A HOUSING SYSTEM:
A STUDY BASED ON THE PRODUCTION CAPABILITIES
OF THE MOBILE HOME INDUSTRY.

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Submitted in Partial Fulfillment of the Requirements
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Certified by

Thesis Advisor

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Chairman, Departmental Committee
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JUN 27 1972
May 26, 1972

Institute Archivist
Massachusetts Institute of Technology

Dear Sir:

This is to acknowledge that the drawings of this thesis do not conform to the standard format set by the Institute.

The authors assume all responsibility for any damages occurring during the binding process.

Respectfully,

Duane A. Kell

Craig E. Rafferty

Eduardo Catalano,
Thesis Advisor
May 26, 1972

Dean William Porter
School of Architecture and Planning
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Dear Dean Porter:

In partial fulfillment of the requirements for the degree of Master of Architecture, Advanced Studies, we hereby submit this thesis entitled:

A HOUSING SYSTEM: A STUDY BASED ON THE PRODUCTION CAPABILITIES OF THE MOBILE HOME INDUSTRY.

Respectfully,

Duane A. Kell

Craig E. Rafferty
ACKNOWLEDGEMENTS

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Professor Eduardo Catalano, Thesis Advisor
Department of Architecture

Professor Arthur D. Bernhardt
Department of Architecture

Professor Waclaw P. Zalewski
Department of Architecture

This thesis is dedicated to Callie and Kathy.
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ABSTRACT

A HOUSING SYSTEM: A STUDY BASED ON THE PRODUCTION CAPABILITIES OF THE MOBILE HOME INDUSTRY

By Duane A. Kell
Craig E. Rafferty

Submitted to the Department of Architecture on May 26, 1972 in partial fulfillment of the requirements for the degree of Master of Architecture, Advanced Studies.

This thesis is intended to develop within the mobile home industry an increased responsiveness to user needs through an understanding of the elements necessary for improved design quality within a living unit.

The written section provides a brief overview of the mobile home industry, establishes areas of concern, long range potentials, and the constraints within which the design proposal is made.

The design proposal demonstrates how modular coordination of basic living elements and a simple expansion technology can generate many combinations called modules. Using eighteen sample modules and varying exterior components, the proposal illustrates the many unit variations possible, and demonstrates new site planning concepts generated by these units.

Thesis Supervisor: Eduardo F. Catalano
Title: Professor of Architecture
Existing technology and production capabilities of the mobile home industry

Modular coordination and organization of existing product

Capabilities of expansion of basic shipping module

Combination of modular coordination and capabilities of expansion based on user needs

Emphasis on exterior components based on user needs

Development of unit planning

Development of site planning

SCHEMATIC ABSTRACT
INTRODUCTION

The housing industry is composed of three sections: the traditional building industry, the manufactured building industry, and the mobile home industry. They differ primarily in their organizational structures and their production techniques. They are similar in their end product, a dwelling unit. Of the total number of new dwelling units produced each year, the mobile home industry produces roughly half. Clearly it is the mobile home industry that has the largest impact on the housing market.

The underlying reasons for this success as a producer of housing are briefly as follows:

- Cost performance and production efficiency
- Managerial structure, organization as industrial process
- Procurement capabilities, bulk purchasing, etc.
- Efficiency in use of time and materials, factory control, repetition, etc.
- Uniform performance code (nationwide accepted)
- Distribution networks, producer - distributor - dealer - consumer
- Political structure and lobbying strength

The industry has a product that has grown out of a need for low cost single-family dwellings in a nation that is confronting an increasing housing crisis and continuing inflation. Unfortunately, the stigma associated with thoughts of "low cost and low income" has affected broad public acceptance. This low public acceptance level
reflects itself in public policy towards taxation, building codes, zoning, and highway regulations that limit further growth of the industry.

Zoning, for example, usually places the mobile home in undesirable and isolated areas that are far removed from urban problems and that produce sub-optimum socio-logical conditions. This, in turn, simply serves to lower the public acceptance level.

It seems obvious that improved public acceptance and creation of an image of the mobile home as a viable living alternative is needed. Of the many steps necessary to achieve a higher level of public acceptance, improved design quality is one of the first. It is the area dealt with in this thesis.
AREAS OF CONCERN AND DESIGN CONSTRAINTS

There are three overriding areas that are important in evaluating the implications of improved design quality. They are: the factors that affect user needs; the factors that affect quality; and, the factors that affect visual aesthetics. Analysis of all of the factors such as circulation, mechanical systems, size of spaces, natural light, etc., must generate a design that concentrates on establishing relationships between the exterior of the mobile home and its surroundings, the functional interior of the mobile home and a variety of user needs, and the interior and exterior spatially.

These areas of concern are inherently in conflict with highway regulations that limit weight, height, length and width. Weight is a minor factor due to light-weight construction, 13'-6" has remained constant as the maximum height, and lengths over 70' require escorts in most states. Regulations that originally limited width to 8' were changed to 10' in the 1950's, 12' in the 1960's, and the 1970's will see national acceptance of 14'.

Despite any of the constraints the mobile home industry is working under, one must think realistically of its potential as a tremendous national resource for housing due to its excellent technological, managerial, and political skills.

The industry is presently recognizing the inherent conflict between the limitations of transportation and the need for larger living areas. Its attempts have incorporated elements that pull, fold, and telescope as well as units that are made in sections or can split into sections at the site.
Further speculation on the long range potentials of the mobile home industry need not be limited to the mobile home per se, but to a full range of housing types, densities, and site situations ranging from the single family detached to the multi-story, multi-family attached.

In view of the extensive range available, the following basic constraints have been established to facilitate the design study and to yield a basis for comparison.

**UNIT TYPE**

Individually shipped manufactured units that incorporate minimum volumes of shipped air and maximum use of existing technology

**UNIT SIZE**

- a. 14'-0" maximum shipping width
- b. 56'-70', minimum to maximum shipping lengths
- c. 13'-6" maximum shipped height

**UNIT CONSTRUCTION**

- a. Standard mobile home steel framing
- b. Standard mobile home wood framing
- c. Standard mobile home expansion technology

**UNIT ERECTION**

Two or three men, two days using standard erection procedures (excluding foundations which can vary in sophistication).

Efficient use of these givens yields a system of organization that produces a maximum number of plan variations with a minimum number of assembly line changes.
COMPONENTS AND DESIGN MODULES

Demonstration of the repetitive design elements of the living unit and their structural composition.
BATHROOM COMPONENTS

INTERIOR COMPONENTS
CLOSET COMPONENTS  KITCHEN COMPONENTS
STORAGE

STEPS

DECK

FENCING

ROOF EXPANSION

EXTERIOR COMPONENTS
BATHROOM CONFIGURATIONS
BATHROOM CONFIGURATIONS
KITCHEN CONFIGURATIONS

KD3

KD4
B1

B2, B2a

BEDROOM CONFIGURATIONS
BEDROOM CONFIGURATIONS
EXPANSION CONFIGURATION

LIVING CONFIGURATIONS

L1, L2
ENTRY / STORAGE CONFIGURATIONS
WALL FRAMING

FLOOR FRAMING

MODULAR UNIT FRAMING
WALL FRAMING

FLOOR FRAMING

ENTRY/STORAGE EXPANSION FRAMING
TYPICAL ROOM EXPANSION

ENTRY / STORAGE EXPANSION

UNIT SECTIONS
CLERESTORY ROOF EXPANSION

SHED ROOF EXPANSION
DESIGN MODULE COMBINATIONS

Demonstration of 18 alternative combinations of the design modules. Letters identify the design module arrangement.
DESIGN MODULE COMBINATIONS
UNIT VARIATIONS

Demonstration of potential living unit plans based on variations of module combinations. Numbers indicate specific module location in a living unit on a 14' modular increment.
MODULE 3
5, 7, or 9
12 or 16
UNIT 36
14 or 16

MODULE 3
6, 8, or 10
12 or 16
UNIT 38
14 or 16

3
6, 8, or 10
12 or 16
UNIT 37
13 or 15
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| UNIT 51 | 13 |

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| 52 | 14 |

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| 53 | 14 |

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| 54 | 14 |
MODULE 3
5, 7, or 9
16
UNIT 55 14

MODULE 3
6, 8, or 10
16
UNIT 57 14

3
6, 8, or 10
16
56 13
NET AREA 944
DECK AREA 351
GROSS AREA 1382
UNIT VARIATION 8

UNIT PLANS
NET AREA 1073
DECK AREA 309
GROSS AREA 1469

UNIT VARIATION II
NET AREA 857
DECK AREA 174
GROSS AREA 1118

UNIT VARIATION 22
NET AREA  1031
DECK AREA  391
GROSS AREA  1509

UNIT VARIATION  32
NET AREA  1118
DECK AREA  261
GROSS AREA  1466

UNIT VARIATION 37
NET AREA 944
DECK AREA 306
GROSS AREA 1337
UNIT VARIATION 45
NET AREA  1118
DECK AREA  313
GROSS AREA  1518
UNIT VARIATION  54
BALCONY EXPANSION

EXPANSION MODULE COMPONENTS IN SHIPPING POSITION
ROOF PANEL
FLOOR PANEL
SIDE WALLS
END WALL
FURNITURE STORAGE

ENTRY WALL IN SHIPPING LOCATION

EXPANSION MODULE COMPONENTS IN SHIPPING POSITION
ENTRY ROOF IN SHIPPING POSITION
STORAGE UNIT IN SHIPPING POSITION

FURNITURE STORAGE

SHIPPING CONFIGURATION - 14'x 56' UNIT VARIATION 45

UNIT DESCRIPTION
STEEL WING
REMOVABLE WHEEL ASSEMBLY
MOVABLE TOWING HI
WELDED STEEL FRAME

TAPERED STEEL WING MEMBER

REMOVABLE WHEEL ASSEMBLY

PRIMARY WF MEMBERS

BUILT-UP STEEL STIFFENERS

REMOVABLE TOWING HITCH

WELDED STEEL FRAME
FLOOR OF EX MODULE IN FOLDED-OUT POSITION

4x4 WOOD POST BEARING ON WING MEMBER BELOW

DECK STRUCTURE IN SHIPPING POSITION

2x6 WOOD joists at 16" O.C.

WOOD FLOOR FRAME

DECK STRUCTURE ERECTED

PRIMARY WF MEMBER

DECK STRUCTURE IN SHIPPING POSITION

4x4 WOOD POST BEARING ON WING MEMBER BELOW

FLOOR OF EX MODULE IN FOLDED-OUT POSITION
ROOF OF Ex MODULE IN FOLD-OUT POSITION

2-2x6 HEADER TO CARRY FOLDING ROOF

BUILT-UP WOOD ROOF TRUSSES at 2' O.C.

WOOD ROOF FRAME
NET AREA  1106
DECK AREA  393
GROSS AREA  1586

63' UNIT

63' UNIT PLAN
NET AREA   1415
DECK AREA   425
GROSS AREA  1917

70' UNIT

70' UNIT PLAN
70' UNIT PLAN

NET AREA  1457
DECK AREA  393
GROSS AREA  1937
56', 63', and 70' SPLIT UNIT

ENTRY ES4
MODULE 2
5
15a
UNIT 25 17a

MODULE 2
5a,7a,or 9a
12, or 16a
UNIT 29 13,15, or 17

1
4a
15a
26 17a

1
4a
16a
30 17a

2
5
16a
27 17a

2
5a,7
15a
31 17a

2
5a,7a,or 9a
12 or 16
28 14 or 16

2
5a,7a,or 9a
16a
32 17a
NET AREA       866
DECK AREA       305
GROSS AREA      1258

UNIT VARIATION  3
NET AREA  944
DECK AREA  327
GROSS AREA  1278

UNIT VARIATION  9
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NET AREA 1127
DECK AREA 348
GROSS AREA 1562
UNIT VARIATION 28
EXPANSION MODULE COMPONENTS IN SHIPPING POSITION

ROOF PANEL

FLOOR PANEL

SIDE WALLS

END WALL

ENTRY WALL

STORAGE UNIT

EXPANSION MODULE COMPONENTS IN SHIPPING POSITION

SHIPPING CONFIGURATION - 2 - 14' x 28' UNIT VARIATION 9

SPLIT UNIT DESCRIPTION
BUILT-UP STEEL STIFFENERS

TAPERED STEEL WING MEMBER

PRIMARY WF MEMBERS

REMOVABLE TOWING HITCH

WELDED STEEL FRAME
WF MEMBER

4x4 WOOD POST BEARING ON WING MEMBER BELOW

2 x 6 JO'ISTS

FLOOR OF EX MODULE IN FOLDED-OUT POSITION

DECK STRUCTURE IN SHIPPING POSITION

DECK STRUCTURE ERECTED

2 x 6 JOISTS

WF MEMBER

WOOD FLOOR FRAME
BUYLIT-UP WOOD ROOF
TRUSSES at 2'O.C.

WOOD ROOF FRAME
EXPANSION TECHNOLOGY DETAILS AND UNIT ELEVATION STUDY

Demonstration of proposed assembly for expandable units and elevational study for window options.
TYPICAL ROOM EXPANSION

ENTRY/STORAGE EXPANSION

DETAIL KEY UNIT SECTIONS
CLERESTORY ROOF EXPANSION

SHED ROOF EXPANSION
BUILT-UP WOOD ROOF TRUSS

2" FIBERGLASS INSULATION

2-2x6 HEADER WITH CONTINUOUS STEEL PIANO HINGE AND COMPRESSIBLE GASKET, BEARING ON

4x4 WOOD POST

2x4 TAPERED ROOF IN SHIPPING POSITION

HVAC DUCT WITH FLOOR DIFFUSER

2x4 FLOOR IN SHIPPING POSITION

SECTION AT ROOF

2x4 FLOOR WITH HVAC DUCT IN SHIPPING POSITION, ATTACHED TO 2x6 STRINGER WITH CONTINUOUS STEEL PIANO HINGE WITH COMPRESSIBLE GASKET

SECONDARY HVAC DUCT FROM PRIMARY FEEDER

2x6 WOOD FLOOR JOIST

4x4 WOOD POST, BEARING ON TAPERED STRUCTURAL STEEL WING MEMBER, WELDED TO WF PRIMARY STRUCTURAL MEMBER

1/2" ASPHALT IMPREGNATED BUILDING BOARD WITH 2" FIBERGLASS INSULATION

SECTION AT FLOOR

EXPANSION MODULE DETAILS
CONTINUOUS STEEL PIANO HINGE WITH COMpressIBLE GASKET WEATHER SEAL

2 x 4 TAPERED ROOF IN FOLDED-OUT POSITION

CANT STRIP ATTACHED TO FACIA, APPLIED TO EXTERIOR WALL AT SITE

CONTINUOUS COMPressIBLE GASKET

FACTORY INSTALLED THREADED SLEEVE TO RECEIVE SITE APPLIED BOLT

SITE APPLIED FACIA PANEL

END WALL OF Ex MODULE IN SITE POSITION

SECTION AT ROOF thru EDGE of MH UNIT thru EXTERIOR WALL of Ex UNIT

CONTINUOUS STEEL PIANO HINGE WITH COMpressIBLE GASKET WEATHER SEAL

2 x 4 FLOOR IN FOLDED-OUT SITE POSITION

HVAC DUCT

END OF TAPERED STEEL WING MEMBER

CONTINUOUS COMpressIBLE GASKET

FACTORY INSTALLED THREADED SLEEVE TO RECEIVE SITE APPLIED BOLT

SECTION AT FLOOR thru EDGE of MH UNIT thru EXTERIOR WALL of Ex UNIT
4 x 4 WOOD POST

2 x 4 STUDS

2 - 2 x 6 HEADER

CONTINUOUS COMPRESSIBLE GASKET

THREADED SLEEVE

2 x 3 STUDS

COVER PLATE

CONTINUOUS STEEL PIANO HINGE WITH COMPRESSIBLE GASKET

SIDE WALLS IN SHIPPING POSITION

PLAN AT EXPANSION MODULE

CANT STRIP ATTACHED TO FACIA, APPLIED TO EXTERIOR WALL AT SITE

CONTINUOUS COMPRESSIBLE GASKET

THREADED SLEEVE

SECTION AT SIDE WALL
2-2 x 6 HEADER WITH CONTINUOUS STEEL PIANO HINGE AND COMPRESSIBLE GASKET

STORAGE UNIT
ENTRY WALL IN SITE POSITION

SITE BOLTED CONNECTION
2 x 6 STRINGER SECURED TO JOISTS AT SITE
2 x 4 DECK STRUCTURE WITH 1 x 4 DECKING
2 x 4 BEARING LEDGER BOLTED TO TAPERED STEEL WING MEMBER
FOUNDATION SUPPORT
SECTION (ERECTED) thru MH UNIT / ENTRY DECK thru ENTRY DECK / STOR UNIT

STORAGE UNIT IN SHIPPING POSITION
2 x 4 DECK STRUCTURE ON ALUMINUM ANGLES IN SHIPPING POSITION SLIDES OUT AT SITE ERECTION
2 x 2 ALUMINUM ANGLES FASTENED TO 2 x 6 JOISTS

SECTION AT FLOOR (SHIPPING)
ENTRY / STORAGE MODULE DETAILS
BUILT-UP WOOD ROOF TRUSSES WITH PLYWOOD GUSSET PLATES

SITE BOLTED CONNECTION WITH 2x4 SPACER

2x3 PARTY WALLS

SITE BOLTED CONNECTION WITH 2x4 SPACER

2x4 FLOOR IN FOLDED-OUT SITE POSITION

1/2" ASPHALT IMPREGNATED BUILDING BOARD WITH 2" FIBERGLASS INSULATION

SECTION thru MH UNIT long/MH UNIT lat thru Ex UNIT/MH UNIT lateral

2x4 CLERESTORY WALL

2- 2x6 HEADER CUT-DOWN, BEARING ON SIDE WALLS

TYPICAL ROOF TRUSSES

2" FIBERGLASS INSULATION

SECTION AT SHED ROOF

ROOF TRUSSES IN SHIPPING POSITION, SHOWN DOTTED

CONTINUOUS STEEL PIANO HINGE WITH COMPRESSIBLE GASKET

SECTION AT ROOF

MODULE CONNECTION DETAILS
SITE PLANNING

Site arrangements based on proposed units demonstrating concept of public entry area versus private lot area. Statistics indicate varying proportions of public common area to private lot area.
INDIVIDUAL LOT PARKING

COMMON PARKING

DENSITY 7 UNITS/ACRE
GROSS AREA / UNIT 6220
NET AREA / UNIT 5000

90° LOT ARRANGEMENT
INDIVIDUAL LOT PARKING

COMMON PARKING

DENSITY  7 UNITS / ACRE
GROSS AREA / UNIT  6220
NET AREA / UNIT  5000

90° LOT ARRANGEMENT – OFFSET
DENSITY  7 UNITS / ACRE
GROSS AREA / UNIT  6220
NET AREA / UNIT  5000

90° LOT ARRANGEMENT WITH ES MODULE
DENSITY 7 UNITS / ACRE
GROSS AREA / UNIT 6220
NET AREA / UNIT 5000

45° LOT ARRANGEMENT
DENSITY  6 UNITS / ACRE
GROSS AREA / UNIT  7300
NET AREA / UNIT  5000

45° LOT ARRANGEMENT
DENSITY 6 UNITS / ACRE
GROSS AREA / UNIT 7300
NET AREA / UNIT 5000

45° LOT ARRANGEMENT
DENSITY  6 UNITS / ACRE
GROSS AREA / UNIT  7300
NET AREA / UNIT  3750

45° LOT ARRANGEMENT - TWO UNIT CLUSTER
DENSITY 6 UNITS / ACRE
GROSS AREA / UNIT 7130
NET AREA / UNIT 6070

TWO UNIT CLUSTER
DENSITY  6.5 UNITS / ACRE
GROSS AREA / UNIT  6660
NET AREA / UNIT  5610

THREE UNIT CLUSTER
DENSITY 5.75 UNITS/ACRE
GROSS AREA / UNIT 7580
NET AREA / UNIT 6660

THREE UNIT CLUSTER
DENSITY 5 UNITS/ACRE
GROSS AREA/UNIT 8670
NET AREA/UNIT 7830
THREE UNIT CLUSTER
DENSITY 6 UNITS / ACRE
GROSS AREA / UNIT 7130
NET AREA / UNIT 6070

FOUR UNIT CLUSTER
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