Understanding Spatial Structure:
Identification, Transformation, Evaluation

by
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May, 1987

Submitted to the Department of Architecture in
partial fulfillment of the requirements of the degree
of Master of Architecture at the Massachusetts
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Abstract

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This thesis outlines a process of observation and transformation using formalized concepts about space, territory, and position as well as transformational rules implicit in these concepts. A set of references is analyzed and explained using a common graphical language which serves to locate the references within a continuum of spatial configurations. Transformational rules are developed which allow for the generation of new configurations. Some proposals are made about inhabiting these configurations and the process of formal observation and transformation is placed within the larger context of design.

Thesis Supervisor: Thomas Chastain

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...to my thesis comrades, curmudgeons and all
...to my friends at M.I.T. and elsewhere
...to my family

for my parents
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Introduction

“Thirty spokes converge upon a single hub; It is on the hole in the center that the purpose of the axle depends

We make a vessel from a lump of clay; It is the empty space within the vessel that makes it useful

We make doors and windows for a room; But it is these empty spaces that make the room habitable

Thus while the tangible has advantages; It is the intangible that makes it useful”
- Lao Tzu (c. 550 B.C.)

“[If, for practical purpose, we separate, limit, and bring into a human scale, a part of unlimited space, it is a piece of space brought to life as a reality. In this way a special segment of space has been absorbed into our human system. Was that general space, then, not to be experienced as reality? It was not real until there was introduced in it a limitation (clouds, trees or something else that gave it a size and that reflected light and sound). Truly, the idea of space, which we accept as existing, manifests itself only as a continuation of such a piece of reality which was produced through limitation.”
- Gerrit Rietveld

Understanding Spatial Structure

This thesis starts with the assumption that an understanding of spatial structure is integral to the production of architecture. Our use of our environment, whether built or otherwise, is conditioned by both the continuity of space and the differentiation of territories within this continuity. One of the tasks of architecture is to provide for both qualities: continuity of space and differentiation of territories as regions of use.

Our intuitive notion of space concerns potential position: the “space” of a form is the accumulation of all the positions that we can occupy. This definition is anthropocentric, but we can generalize this conception to consider space as the “potential position” of anything: building elements, cars, birds, etc. We can speak of a birds’ space as the range over which it has freedom of occupation; i.e. the set of all potential positions.

But how is “position” determined? Our sense of position comes about relative to a reference. We speak of an element placed a certain distance away from another element that serves as a reference position.

In a Cartesian coordinate system, position is determined with respect to a fixed, universal origin that serves as the reference for two, or more, orthogonal directions. Position is the measurement of a dimension from the origin in each of these directions. In this system, space, defined as potential position, becomes infinitely extendible, but undifferentiated.
Our everyday notion of space involves a relative sense of position; we speak of being "inside" with respect to an "outside", "above" something that is "below", etc. In this sense, position is determined with respect not to an absolute, fixed origin that positions everything, but to a reference that in turn is positioned with respect to other phenomena.

This notion of position with respect to reference involves control. It is true that two elements can be positioned solely with respect to each other (as in a binary star system) but it is more usual for one element to position the other (planets around star, houses on a street, etc.). The control exerted by the reference position both allows the positioning of an element while at the same time constraining that position. By positioning an element with respect to a reference, we are limiting the potential position yet there is no position at all without the reference.

This observation points to a question of this work: how to provide for the definition of spatial forms without overly constraining the potential positions (actions) available within these forms? How can we differentiate territory within a spatial continuum without destroying that continuity?

An answer to this question involves a firm understanding of the implications of position and constraints on position. This thesis constructs some elements of a formal system (algebra) : an association of sets of elements, relationships and operators that together define a domain of potential values. By locating specific spatial forms within this domain we can arrive
Introduction

at an understanding of the implications of our actions on (and within) the form. An assumption of the work is that environments that provide a richness of spatial experience incorporate a parallel richness of spatial operations.

To provide material for the development of this "spatial algebra", a set of environmental and architectural form references has been assembled. These references vary greatly in time, scale, and culture, ranging from houses by Frank Lloyd Wright and Rudolf Schindler to ceremonial centers from pre-Columbian Mexico. Yet despite the obvious distance between these forms, there is a sense of familial resemblance: all of these references provide a richness of spatial experience from a comparatively limited set of elements. The Mesoamerican centers were built from pyramids, mounds, and platforms; these environments are articulated ground forms with very little interior space. The two projects by Schindler employ wooden screens, concrete panels, and simple landscape elements. The houses by Wright utilize a sophisticated formal vocabulary based on simple elements: piers, screens, and landscape forms. In these examples, the built elements are discrete and discontinuous. It is the way in which the elements are positioned in space that produces the coherence and continuity of the artifacts.

The first task of this thesis is to uncover the logic of the positioning rules that build spatial structure: Part One develops a set of terms and explanatory diagrams from a close analysis of the house that Rudolf Schindler built for his family on King's Road, in Hollywood, California. This graphical language is employed to identify
similar structuring elements and relationships in the other references. The observations of each reference are presented from specific to general, with the common graphical diagrams presented on the right margin of every page to facilitate cross-referencing between references. In this way, the relationships among these examples are emphasized, and the larger family of spatial forms, of which these references are a subset, is implied.

However, to generate this larger set of forms, to fully place the references within a continuum of similar spatial structures, we must also identify a set of transformations: rules that alter the structure of an environment. Transformational rules fill in the gaps between the references, allowing for both the precise comparison of two examples, and the generation of new configurations. Part Two develops a simple set of spatial transformations and applies them to the references described in Part One.

The last task presented by this thesis is the evaluation of the structures as they are observed and transformed. The graphical language used in this thesis provides only the identification of elements, relationships and transformations. To fully understand the implications of the observations, the representations must be returned to a context and evaluated within a framework: the set of spatial relations observed in an automobile is not appropriate for a house. Some of the transformations generated in Part Two are reasonable in some contexts and not in others. The question of evaluation will be discussed in both Parts One and Two, with concluding remarks in Part Three that place this work into the context of architectural design.
"And, stooping through the doorway of the bulky, spreading house, I looked up into the sky. Here I saw the real medium of architecture - SPACE. A new medium as far as human history goes. Only primitive uncertain gropings for its possibilities can be found in historical buildings. Even the gothic builder merely caught it between his sculptural pillars without attempting to use it consciously as a medium of his art."

"...He (the architect) is not primarily concerned with the body of the structure and its structural possibilities. His one concern is the creation of space forms - dealing with a new medium as rich and unlimited in possibilities of expression as any of the other media of art: color, sound, mass, etc."

- Rudolf M. Schindler 3
Identification

Introduction
When approaching a spatial artifact like a house by Wright or a Maya ceremonial center, one of the first tasks is to define its territories. The identification of a territory, the differentiation of one spatial region from another, implies an association of the elements that build the territory. This association can come about through a consistency of the elements themselves. For example: a continuous application of color, or the use of a repetitive building element can be used to differentiate spaces and build territories. Another way to build territorial association is through consistency in the relationships between elements. These relationships are most generally expressed as relative position, dimension, and control. For example, a city street can control the position of buildings by defining a reference for a common setback distance (at top left).

The house built by Rudolf Schindler on King's Road in Los Angeles will serve as an example of these concepts. The house was designed for two families. The spaces for the Schindlers, marked "R.M.S." and "S.P.G.", are grouped around a patio which is part of a large, private garden at the back of the site (on the left). At the top right of the plan is the unit for the Chase family, designated "M.D.C." and "C.B.C.". The patio which organizes these spaces is part of a larger entry garden which buffers the living spaces from the public access along King's Road (at the right of the plan).
**Territories : Dimension**

For this thesis, we will consider territories that are built through a certain kind of consistency in the positioning of elements: the requirement of dimensional stability. This claim is based on the appearance of the same dimension in the two orthogonal directions. For example, the front yard of the Schindler Residence is built by two similar, but orthogonal dimensions: the length of the path from the sidewalk to the entry of the Schindler unit, and the distance from the lower lot line (emphasized by hedges) and the patio/living room of the Chase unit (at the top of the plan). The diagram at left isolates these two dimensions with the territory that they define. This territory is represented geometrically as a square: many of the diagrams in this thesis use square figures to imply stable territories. However, it should be noted that stable territories are primarily spatial and not figural. Spatial elements are zones of potential occupation, whereas figures imply a mandatory completeness. To claim that the front yard of the Schindler house is a stable territory is not to imply that it has a square shape, but to say that there is a potential association of all the elements within a roughly square region.

The Schindler house contains two pairs of stable territories. The front yard is almost identical dimensionally with the back garden. The Schindler unit, with its associated patio, defines a stable territory of an equivalent size with the Chase dwelling.
Identification

Building Territories
Defining the stable territories is the first step of this analysis. The next question to ask is how are the territories made? What are the elements that build the territories? What are the rules that determine the position of these elements?

Looking again at the Schindler House, we can define a vocabulary for answering these questions:

As we saw previously, the front yard is made by a continuous pathway that defines a dimension, and the displacement of the Chase patio/living room from this pathway by the same dimension.

The territory of the back garden is built by a continuous hedge on the left margin, with the Schindler patio/living room displaced from it by its size.
The Chase unit is built by a relationship between the patio and the interior spaces around it. In terms of built elements, the size of the unit is defined by the continuity of the living room wall into the patio hedge. This size displaced laterally positions the supports that define the interior zone.

The territory of the Schindler unit is built through a similar combination of continuous patio wall and displaced structural supports.
Identification

Classifying Territories: Behavior

The descriptions of the territories in the last section share some common observations. Common to all the examples is the appearance of a continuous zone that defines both a dimension and a reference for the positioning of elements. The positional reference serves as a registration for the territory (diagram B at left). A registration positions elements within a territory and orients the territory with respect to other territories.

Some territories contain another registration that restricts the position of elements in the secondary direction (diagram C at left). For example, the location of the Chase unit is determined not only by a displacement from the entry path, but by the left margin of the entry path’s zone.

A second registration can also be produced by two zones in the same direction, displaced from each other from by the same dimension (diagram D at left).

At right is a chart that matches the territories observed in the Schindler House matched with the diagrams at left. Throughout the thesis, observations about the construction of territories are presented using these generalized diagrams.
Identification

Interactions
Territories do not exist in isolation. Just as territories are built by relationships between elements, so too do the territories interact with each other. Any pair of territories have the potential for spatial interaction. In this thesis, we will look at the zones common to paired territories. For example, the two dwelling units of the Schindler house produce a zone that extends from within one territory to within the other.

There are four categories of interactions which we will discuss, and these relationships are independently determined in the two orthogonal directions of the plan: horizontal (directional) and vertical (lateral).

Edge Control: Extension and Mirroring
When two territories are positioned so that the extension of the boundary zone of one territory encompasses the boundary of the other, there is the implication of edge control. If it is the corresponding edges that are in question, there is the implication of extension of one territory into the other: both territories act together as a directional zone at a larger size. For example, the front and back territories of the Schindler house are both positioned along the lot line of the site. These two territories imply the directional extension of a zone that includes both.

If two territories share a common edge, but are on opposite sides of the common zone between them, we call it mirroring. For example, the two units of the Schindler house share an edge in common (in the horizontal direction) but are disposed on opposing sides.
Exchange

When the zone common to two territories does not involve edge control, but there is the possibility of continuity between the two territories, we can refer to a zone of *exchange* between the territories. For example, the Chase unit contains zones of exchange with the front territory in both orthogonal directions.

Separation

If there is no edge control between two territories, and it is not possible to define a directional zone that includes both territories, then there is a zone of *separation* in that direction. For example, the front and back territories of the Schindler house are separated by a vertically oriented zone that contains some of the interior space of the two units.
The four interactions mentioned above can be grouped together in two ways according to how they imply control between two territories, and whether there is the possibility of continuity between them. The groupings above are determined from relationships of control. However, it is also possible to see extension and exchange as related behaviors since they both imply the potential for spatial continuity between two territories. The chart on the left explains the relationships between these qualities and the terms defined above.

The chart at right explains the permutations of these four relationships in two directions. These diagrams are used throughout the thesis whenever positional interaction among territories is isolated and observed. The territories are represented as the Schindler logo so as to be easily differentiated by the behavior diagrams presented in the previous section. (p. 16)

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"This total field being the only means of description of the real world. The space aspect of real things is then completely represented by a field, which depends on four coordinate parameters; it is a quality of this field. If we think of the field as being removed, there is no 'space' which remains, since space does not have an independent existence."

- Albert Einstein 4

**Field Relationships**

In the last section we considered the specific interactions between isolated pairs of territories. The accumulation of these interactions builds the spatial field of the artifact: the structure that informs the positioning of all the elements. This structure is expressed through directional orientation and site registration.

In the Schindler House, it is clear that the lower lot boundary acts as a registration for the two large landscape territories and one of the unit territories. Furthermore, the zone of mirroring that was observed between the two units is parallel to and displaced from this registration. The diagram at left shows the important directional and lateral registrations observed on the site.

The spatial field is built through a combination of directional and lateral registrations. The references are each explained in terms of the site-sized registration, smaller registrations produced by individual territories, and the directional registration of the larger context of the site, i.e. landscape features, public roads, etc.
Evaluation

So far the observations have limited themselves to descriptions of an artifact, in this case the Schindler Residence. The discussion has focused on the definition of territories, their interactions, and the construction of a field organization. Based on these observations of specific formal phenomena, certain conjectures about the logic of the form can be advanced:

A) The Schindler house is actually two units sharing certain communal facilities. The zone of mirroring between the two units defines a privacy relationship, but with a minimum of distance.

B) The two patio spaces are positioned by landscape features: in the front by the walkway, in the back by a series of garden hedges. This indicates the importance of the outdoor territories to the quality of the dwelling. In fact, the unit territories are dependent upon the outdoor and garden territories for their position.

C) The definition of the field of the site through directional registrations points to the need for access into a rectangular site, as well as the realities of lot lines and zoning setbacks in a modern city. The fact that the site's directional orientation is actually perpendicular to the public access of the street (at the right of the plan) reinforces the dwelling as a privacy in the larger structure of the neighborhood.
References

The following section involves the identification and evaluation of a set of references using the spatial concepts developed earlier in this chapter. This analysis is presented using the graphical language used to describe the Schindler house, which is presented again so as to provide a key to the following projects.
Schindler Residence

Rudolf M. Schindler
Los Angeles, California, 1922
This house was built by Rudolf Schindler as a two-family dwelling. Each family has a living space with its own outdoor patio. The patios are part of two larger garden territories that act as virtual landscape by positioning the built elements.
The back garden territory is built by landscape and built elements.

The front garden zone is built by an entry pathway with its landscape definitions, and built elements.

The living/patio zone is built by the displacement of the built elements from a building edge.

The living/patio zone is built by the displacement of the built elements from a garden wall.
Schindler Residence

The larger site registration is perpendicular to the ongoing street access, reinforcing the privacy of the dwellings within a larger neighborhood structure. Minor registrations that serve to position the unit territories are displaced from the major directional registrations.
This Schindler and Chase units are positioned for mutual privacy with the potential for communication.

The Schindler unit is virtually continuous with the back garden.

The Schindler unit has minimal contact with the front territory.

The two garden territories are separated, with the possibility of continuous access between them.
Carlton Park Residence

Rudolf M. Schindler
Los Angeles, California, 1924
The house for Carlton Park designed by Rudolf Schindler utilized the same building system as the Schindler residence: tilt-up panels, wooden screens, and garden elements. Two large garden territories serve to contain and position smaller patios. There is only one dwelling unit in this project (at the top of the plan at left).
The back garden territory is built by a large landscape containment which positions a pergola and outdoor fireplace.

A small courtyard is made by the displacement of a hedge from the built/living spaces.

The large, front entry territory is built by the displacement of a shed from the living room and pergola.

The smaller forecourt territory is made by the positioning of trees from a landscape/garden wall.
Carlton Park Residence

A strong directional registration, built by landscape elements, is displaced from the continuous, public access. The site access provides lateral registrations for positioning the built elements.
The access between these territories follows the zone of mirroring.

The back garden and the forecourt are disconnected in both orthogonal directions, implying mutual privacy.

The two large entry territories produce a zone of exchange which locates the pergola, outdoor fireplace, and living room.

The zone of exchange between these two territories is perpendicular to both the landscape and the public access, implying a privacy boundary.
Wright House

Frank Lloyd Wright
Oak Park, Illinois, 1889
This house was produced by Wright very early in his career. The stabilities observed in the plan correspond closely to particular programmatic needs: entry, living, dining, and kitchen. These territories were built as rooms, almost completely by walls with the potential exchanges between the rooms undeveloped.

The pieces isolated from the plan (below left), demonstrate incomplete, but sufficient, definitions derived from the plan.
The back porch and the building edge define the registration of the kitchen elements.

The entry defines a directional zone.

The living room is oriented by the entry zone and the front porch.

The back porch serves as a registration for the elements that define the dining room.
Wright House

A directional registration builds the major access to the house, with a secondary registration defining the back boundary. The on-going public access is perpendicular to the site access, emphasizing the privacy of the house within the larger neighborhood structure.
The dining and kitchen spaces produce a potential zone of exchange, which is occupied by a wall.

The dining and living rooms produce a zone of potential exchange which is permeable.

The dining room is removed from the entry, reinforcing the mutual privacy of the two spaces.

The living room and entry share a large zone of exchange, implying a public function for the two territories.
Ward W. Willits Residence

Frank Lloyd Wright
Highland Park, Illinois, 1901
Ward W. Willits Residence

The Willits house contains many elements typical of the Prairie houses of Wright built in the first decade of this century. In particular, the attitude towards the building of territory has shifted: no longer are the living spaces seen as rooms to be enclosed but as integral pieces of an indoor-outdoor continuity.
A garden/access territory is built by the extension of the service zone from the living room.

An entry court is built by the extension of the dining wing from the entry zone.

A front yard territory is built by the extension of the dining wing from the living room.

A private, back courtyard is created by the double registration of the access and the service wing.
A strong directional registration is provided by the continuation of the entry zone into the living zone. This registration is displaced from the on-going public access, with the site access generating privacy.
Two outdoor territories exchange to produce a living room.

The entry territory and the back garden are separated by the chimney/utility core.

The smaller back courtyard and the larger garden are separated by the service zone.

The front yard and the back courtyard are separated by the dining room and the chimney/utility core.
Jacobs Residence

Frank Lloyd Wright
Madison, Wisconsin, 1936
Jacobs Residence

This project is one of over a hundred Usonian houses that Wright designed. These houses were characterized by a standardized building system deployed to provide partial and incomplete definition of territories. The spatial richness of the plans is even greater than the Prairie houses due to a reduction in the use of figural elements and symmetry.
The garden territory is defined by a landscape containment that positions the small, dining nook.

The entryzone is defined by a strong edge reinforcing the lot line and building the site access.

An interior space defined through the positioning of a core element against the lot-line registration.

A landscape definition positions an interior wall and screen.

The front yard is built through the extension of a garden wall away from the building edge.
Jacobs Residence

The major site registration, determined by the site access, is perpendicular to the on-going public access, defining the house as a privacy in the larger, neighborhood structure.
The exchange between the entry territory and the garden produces the zone of the living spaces.

The extension of the two territories produces the site access direction.

The front yard is separated from the privacy spaces by the utility core.

The exchange between the privacy territory and the garden provides a zone for the dining space and a small "kitchen garden".
Monte Alban

Zapotec Culture
Oaxaca, Mexico, 300-900 A.D.
Monte Alban

Monte Alban is one of the more spectacular of the Mesamerican sites: it is perched atop a ridge running directly through the valley of Oaxaca. The use and purpose of its spaces is little known, so it is difficult to make an evaluation of its form. The observations rely on the elucidation of the capacities of the spaces, rather than their use.
A large territory is made by the symmetrical placement of two temple complexes and a displaced edge.

A territory is built by the displacement of a small, diagonally oriented platform from a continuous edge.

A territory is defined by two directional platforms.

A territory is produced by the positioning of a monumental stair with reference to a built edge.
Monte Alban

The strong directional orientation of the ridge produces the major registrations of the site. Little is built beyond the edge of the flattened platform constructed at the top of the ridge. We can infer that the site access moves with the landscape, parallel to the registrations.
These two territories share a large common zone.

These two territories are separated by the large platform in the center of the space.

These two territories produce a small zone of exchange.
Uxmal

Maya Culture
Yucatan, Mexico, 300-900 A.D.
Uxmal was an important city of the Puuc region of Yucatan. The plan of the city shows less built continuity the other references do: several quadrangles are dispersed among an occasional pyramid or platform. Nevertheless, there is a territorial structure to this site.
A territory is produced by the displacement of a quadrangle from an implied built zone.

A territory is produced by the displacement of a quadrangle from an implied built zone.

A territory is produced by the displacement of a courtyard space from an implied built zone.

A large platform is positioned with respect to a built zone.
Uxmal

A zone of registration is implied by the alignments of the elements along the bottom portion of the plan: this zone is partially built. A strong secondary registration is positioned with reference to this primary registration.
Two territories produce a zone of extension.

Two territories produce a zone of exchange.

Two territories produce a zone of exchange.

Two territories are separated by an intervening zone.
"This gives us a new understanding of the task of modern architecture. Its experiments serve to develop a new language, a vocabulary and a syntax of space. Only as far as various schools help us in that direction can they be considered significant."

- Rudolf M. Schindler
Part Two: Transformation

Part One made the proposition that artifacts as unrelated as Pre-Columbian cities and Wright Usonians can reveal similarities and common structures. The development of the concepts and the utilization of those concepts to explain the references serves to locate the references within a "family of forms" - a space of potential configurations that are both defined and differentiated by those concepts. At this point, the family tree is represented by only a small number of examples; there are large gaps and entire branches are empty. However, with the concepts used to locate the references comes a set of operations that can transform the artifacts. For example, in the previous section we observed the interaction of the two units of the Schindler house in terms of a directional mirroring and a lateral exchange. The diagram at left represents this observation, and the chart on p. XXX locates this specific behavior within a matrix of similar but differentiated relations. The implication is that the position of the two territories can be shifted into any of the neighboring relations on the chart. In fact, all sixteen variations are available through one or two displacements.

Clearly, even a small number of transformations can produce a seemingly infinite world of configurations. Part of the process of this thesis is the explicit definition of the transformations that are available for transforming an artifact as well as the logic of those transformations.
A transformational operator is a procedure that alters the state of an environment. In a "real-world" construction environment, every act of building (bringing materials to a site, nailing pieces together, shingling, etc.) is a transformation of some magnitude. These operations are subject to a variety of constraints: physical, financial, logistical.

In the process of design and analysis, however, the range of operations that are available are potentially greater: they operate on descriptions of environments, and so are only analogies of a "real-world" actions.

For this thesis, a set of operators was chosen to provide a framework for both describing, altering, and evaluating the references.

Displacement

This operation involves altering a territory's position by moving it either directionally, laterally, or both. Displacements do not effect the orientation, size or "behavior" of the territory, although the interaction of the territory with its neighbors and the overall site structures will be altered in the process. For example, by displacing the Schindler unit laterally, a directional zone of exchange develops between the two units. In addition, the site registration (the lot line) no longer controls the position of the territory.
Part Two: Transformation

Rotation and Reflection

These operations involve an alteration in the way a territory is built, specifically, the location and direction of its internal references. Usually, the position of the territory in the larger field organization remains the same, although the character of the field may change. For example, rotating the Schindler territory alters the location of the built and landscape zones that define its territory.

Substitution: Behavior

So far, we have considered operations that alter the position, or orientation of territories. It is also possible to change the way a territory is organized. The chart on page 16 outlines three general territorial behaviors that can build dimensional stability. The substitution of one of these behaviors for another can yield a new artifact. For example, it was observed that the front territory of the Schindler house is built through two registrations: the primary registration of the path, with a secondary zone positioning the Chase patio (C on p. 16). If the secondary registration were ignored (B on p. 16), the patio would be free to slide anywhere within the front yard territory.
Evaluation

The transformations presented in this chapter have involved the alteration of a diagrammatic representation of spatial artifacts. Tokens representing different territorial relationships have been shifted, rotated, scaled, etc. To evaluate the results of this process, we must return the diagrammatic representation to a context. The diagrams represent only the potential location of elements. To reach a judgment of the success or failure of a transformation, the process of identification presented in the previous chapter must be worked in reverse: the generalized territorial diagrams must be reinvested with building elements and uses. With the Schindler project, the transformed diagrams have been reinhabited using pieces based on the original reference. With the Wright and the Mesoamerican examples, a new vocabulary was proposed involving simple containments and the suggestion of access.
Transformation One: Schindler Residence to Carlton Park

These two projects bear a lot of similarities in terms of both building systems and territorial structure. Both projects involve large landscape/garden territories that position built elements. Both projects also involve smaller patio territories that include interior and landscape elements. The steps at right show how one plan can be transformed into the other using a few simple rules.
The two large territories of the Schindler house serve as a starting point.

One of the territories is displaced laterally to develop a second direction.

The other territory is reflected to define a directional registration.

The directional registration is enhanced by the substitution of a doubly registered territory.

This configuration matches Carlton Park.
Transformation Two

The transformation outlined here sought to increase the connection between the two larger territories while separating further the smaller unit territories (which no longer represent separate dwellings). The transformed diagram was reinhabited using a representation of the building systems employed by Schindler. Basswood represents the tilt-up panels; wire-frame the wooden screen system; nails the major structural supports; and the flat wood, the landscape elements.
A directional displacement increases the zone of exchange between the two large garden territories.

A lateral displacement increases the separation between the two smaller stabilities.

One of the smaller units is reflected to change its relationship with the garden territory.
Wright House

Transformation One:
Directional Displacements

The Wright house is transformed through a series of directional displacements with the aim of reducing the lateral control relationships and producing a directional form. The diagram has been re-inhabited using a vocabulary of basswood walls, and nails implying access.
A generalized diagram of the original Wright House.

The lateral control relationship between two territories is alleviated by displacing one directionally.

Two territories are further separated by a directional displacement.
With this exercise, the lateral direction was emphasised through a series of displacements. The diagram was reinhabited with the same vocabulary of pieces used in the last transformation: basswood walls and access built by nails/columns.
The Wright house serves as a point of departure.

A lateral displacement increases the separation between two territories.

A second territory is displaced to associate with the first territory.

A third territory is displaced to associate with the first territory.
Monte Alban

Transformation One:
Lateral Displacements

A series of lateral displacements seek to unpack the plan of Monte-Alban. The diagram was inhabited using a vocabulary of partial containments and piers.
The plan of Monte Alban serves as a starting point.

A displacement decreases the connection between two territories.

A displacement increases the separation between two territories.

A displacement creates a minimal exchange between two territories.
Monte Alban

Transformation Two: Directional Displacements

A series of directional displacements maintain the site registration observed in Part One. The diagram was inhabited using a vocabulary of partial containments and piers.
The plan of Monte Alban serves as a starting point.

A directional displacement reduces the connection between two territories while reinforcing the directionality of the site.

A second directional displacement further reinforces the directionality of the site.

A lateral displacement defines a potential privacy.
Transformation One: Unpacking

A series of displacements unpack the form. The diagram is inhabited using a vocabulary of partial containments and piers.
The plan of Uxmal serves as a point of departure.

A lateral displacement separates two territories, building a potential privacy.

A second displacement further separates two territories.

A directional displacement extends the zone of inhabitation and enhances the site registration.
Transformation Two: Rotations

The directionality of the site is altered through rotations. The diagram is inhabited using a vocabulary of partial containments and piers.
The plan of Uxmal:

A series of rotations alters the directionality of the site.

A lateral displacement extends the site in a new direction.
"Most of the buildings which Corbusier and his followers offer us as 'machines to live in', equipped with various 'machines to sit and sleep on', have not even reached the state of development of our present machines. They are crude 'contraptions' to serve a purpose. The man who brings such machines into his living-room is on the same level of primitive development as the farmer who keeps cows and pigs in his house. Mere instruments of production can never serve as a frame for life."

- Rudolf M. Schindler 6
Conclusion

Transformation and Design

This thesis has outlined a process of observation and transformation using formalized rules about space, territory, and position, as well as operations that are implicit in these rules. Even the limited set of transformations presented in Part Two can produce a bewildering array of possibilities, some of which adhere to the logic of the references, and some which do not. How does we move within this world of potential form? How do we design using these formalized observations?

Design involves specification: as designers, we propose a particular configuration of spatial and built elements for a particular time and place. Transformational rules like the ones presented in this thesis, produce possibilities, from which a specific case is selected for a given purpose. One aspect of design, then, is the use of a particular set of transformations to produce a specific configuration. But how do we identify which transformations?

The work of this thesis implies two different answers to this question. One involves a rigorous formalization of analytical concepts, rules, and decision-making. The other involves a more opportunistic approach: changing concepts and frames of reference throughout the process.

Formalization

One direction implied by this thesis involves a rigorous formalization of analytical concepts and transforma-
tional rules, with the addition of decision-making rules that define when to employ transformations. In Part Two, we discussed the differences between the Schindler Residence and the Carlton Park house in terms of the direction of movement through the site, and the interactions among the two large territories and the two small territories. In particular, it was observed that the living rooms of the two houses occurred between the two large outdoor territories: in the Schindler house, in the zone of separation while at Carlton Park, the zone was produced through exchange. We could attempt to codify this observation as a prescriptive rule:

If there are two large garden territories,
then place the living room space in the zone between them.

This rule maps a particular aspect of the form onto a requirement of use: i.e. "living room" equals "exchange/separation of garden territories". By defining a list of rules of this sort, in addition to the transformational operations employed by them, we might be able to generate a set of houses similar to the two Schindler projects. This is the strategy employed by a "shape grammar": a rigorous description of the shapes, the rules of transformation and the logic of selection inherent in a particular family of forms. Shape grammars have successfully reproduced Wright Prairie Houses and Palladian Villas.

But what does this imply about the process of design? A formalized system of this sort requires that the rules
Conclusion

are all available at the beginning, especially the rules that map requirements onto formal relationships (like the living room/garden rule above). In this view, the process of design occurs through a selection of the rules that produce these specific formal relationships and the outcome of the process satisfies the initial requirements in a way that is objectively measurable.

Opportunism

The assumption of the formal method described above is that the requirements of a design can be defined at the beginning of the process, and that those requirements can be mapped deterministically onto a specific (and finite) set of formal relationships. This view seems to run counter to our experience of design in a studio environment. As designers, we continually shift the scale of our drawings, change modelling systems, and, most importantly, alter our understanding of what our design requires: John Habraken has defined design as the "continuous attempt to describe the thing to be designed". Design is not just the formal outcome of a set of initial assumptions, but the definition of those assumptions themselves.

A design process incorporating these observations would be opportunistic: the rules of transformation and decision-making would be constantly changing as the process proceeded. This adjustment can occur on two levels. First, there is the continual reworking and broadening of the analytical language: this thesis focused on a specific type of territory, the dimensional
stability, so as to allow a clarity of description. But what about directional territories? Territories in section? Territories built through color instead of dimension? What about the building systems? A complete design process must consider all of these questions in some fashion, and each analytical framework brings with it and contributes something different to the form.

The second adjustment that occurs continually throughout the design process involves restating the requirements of the project, as well as the relationship of those requirements to the formal language that is being employed. If we take the houses by Frank Lloyd Wright, we find a disparity between the Oak Park house of 1889 and the later Prairie houses. Both houses employ a similar strategy of building the zones of exchange and separation between territories. But, with the Wright house, these zones are occupied by walls, while in the Willits House, the zone is occupied by the dwelling spaces. This shift is not just a change of formal language, but a reinterpretation of dwelling. In 1889, the living spaces were seen as isolated, disparate "cells", and the potential exchange between the different territories was unimportant and undeveloped. With the Willits house, however, the emphasis on continuity rather than isolation implies a new attitude toward dwelling and a shifting of the requirements of the design. While these two houses were not produced as part of the same design process, the reinterpretation of the requirements of dwelling evidenced in the two projects (and the later Usonian) occurs within every
Conclusion

It is important to place this thesis and its formal methods within a larger process of designing. To take the formal descriptions and transformational rules as a complete design process is to mistake the part for the whole. Design always involves adjustment and reinterpretation. The concepts and rules of transformation are themselves continually being defined. However, this thesis proposes that the explicit, though provisional, definition of concepts and rules and the awareness of potential outcomes, produces knowledge important for designing. To propose a design, however, is to employ many other types of knowledge. The formal methods of analysis and transformation of this thesis produce only a piece of that larger world.
Endnotes


### Illustration Credits

All photographs, drawings, and models by author unless otherwise noted.

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<td>p. 8, 33-37, 76</td>
<td>plan of Carlton Park</td>
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