enough, certain building systems may be used in the United States. This situation might occur in the future if: (1) the demand for apartments and for
Table XXXV

Extent of Industrialized Home Building (14)

(per cent)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>France</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td>65-70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td>66*</td>
<td></td>
</tr>
</tbody>
</table>

single-family housing exceeds our ability to meet it using existing methods, (2) the government creates this demand by allocating much more money to the public housing sector of the construction industry; or, (3) the government changes the bidding procedure on some very large jobs or allocates extensive funds for building entirely new cities as is proposed in the "Urban Growth and New Community Development Act of 1970" (15).
F. Other Attempts at Low Cost Housing. (16)

A number of attempts have been made at building low cost housing since WW II. This section will briefly summarize some of these attempts both by the private and government sector at low cost industrialized housing and components.

1. Steel Houses. The most ambitious attempt ever to produce a complete steel house in the factory and pass the savings on to the home buyer was made by Lustron in 1949. The Lustron house was considered extraordinarily attractive and livable when it was introduced. Initial goals were an output of 100 houses per day that would sell for $7,000 each.

Naturally, the cost of a prototype was high. Moreover, tradition-bound building code officials often made acceptance tough. In Princeton, New Jersey for example, it took almost a year to convince local officials that steel was strong enough for a house so that one of the Armco prototypes could be built there.

Some manufacturers lost heart prematurely. A New England developer wanted to put up 200 steel houses, but the company wouldn’t invest in the large press required to mass-produce panels for them. The alternative was fabricating the panels by hand, which meant an excessive cost, and the deal fell through.

The steel house introduced by Rheem adapted a structural system used successfully for schools and factories. According to a Rheem official, the house failed to catch on partly because
"builders didn't want to take on an unfamiliar construction system."
The company also felt the contemporary appearance limited their market, so they abandoned the house.

2. Aluminum Homes. The same lesson as Lustron was learned, unfortunately, by the Alside Homes people, who introduced a handsome factorymade aluminum house in 1962. It was originally designed to sell for a very low $12,000 plus land. A series of cost increases forced the price up considerably (but not much beyond conventional houses of the same size). For one thing, the company was pioneering a new kind of steel framing system enclosed with low-maintenance, high-thermal-resistance wall and roof panels. Other high-quality design and construction features which further increased costs included all doublepane glass, central air conditioning, and a deluxe kitchen and bathroom.

Initial sales of the house were slow as the company struggled to build up distribution and sales. It was said that many builders held off because of the contemporary design and unfamiliar materials. Yet large numbers of people from all over the country wrote in wanting to buy the house.

The Alside people had sunk ten million dollars into producing their houses, but more capital was needed to get them accepted and sold. They didn't have the money and reluctantly ceased production in 1963.
3. **Precast Concrete Panels.** Precast, hollow-core concrete panels were used in housing projects as early as 1906. In the 1940's, World-renowned architect Walter Gropius and his associate Conrad Wachsman developed a highly flexible modular panel system. Their limited number of standard panels could lead to as many as 25 radically different house designs. The architects were ahead of their time, however, and had to give up.

4. **Plastic Panels.** Other people with Alcoa and the Koppers Company developed building panels which used a strong and durable polystyrene plastic core. For undisclosed reasons, Alcoa apparently lost interest after completing its first attractive prototypes, and no more were built. Koppers spent years and a reported $18 million on its Dylite building panel system. It opened a new plant in Detroit to manufacture the panels, but found it difficult to get the system accepted for houses.

   One of Koppers' successes was in a research house sponsored by the National Association of Home Builders and shown in the November, 1960 issue of Better Homes and Gardens. The panels had a variety of exterior and interior finishes. Here, the "brick" was actually cement applied to a plywood skin and scored in a mortar pattern.

   This panelized system initially cost about 10 to 20 percent more than a conventional structure. Moreover, the Dylite system often had to be individually tested and approved by local building code officials before it could be used. This meant extra money, and sometimes the system was simply turned down cold. Koppers
was caught in the same vicious economic circle that stopped other innovators. Initial sales were not high enough to get into really economical mass production. But before sales could go up, the price of the panels had to come down in order to sell them. It was the classic old chicken-or-egg conundrum - which comes first?

Dylite panels were used in about 800 houses, but they were still not a going thing. So in 1963, a period of semi-recession in the home building field, Koppers stopped production and withdrew its panel system from the market.

It was a sad day. A proven panel building system might well be the answer today to a runaway lumber prices and the growing shortage of skilled construction labor. Foam-core panels, for example, could give lumber a run for its money, since it requires less on-site labor than does conventional house construction.

5. Levittown. There is absolutely no doubt that mass production can cut costs sharply and give us better houses. This has been demonstrated by a number of large-scale development builders - and in spectacular fashion by the Levittown houses of builder William Levitt and his late brother Alfred.

Instead of a factory assembly line moving past waiting men and materials, the Levitts moved their workmen and materials past a kine of stakedout house sites. In short, they moved the factory to the field.

Twenty-six crews of masons, carpenters, roofers, painters (and so on) moved from house to house, one after the other like clockwork. Trucks arrived at each house with just the right ready-
made materials at just the right moment for just the right men. At the peak of their postwar production, the Levitts were turning out 100 houses a week, 20 every working day.

They could sell the houses as much as 35 to 40 percent cheaper than comparable houses of conventional construction. But this was possible only because each Levittown was built in one large suburban land area subject to just one building code. Therefore, the basic house structure could be standardized for real efficiency.

The exterior appearance, however, was varied from house to house - to avoid look-alike monotony. Today, each Levittown is an attractive community in which to live, characterized by wide curving streets and a wealth of shade trees.

If the Levitts are to be criticized, it is for the somewhat uninspired architectural design of their houses and their lack of major technological innovation (which is not to criticize the quality of their construction). Obviously, the Levitts elected to build and sell houses of accepted design at the lowest possible price. And sell they did.

6. Kitchen, Bathrooms, and Utility Cases. A large percentage of the finished price of a house is accounted for by the kitchen, bathroom and utilities. The kitchen is the single most expensive room in any house. Several companies entered the field starting in 1955. These are summarized in Table XXXVI.
### Table XXXVI

**Companies Originally Involved in Utility Core Production**

<table>
<thead>
<tr>
<th>Company</th>
<th>Year</th>
<th>Type</th>
</tr>
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<tbody>
<tr>
<td>Borg-Warner</td>
<td>1946</td>
<td>kitchen-bathroom back to back, with furnace water heater, central plumbing tree, wiring center and laundry equipment</td>
</tr>
<tr>
<td>Frigidaire</td>
<td>1955</td>
<td>&quot;Holday Kitchen&quot; modular design</td>
</tr>
<tr>
<td>General Electric</td>
<td>1958</td>
<td>&quot;Kitchen Center&quot; combined seven household kitchen operations in one compact eight foot wide unit with a continuous stainless steel counter top</td>
</tr>
</tbody>
</table>
Other utility cases were introduced later by several prefab house manufacturers - but building codes and local building officials were largely responsible for stopping each one in its tracks. Many demanded changes or modifications: others simply outlawed the utility core. Borg-Warner was compelled to operate on a stop-and-go production basis, changing the design of cores on his assembly line according to codes in areas where the particular units were to be shipped. It was impossible to standardize on a basic design that could be mass produced economically.
7. **Mobile Home Technology.** The first systematic application of mobile home methods in the production of low-cost "fixed" housing for lower-income families was the wood-frame Fredella Village project completed in Vicksburg, Mississippi, in December 1967. The fabricator of Fredella, Magnolia Homes Corporation, has also completed a more elaborate wood-frame project in Amherst, Massachusetts.

Slower progress has been made in metal-frame construction. An on-going project in Michigan City, Indiana, involves the use of metal-frame modules clustered around a core unit. Another project underway at Reston, Virginia, is exploring metal-frame suspension methods for multi-story structures and the use of modular housing in the "New Town" setting.

8. **Puffton Apartments: FHA 233, EH-134.** The purpose of the project was to find if the regular production methods of a mobile home manufacturer could satisfactorily produce architecturally sophisticated clusters of garden apartments of low-cost wood construction containing a variety of apartment sizes.

Puffton apartments has been completed at Amherst, Massachusetts. Project sponsor was Puffton Associates and fabrication was carried out at the South Hill, Virginia, plant of the Magnolia Home Corporation. The development consists of 104 garden apartments arranged in clusters of 4 apartments each. Each cluster contains 1 three-bedroom apartments (864 square feet), and 2 one-bedroom apartments (672 square feet). The multi-bedroom units have second floors,
2 baths and cathedral living room ceilings. All units have separate dining rooms.

Each rectangular cluster of 4 apartments is formed by assembling 6 modules; 2 second floor modules are placed on top of 4 ground floor modules. On the ground floor, the 2 interior modules placed back to back contain the mechanical systems. Paneling is added to the second floor to complete the sloping roof.

Modules were produced at the average rate of 2 per day on regular mobile home production lines, using normal tools and methods. The total in-plant production of 162 modules was completed in 90 calendar days with a work crew of 120 non-union unskilled laborers, plus a small number of skilled "lead men." Transportation of flat bed trucks took 2½ days for the 600 mile trip from Virginia to Massachusetts.

9. **Housing Research Inc.: Indiana LIHD-2, H-608.** This project was designed to investigate whether a mobile home manufacturer could produce an architecturally pleasing, in-town, multi-level cluster of low-cost dwellings. Model dwellings are to be designed, fabricated, erected and sold to a non-profit foundation for occupancy as low-income housing, in Michigan City, Indiana.

The notable architectural features of the project's building design as it has developed are: a central core containing, on each floor, the kitchen and bathroom facilities for 2 apartments; 4 pre-fabricated modules arranged in pinwheel fashion around each core, supplying dining rooms and bedrooms; and exterior stairways
providing 2 means of egress from each apartment. The structural design calls for the use of standard steel framing elements generally finished with vinyl-clad sheetrock. The only wood used will be the sub-floors. The units will meet the BOCA code, which is acceptable in Michigan City.

10. Reston: Virginia LIHD-1, H-748. This project was to investigate whether or not a mobile home manufacturer can produce low-cost housing suitable for inclusion in a new town. If the concept proved feasible, Gulf-Reston, Inc., the general contractor, would apply for approval for 200 units of 221-d-3 housing. The contract produced architectural studies, structural designs, a site plan and other necessary plans for the implementation of the project. Three prototype modules were fabricated and subjected to various transportability and stacking tests. The prototypes were also used to experiment with a number of building materials and components.

The modules were to be factory fabricated of steel components to be assembled into rectangular dwelling units of two, three, and four-bedrooms, complete with kitchen, bath and storage facilities. They were transportable by road or rail. The dwelling units were studied for arrangement variously as town house clusters, garden apartments, and terraced hillside dwellings; and possibly vertically into elevator-served high-rise buildings. A common structural and mechanical system, though varying dimensionally, was proposed for all these types. For high-rise structures, the units could
be supported within a network of hollow steel columns or masts with a large private outdoor space over, under, or to the side of each individual unit.

Estimated construction cost per dwelling unit (1152 square feet) was $10.00 per square foot, an anticipated saving of approximately 10% over conventional cost. Total development cost expected to be in the region of $13.40 per square foot.

11. Precast Concrete Modules. The basic steps of the method begin with the casting of the modules in a yard or plant, followed by a varied degree of finishing, ranging from the installation of basic fittings to complete furnishings. Modules are then transported to the site, erected by a crane in various stacking arrangements, and joined. Finally, finishing is completed and utilities are connected.

The use of concrete modules in residential construction originated in Europe, Russia and Israel. The first building in North America to be constructed with this method was Habitat at the Montreal World's Fair of 1967. Habitat was a very expensive but dramatic exhibit of a combination of concrete module techniques and architectural concepts appropriate to a high density urban environment. Another center of activity was San Antonio, where the H.B. Zachary Company used concrete modules to build: first a motel in 1967; next, a hotel in the Spring of 1968; and presently, a garden apartment complex. Zachary has achieved very rapid
construction times and has greatly reduced costs from the Habitat level. Another (HUD) project completed in the Spring of 1968 is Uniment, in which an attempt was made to cut costs still further with a method of chemically reinforcing concrete. A different approach to cost savings in a (HUD) project has been followed by the Illinois Institute of Technology Research Institute, which has conducted a systems analysis of alternative techniques leading to a construction system design specification. At the present time, concrete module buildings are planned or under construction at New York University, Puerto Rico and in the District of Columbia.

12. "Phoenix": Michigan LIHD-4, H796. The purpose of the project is to determine whether in-city, scattered-site, low-cost housing can be produced under the following set of three conditions: (1) the use of land owned by the Archdiocese of Detroit, and the active participation of the Archdiocese in the experimental project; (2) the involvement of members of the low-income community to be served in the planning and direction of the experimental project; and (3) the employment of the Neal Mitchell housing system consisting of precast modular posts, beams and slabs of cellular (foamed) concrete, site-assembled into a set of structures with great architectural flexibility.

13. Rehabilitation Projects. The problem of deteriorated housing exists in every major U.S. city and in most smaller ones. Although such housing affords shelter, it does not provide a satisfactory living environment by any reasonable standard.
In addition to attempting to alleviate this major problem, the HUD rehabilitation projects were addressed to the following problems:

**Cora Street EH-90** - How inexpensively can an adequate rehabilitation job be done?

To what extent can the elements of the building to be rehabilitated be repaired rather than replaced by new elements?

**N.Y. LIHD-2.** - Can a rehabilitation effort be effectively accomplished without removing the tenants from the building?

Can a large scale rehabilitation effort be carried out without a major disruption of the community and its residents?

Can private owners be interested in rehabilitating their buildings under one of the HUD programs?

Can the social and economic factors at work during and after a rehabilitation project be usefully analyzed?

**Douglas-Lawndale** - What organization, city government or private contractor is most effective in rehabilitating dwellings?

To what extent and how can residents of the area to be rehabilitated be employed in a large-scale rehabilitation?

To what extent can the small contractors resident in the area to be rehabilitated be employed as sub-contractors in a large-scale rehabilitation?

14. **New York LIHD-4: Instant Rehab, H-671.** The "Instant Rehab" project developed a method which will allow a five-story tenement to be completely rehabilitated in just a few days. This is accomplished by moving the tenants to a hotel, working around the clock in a carefully planned manner with a large trained crew, and using special components and subsystems such as prefabricated stacking core units.
The core units contain all mechanical and electrical systems, a full bathroom and a pullman kitchen. Three 9 x 9 foot holes were cut vertically through the building; the cores were lifted from the street by a crane and lowered into the building. The cores were then leveled with the floor and secured, and the mechanical and the electrical were made. The remainder of the rehabilitation proceeded in the normal fashion.
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APPENDIX IV

SELECTED SURVEY COMMENTS
Selected Survey Comments.

The following are selected comments made by persons interviewed with regard to low cost industrialized housing, the housing industry, Operation Breakthrough, the unemployment of scientists and engineers, transferability of their skills to the public sector, and experience of aerospace contractors working on public sector programs.

1. High Government Official

Aerospace firms specialized engineering organizations. Even organizations like NASA resistant to change. Aerospace people like technology don't like to be directed. Similar problems of aerospace firms were textiles. Get companies and individuals turned and retrained. Opportunities for retraining in occupational health and safety field - Safety engineers. Scientists and engineers like loom fixtures difficult to know what to do with them.

2. Staff Member, Counsel of Economic Advisors

Aerospace transition made too rapidly Difficult problem No solution in sight.

3. V-P Finance Large Metals Company

Acquired medium sized home builder in California (200 units/year) Because of concern over acceptance with modules went to panel construction for Operation Breakthrough Zoning bigger problem than building codes Homebuilders don't have sufficient capital, one of the advantages of a large corporation
Sees no cost advantage of modular housing

Advantage of large corporation in home building field, expertise in finance, production, R&D etc. within the organization

Not constrained to aluminum construction, using concrete modules in Florida

Housing costs - 45% development and financial costs, 55% construction

Problems with large corporations
- Difficult to face people
- Problems with acquisitions
- Whims of top executives
- Long decision times

4. MIT Professor

Homebuilding complex market
Homebuilders think market will always be that of small builders

5. NASA Official

Top 10-15% aerospace engineers could get job anywhere, remaining may require retraining

6. DOT Official

NASA - objective clear, technical objective solveable
DOT - Bureaucracy, objectives not clear, problems not technical
Semi autonomous agencies within DOT difficult to turn around
Vested interests within the same department i.e., highways versus high speed transportation
Transportation systems center - technical arm, job shop, consultants

Difficult environment in which to plan, objectives not clear

Emphasis in rapid contribution, not basic research center,
on line real time help, not transportation for year 2000

Transportation requires more ME and CE's rather than Aerospace engineers big heavy structures, flutter analysis, etc.

Modeling and simulation of total systems being done

Close control over budget,-salaries, overhead, equipment, etc.

run like industrial organization

Lack of National will or objective in transportation

NASA - Industry team - no different in DOT

Many projects of short term nature, engineers have been able to turn around

80 discrete tasks - majority in-house, forcing function for contractors

TSC main link with university and contractors

Technology in order of importance (1) space, (2) transportation, (3) construction

Transportation contractors not vertically integrated

DOT - until recently was not in the systems contracting business

In some NASA operations couldn't tell contractors from government people, good relationship

Tracked air cushion vehicle - first systems approach with a single prime contractor

Greater flow of people from NASA to DOT

7. NASA Contractor

Not impressed with NASA management techniques

Innovative management techniques developed by ABT
multi-engineer game-forecasting, planet-planning, evaluating technique with budget restraints

NASA contract to study application of space hardware to urban problems

Intermediary between user and producer-applications engineering

Show user how to aggregate market

NASA aware of every material property, knew most important characteristics and parameters

Construction industry doesn't know difference between two properties, strong intuitive feelings, efficient evaluation of new materials through years and years of experience

Suboptimization in construction

No good systems approach in housebuilding, giant segregated market

Architect specification - technical specifications, performance specifications, or generic problem statement needed i.e. cooking device functions.

How do you market new technology developments?

8. Official of Modular Home Building Division of Large Conglomerate Builders very lack on schedules

AVCO thru aerospace experience very conscious of keeping schedules

Drawings not normal in home building industry

AVCO developed detailed drawings for flexibility, control of frame, and quality control

Minimum property standards - federal and in addition must consider local codes

Because of local codes have to tailor each house, local building inspector holds power
Need area or state control over codes other than local
Weather determining factor in home building
Cape Cod Inspector likes double floor timbers, not load
bearing, hence unessential, either conform or else
No difference in production process or techniques missiles
or houses
Many ways to improve house but people are resistant to
change
Learning curve predicted
Assistance from Wilmington plant in production fixture
design
Erection time on site 2 days
Factory built house better home for the money
Factory labor - high technician class of carpenters and
plumbers
Have architect as chief designer
$2-3 million required to start modular housing factory
Mobile homes sacrifice quality
9. V-P of Large Conglomerate
ROHR built prefab bathrooms but failed because of labor
problems
Suncook, N.H. pilot plant - 100 employees
Richmond, Indiana, have plant, market for modular motel
rooms at $5,000/room
Have production capability
In home building marketing - have gone thru 3 marketing men
Project manager needed for high technology programs
Went into printing business in Roxbury with hard core
unemployed and did poorly because they knew nothing
of printing
10. Official of Federal Contract Research Center

Major innovation would be to break existing road blocks with existing technology.
Defense has had open-ended blank check, doesn't have constraints of public sector.
Defense equates technical sophistication with technical performance.
Modern counterpart of the application of Social Engineers' mentality had beginning play in mid 19th century in France.
DeLessups was Social Engineer, reference- F. Von Hayek, "Counter Revolution in Science", Glencoe Free Press.

Sociology of Knowledge - Applying physical science models.
Use of aerospace industry in public sector would be disastrous.
Industrialized housing has been a series of one shot endeavors, benefits of learning from production not there.

11. Government Building Official

Building industry lacking in logical thinking.
DOD study with appendix on Systems Approach, SCSD, and SCF Toronto.

Problems of industrialized housing - quality certification, codes.
Low income housing becoming housing for middle income.
Professor J. Brown of George Washington University, working on land problems.

Building codes cover a spectrum.
Technical forecasting just being introduced into building industry.
Home building is not a controlled environment, no new technology required, but how to use existing technology.
Performance requirements in building industry not well defined.
Building industry information network is poor, no statistics, particularly on costs
Lack of research on fire
Building guide criteria problems
evaluation interpretation, building in excess
European problems
lack of flexibility with concrete, ...how far do you go with industrialized housing?
Federal Construction Council (FCC)

DOD, Veterans Administration, GSA, Post Office and HEW,
market aggregation in government building and standard performance

Air Force Mod Program - General Performance Criteria

12. United States Air Force Home Building Official
Aerospace geared to CPFF contracts, experience
" not mentally equipped to build house - too concerned with tolerance when they are not critical in home building
Aerospace engineers think about materials differently than homebuilders, homebuilder usually not concerned with material efficiency
Aerospace engineer concerned with material efficiency but not cost effective in housing
Aerospace companies put massive engineering in least cost areas To make factory production economical 500-700 units/yr.
rather than 200/yr originally estimated, min. size project 5000 units
Demountable factory originally planned for 2 week erection time, took 90 days, still required permanent facilities: asphalt drainage, hold-up tanks, tie down bolts
Transportation of modules not a problem, cast plaster held together well
Key to success at George Air Force Base, was the use of
Davis-Bacon Act
Modular house at George aesthetically equal to conventionally built house, superior in strength and sound attenuation
Building 1 home/day, erecting 2/day with 8 person crew (including oiler and attendant on crane)
G.E. Honeycomb floor too expensive, cast plaster walls very good
G.E. provides good technical management, and production experience
AF management personnel for George project. One man full time for year, followed by 20% of one man's time for 9 months
G.E. matrix organization does not fit housing well
G.E. lack of empathy with building construction
Different mentality - builder closer to people, aerospace too discipline oriented
HUD and FAA contractor oriented rather than life cycle oriented
Air Force developing relocatable, modular homes
AF not going back to mobile homes and all that they stand for

13. NASA Official

Many things developed for space cannot compete in commercial markets
Aerospace can and should remain in high technology areas i.e. transportation not sewage where the problem is not technical but matter of regulation
Aerospace costs roughly $50,000/man year of effort
40,000 unemployed scientists and engineers would require $2 billion expenditure on other programs
Technology must move forward, more R&D funding needed,
SST—Forewarning of being second best in technology,
Anti technology bias

14. University Professor
Aerospace skill transferable
Transfer of complete management teams may be preferable
On the job training would be productive, aerospace people
quite adaptable

15. Aerospace Company Official
Aerospace too fat
Have to face the world
Aerospace people like machinists
Can't turn people around over night
Housing bad investment, labor main problem, everyone builds
homes
Stick to existing capabilities
Aerospace's soul is research, heart is engineering and
development
NASA has great deal of people who could help HUD, HEW

16. Rand Official
Public sector problems
40% problem definition, 10% model building and
simulation, 50% implementation
Problem of introducing new technology to old line companies
using outmoded technology, i.e. fire fighting
NYC Fire Department has $300 millions
Problem of working within the existing institution
Many at Rand, N.Y. do not have aerospace backgrounds
17. Aerospace Contracting Official

Government never pays twice for anything
Requires an unbelievable amount of paper work for even screws, tc.
Low cost housing being buried under paper work
NASA people brought reporting and management ideas with them

18. President of Large Metals Company

Picked up engineering firms and architectural firms for housing
Turnkey housing only government program which is working well,
cut red tape, 20-25/unit
Bought Housing Corporation of America
Building concrete modular houses outside country
Building military housing for the Navy

19. MIT Researcher and Aerospace Retrainer

How do you teach people changing careers?
Public sector 0.9 political sensitivity
Political sensitivity not learned in classroom

20. Aerospace Company President

Transportation not technical problem, but political, all sorts
of people involved, Port Authorities, etc.
Subsidy in Washington - labor problem, types of people you
have to hire, politics, etc.
Housing, labor problem strangling the industry, need innovative
ways to build
Opportunities for aerospace firm in public sector, housing,
waste management

21. V-P Aerospace Company

No difference between George program and HUD Operation Breakthrough
program
AF has labor and code programs
Learning curves developed on houses produced, trying to improve on their mistakes

Who wants to live in mobile homes, not well constructed, only reason industry has grown is because of lack of low income housing

Major housing costs are in materials ans labor, with miscellaneous costs for paperwork and other things

Makes sense for aerospace companies to go after business in closely allied fields, i.e. high temperature incinerator rising aerodynamics, combustion and materials technology developed in missile field

22. Manager of Housing Market Planning, Aerospace Company

Different marketing problems in defense vs. consumer products
G.E. homebuilding operation hired marketing manager from mobile home manufacturer
Defense contractors don't do planning
Defense single customer vs. millions of consumers
Consumer not technology but price oriented
Problems of getting high technology engineers to work on housing problem
Housing production drawings by G.E. too detailed, close tolerances not required
Major housing problems not technology but finances and land
Aerospace firms too rigid in their thinking and organization
Aerospace companies don't attack problem by saying what is needed, rather here is a new technology, where do we apply it?

23. Manager Housing Materials Development

Developed plaster cast wall for production line, this idea would not have come to fruition if he had been in construction industry
Felt that they were able to develop process because they didn't have blinders on
Most revolutionary development in the building industry in years
Great potential for both inside and outside walls, inlaid wiring, cost moldings, different finishes, textures and colors, jointed sections for showers
Helped by Gypsum manufacturers who said it couldn't be done
Sees all sorts of possibilities for technical innovation in house building

24. Housing Factory Manager

Major problems are in materials handling
Setting up production line for houses no different from nose cones, jet engines, air crafts, etc.
Modules 30' x 12', completely plastered in 1 hour
Could produce 8 houses / 8 hour shift but assembly and storage problems limiting factors
Mobile home industry maximum production 10-12/day. large leverage on suppliers, no inventory
Use of low skill level employees
Keep good records on time spent on each operation so that improvements can be made

25. Breakthrough GTR

Most R&D people at HUD working on Operation Breakthrough
No one designed Breakthrough contracts

Requirements -
longerterm planning, types of research that should be done
look for alternatives to solve problems, include R&D in contracts to Housing Systems Producers, Should be an element of entrepreneurship in the GTR operations
Emphasis in Breakthrough on cost reduction rather than livability or habitability
FHA resentful of Operation Breakthrough
Breakthrough is an island within HUD

26. HUD Regional Manager

Interest of builders and developers in Breakthrough, Housing Authorities, Model Cities, Banks, Urban Renewal lukewarm
Massachusetts, Connecticut and R.I. codes present no major problems
Zoning tougher problem, doesn't have teeth
Seminar held with N.E. builders on Operation Breakthrough
with a great deal of interest
Information dissemination
Market aggregation studies

27. Architect

More experience than most in industrialized housing
Lack of government money building up programs
Problems with industrialized housing -
lack of experience, no national commitment to housing,
individual home requirements, land aggregation
Problem with Operation Breakthrough, there is no plan for a follow on
Space success -
new program, started from scratch with no tentacles to break, funded, national commitment

28. Marketing Manager Aerospace Firm

Difference between aerospace and industrial markets, aerospace -
detailed specifications, industrial - purchase order
$100 million business
production  engineering  marketing
aerospace  3500       1000        25-40
industrial  4000       400         300-250
appliance   5000       50          350-500

29. Urban Systems Contractor

Don't think Operation Breakthrough will work
May be successful in getting big companies involved
More publicity than any other program
Don't believe in industrialized housing -
  cheaper to build with old housing methods, older techniques
  good and cheap, management gives real savings, construction
  cost not the right revenue, closing costs and final costs,
  barriers are institutional, legal
The only markets in major American cities to support assembly
  line is in New York and Los Angeles, others transportation
  costs too high

30. Breakthrough Contractor

Design review function to verify contractors meeting criteria
  25% earnings
  95% "
  100% "
Recommend to HUD certification
Housing Systems Producer must show how they plan to meet criteria
  by inspection, calculation, test or demonstration
Over 1000 products to be monitored
Closer monitoring of schedules required
Monitor type B proposals

31. Breakthrough Contractor

Cost accounting system to determine costs
Abandoned attempts to get handle on learning curve since on
  few Breakthrough Contracts will build greater than 200
  units
Designing format for cost estimation, 22 widely different building techniques
Produce manual and procedures for reporting actual costs
Set up files on costs - cost performance ratio between technologies, Housing Systems Producers baseline costs
NAHB cost accounting training handbook good for middle range of NAHB
NAHB - 75,000 members compared to 200 industrialized builders gives them more political clout

Cost is function of:
1. number of square feet
2. linear feet of perimeter x 8.5 x number of stoves
3. number of apartments and bathrooms
4. number of buildings in project
5. decent carpeting
6. air conditioning

Building cost determined by rent in area
FHA 300 manual minimum property standards, NBS guideline criteria 2x7 as minimum property standards

32. University Professor
Retraining of aerospace engineers needed
Institutions have not developed to reemploy aerospace talents
1957 Space program had to train large numbers of engineers, this was done by inefficient training through studies

33. Breakthrough GTR
1968 Housing Act - planning assistance money must include housing
Government actively involved in market aggregation activity
Breakthrough agencies and regional councils being used to aid in market aggregation
Breakthrough proposals evaluated to see who had best marketing approaches
Cost data on housing production costs needed for marketing
Little known about the impact of aerospace management techniques

34. President, Aerospace Company

12% defense business
Socio-economic division
LLLTV for crime prevention
Crime market fragmented
Difficulty with municipalities and contracting systems, politics
Unfamiliar with how to deal with market, trying to retrain marketing people
Strategy is to go slow, don't expect too much too soon

Information systems division
Forecasted great growth in education field which did not materialize
Plunged into education field
Found market fragmented
Built up marketing staff but who was the customer?

35. Operation Breakthrough

June-July 1969 National Observer article on "In-Cities Program"
quite detrimental
No long range research plan for housing
Previous demonstration programs aimed at structure, i.e., instant rehab
What is the process of introducing innovation into cities?
In-Cities program - an experiment to document constraints and costs

Nov. 1968 picked cities for "In-Cities Experiment"
Jan. 1969 - new administration; 6 cities allotted, $5 million in 2 yrs., 10 million in 4 yrs.
36. **Operation Breakthrough**

April 1969 – cut out five cities, Miami only one left, program budget 5.5M, changed to an experiment in financing, section 23g

**Public Housing**

Locate land, find financing

Scattered sites, 45 units in 6 sites

Dade County let Kaiser Engineers do other public housing

**Turnkey III - 330 units**

Housing Corporation of America using concrete modules

37. **Operation Breakthrough**

Breakthrough proposal – important factors

a) business savvy; b) construction capability; c) industrial background; d) innovative; e) later sensitivity to social needs

Space people – less knowledgeable about competition, tend to concentrate on technology and in plant production, can handle complex problems but lack sensitivity to people's needs, social marketplace

**Convention builder – market oriented, what people wanted, demand side**

**TRW** spends most of time on technical aspects, little time on other aspects

**FHA** people conservative – fear that they would wash out all innovativeness

**Aerospace** – ponderous, may need different structure to get into new business, i.e. venture groups with low overhead

38. **USAF Housing Official**

Minimum Air Force standards higher than Breakthrough standards

"Relocatable" industrialized housing goal of AF have lost greater than 16,000 units due to base closings since 1964
Goals reduce construction costs

69  19,000/unit
70  20,000/unit
71  23,000/unit
72  24,000/unit

FY 72 - 3500 industrialized units - should they be bought on a national scale, regional, etc.

One man operation

39. Operation Breakthrough
   Management evaluation of Phase I proposals
   Evaluation Criteria: Site management 230 points, management 230 points, business 130 points, technical background 470 points

40. Non-profit Research Corporation
   Military budget - 50% goes into operations and maintenance but no R&D goes into housing, education, and training, etc.
   Wanted to get large programs started
   Wanted to get big companies involved to overcome local political problems
   Market aggregation one of the biggest problems

41. Operation Breakthrough
   Administration and Congress split
   NAHB against Operation Breakthrough
   Benefits of Breakthrough to home building industry
   Housing miserably underfunded - 1) increased R&D funding from Congress $10.5 million to $.05 million to $45 million; 2) building codes will help all; 3) overcome local problems by Federal power

42. Library of Congress
   Aerospace lack of financial constraints, high overhead rates
Lustron – high overhead rates
Operation Breakthrough needs continuous production run,
market aggregation
Local impediments – codes, zoning
Catalysts – local level, market
Could you have same program with less units, more paper
analysis, less show sites

43. Library of Congress Official
FT Lincoln Development
Developing new communities – applications of technical innova-
tives
SCSC – systems approach
Have tenant design his own environment
DOD more experienced in dealing with the appropriations
subcommittee

44. Operation Breakthrough Official
Stabilizing influence of large companies longterm outlook
take out seasonality
Space type people – analytic, tinkers, don't care about time
Big housing management – high management turnover
Four building code groups
Fear and ignorance about codes

45. Small Business Administration
Operation Breakthrough official will bring in large companies
and force out small ones
Major problem in housing costs is non-standardization, would lower
skilled requirements
Insufficient supply of on site trained people, the reason
why industry cannot supply the required housing

46. Office of Management and Budget
No panacea for aerospace industry
Materials, procedures and personnel required for low cost
industrialized housing
Technical small part of the overall problem
Jury still out on R&D for housing, better grouping for better balance, strategy burning question
Systems analysis important in identifying problems

47. Breakthrough GTR
G.E. engineering outfit, no marketing competence in housing
TRW - thorough, highly engineered, testing, lab work, high level employees
Good management control system for funds and resources
Their in-house construction experience very useful
No management capability in non defense

48. Small Non-Aerospace Company Official
Don't hire aerospace engineers
Too highly paid
Cannot produce at low cost