

Lion Battery Museum



Design Research Project APG5058S

partial fulfilment of the requirements for the degree
Master of Architecture (Professional) by

Duncan Fraser

October 2012

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COURSE CODE APG 5058S

COVER SHEET

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Introduction: At least one paragraph which introduces the essay topic. It includes the thesis statement, usually as the last sentence in the first paragraph.

Body: Develop the themes and points that explicate your thesis in the body of the essay.

Conclusion: A final paragraph(s) that re-states your thesis and contextualizes or summarizes the body of the essay. Never add a new topic or point of explication in your conclusion.

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- **Name** of the originator(s) of the document or the part of a document you are using as a source.
- **Date** of publication (some citation styles give the date immediately after the author; otherwise after the name of the publisher). For an electronic resource, look for the date on which the document was produced or updated.
- **Title** of the publication (and, if it is part of a larger work, e.g. an article in a journal, or one paper in an edited collection, also the **title of the whole** publication).
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- Inclusive **page numbers** if the reference is to an item smaller than a whole book.
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Harvard System

In the Harvard system, referencing is done by inserting the author surname and publication date in parenthesis within the main body of the text. For a complete guide to the Harvard system, see

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In the footnote system, a reference in the text to another source is signalled by a numeral giving the number of the citation. This numeral corresponds to a numbered note at the bottom of the page (a footnote), or at the end of the paper. For a complete list and discussion of footnoting, see <http://www.lib.uct.ac.za/infolit/bibchicago.htm> or Turabian, K. 1996. *A manual for writers of research papers, theses and dissertations*. 6th ed. Revised by John Grossman and Alice Bennet. Chicago: University of Chicago Press.

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Figure 1. The Lion Battery, Looking North-east with a view of the deserted upper gun site, looking over the harbour.

Introduction

The idea of space lies at the root of all architecture; architecture is about spatial experience.

This thesis is an investigation around the ideas of architectural spatial experience, how we experience space and how to construct rich spatial experiences in architecture.

The design project revolves around re-imagining the Lion Battery site on the slopes of Signal Hill.

The design tests out the theoretical explorations laid out in this document and then incorporates traditional and parametric approaches in the resolution of the design.

The aim of this project is to explore experiential architecture.

What is space in architecture?

"The root of architecture lies in the mastery of the problem of space." (Moholy-Nagy, 1939)

"Space is the essential medium of architecture." (Holl, 2000)

"The discourse on space is one of the defining characteristics of what it means to be modern in architecture." (Hensel, Hight, & Menges, 2009)

The concept of space only entered architectural theory roughly around the birth of modernity. Before this it had been the domain of mathematics and physics. Gottfried Semper was one of the first architects to identify space as an element, a volume or an entity that could be operated upon by an architect. The concept of space only became a common architectural term with the publication of Sigfried Giedion's *Space, Time and Architecture* in 1940. Giedion argued that Cubism, Russian Constructivism and Futurism all broke with his existing understanding of Euclidian geometry from the Renaissance perspective. For Giedion these new examples showed that the world had entered into a new era, what he call a "new space-time concept".

The concept of space is a continually changing and mutating idea allowing for multiple readings.

"Space, a boundless, three-dimensional extent in which objects and events occur and have relative position and direction." (Britannica, 2012)

"Aristotle defined space as a container of things. Space is, therefore of necessity a hollow, limited externally and filled up internally." (Meis, 1990)

"Space is a reality in our sensory experience." (Moholy-Nagy, 1939)

"Architectural space is born from the relationship between objects or boundaries and form planes which do not themselves have the character of the object, but which define limits." (Meis, 1990)

"The essence of space as it is conceived today is its many-sidedness." (Giedion, 1941)

"Space is a reality and once it has been comprehended in its fundamental essence it can be grasped according to its own laws, arranged according to its own laws." (Moholy-Nagy, 1939)

"Space came to be seen both as an essential underlying condition for aspects of architecture and a quality architects could produce and control for a variety of effects." (Hensel, Hight, & Menges, 2009)

Although ideas around space are multifaceted, they can be roughly split into two streams of thought—the ideas around “absolute” space and those around “relative” space.

In his book, *Projective Cast*, Robin Evans called these two categories, “uniform metric space of everyday physics” and the “non-uniform space of perception”.

Absolute Space

Ideas of absolute space or uniform metric space revolve around the understanding that space is a constant; a uniform baseline precondition against which any material condition could be measured. The Cartesian coordinate system is the perfect method to describe absolute space.

Absolute space is uniform, infinite and exists independently of bodies. The idea of Absolute space was initially imagined as being completely empty, simply the space between bodies.

“In Einstein’s special and general theory of relativity objects are not ‘in’ space but extend into it as their mass configures the field-space that is always active and differentiated.” (Hensel, Hight, & Menges, 2009)

Relative space

Relative space or non-uniform space of perception is constructed by relationships between bodies. Each body has a different point of view and is measured by its relationships relative to other bodies. Relative space can be measurable by the human senses and could be understood as architecture’s aesthetic effect on the subject.

“Space was not an objective thing but a ‘form of intuition’ necessary for the subject’s perception of things”. (Hensel, Hight, & Menges, 2009)

Relative space is not a phenomenon belonging to the realm of the subject but allowed phenomena to be meaningfully understood by the subject. Architecture is unique among the arts simply because it is experienced in time and motion and thus in a relation between the body and the form. If relative space is the space of subjective experience of spatial relations, absolute space is more pragmatic and measurable.

Bernard Tschumi created a thought provoking set of questions on space which can be read in relation to the ideas of absolute and relative space

Bernard Tschumi's Questions on Space

1. Is space a material thing in which all material things are to be located?
 - 1.1. If space a material thing, does it have boundaries?
 - 1.2. If space has boundaries, is there another space outside those boundaries?
 - 1.3. If space does not have boundaries, do things then extend infinitely?
 - 1.4. As every finite extent of space is infinitely divisible (since every space can contain smaller spaces), can an infinite collection of spaces then form a finite space?
2. In any case, if space is an extension of matter, can one part of space be distinguished from another?
 - 2.1. If space is not matter, is it merely the sum of all spatial relations between material things?

3. If space is neither matter nor a set of objective relations between things is it something subjective with which the mind categorises things?

3.1. If the structure of the mind imposes an a prior form (that precedes all experience) to the perception of the eternal world, is space such a form?

3.2. If space is such a form, does it have precedence over all other perceptions?

3.3. Etymologically, if 'defining' space is both making space distinct and stating the precise nature of space, is this an essential paradox of space?

3.4. Architecturally, if defining space is making space distinct, does making space distinct 'define' space?

3.5. If architecture is the art of making space distinct, is it also the art of stating the précis nature of space?

3.6. If the history of architecture is the history of spatial concepts, is space as a uniformly-extensive-material-to-be-modelled-in-various-ways at the origin of architectural space: a) the power of volumes and their interaction; b) hollowed-out interior space; c) the interaction between the inner and outer space; d) the presence of absence?

Bernard Tschumi does not answer his questions on space, he rather creates a logic path for one to work through.

How is space experienced?

Christian Norberg-Schulz, in his book *Existence, Space and Architecture*, discusses how we experience space.

"The problem of 'human' space has been studied by psychologists for about a hundred years. Taking up the question of man's experience of his environment, it has been proved that space perception is a complex process where many variables are involved. We do not simply perceive a world which is common to all of us, but different worlds which are a product of our motivations and past experiences." (Norberg-Schulz, 1971)

Although it would be unfair to assume that we all experience the world in the same way, László Moholy-Nagy states in his book, *The New Vision*, "Space experience is not a privilege of the gifted, but is a biological function. This is because each of our senses which record the position of our bodies allows a grasping of space." (Moholy-Nagy, 1939)

We all exist in the same world, yet every individual experiences the world in a unique personal way. Norberg-Schulz called this process "space perception".

Space perception is the process of an individual interpreting their external environment; the physical world is experienced through the subject's senses. But these senses are subjective; they are affected by emotion and past experiences.

Two people can walk through the same physical space yet each experience the space completely differently.

This leads us to ask: is space a constant material thing that can be experienced differently or is space itself only created as we experience the physical world?

This question brings us back to Bernard Tschumi's first question on space "Is space a material thing in which all material things are to be located? If space is not a matter, is it merely the sum of all spatial relations between material things?"

If space is neither matter nor a set of objective relations between things is it something subjective with which the mind categorises things?"

(Tschumi, 1990)

Architecture is unique among the arts as it is experienced as the subject moves through space. Architecture is experienced from multiple points of view, as Steven Holl put in his book *Parallax*, "The movement of the body as it crosses through overlapping perspectives formed within space is the elemental connection between ourselves and architecture. Judgment is incomplete without this experience of crossing through space. The turn and twist of the body engaging a long and then short perspective, an up-and-down movement, an open-and-closed or dark-and-light rhythm of geometries - these are the core of the spatial score of architecture." (Holl, 2000)

Movement is inseparable from time, movement can only happen over time; architecture is experience in time as the 4th dimension.

Space is experienced by the body as it moves through time, the process of experiencing space or spatial perception is entangled in emotion and our past spatial experiences.

Christian Norberg-Schulz introduces the idea of 'place' and the concept of 'genius loci'. He uses the term 'place' to encapsulate the qualitative qualities of space rather than just the quantitative qualities of space.

"Place, in totality is made up of concrete things having material substance, shape, texture, and colour. Together these things determine an 'environmental character' which is the essence of the place. A place is therefore a qualitative, 'total' phenomenon, describing character and atmosphere." (Norberg-Schulz, 1971)

The concept of 'genius loci' is translated as 'the spirit of place', and denotes the essence of place. "Space denoted the three-dimensional organization of the elements which make up a place, 'character' denotes the general 'atmosphere' which is the most comprehensive property of any place, 'character' is determined by the material and formal constitution of a place." (Norberg-Schulz, 1971)

As Christian Norberg-Schulz puts it, "Places are designated by nouns. This implies they are considered real 'things that exist' which is the original meaning of the word 'substantive'. Space, instead, as a system of relations, is denoted by prepositions. Finally 'character' is denoted by adjectives." (Nesbitt, 1976)

Spatial Cognition and Spatial Schemata

As space is experienced we build up a spatial memory or cognitive map. We record where something is relative to something else and each spatial memory is associated with layers of information and emotion.

We build our spatial knowledge as we move through our environments as well as from secondary sources, such as a map or a description. We continuously build a network of spatial relationships.

In his book, *Existence, Space and Architecture* Christian Norberg-Schulz quotes Jean Piaget, a psychologist and philosopher known for his theory of cognitive development and epistemological view which together he called 'genetic epistemology' or origins of knowledge.

"A schema may be defined as a typical reaction to a situation. They are formed during mental development through the interaction between the individual and their environment and by this process a man's actions or 'operations' are grouped into coherent wholes." (Norberg-Schulz, 1971)

"Piaget shows that our 'space consciousness' is based upon operational schemata, that is experiences with things. The space schemata may be of very different kinds, and the individual normally possesses more than one schema, to allow him a satisfactory perception of diverse situations. The schemas are culturally determined and comprise qualitative properties resulting from the need for affective orientation to the environment." (Norberg-Schulz, 1971)

It is these spatial schemata that structure our spatial network that allows us to orientate and navigate ourselves in space.

"We use all our senses to understand space. The resulting overall idea of space is not objective fact, but rather space is experienced, passed through the subjective filter of perception, conditioned by our previous experiences, our language and our culture." (Meis, 1990)

If you understand the concept of space being split into the two view points of absolute space and relative space, relative space describes how we experience space. Relative space is experience subjectively as we interpret our physical environment; we rely on our personal spatial schemata to understand our cognitive map of spatial relationships. Then in contrast to this, absolute space is devoid of interpretation, it is the uniform baseline precondition against which any material condition can be measured.

"Experience is understood not only via objects or things, yet space is only perceived when a subject describes it. As that subject occupies a particular time, space is thus linked to a perceived duration. The virtual body, as a system of nerves and senses, is 'orientated' in space. The body is at the very essence of our being and our spatial perception." (Holl, 2000)

Traditional architectural drawing of space refers to space as absolute or uniform metric space and not to the experiential space of relative space.

The representation of relative space has typically been the domain of the artist rather than the architect.

Table Mountain Exercise

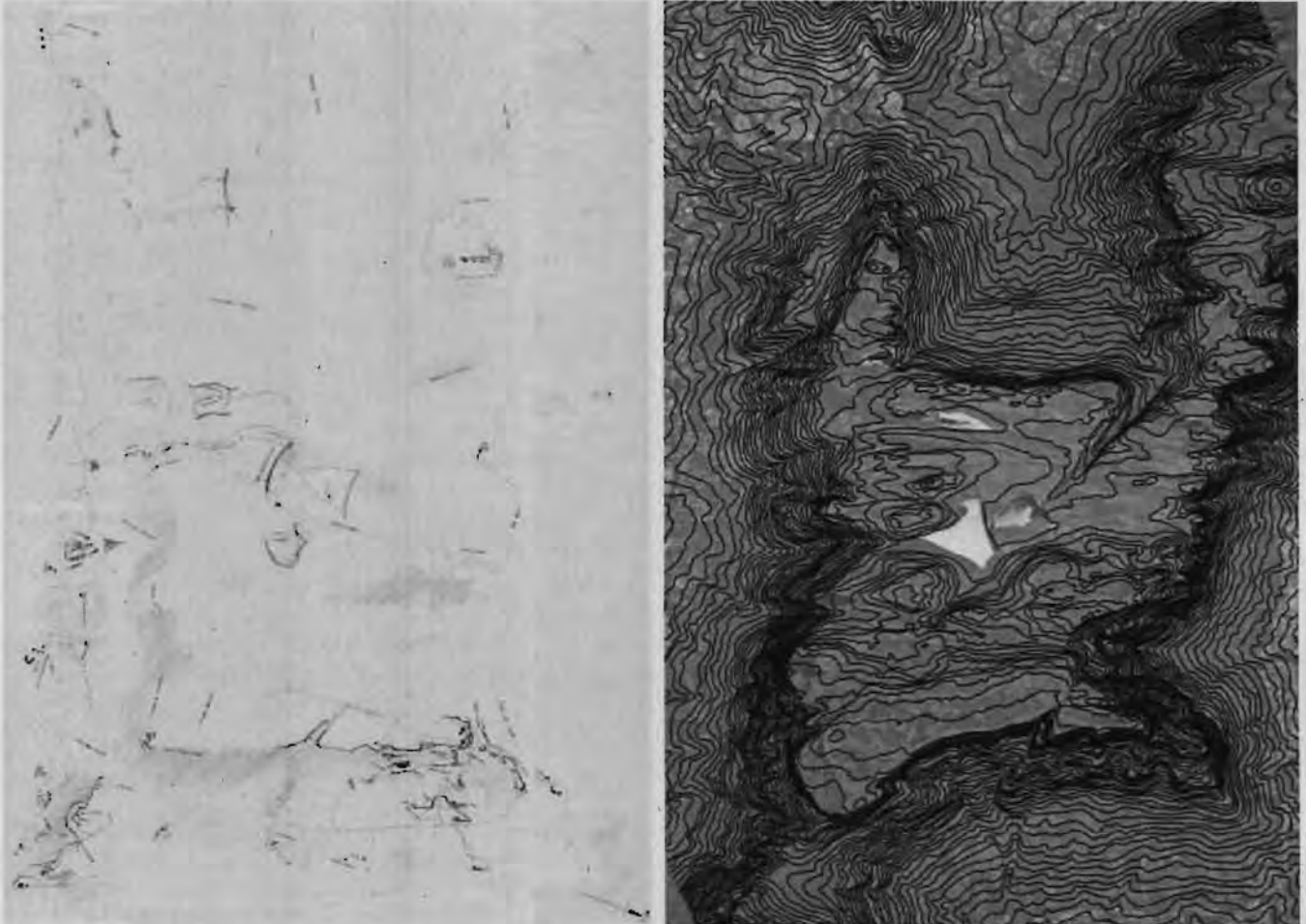


Figure 2. The left image shows Table Mountain drawn from memory and right shows the reality of Table Mountain.

The Table Mountain mappings serve as an initial investigation into the ideas of the perception and memory of space versus the measuring of space. Table Mountain is an incredibly complex form and is difficult to comprehend as a whole because one never experiences it in its entirety, only in proportionally tiny segments, and is thus a complex space to map.

The first step was to map Table Mountain purely from memory. The left hand side of Figure 2 shows this spatial memory map. The drawing was done incrementally, plotting the paths of individual memories one at a time, slowly building up the whole.



Figure 3. The left image shows the distortion of the map drawn from memory compared to the accurate map of the mountain.

When this map is compared to a topographical map of Table Mountain it is clear to see how distorted and disproportional the map drawn from memory is. Figure 3 shows this distortion.

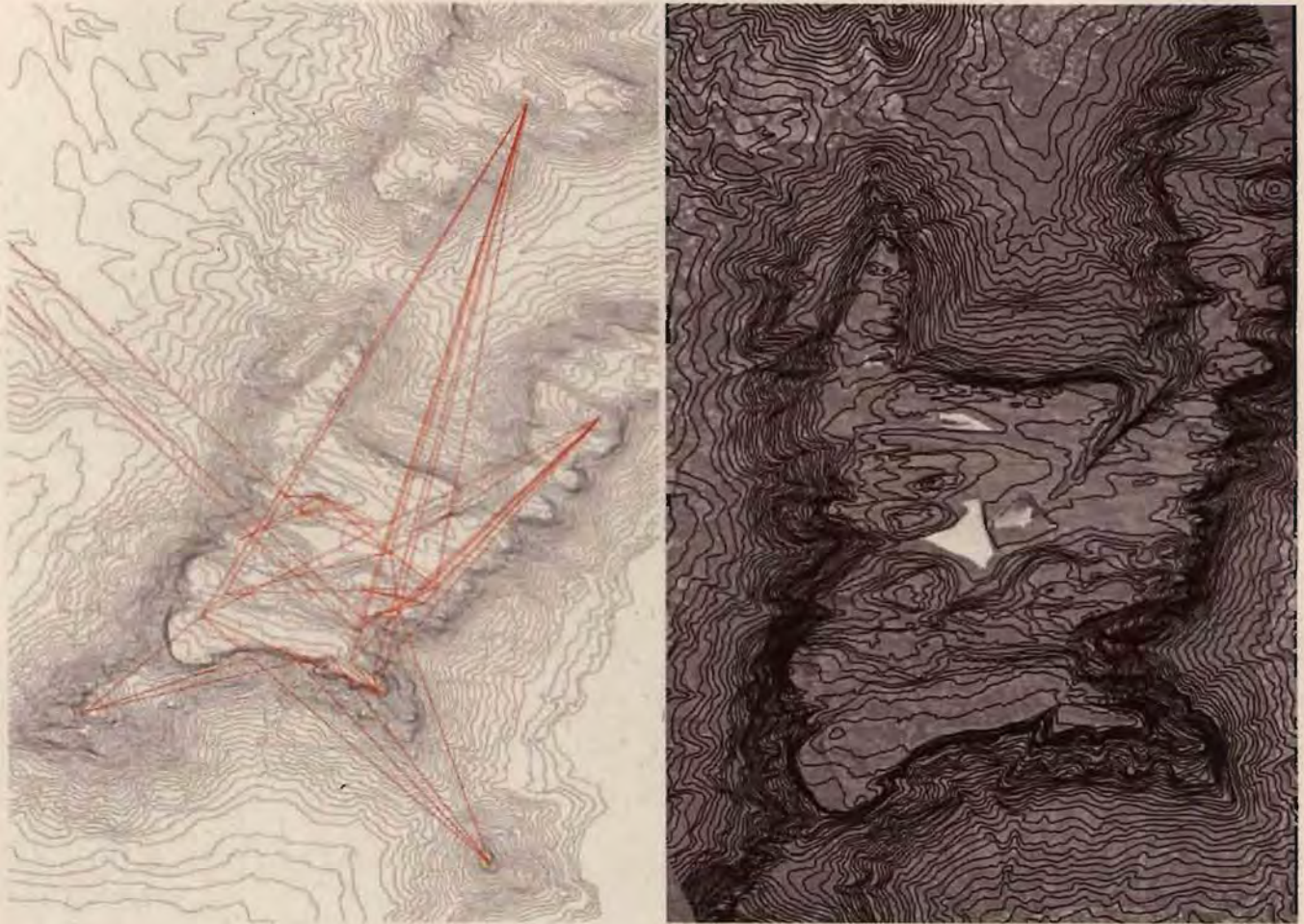


Figure 4. The left image the process of navigation using triangulation.

The second part of the exercise was to map Table Mountain spatially. A route on Table Mountain was walked and at regular intervals bearings to navigational land marks were taken. If more than one bearing is taken at one point to multiple landmarks then it is possible to triangulate your position in space. With this process it is possible to reconstruct the path walked on a 2D map.

Image 4 shows this process of triangulation. Although both these mappings are of the same subject matter, they reveal very different information. Unlike the triangulated spatial map, the spatial memory map has passed through the subjective filter of the mind. This creates a separation between the two mappings

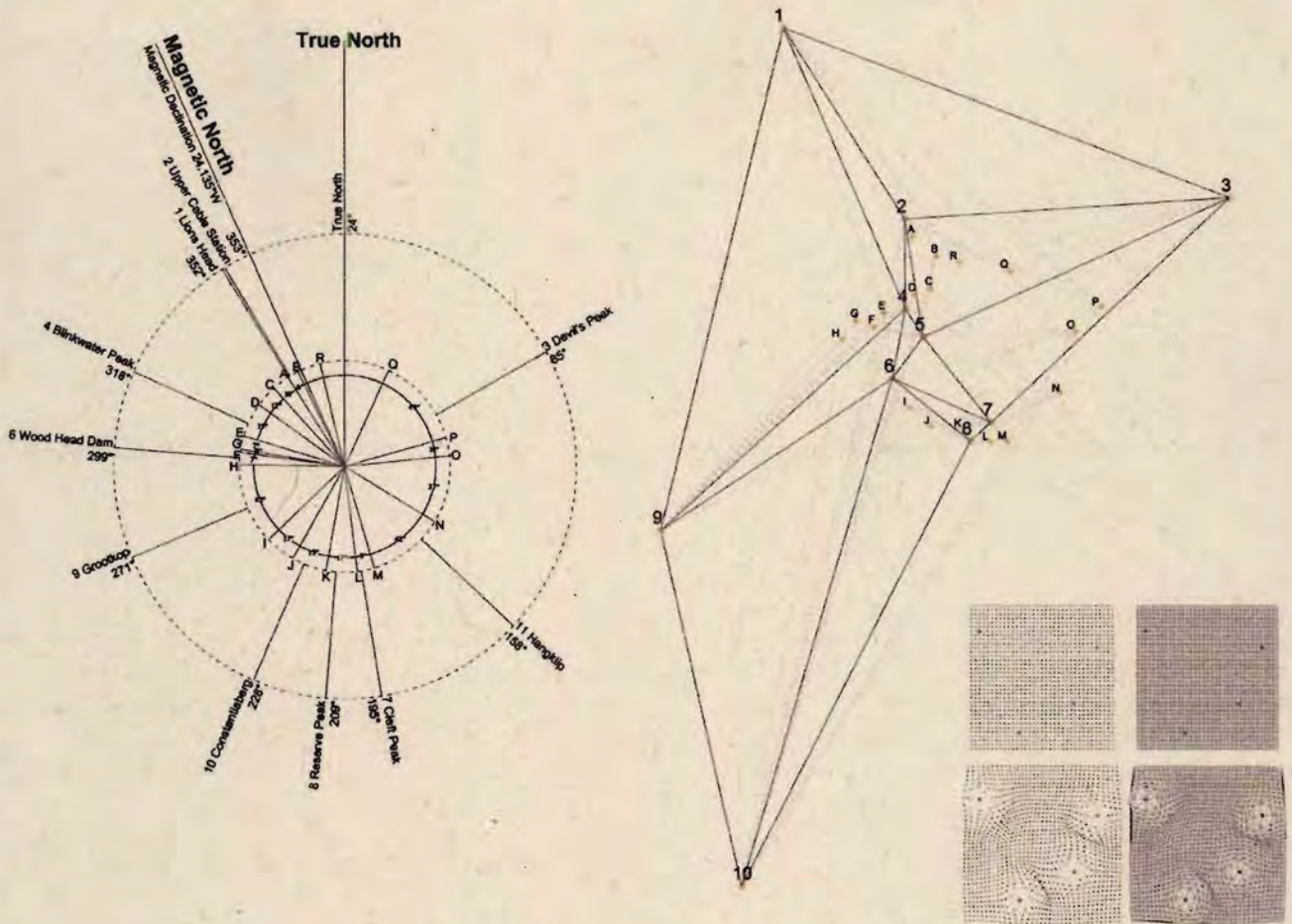


Figure 5. Shows the abstracted cartographic information. The image on the left shows the bearings of every other point relative to one point. The image on the right shows the process of triangulation.

This exercise raises a number of issues:

The drawing is only the two dimensional mapping out of physical objects remembered in relation to each other. The drawing does not capture anything more about each memory; there is no depth or emotion. Can space be mapped showing such qualitative properties, such as emotion?

Experiential Architecture

The focus of architectural design needs to be shifted from object orientated form to the spatial experience of the building. This is a shift from understanding architecture as an object to understanding architecture as a network or field of spatial relationships.

Architectural space can be seen both as absolute space and relative space. Once this separation has been made these two sides of architectural space must be represented appropriately and drawn accordingly.

Absolute space must be drawn for what it is—the positions and locations of objects in space. The Cartesian coordinate system symbolises the ideology of absolute space perfectly. Every point has its X, Y and Z coordinates all measure relative to a constant uniform baseline, or precondition. Architecture has become the representation of absolute space.

Relative space itself cannot strictly be drawn, but the qualitative aspects of the space must be drawn for what they are. The character or atmosphere of a space needs to be drawn.

Both, measured and experiential space need to be considered at the same time in order to design rich architecture. The focus of architecture must

shift from the building as an object to a system of spatial relationships making up a building. This shift is key, but must be undertaken with the understanding that spatial experience is subjective. Multiplicity of interpretation is a strength of subjective spatial experience, as it allows every individual to make the space their own through their interpretation of the space. The architects role is to script the sequence of experience, embracing multiple meaning and richness of spatial experience.

The gap between architectural space as it is represented and the subjective, real-life experience of space needs to be narrowed in order to give architects the tools to design truly experiential architecture.

In the words of Rem Koolhaas “When we think about space, we have only looked at its containers. As if itself is invisible, all theory for the production of space is based on an obsessive preoccupation with the opposite: substance and object, i.e., architecture. Architects could never explain space; Junkspace is our punishment for their mystification.” (Koolhaas, 2004)

The focus of architecture must not be the building itself but rather the spatial experience of architecture.

Investigation and definition of Site



Following on from the Table Mountain spatial mapping exercise I mapped out the manmade interventions on Table Mountain. I was interested in the tension between the natural landscape as a wild landscape and the manmade landscape. This mapping led me to discover a range of forgotten and abandoned sites, where nature was reclaiming the manmade.

One site in particular caught my attention due to its experiential nature and unique history as well as its proximity to the fringe of the city.

Figure 6. Mapping of man made and abandoned structures on Table Mountain.

Lion Battery, Signal Hill

33°40'54.80"S 18°24'41.87"E 158m

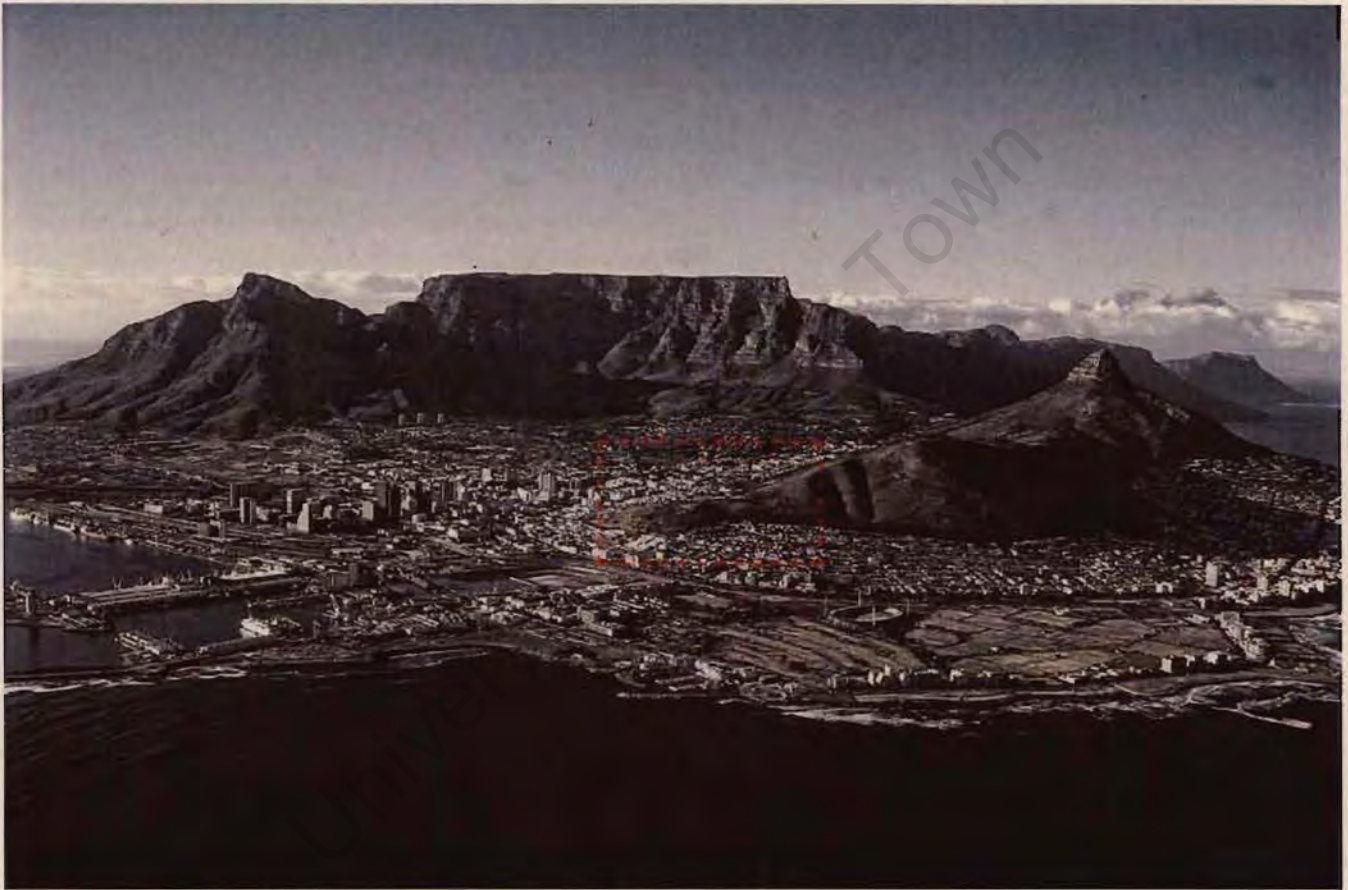


Figure 7. Location of the Lion Battery on the lower slopes of Signal Hill, watching over Table Bay.



Figure 8. Location of the Lion Battery on the lower slopes of Signal Hill, On the fringe of the city.



Figure 9. The Lion Battery has only recently been made accessible to the public.



Figure 10. The empty gun site which use to house a BL 9.2 inch Mk IX-X British 46.7 calibre naval and coast defence gun.



Figure 11. The empty gun site with all its supporting services and protective concrete work.



Figure 12. 21-gun salute guns, these guns are still in use and are fired by the South African National Defence Force.



Figure 13. The empty gun site with all its supporting services and protective concrete work as well as a collection of older cannons moved here when the site was opened to the public.



Figure 14. The gun sites are surrounded by a series of concrete machine gun emplacements protecting the site.

History

Fortifications in Table Bay 1815

1. The Castle
2. Imhoff Battery
3. Elizabeth Battery
4. Helena Battery
5. Charlotte Battery
6. Tufvagh Battery
7. Fort Knokke
8. Intermediaire Battery
9. Nieuwe Battery, later Craig's Tower
10. Holland's Redoubt
11. Centre Redoubt
12. Burger Redoubt
13. Coeshoorn Battery
14. Gordon Battery
15. Cradock Battery
16. York (later Queen's) Blockhouse
17. York Redoubt
18. Prince of Wales' Blockhouse
19. King's Blockhouse
20. Rogge Bay Battery
21. Amsterdams Battery
22. Charvonne Battery
23. Wijk-in-de-Pot Battery
24. Groote Mouille Battery
25. Three Anchor Bay Battery
26. Kooft Nek Battery
- 27/8. Camp's Bay Batteries



Figure 15. Fortification in Table Bay 1815.

In August 1939 Britain declared war on Germany. Shortly after this Jan Smuts became Prime Minister of South Africa. He immediately set about fortifying South Africa's coast line against any possible German sea invasion, protecting South Africa's global strategic importance controlling the sea route around the Cape of Good Hope. This led to the construction of a network of coastal gun batteries spread around the cape peninsula and on Robben Island. The Lion Battery is one of these batteries.

The Cape has always been of naval strategic importance. Cape Town itself was founded as a refuelling stop for ships travelling between Europe and Asia. Throughout Cape Town's history its strategic position has led to a number of conflicts between the British and the Dutch, notable the Battle of Muizenberg and the Battle of Blaauwberg. The constant threat of conflicts has meant that Cape Town has a long history of constructing coastal defences.

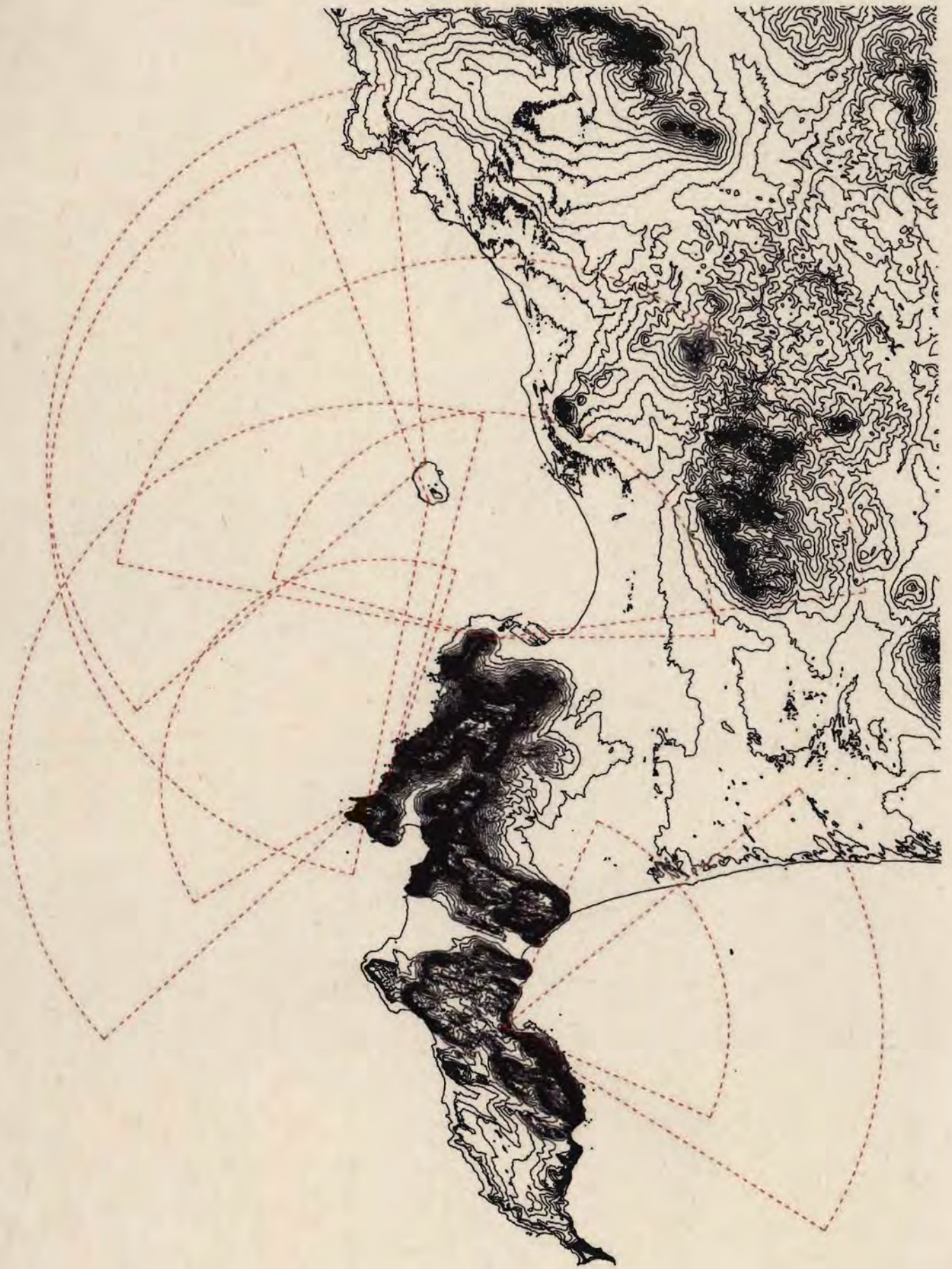


Figure 16. Coastal defence network for the Cape Peninsular set up for WWII.



Figure 17. Examples of other WWII coastal defence bunkers established in Europe at the same time. Naval observation post and range finder emplacement overlooking the coast near Cherbourg.



21



Figure 18. Examples of other WWII coastal defence bunkers established in Europe at the same time. Longues Naval Battery Normandy.

Noon Gun



Figure 19. The two English 18 pounder cannons.



Figure 20. Crowds gather daily to watch the firing of the Noon Gun.

On the 4th of August 1902 the Noon Gun was first fired from the Lion Battery and has been fired every day since (except Sundays and Public Holidays). The Noon Gun was originally a Dutch signal gun from the regular artillery at the Imhoff Battery at the Castle established in 1652. From 1806 the guns were used as time signals, allowing the ships in the port to check the accuracy of their marine chronometers.

Since the invention of the telegraph in 1864 the Noon Gun has been fired remotely from the master clock at the observatory. The ritual of the Noon Gun represents one of the oldest living traditions in Cape Town.

Today South African Navy still fires the Noon Gun as well as a set of four smaller guns that they use for the 21-gun salute.



Figure 21. Firing the Noon Gun. Both guns are loaded, but only one is fired, the second serving as a back up.



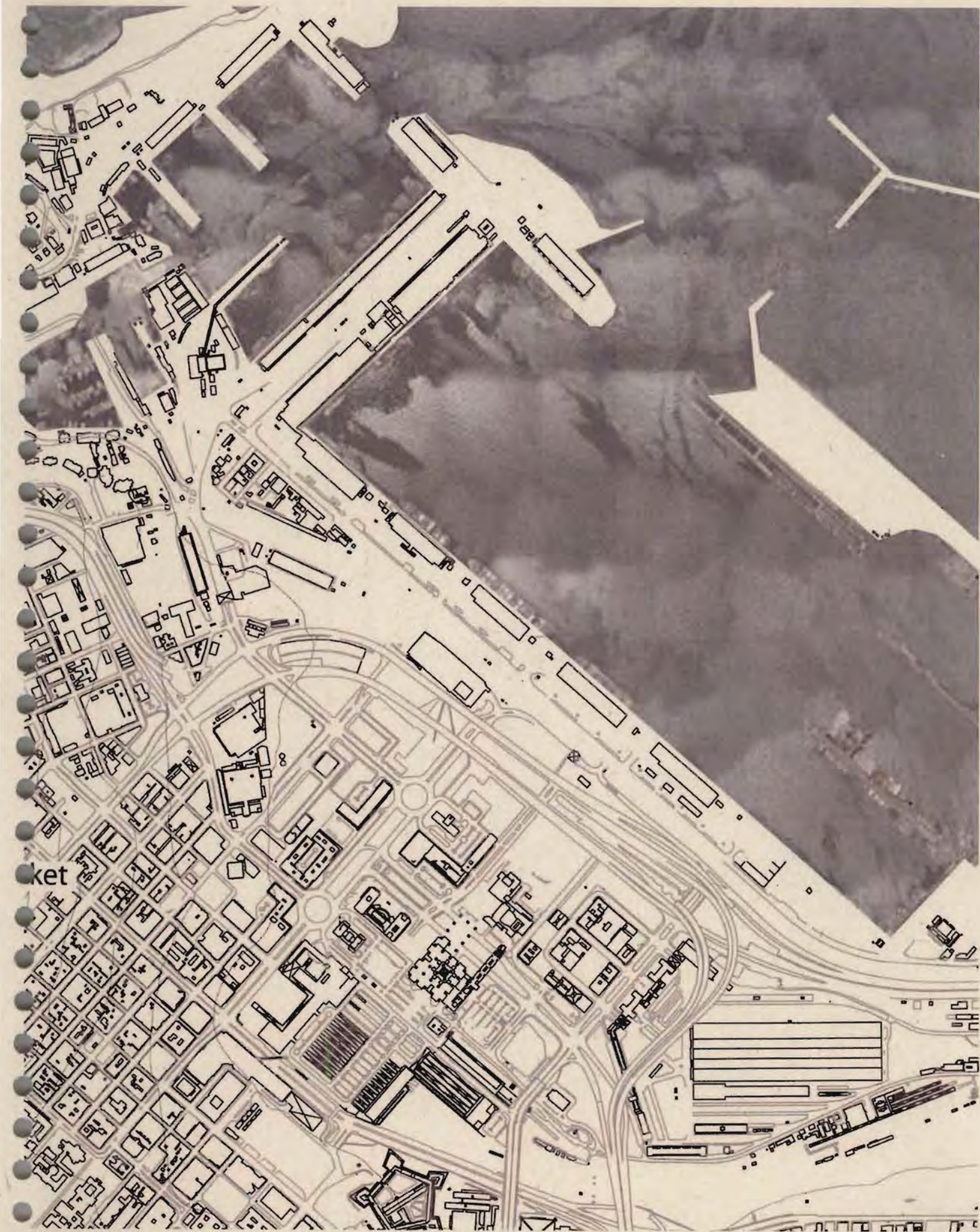
Figure 22. The Noon Gun.

The South African National Defence Force owns the land but is currently in talks with SANParks who will take over the management of the site but the SANDF will still fire the guns.

In the Initial Development Framework set out by Cape Peninsula National Parks the Lion Battery site has been earmarked for potential development.



Figure 23. Site plan and access.



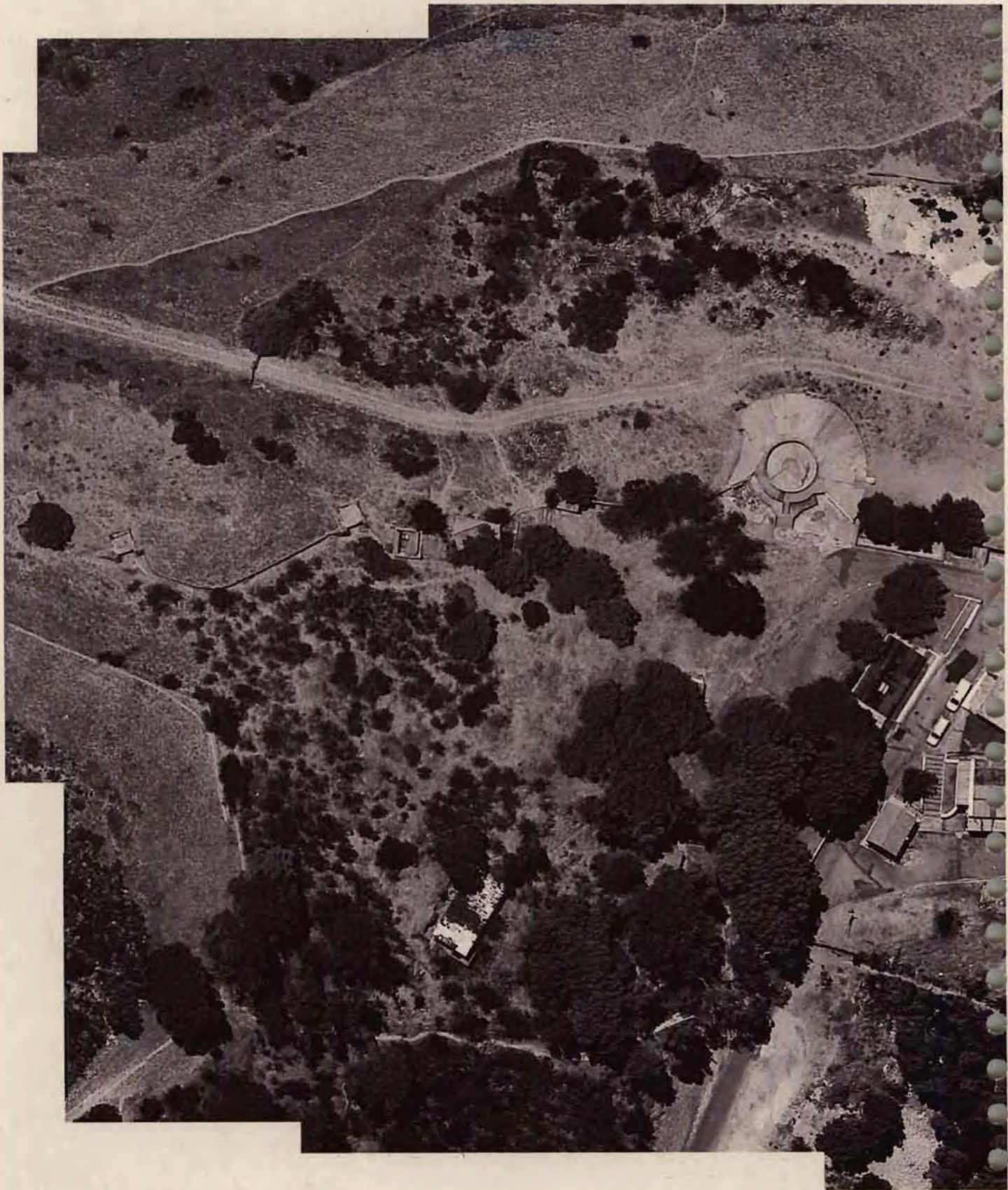
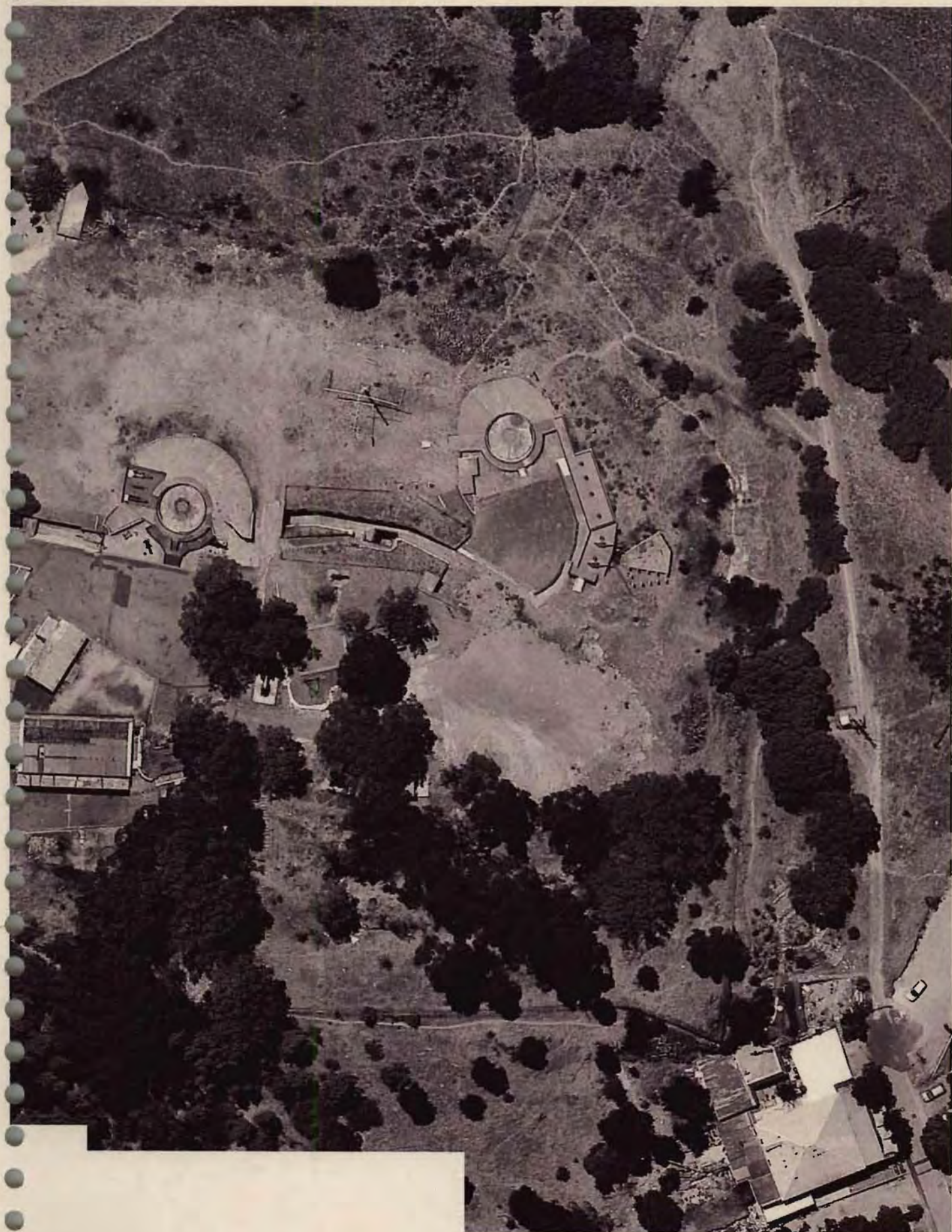


Figure 24. Aerial Photograph of the Lion Battery.



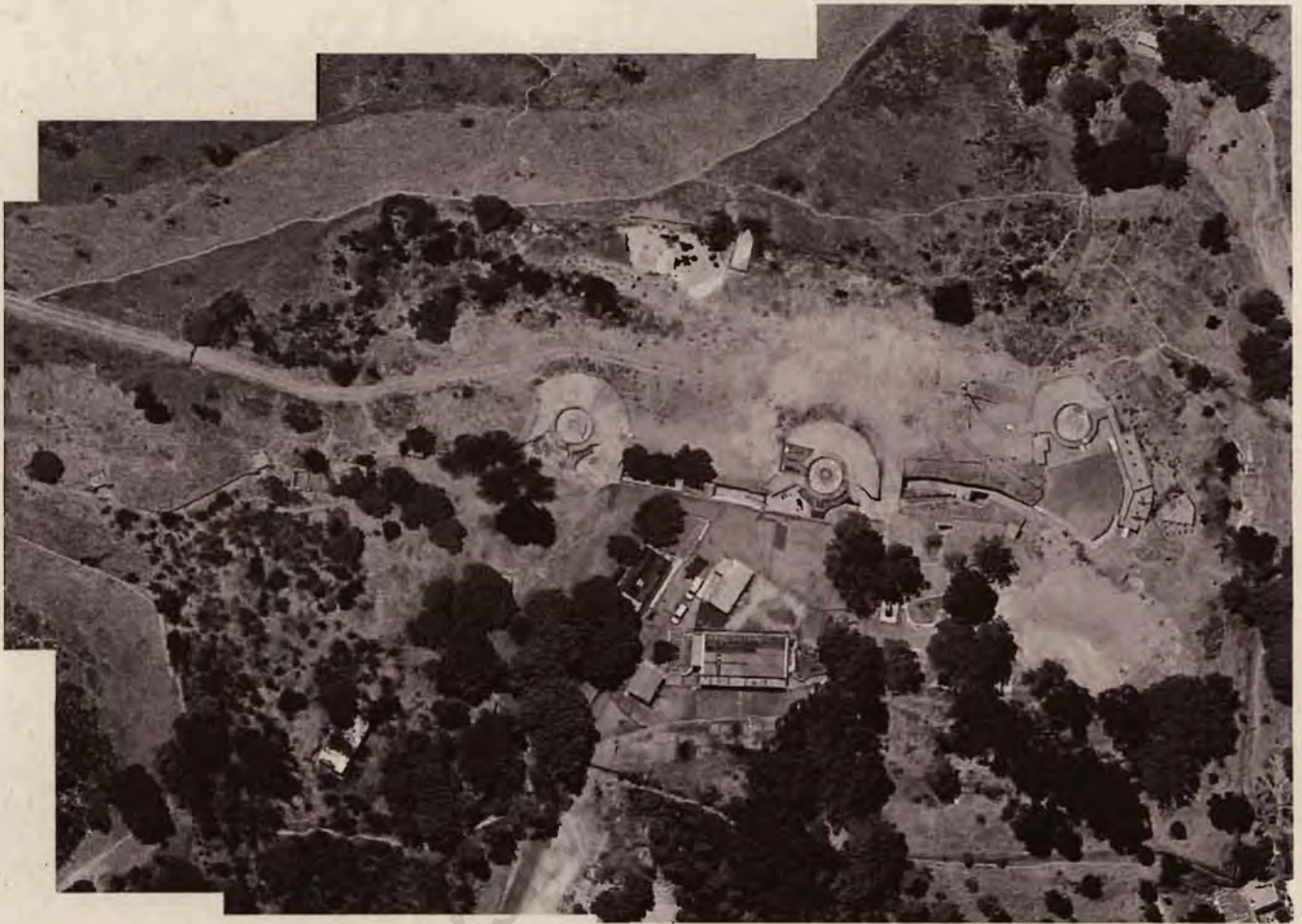


Figure 25. Aerial Photograph of the Lion Battery.

Edge of city and nature

The Lion Battery sits on the lower slopes of Signal Hill, right on the edge of where the city transitions into the natural landscape. It is situated on a ridge line running East-West and has a commanding view of Table Bay and the Harbour.

The Lion Battery is part of a larger network of lookout posts spread out over Signal Hill and Lion's Head. These lookouts use to be manned by the Women's Royal Naval Service (WRNS). Many of these lookouts and RADAR posts still remain, but in a rather dilapidated state.

Access

The site was made accessible to the public in 1997 and can be accessed from two sides. Longmarket Street terminates directly below the site and serves as a particularly direct means of accessing the site. The existing entrance to the complex is off Military Road that winds its way up from the Bo-kaap. Military Road continues through the site and around Signal Hill, but is only used to give emergency vehicles access to the mountainside.

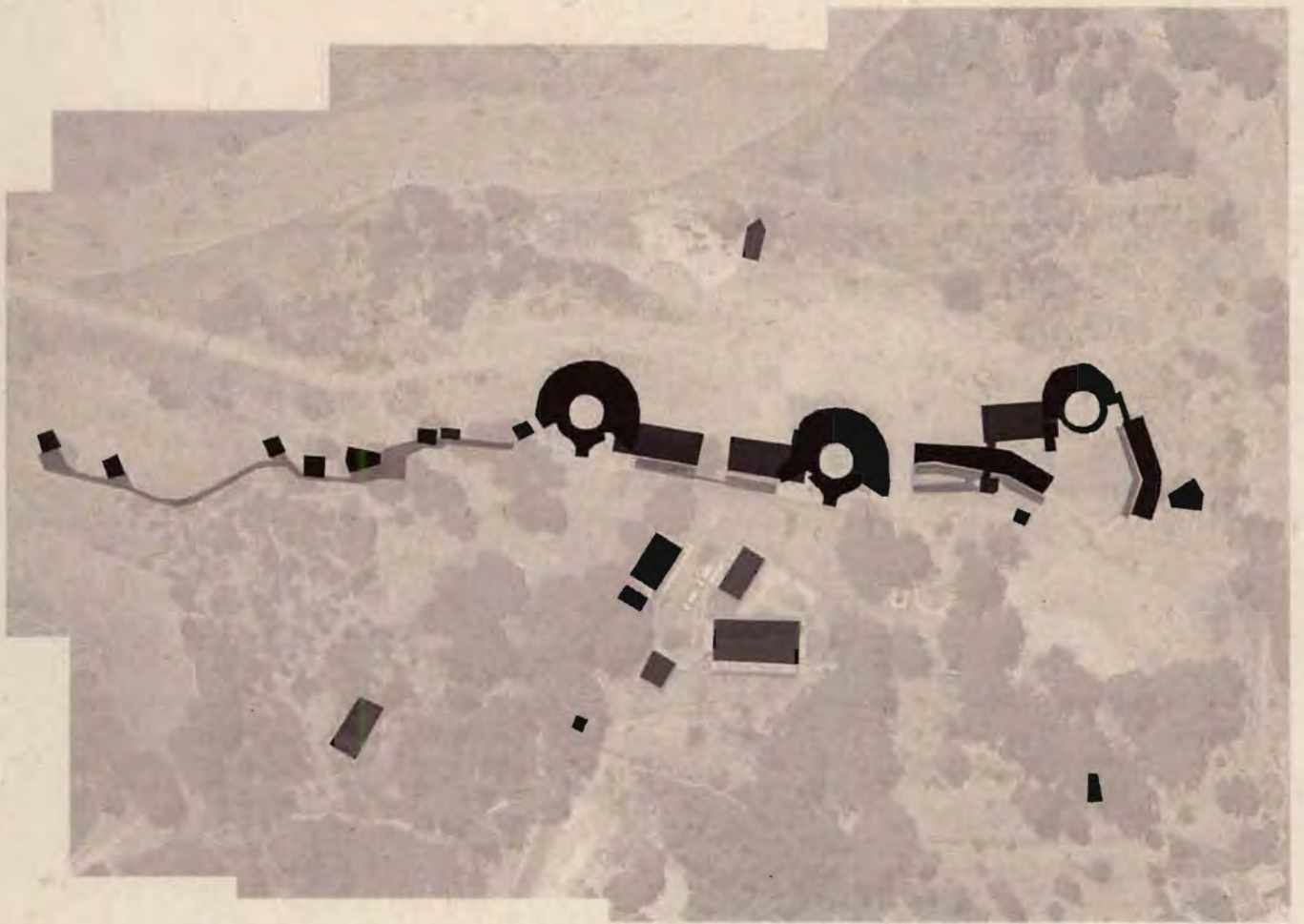


Figure 26. Physical form of the Lion Battery site.

Physical Form

The Battery is made up of three gun points each with a dedicated underground ammunition store. There are two observation and range finding bunkers, one at the lower point of the site and the other at the highest with one fire command bunker overlooking the three gun sites. There is also a series of secondary support structures spread along the site. There is a series of passages linking all the individual functions. All of these are protected by a number of outward facing machine gun emplacements surrounding the site. These form a primary "spine" that runs along the ridge and a secondary collection of scattered support buildings. This forms the basic spatial layout of the site.

Views, platform and bunkers

The site is made up of a series of platforms sculpted into the hillside. These platforms are sculpted according to the view, either opening up to survey certain views or blocking and sheltering from other views. There are a number of tight passages and deep cavernous trenches that link the platforms to the subterranean bunkers.

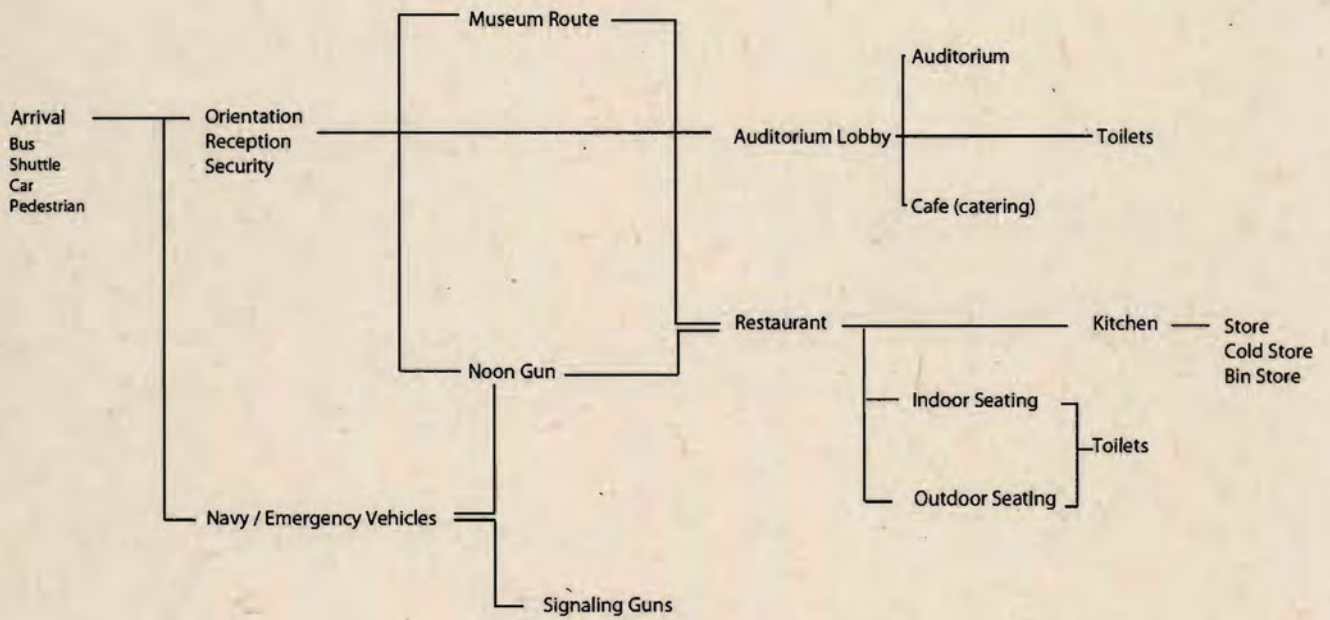


Figure 27. Historical photograph of the BL 9.2 inch Mk IX-X British 46.7 calibre naval and coast defence gun before they were removed.



Figure 28. Range and firing arc of the guns over Table Bay.

Program



A long time was spent on the process of researching and selecting an appropriate program for the site. The program needed to activate the site by bringing people to the site without over power it. From the offset the site lends itself towards becoming a museum, but at the beginning time was spent investigation other options.

The Museum, Auditorium, Restaurant and the Noon Gun all need to be able to function together as well as separately.

Qualities of the site

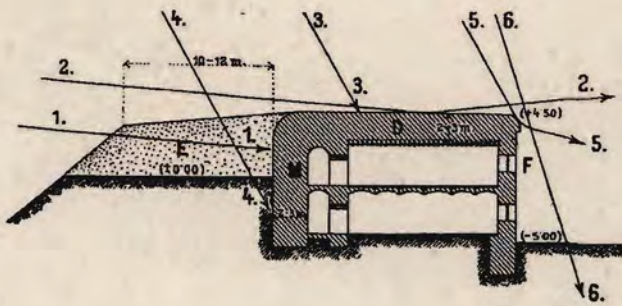


Figure 29. The relationship between ballistics and detail design.



Figure 30: Drawing of submerged trench and windows into the subterranean bunkers.

The Lion Battery was build single-mindedly to perform the function of firing the guns efficiently and accurately. Its layout, structure and detailing are all purely functional.

It is interesting to note that the site never fulfilled its function as the guns were never fired. The site never completed the only function it had. There is strong sense of abandonment but almost a sense of pent up energy or squandered energy.



Figure 31. Drawing of protected walkway and underground storage rooms.



Figure 32. Drawing of fire command tower and protected walkway.

The Lion Battery site is hidden from the view of the city. There is a kind of mystery about a hidden WWII bunker on the edge of the city where previously the public was forbidden.

Due to the embedded nature of the structures, it's hard for a visitor to understand the site as a whole. The site needs to be explored and its layers discovered.

I feel it is important not to lose the qualities of abandonment and the sense of discovery. This project seeks to build on the experiential nature of the site, adding a new layer of history to the site.



Figure 33. Nature reclaiming the concrete.

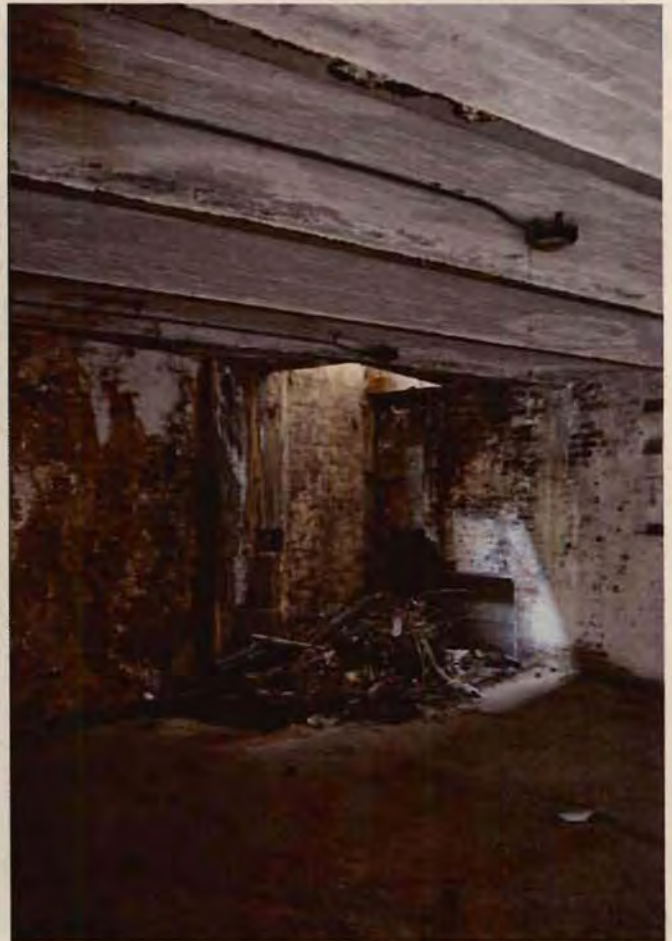


Figure 34. Decaying underground bunker.

There is a very distinct sense of decay on the site. The strong concrete forms are slowly being degraded and transformed, the decayed state adding a new beauty to the site.



Figure 35. Burnt out radio room.



Figure 36. Textured decay.

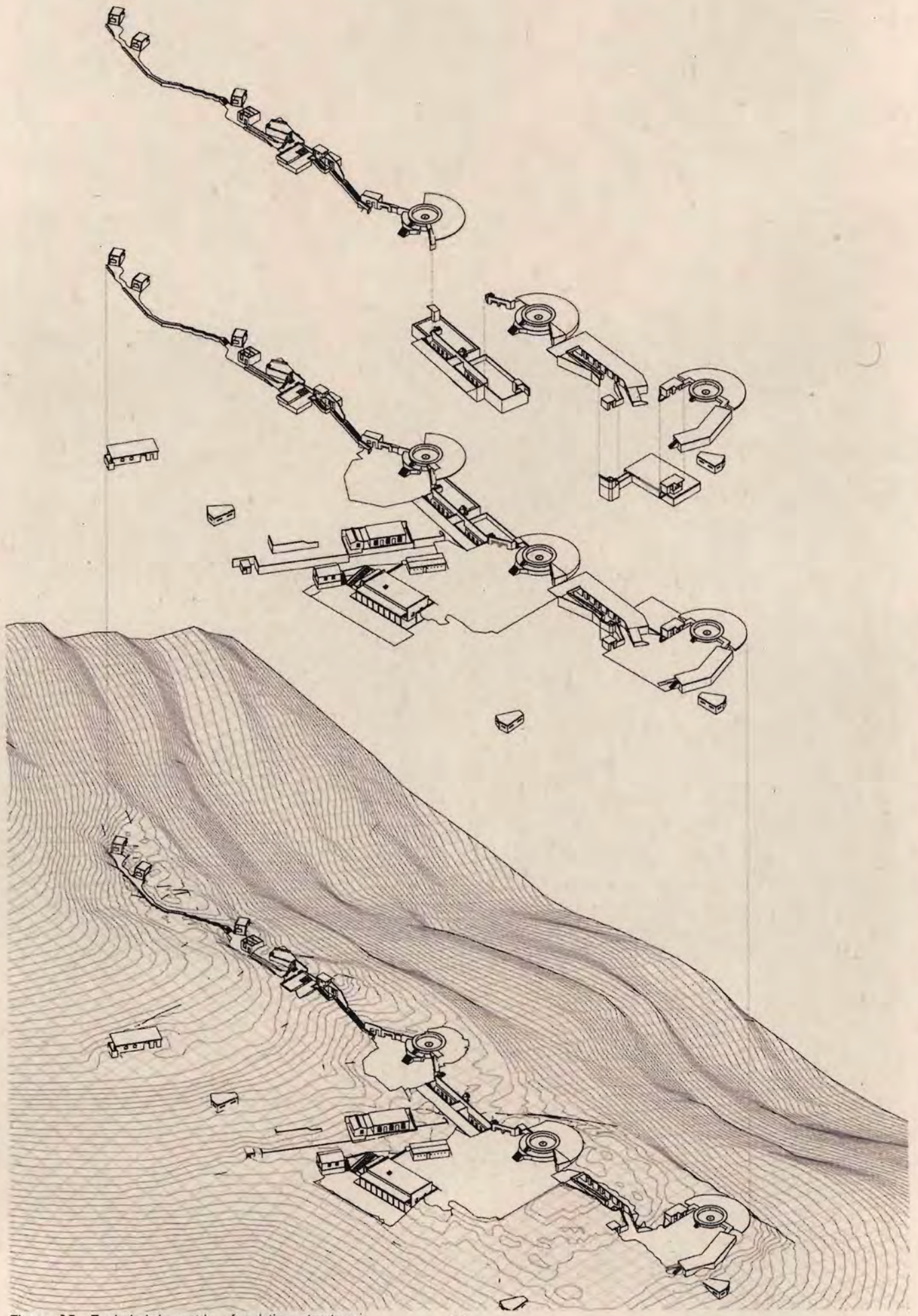


Figure 37. Exploded Isometric of existing structures.

Design Process

At the start of the design process I looked at a number of existing adaptive-reuse projects. The Lion Battery site is robust and powerful, and needs to be treated in the same way.

At the beginning of the design process I saw the site as a series of existing rooms that needed to be filled up with museum displays and exhibition spaces. This created a functional and traditional museum.

After evaluating this approach I realised that the museum I was creating was going against everything I was attempting to achieve. I feel the reason for this was that I was only taking advantage of the site for its superficial qualities.

What is powerful about this site is its emptiness and sense of abandonment as well as its position relative to the city.

The Lion Battery site is particularly complex with a large range of conditions. Because of this it is hard to comprehend or represent the site as a whole with all its nuances.

I went through a long and in-depth process to understand the complex site. Firstly in order to understand the site I spent a lot of time taking photos and sketching, while constructing a digital 3D model of the entire site.

This helped in understanding the formal and spatial relationships within the site.

The next step was an iterative design exploration. In order to come to terms with the site I started testing different ideas and forms on the site through a series of sketches to scale, continuously overlaid and building on the previous sketch.

Iterative design process

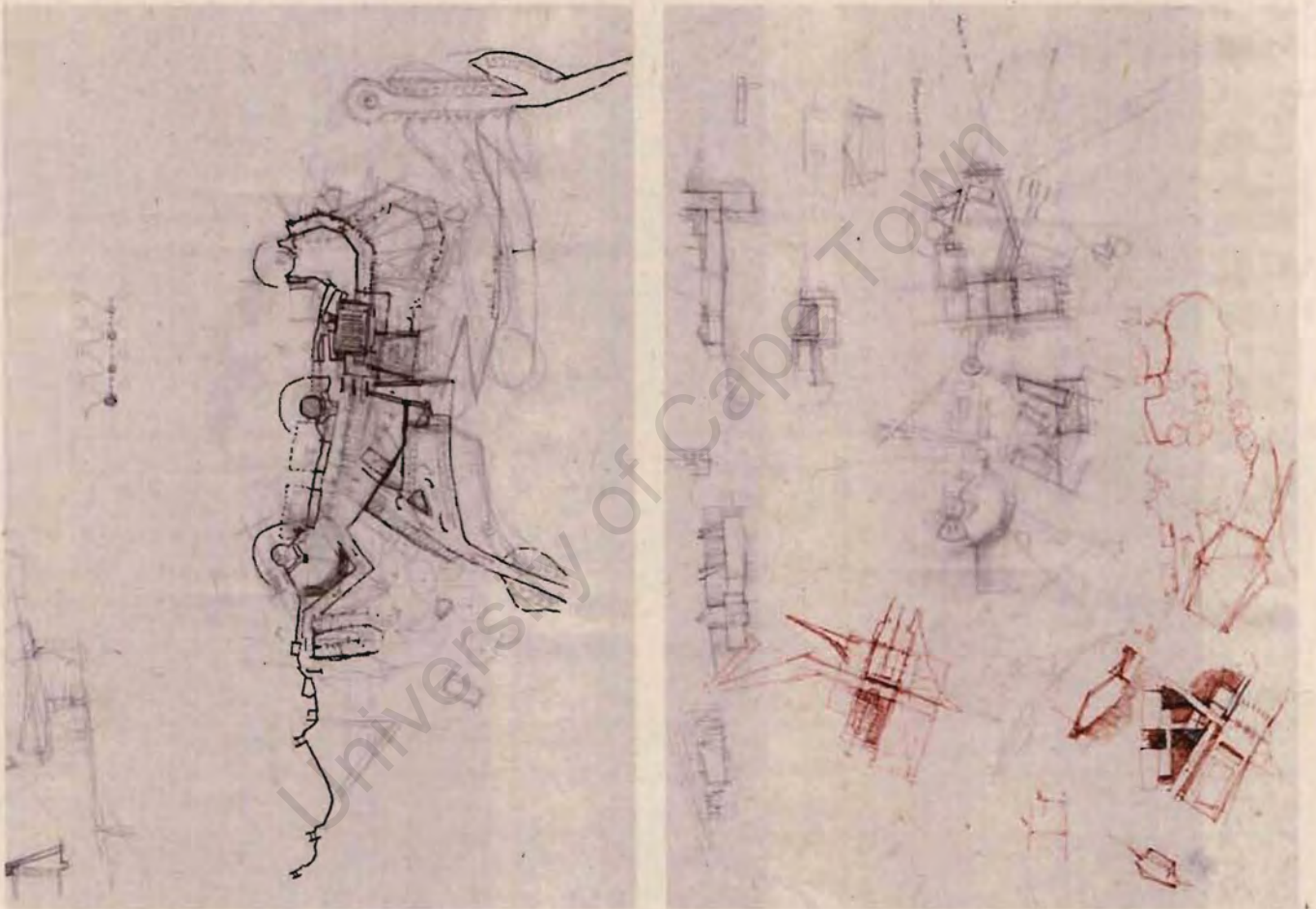


Figure 38. Series of sketches testing out design option.

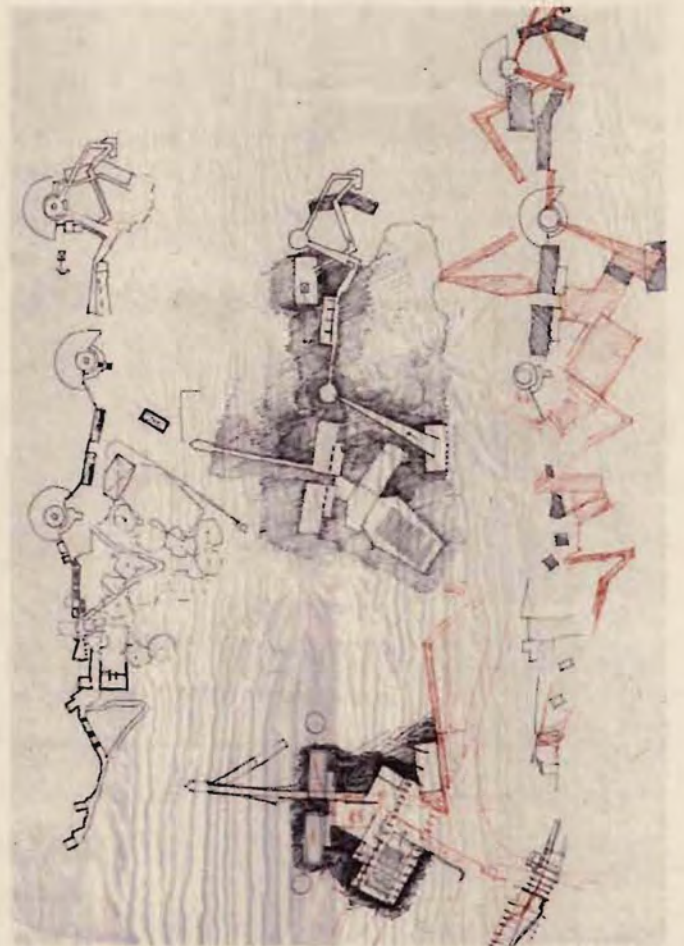
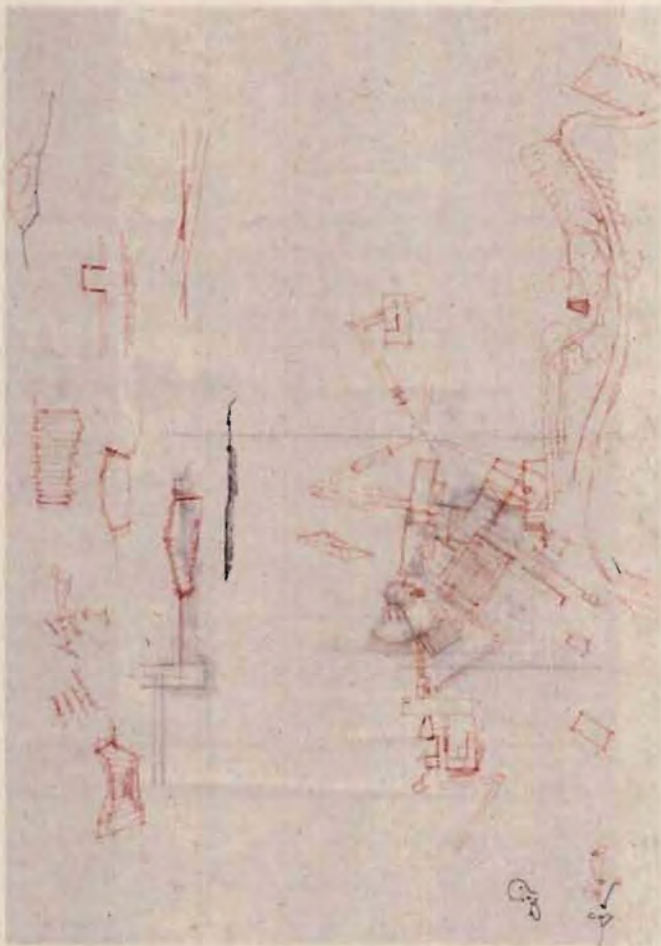
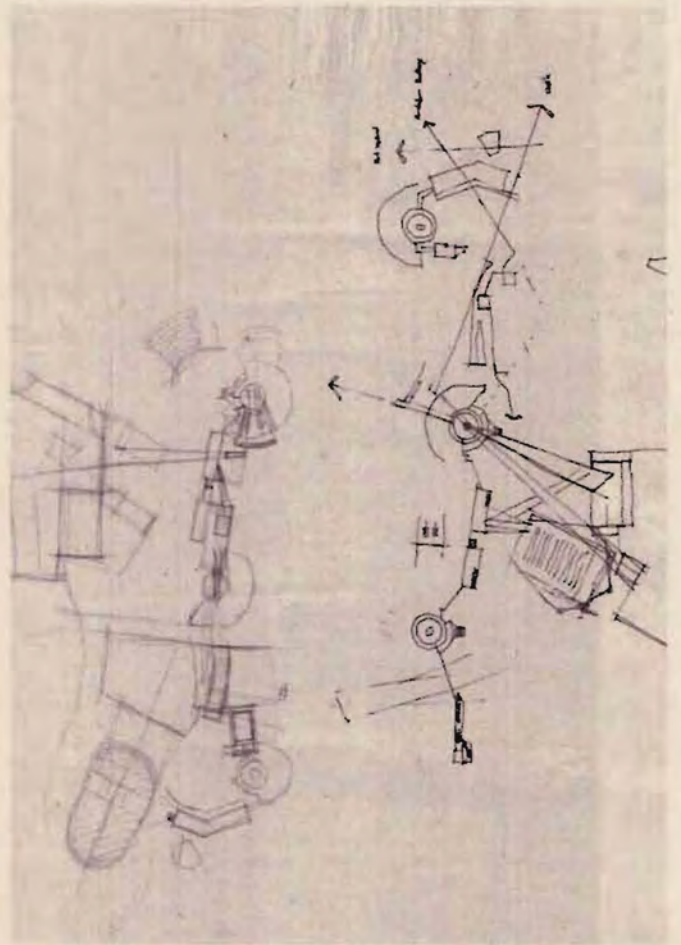
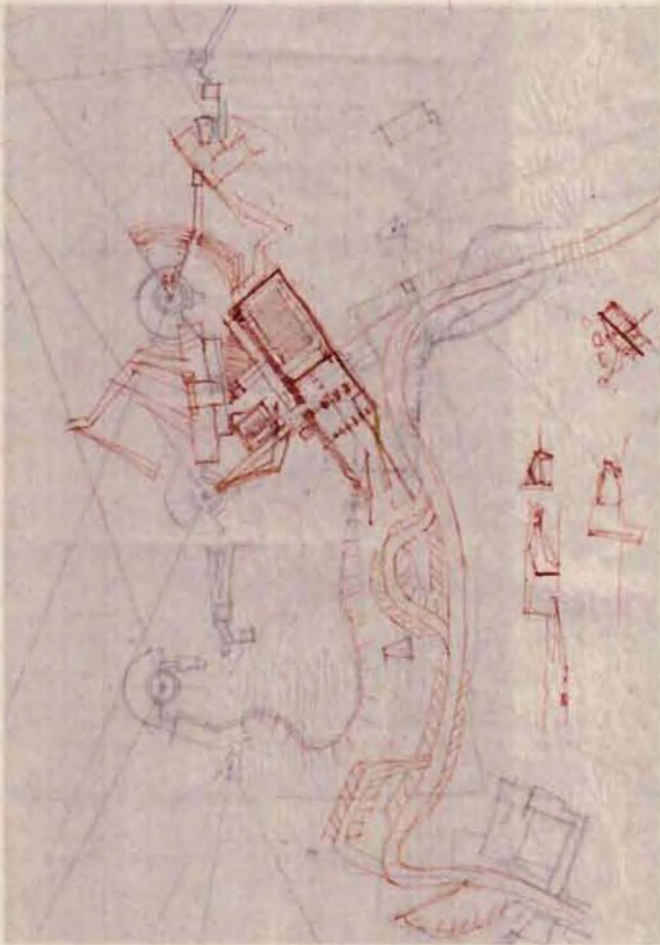


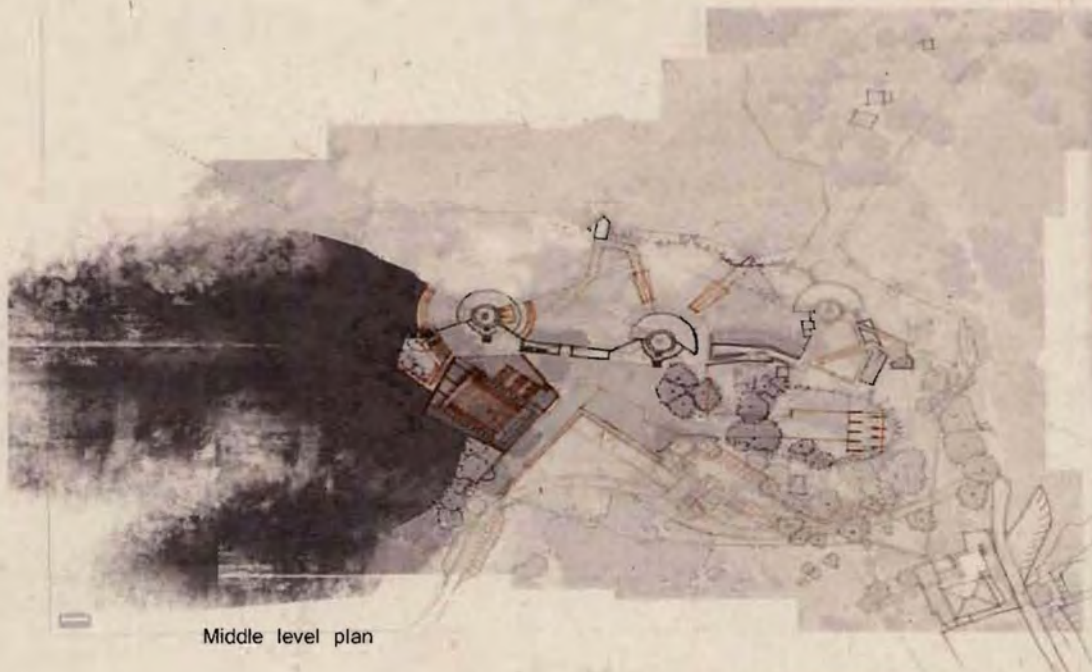


Figure 39. Series of sketches testing out design option.





Upper level plan

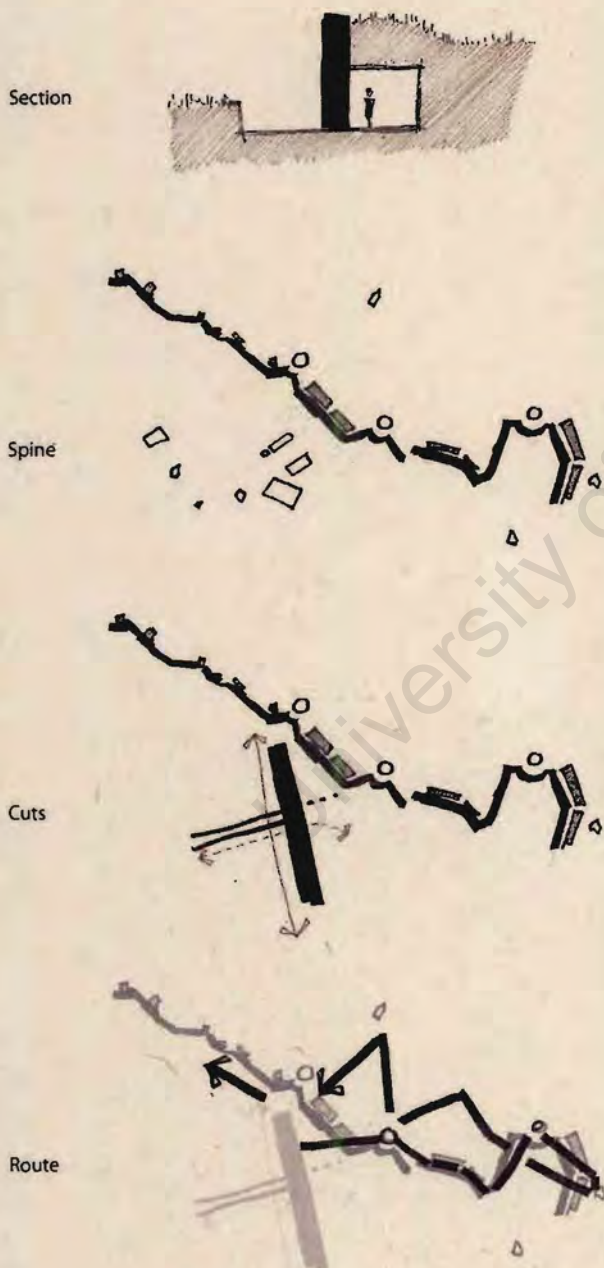


Middle level plan



Lower level plan

Figure 40. Plans.



Approaches

The existing structures form spine. The new building weaves in and out of this spine, intersecting it, but not competing with it.

The first action is to create one simple cut that runs from the entrance of the museum straight up to the Noon Gun site. The tectonics of the way this cut is made builds on the existing forms already on site; a cut trench protected by a heavy wall.

From this cut the building splits off to the East to create a route. This route serves as the museum, a scripted sequence of spatial experiences, allowing the viewers to explore and experience the site.

The museum route ends at the Noon Gun where there is a restaurant.

There is an auditorium that is part of the museum, but has been positioned in such a way that it can be used independently of the museum.

Figure 41. Approach Diagrams.

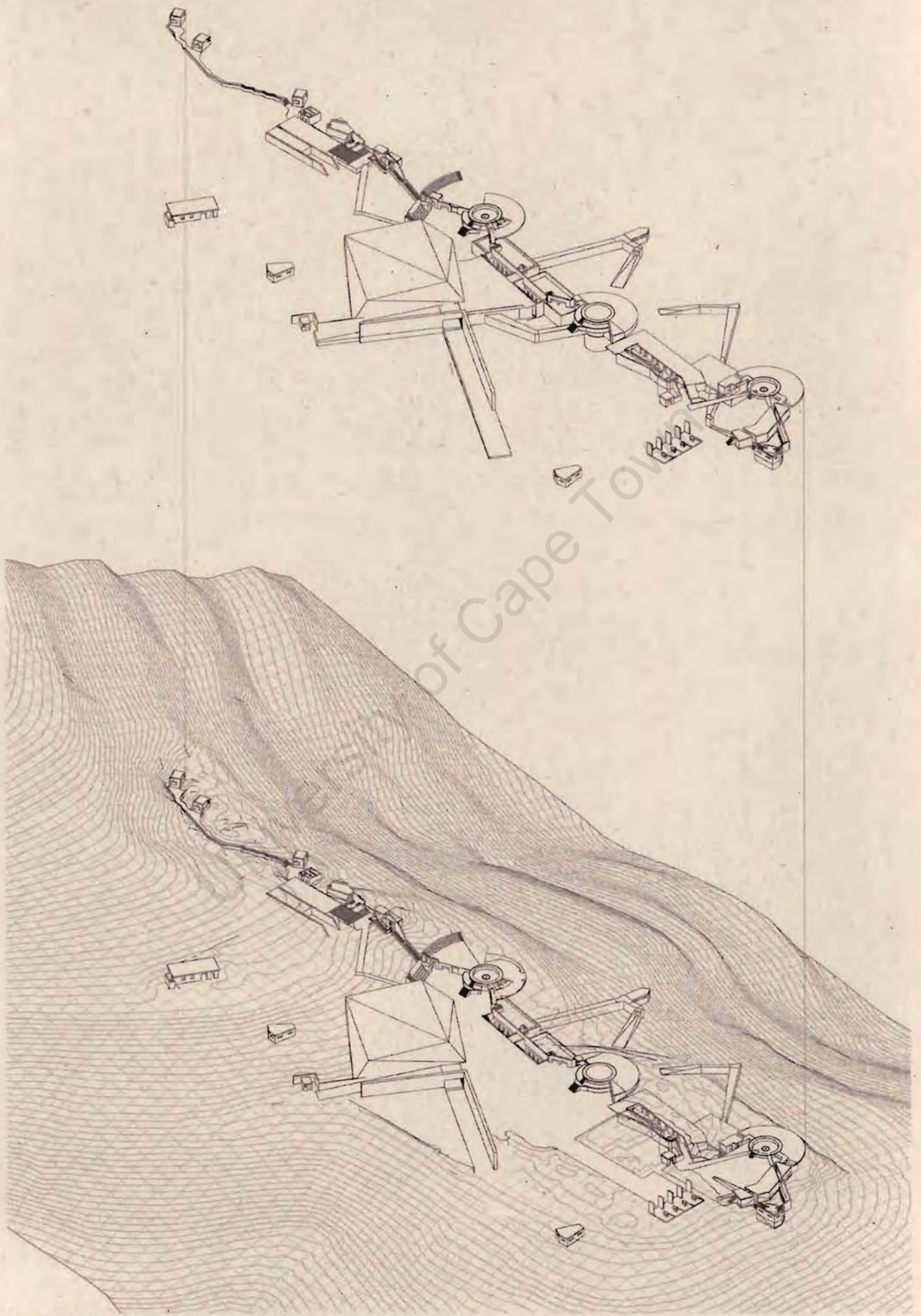


Figure 42. Exploded Isometric of new and existing structures. 50



Figure 43. Early sketch of entrance and primary cut.



Figure 44. Render of entrance and primary cut.

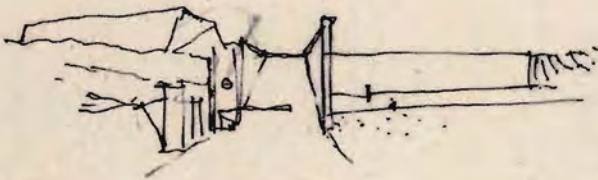


Figure 45. Early sketch of SANDF ramp over the entrance.



Figure 46. Render of hollowed out gun site.

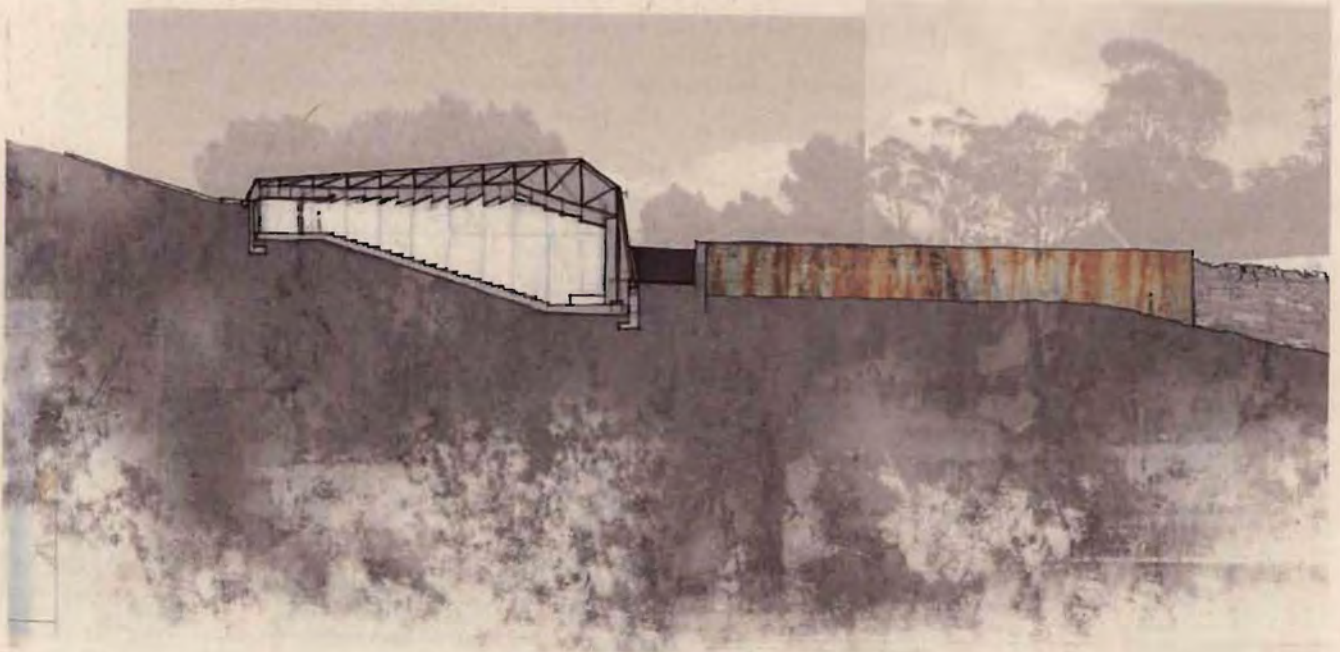


Figure 47. Section A-A

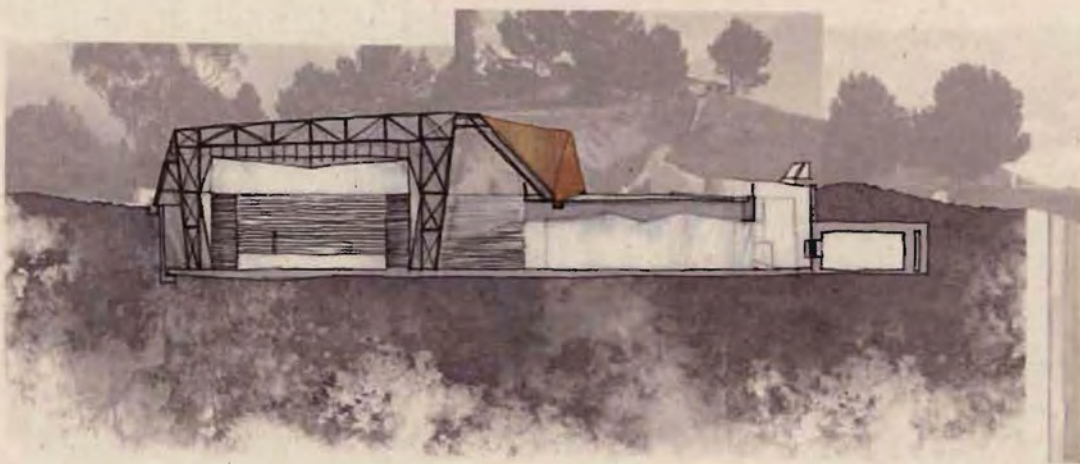


Figure 48. Section B-B



Figure 49. Materiality pallet.

Materiality

The site is predominantly thick concrete, stone walls, earth berms and prefab corrugated iron structures. As time has passed all these materials have weathered, roofs have fallen in, paint has peeled off and nature has reclaimed its space in the manmade landscape.

There is a tension between the manmade structures and the wild nature, it seems as if nature is taking back the manmade.

The materiality of the new buildings work with weathering, building on the ideas of decay. Heavy concrete is set up against corroding steel and weather timber.

Technical Resolution of Auditorium

From the beginning of this thesis I was interested in how parametrics software could be used in the design process, in particular the potential to introduce self organisation and evolutionary design into the process of design.

In Patrik Schumacher seminal paper *Parametricist Manifesto* he stated that "Parametricism is the great new style after modernism. Postmodernism and Deconstructivism have been transitional episodes that ushered in this new, long wave of research and innovation." (Schumacher, 2008)

I feel that "Parametricism" as a style runs the risk of becoming too entangled with form generation for the sake of new form generation. Parametricism must be seen as a way of thinking. There is a shift in thinking that needs to happen. A shift from focusing on the object to focusing on the relation between objects.

A relationship-based thinking combined with the ability to deal with complexity could be a powerful tool for architects. It allows for a new way of thinking about and representing ideas of space in architecture.

It is important to see parametric design as a tool that is used in conjunction with more traditional approaches. There needs to be a balance. Computer aided design has very distinct advantages and disadvantages that need to be acknowledged. I feel that often the strengths and weaknesses of parametric design complements the strengths and weaknesses of more traditional design approaches.

Computers have no ability to think, a computer can only calculate. This means that computers can only deal with number and thus any input or output the computer deals with have to be numerical.

In architecture we deal with some things directly in numbers, things that can be equated to number and then some things that are extremely hard to equate to numbers.

A parameter can be seen as any factor that defines a system and determines or limits its performance. These can vary from a set of measurable factors, such as distance, colour, temperature, strength, etc or a set of nonfigurative factors such as emotion or aesthetics. (Gane, 2004)

Parametric architecture can be simplified to architecture based on parameters.

Historically architects have always relied on drawing to communicate and realize their designs. The introduction of CAD software brought about change in the architectural office but has not changed how architects fundamentally work. Standard CAD software is a tool that facilitates the representation of design. For example, AutoCAD and REVIT are most commonly used as nothing more than complex drawing tools, fundamentally the same as an architect's drawing table. They greatly speed up production time and construction time. It must be remembered that all tools have restrictions, for example CAD software struggles with imperfection - if two walls are not exactly straight lines or just off exactly perpendicular the efficacy of the CAD software is massively reduced.

In recent years digital technologies use by architects have undergone a significant shift in the introduction of parametric software.

The difference between standard CAD software and parametric software is that the core focus has changed. In standard CAD software the focus is on drawing and representing objects and space. In parametric software the focus is on the relationships between the objects and space. This is a significant shift as it completely changes the thought process of the architect in the creative design process.

"Designers don't think in numbers. They think in relations. Standard CAD systems don't store relations. They store numbers, numbers that change while relations remain stable. Parametric CAD models capture those persistent rules behind the developing form, reducing thousands of coordinates to a handful of parameters." (Meredith, 2008) Parametric CAD software stores relations not the numbers.

The strength of parametric software is this focus on relationships. As architects design they are establishing relationships whether it is conscious or not. The process of design is the process of setting up relations between things.

It is interesting to see a graphic description of the relationships that make up a building explicitly represented.

The focus of my investigation into parametric design has been an investigation into genetic algorithms and evolutionary optimization.

I have made use of software called Grasshopper, an independent plug-in for Rhinoceros3D (Rhino) which is a stand-alone, commercial NURBS-based 3-D modelling tool, developed by Robert McNeel & Associates.

Grasshopper is simply a graphic interface for scripting information flows within Rhinoceros3D.

The auditorium roof is a steel structure clad in cor-ten steel with an internal acoustic skin suspended from the structure.

The beams in the auditorium roof need to span the 18 meters between the columns.

Using Grasshopper I scripted a parametric beam. The beam is based on 4 parameters: the depth of the beam, the number of cross members in the beam, the profile of the steel in the top and bottom members and the profile of the steel in the cross members.

Making use of a genetic evolutionary algorithm the beam is optimized so as to be as strong as possible but use as little steel as possible.

The beam is tested with real life forces in a virtual physics engine. The steel sections making up the beam are real IPE sections with accurate properties.

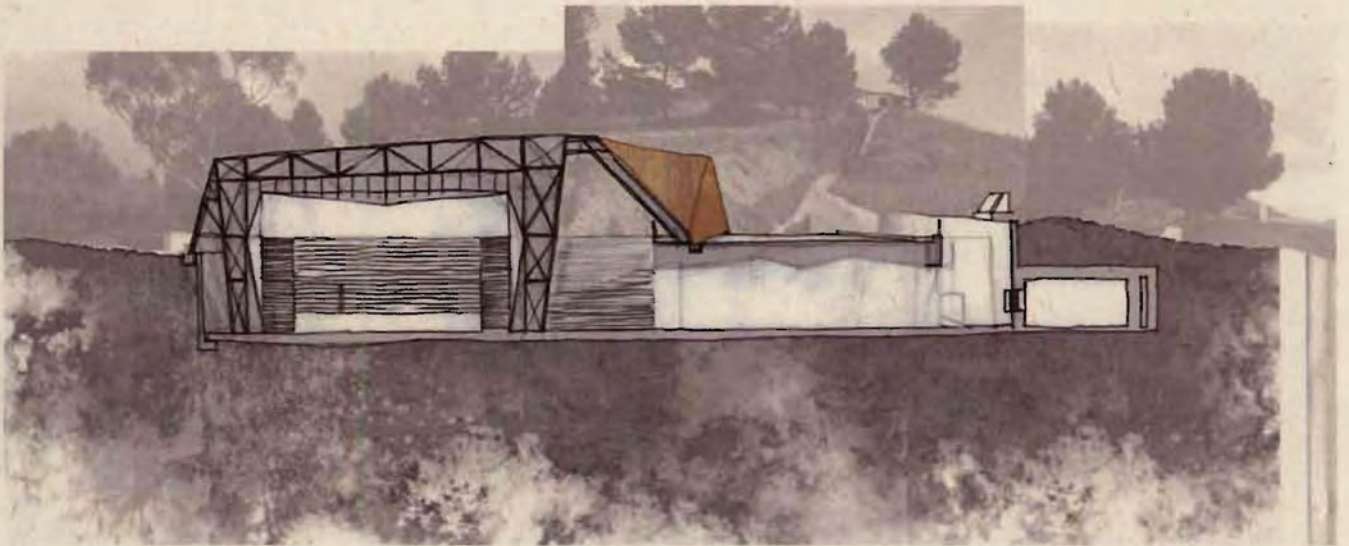


Figure 50. Section B-B

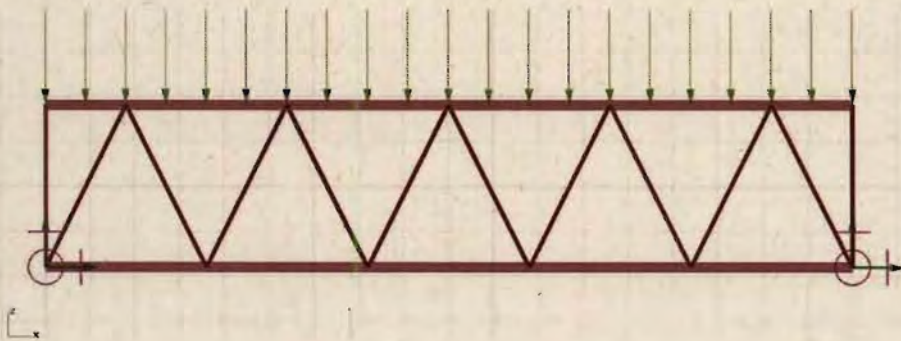


Figure 51. Auditorium roof beam.

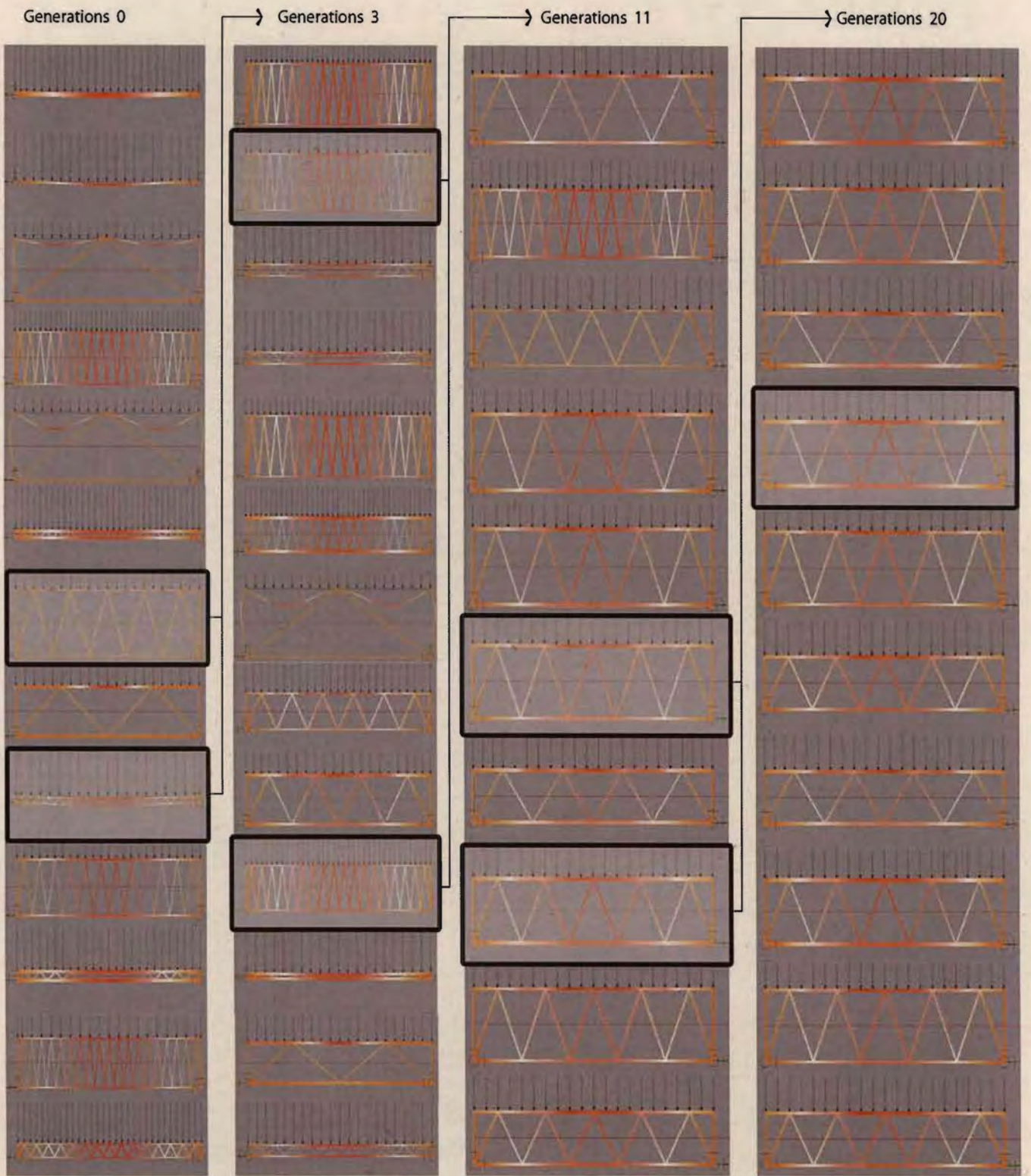


Figure 52. List of selected beams from generation 0, 3 11 and 20. With the strongest two of each generation highlighted.

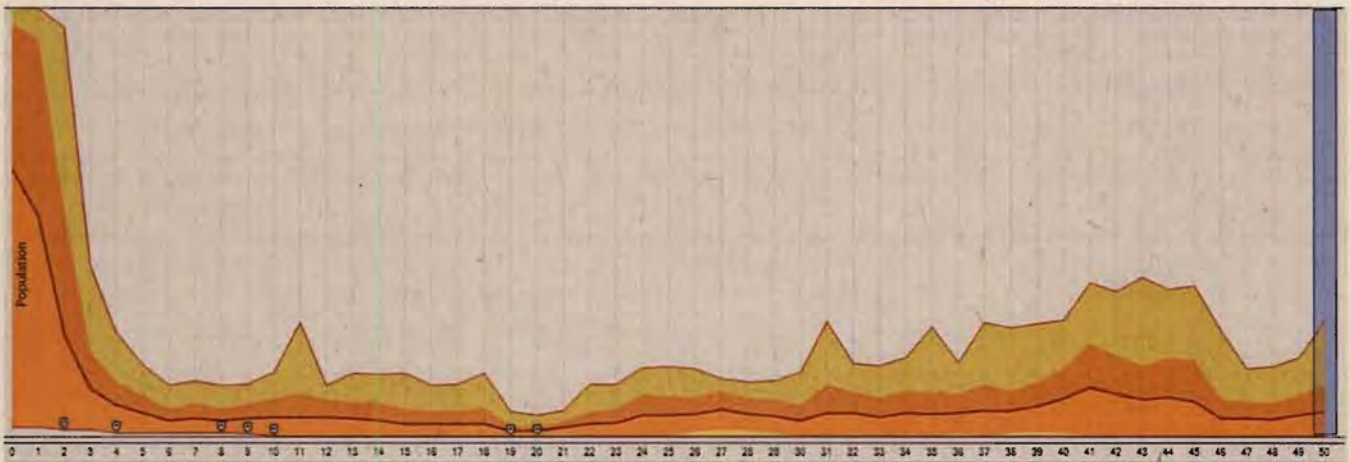


Figure 53. Population diversity/fitness over time.

Genetic Beam Evolution

First the algorithm creates a random population of 50 beams, each with a different set of properties, this is generation 0. Then each beam is evaluated on how strong it is and how much steel it uses- this is the fitness test for each gene (beam). Only the best (fittest) beams are selected to populate the next generation. With each successive generation the strongest genes reproduce, slowly optimizing the beam.

It is interesting to see in the first few generations, a deep beam with few cross members was similarly efficient and a shallow beam with lots of cross members.

The graph above shows how the population fitness becomes more and more refined as the generations increase. After 50 generations the optimal beam was evolved.

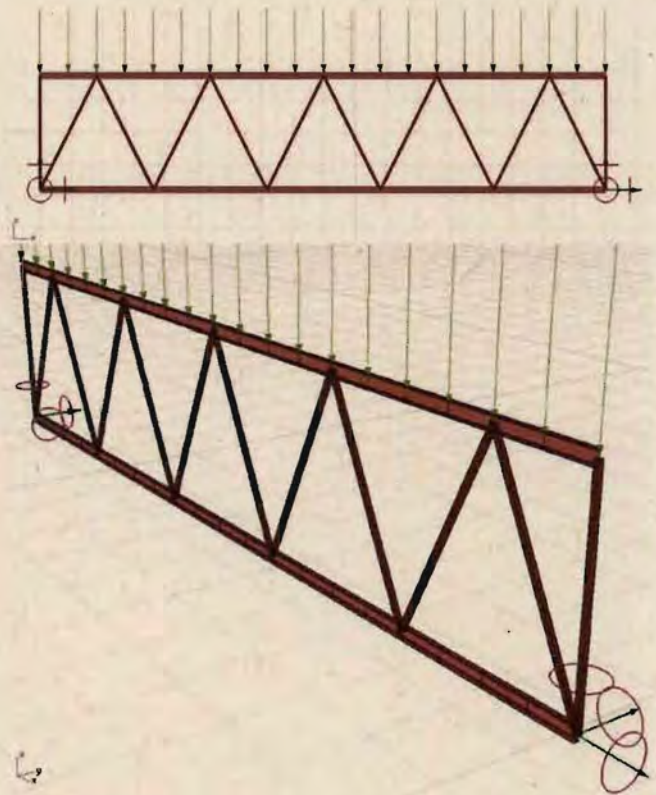


Figure 54. The optimal beam in this case, to span 18 meters is 1.8 meters deep, with 10 cross member made of EA100/60 steel sections. The upper and lower members are IPE220 steel sections.

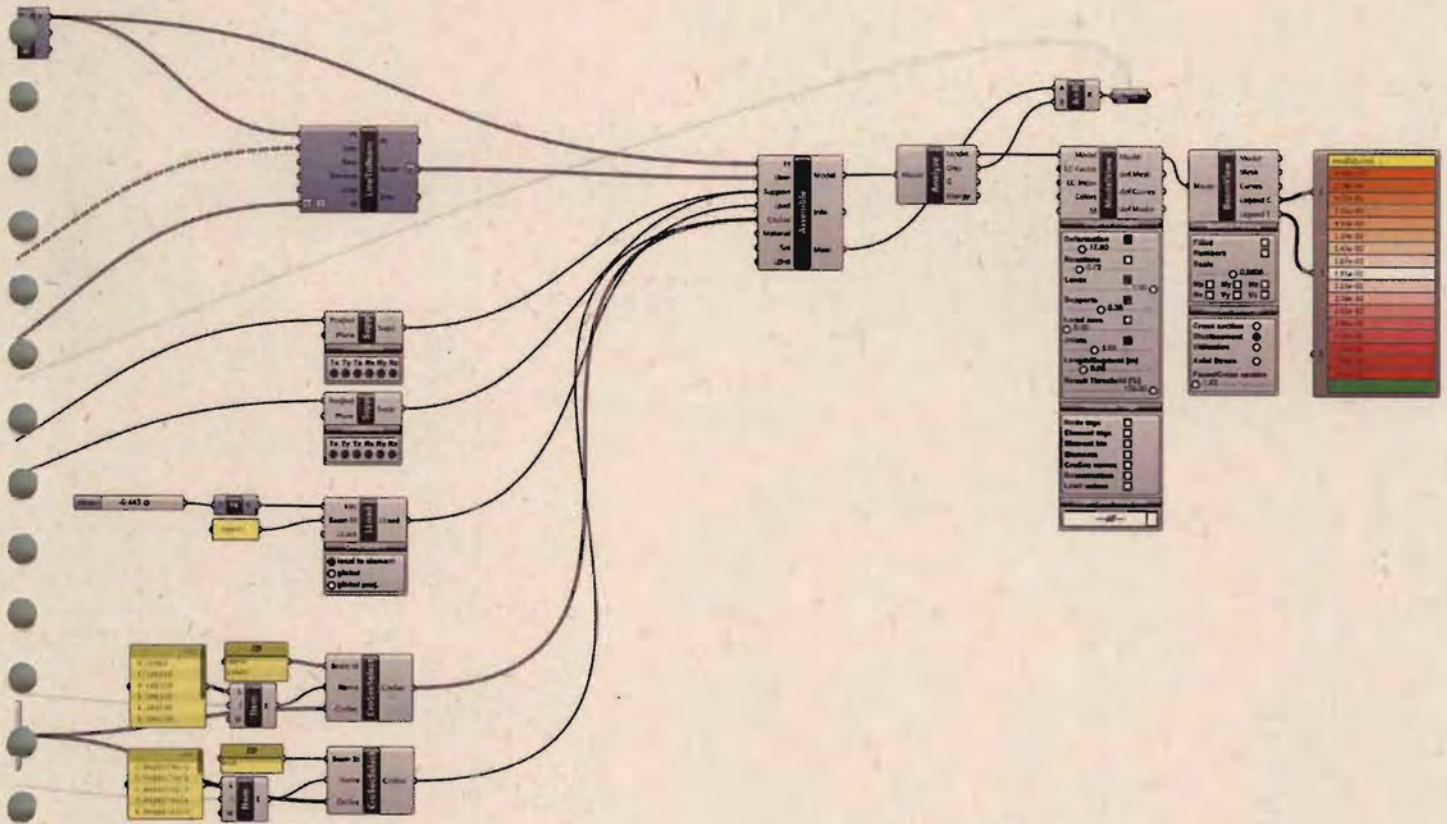




Figure 56. Internal render of auditorium.

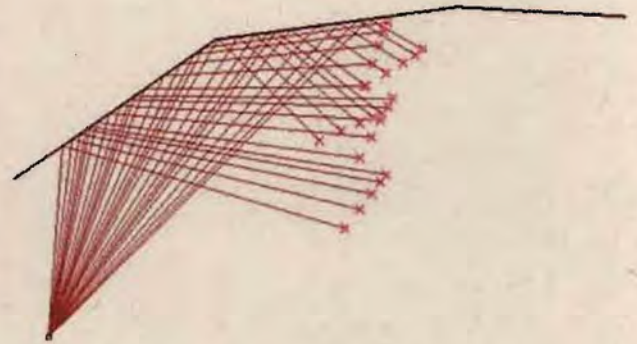


Figure 57. Sound reflection off a surface.

Auditorium Acoustic Paneling

The acoustic panels are suspended from the beams in the roof and are non-structural components. Their purpose is to reflect sound from the speaker on stage down onto the audience without creating any delayed echoes.

Using Grasshopper I scripted a parametric folded plane structure as the acoustic panels. Each panel is allowed to move and rotate within a set range.

The scrip also projects the sound trajectories from a speaker on stage. As each sound trajectory hits an acoustic panel it is reflected as it would do in real life. The script then calculates the number and distribution of the vice trajectories that land on the audience.

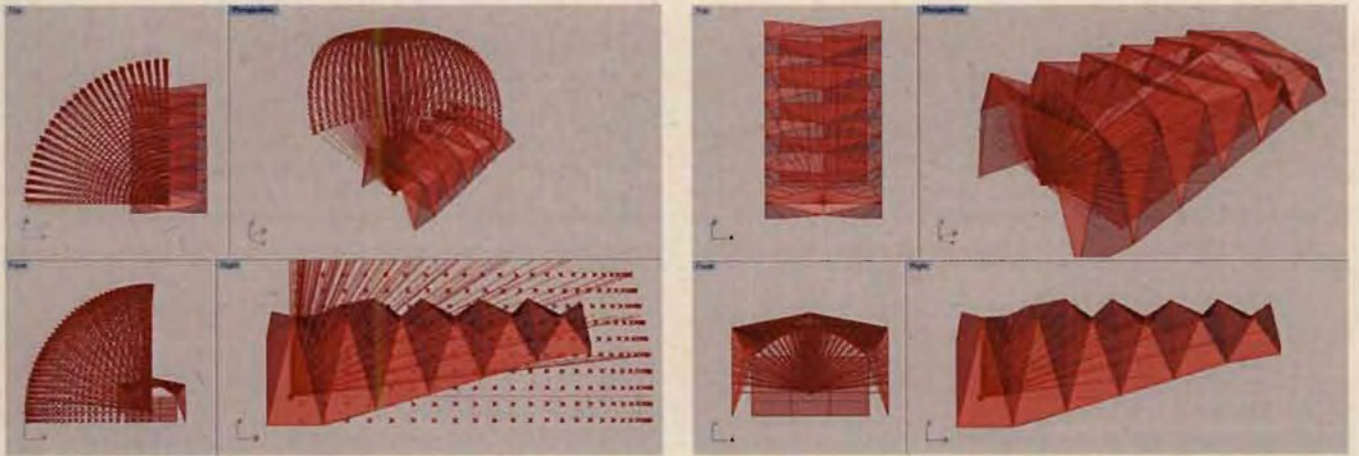


Figure 58. Projection of speakers voice.

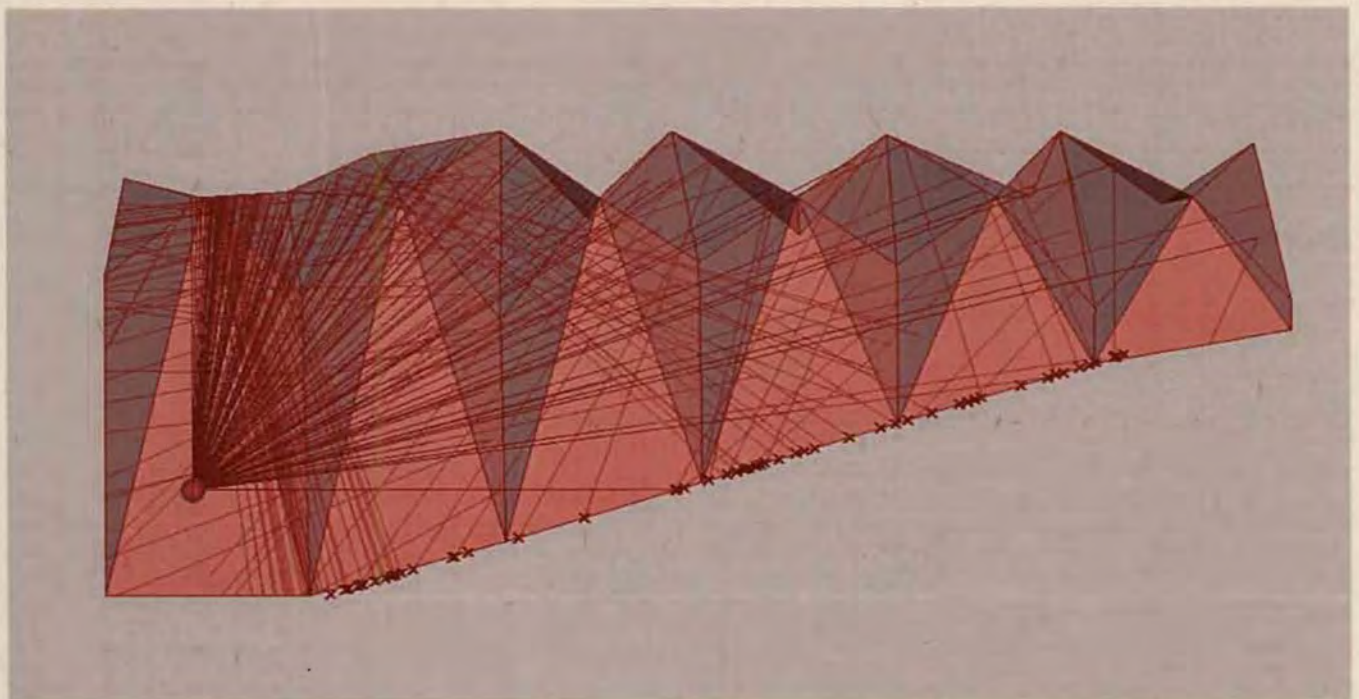


Figure 59. Speakers voice reflected down to the audience.

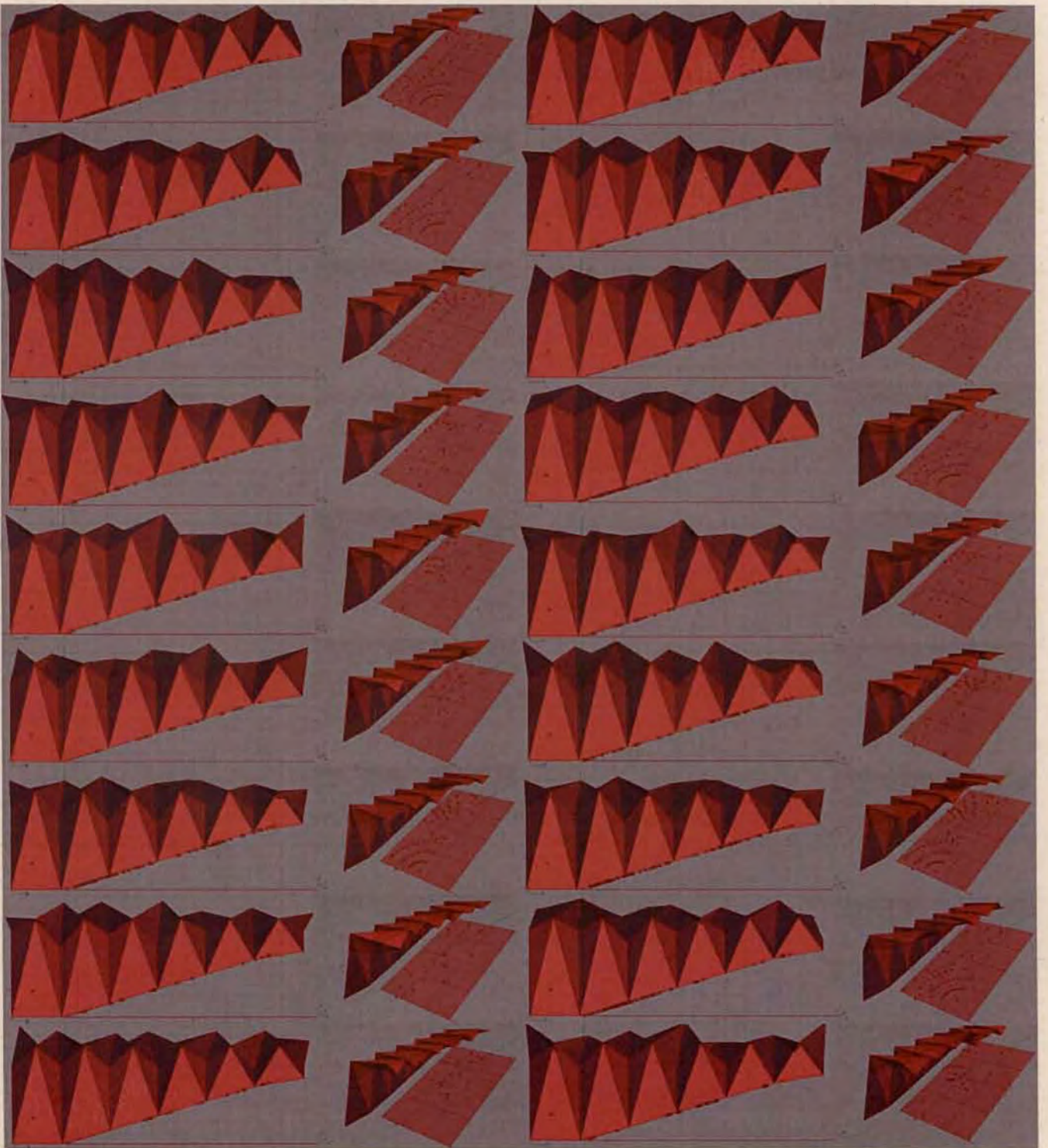


Figure 60. Selected generations of the acoustic panels as they evolved.

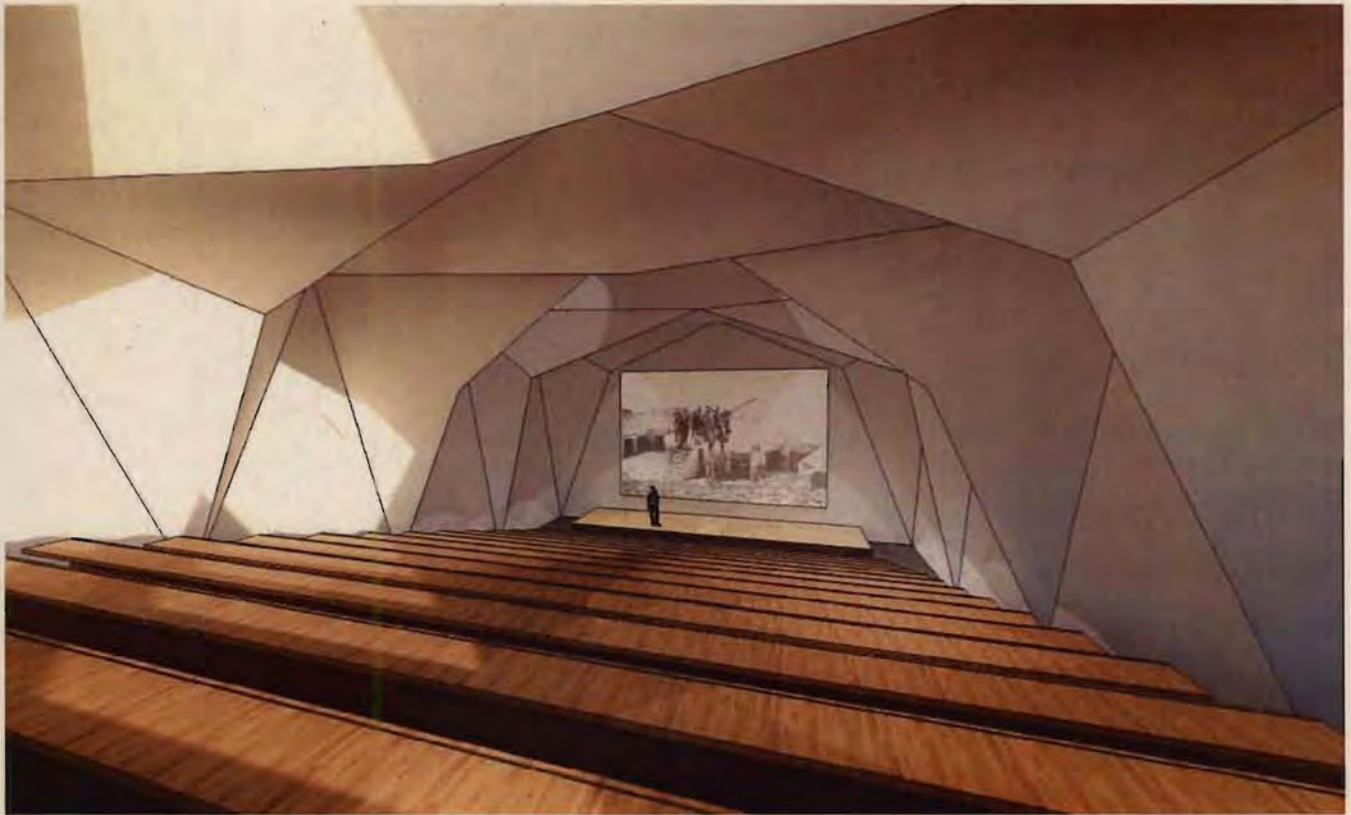


Figure 61. Internal render of auditorium.

Evolutionary Parametric Acoustic Paneling

The evolutionary algorithm for the acoustic panels works in the same way as for the beams.

First the algorithm creates a random population of 50 panel positions, this is generation 0. Then each panel is evaluated on the number of reflection that reach the audience and how well these reflections are distributed among the audience, this is the fitness test for each gene. Only the best (fittest) combination of panel positions are selected to populate the next generation. With each successive generation the strongest genes reproduce. Slowly optimizing the reflections so as to maximize the number of reflections that reach the audience and how equally dispersed they are.

The graph shows how the population fitness becomes more and more refined as the generations increase. After 20 generations the optimal panel position has evolved within the given constraints. It is important to note that there are simply optimizations within defined constraints

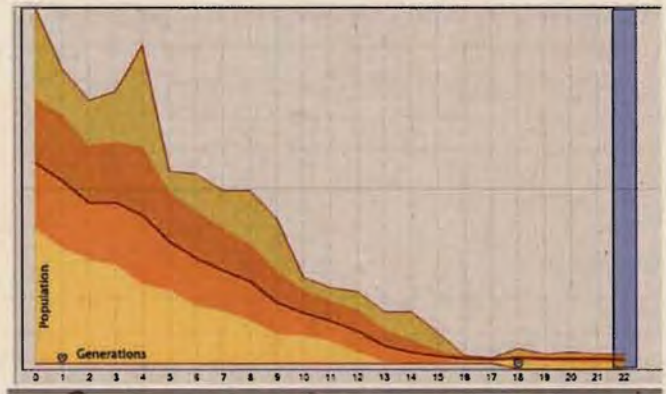


Figure 62. Population diversity/fitness over time

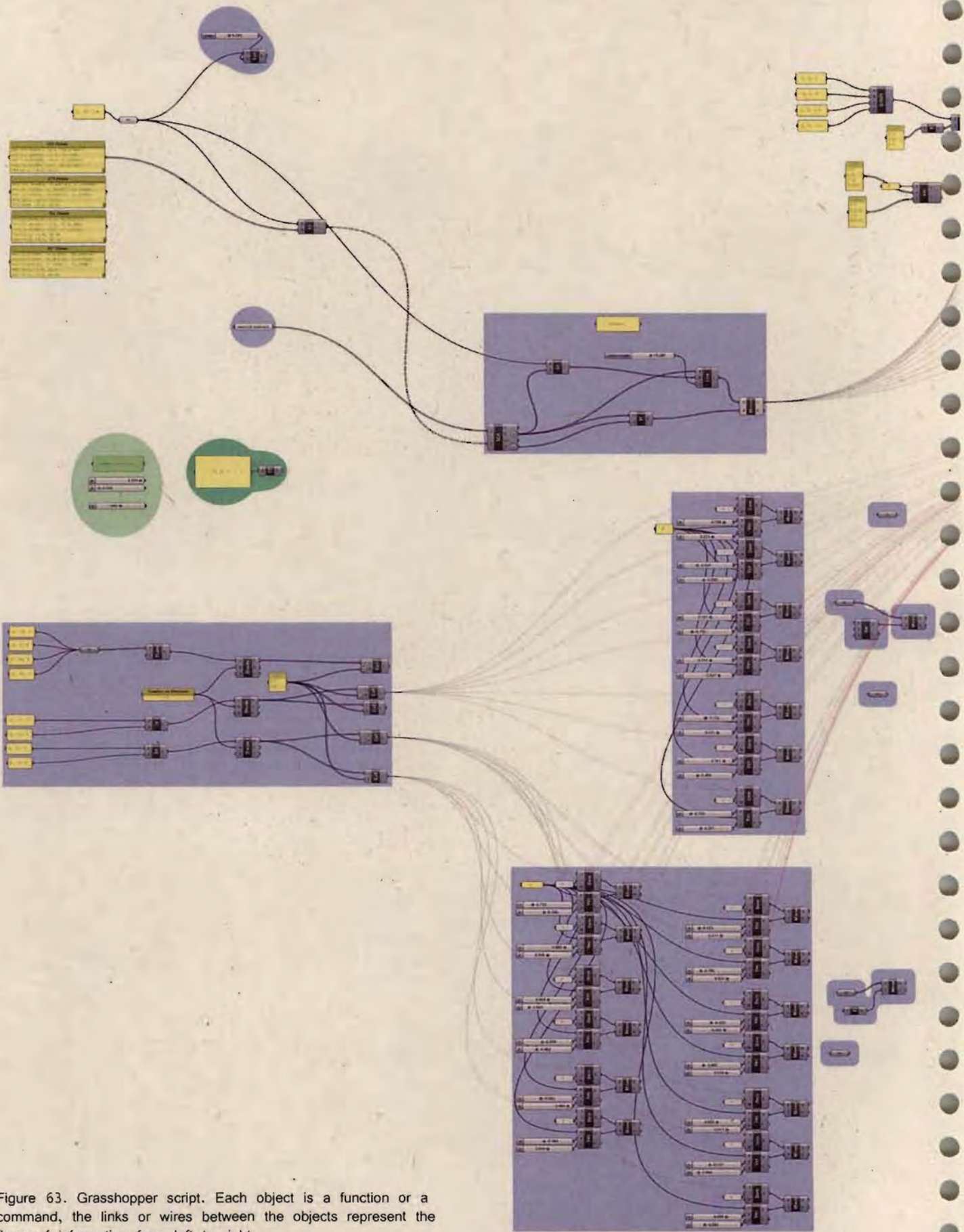
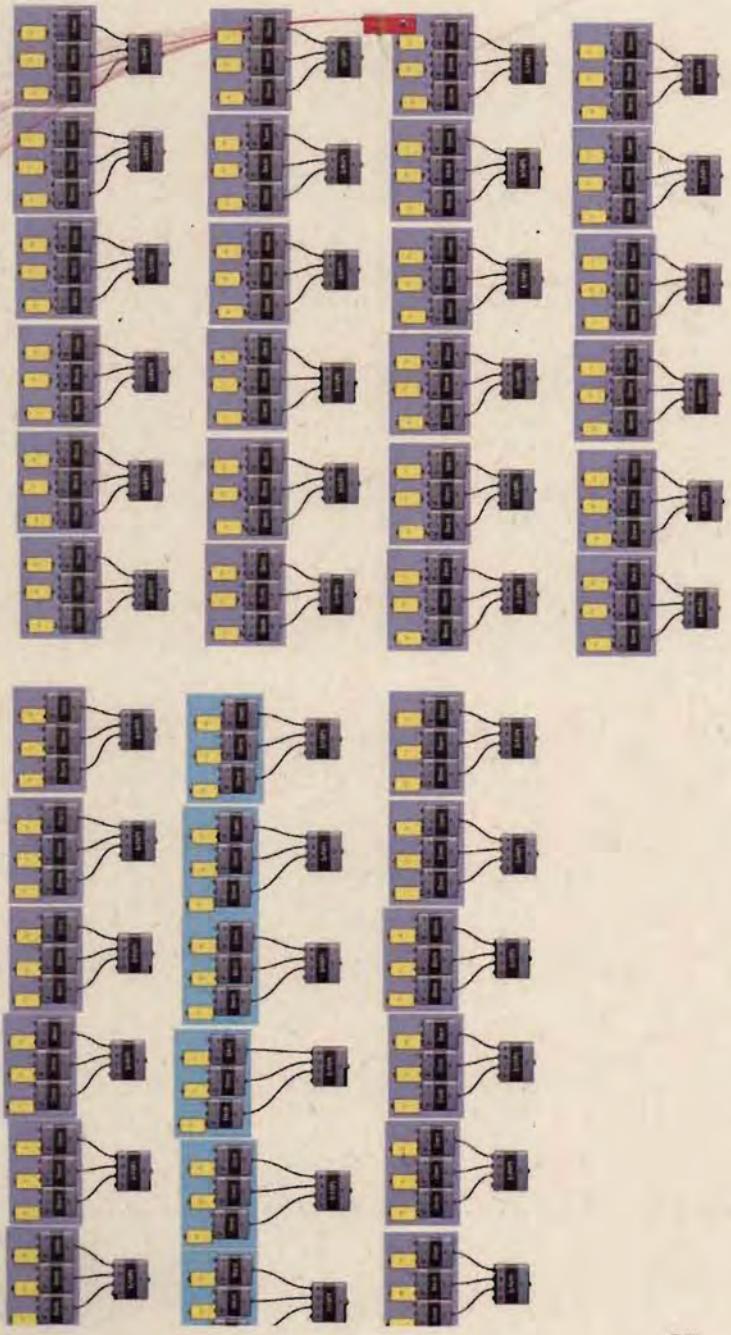
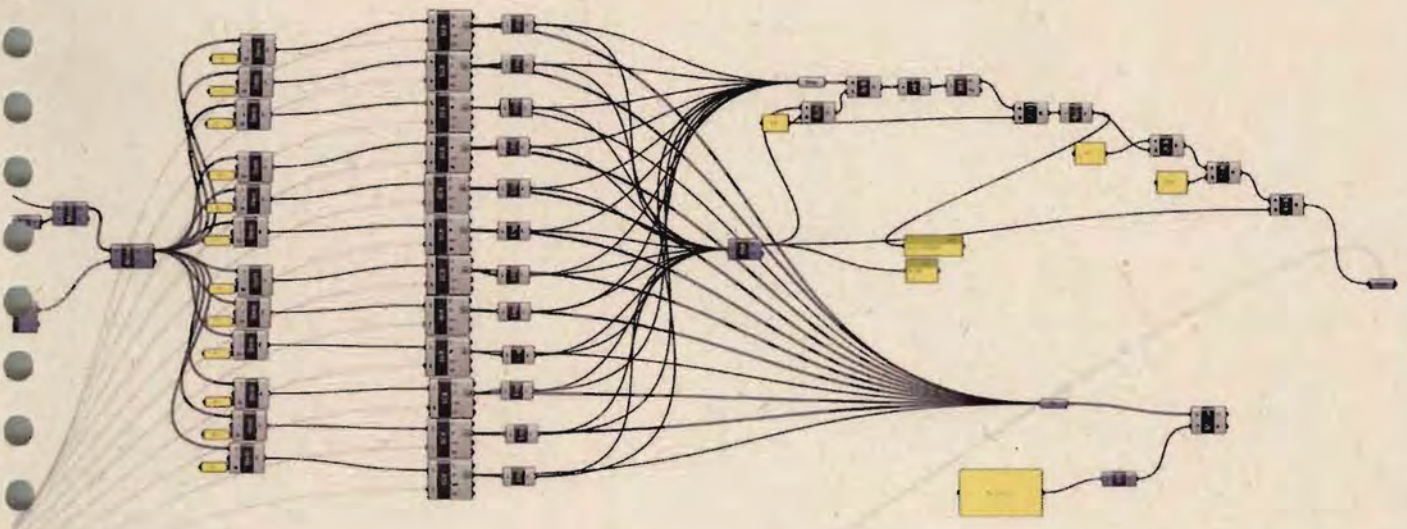


Figure 63. Grasshopper script. Each object is a function or a command, the links or wires between the objects represent the flows of information from left to right.



University of Cape Town

Reflection

“When we think about space, we have only looked at its containers. As if itself is invisible, all theory for the production of space is based on an obsessive preoccupation with the opposite: substance and object, i.e., architecture. Architects could never explain space; Junkspace is our punishment for their mystification.” (Koolhaas, 2004)

This thesis explores an architecture of spatial experience, re-imagining the Lion Battery site.

The focus of the architectural design is the spatial experience of the building and is a shift away from object orientated form.

The project takes advantage of the unique and powerful qualities of the Lion Battery site. Building on these qualities to create a museum focusing on human spatial experience enhancing the site.

The project works with ideas around Relative Space as well as Absolute Space. This can be seen in the contrast between the traditional hand drawing the computerised parametric algorithms.

The focus of architecture must not be the building itself but rather the spatial experience of architecture.

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Table of Figures

Figure	Page	Source
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