A STUDY OF PALLADIO'S PARAMETRIC DESIGN PRINCIPLES
MASTER THESIS EXPLANATORY DOCUMENT

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“Beauty will derive from a graceful shape and the relationship of the whole to the parts, and of the parts among themselves and to the whole, because buildings must appear to be like complete and well-defined bodies, of which one member matches another and all the members are necessary for what is required.”

Abstract

The intention of this project is to study methods for the coordination of internal spaces and external visual elements on a building. Prototypical models of such coordination that I intend to study and on which I will base my mathematical analysis is Andrea Palladio’s (1508-1580) Palazzo Chiericati (1550 – 1557) in Vicenza, and Villa Cornaro (1551 - 1552) in Piombino Dese.

These buildings exhibit very complex relationships between the proportional geometry of the external elements and interior spaces, which determine the overall morphology of the building. The coordination between the internal spatial composition and external elevation composition can be seen in the alignment of the positions of the interior walls with the location of the external elements (columns). Throughout the buildings, the internal room sizes, length, and width, are determined according to Palladio’s proportional rules and preferred length to width ratios. These then inform the height of the rooms, which must equal the height of the columns plus the entablature. The total height of column and entablature is determined by the proportions associated to the chosen systematic rules (orders), which in turn determine the spacing of the columns (intercolumniation).

My approach will be to analyse the geometry and proportional relationships present in the buildings. The methodology used to coordinate the design of the interior forms with the external elements will be quantified through definition of the compositional and dimensional rules employed, and will be made available as a tool-set for application in other architectural designs.

Both buildings illustrate the approach whereby parameters that define one shape, are linked through a series of rules to the parameters of another shape. Modification of one leads to the changing of a related other. This can be described as a parametric design system, or Parametric Object Modelling (POM). For an architect working in the sixteenth century, devising such a system would have required a complex system of mathematical equations. Using computer aided design (CAD) software, specifically CAD software that incorporates parametric objects, combined with spreadsheet programme applications, a building’s geometry can be modelled digitally and relationships between elements created. Once the central logic and design relationships have been defined the shapes and proportions of elements or objects can be manipulated as different parameters are changed. For example, the modification of the overall width of the building can be altered to explore how the related objects or elements change. Numerous formal variations can be quickly generated and analysed with the use of CAD software, enabling the formulation of a design approach and tools.

3 Branko Mitric, Learning from Palladio (New York: W.W. Norton 2004), 101-112.
Acknowledgements

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1.0 Introduction

1.1 Research Question

*Design a contemporary classical building using an historical design theory.*

1.2 Objectives

The central focus of this project is research by design. The aim of the proposal is to analyse and understand an historical system of design, one that can be defined as a parametric system of rules. The system is recognisable within two building designs, and the analysis of these, together with the current available knowledge, will assist in the formulation of a systematic design approach. Is it possible to understand, define an existing system, and then use its application in finding an architectural solution? Will the application of the methodology to the process of designing a building, result in a form with a coordinated spatial composition and external elevation?

1.3 Scope and Limitations

The scope of this project will include the design of a large public building located within Auckland’s Aotea Square. The building will require the composition of numerous spaces, and possibly buildings of varying sizes and hierarchies. There will be important relationships between the internal rooms and the exterior public plaza, the entries, and public and semi-public spaces contained within the building. The existing buildings will provide a built-environment context which will require a formal response, both in terms of spatial and external composition. The choice of building programme will reflect the need for a several large main spaces, which will be linked through a series of series of rules, or parameters, so that the proposed design methodology can be demonstrated.

The Aotea Square (refer to figure 1.1 on page 2 and appendix 9.1, figure 9.1, page 79) was selected as suitable due to the availability existing site information, and site analysis. It provides a setting within a dense urban environment, and the variation of surrounding building typologies allows for a degree of flexibility when choosing a suitable programme for this project. This enables the project to focus primarily on the formulation of a parametric design methodology, and not be dominated by the principles associated with urban design or an overly complex programme. The

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provide a number of physical constraints that will need to be incorporated into the parametric equation, and contribute to final design resolution.

The location of the proposed building’s exterior public entries will partially determine the placement of the larger interior public or semi-public spaces. Similarly, the formal response to the existing buildings will determine the location of external elements, possible storey heights, fenestration, and entries. Entry points into the plaza will influence how the building as a whole addresses the site.

The composition of numerous internal spaces of various sizes, and the public/private requirements of each, combined with the relationship to the exterior public spaces will generate a requirement for complex interrelationships between the composition of internal forms and external composition.

Fig. 1.1 Site location, shown shaded (not to scale). Image from Auckland Council Map Viewer, http://maps.aucklandcouncil.govt.nz/AucklandCouncilViewer/ (accessed August 31, 2012).
2.0 Current State of Knowledge

2.1 Definition and History

Born Andrea Di Pietro Dalla Gondola in 1508 in Padua, Veneto, Northern Italy. Andrea Palladio was originally trained as stonemason and he did not begin his architectural career until the age of thirty. A career that went on to last for almost forty years. An important contribution came from the architect Sebastiano Serlio, in the form of his architectural treatise, *I sette libri dell’architettura* (Seven Books of Architecture.) The first instalment, *Book IV On the Five Styles of Buildings*, appeared in Venice in 1537, written in Italian and supplemented with illustrations, it was aimed at architects, builders, and craftsmen. Here Palladio would have read of Serlio’s ideas on the rules of the classical architectural orders, documented by Vitruvius in his treatise, *De Architectura libri decem* (Ten Books on Architecture.), and visible in the buildings and ruins from the Roman age.

The Humanist Giangiorgio Trissino was responsible for ensuring Palladio received a part-Humanist type education, one that specialised in architecture, engineering, ancient topography, and military science. Trissino also had contact with numerous architects, scholars, and practitioners in the region surrounding Padua, a useful influence for a trainee architect. Study of the classics would have almost certainly included the architectural treatise of Vitruvius, and importantly Trissino facilitated Palladio’s first trip to Rome in 1541, where he was able to experience and document the use of the classical orders as interpreted by ancient Roman architects.

The orders provided Palladio and other architects with a method for composing architecture in the classical tradition. The elements, columns (supporting) and entablature (spanning), are assembled in a certain order according to the type; Tuscan, Doric, Ionic, Corinthian, and Composite. Each type has a distinct set of principles pertaining to the proportions and use of specific profiles and details and proportions.

Palladio’s early work (1540-1550) displays little use of the orders, but does display use of geometrical shapes to adorn the facades. Two examples are shown in figures 2.1 - 2.3.

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6 James S. Ackerman, *Palladio*, (London: Penguin, 1966), 20. Received his classical name, Palladio from the pre-eminent Vicenza intellectual Count Giangiorgio Trissino while under his scholarship.
7 James S. Ackerman, *Palladio*, 19.
9 Ackerman, *Palladio*, 21.
Fig. 2.1 Villa Godi, 1537-1542. As it appears in *I quattro Libri*.

Fig. 2.2 Villa Godi, 1537-1542. As it was built and appears now. (Paolo Marton)
To be examined in this thesis is the design methodology Palladio displayed in his works from the late 1540s and early 1550s. A methodology that could be described as a parametric design system.

The definition of a parametric design system can be defined as a methodology that has a number of rules, or functions linked together. Palladio had developed a list of preferred room sizes and shapes, and a set of relations and rules to control the dimensional size of these internal spaces, and combined these rules with those of the orders.

A parameter is a variable to which other variables are linked. The method of parametrically designing volumes, for example the composition of the spaces required for the internal rooms of rooms of a building, requires the linking of dimensions and variables to the geometry of the volume.

By this time of Palladio’s career the use of the orders is visible throughout most of his works, but rather than using the orders as a system with which to compose the elevation ornamentation, Palladio sought to integrate the orders with the composition of the entire building. So that a unity existed between the geometry of the external ornamentation, determined by the principles associated to the selected order, and with the geometrical organization of the internal spaces. What Ackerman describes as the co-ordination of groups of elements in three dimensions, in a system that integrates the proportional relationship of plan and elevation, interior and exterior.11

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11 Ackerman, *Palladio*, 167
Just as principles of the type of order determine the proportional relationship of the associated elements within one group of an element, then correspondingly there are rules defining the relationship between the groups. The spacing between columns, or intercolumniation. Palladio identified the Vitruvian systems of column dispositions with the orders (see figure 2.4) and expanded this idea to cover all structural elements within a building.\(^{13}\)

<table>
<thead>
<tr>
<th>INTERCOLUMNATION TYPES</th>
<th>DISTANCE BETWEEN COLUMNS</th>
<th>APPROPRIATE COLUMN HEIGHTS (VITRUVIUS)</th>
<th>PALLADIO</th>
<th>APPROPRIATE ORDER IN PALLADIO'S VIEW</th>
<th>INTERCOLUMNATION FOR THESE ORDERS ACCORDING TO VIGNOLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARAESTYLOS</td>
<td>More than 3D</td>
<td>8D</td>
<td>7D</td>
<td>Tuscan</td>
<td>2.33D</td>
</tr>
<tr>
<td>DIASTYLOS</td>
<td>3D</td>
<td>8½D</td>
<td>7½-8D</td>
<td>Doric</td>
<td>2.75D</td>
</tr>
<tr>
<td>EUSTYLOS</td>
<td>2½D</td>
<td>8½D</td>
<td>9½D</td>
<td>Ionic</td>
<td>2.25D</td>
</tr>
<tr>
<td>SIASYLOS</td>
<td>2D</td>
<td>9½D</td>
<td>9½D</td>
<td>Corinthian</td>
<td>2.33D</td>
</tr>
<tr>
<td>PIACOSTYLOS</td>
<td>1½D</td>
<td>10D</td>
<td>10½D</td>
<td>Composite</td>
<td>2.33D</td>
</tr>
</tbody>
</table>

\(D\) is the lower-column diameter.

Fig. 2.4 Palladio’s Canonical use of intercolumniations.

Palladio sought to intricately link the dimensional form of an internal space to those of structural elements, such as exterior walls or columns. The proportional relationship that defines the room size, the length-width to height ratio, is determined by two properties, and as the room plan ratio changes, so does the corresponding height. The volume therefore has a proportional geometric relationship, which is described as a variable. As the plan ratio changes so does the position and height of walls or columns. The positions of which need to correspond to the variable defined by the intercolumniation associated to the order type.

The parametric equation can be described as mathematical relation between the variable width (\(w\)) which determines the variable height (\(h\)), according to the selected parameter. For a rectangular room, selection of either one of the principle means; arithmetic, geometric, or harmonic will result in a slightly different ceiling height.

Palladio’s list of preferred length-to-width types; circular, square or rectangular with length-to-width ratios of 2:1, 3:2, 4:3, 5:3, \(\sqrt{2}:1\) or \(\sqrt{3}:1\).\(^{14}\) This is a list of variables which can then be related to another list of variable to generate the most appropriate ceiling height. Methods described in *I quattro libri dell’architectura* determine the height mean. This provides the principle mean list of rules.

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13 Mitrovic, *Learning from Palladio*, 100.
14 Andrea Palladio, *I Quattro Libri dell’architettura*, Book 1, chp 1, 54.
The sum of length ($ab$) and width ($ae$) is divided in half, the result ($fe$) is the height of the vaulted ceiling.

Fig. 2.5 Height generating method 1. From *I quattro Libri*

The sum of length ($ab$) and width ($ae$) is divided in half, a half circle is formed ($bgf$) line ($ac$) is extended to the circumference ($g$) and ($ag$) is the height of the vault.

Fig. 2.6 Height generating method 1. From *I quattro Libri*

The sum of length ($ab$) and width ($ae$) is divided in half, a half circle is formed ($bgf$) line ($ac$) is extended to the circumference ($g$) and ($ag$) is the height of the vault.

Fig. 2.7 Height generating method 1. From *I quattro Libri*
If the ceiling is vaulted, the room’s height should be equal to the arithmetic, geometric, or harmonic mean between length and width. These methods can be described mathematically (where height = h, width = w, and length = l) as:

- Arithmetic mean
  \[ h_a = \frac{(w + l)}{2} \]

- Geometrical mean
  \[ h_g = \sqrt{wl} \]

- Harmonic mean
  \[ h_h = \frac{2wl}{w + l} \]

For a vaulted square room the method is described as,

\[ h_s = \left(\frac{4}{3}\right)w = \left(\frac{4}{3}\right)l \]

If the ceiling is flat, then,

\[ h = w \]

Importantly Palladio provided the caveat allowing other vault heights, which do not fall under any rule other than looking appropriate according to the architect. This concern cannot be described mathematically but can be taken into account when considering the design principle mentioned by Palladio in his treatise, that rooms in the same row should have equal heights.

A example of this is as follows. A room size is selected from the list of seven preferred shapes, a rectangle of ratio 5/3. The ceiling height is determined from the one of the three principle means (the arithmetic, geometric, and harmonic).\(^\text{15}\) The selection of one of these parameters enables a variety of heights to be generated. From the list of preferred length-to-width ratios with corresponding ceiling heights can be selected and placed adjacently.

\(^{15}\) Palladio, however never uses the terms arithmetic, geometric, or harmonic mean, and his methods for determining these proportions are rather complex, Branko Mitrovic, “Palladio’s Theory of Proportions and the Second Book of the Quattro Libri dell’ Architettura”, *Journal of the Society of Architectural Historians*, 49 (1990). 279.
The rooms can then be grouped together as an object. The form of each room is dependent on the relationship to the common parameter, room width.
Mitrovic identified a design principle, described as the Condition on the Concordance of Heights, or CCH rule. This condition identified that by using differing means to calculate the ceiling height, it is possible to achieve the same height for rooms in the same row. If the CCH rule is applied to rooms with one dimension in common, only one combination of length-to-width ratios is possible for a row of three rooms (2/1, 5/3, and 1/1) and there are four possible combinations for rows of only two rooms (2/1 and 5/3; 2/1 and 1/1; 5/3 and 1/1; 3/2 and 5/3).\textsuperscript{16}

Coordination between the internal spatial composition and external elevation composition can be achieved by grouping the room size object with the external elements, the order object.

There are specific ratios associated to each type of order that determine the height and width of the column and its associated elements. The order type will generate the column spacing, a variable which will be linked to the width or length and height dimension of the internal space. The order type and its associated proportional rules, combined with the ideal spacing between columns will generate the overall height of the column and its associated elements. An appropriate height, one that suits the ceiling height and type, and is suitable for the exterior composition can be designed by the selecting the order type and adjusting variables within the object.

The following are examples of linking the generation of external elements to the internal space that conform to the appropriate intercolumnar distance.

\textsuperscript{16} Mitrovic, \textit{Learning from Palladio}, 65.
Fig. 2.10 Corinthian Order with a three bay configuration.

Fig. 2.11 Corinthian Order with a five bay configuration.
In order to integrate the column positions with the placement of the internal walls, the variable which determines intercolumniation and height of the columns must produce a composition that corresponds in both plan and elevation.

As seen in figure 2.2, Palladio had identified the Vitruvian systems of column dispositions with each of the orders, the type determining what he deemed the ideal dimension for spacing. There are specific ratio’s associated to each type of order to determine height and width of the column and it’s associated elements. Selection of a particular order defined what the intercolumniation would be, the diameter of the column (D) would be defined by the associated proportional principle.

Fig. 2.12 Ionic Order with a three bay configuration
If the definition of a parametric design system is understood as being a methodology that has numerous rules that are intricately linked then Palladio’s buildings Palazzo Chiericati, and Villa Cornaro are examples of this methodology put into practice.

2.3 Palazzo Chiericati

Palazzo Chiericati exhibits a very complex relationship between the proportional geometry of the external elements and interior spaces, which determines the overall design of the building. The coordination between the internal spatial composition and external elevation composition can be seen in the alignment of the positions of the interior walls with the location of the external elements (columns). Throughout the palazzo, the internal room sizes, length, and width, are determined according to Palladio’s proportional rules and preferred length-to-width
ratios. These then inform the height of the rooms, which must equal the height of the columns plus the entablature. The total height of column and entablature is determined by the proportions associated to the chosen systematic rules (orders), which in turn determine the spacing of the columns (intercolumniation).

Palladio required that rooms in the same row should have equal heights, accordingly their proportions must be carefully coordinated. In rooms with flat ceilings this can be easily be achieved by ensuring they have a width dimension in common. In the case of vaulted ceilings the requirement becomes more complex. The plan is proportionally integrated internally, two rooms in sequence with same the same height-to-width ratio.

Room A has a length-to-width ratio of 5:3, (30 x 18 feet) the next room (Room B) is square, a length-to-width ratio of 1:1, (18 x 18 feet). If the height of the vaulted ceiling for Room A is calculated from the arithmetic mean:

\[
\text{height} = \frac{\text{width} + \text{length}}{2} = \frac{18 + 30}{2} = 24
\]

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17 Ackerman, *Palladio*, 167.
18 Mitrovic, Learning from Palladio, 71.
The height of Room B, a square is calculated as:

\[
\text{height} = \frac{4}{3}w = \frac{4}{3}l \\
= \frac{4}{3}18 = \frac{4}{3}18 \\
= 24
\]

Fig. 2.15 Room A & B

Mitrovic identified this design principle, and described it as the Condition on the Concordance of Heights, or CCH rule. This condition stipulates that by using differing means to calculate the ceiling height, it is possible to achieve the same height for rooms in the same row.

Demonstration of the coordination between the internal spatial proportional system and the system of the external elements composition can be seen in the alignment of the positions of the interior walls with the location of the external elements (columns). The total height to the top of the entablature aligns with level of the upper floor. The intercolumniation of the lower floor Doric columns is close to 2.5 column diameters. This does not correspond with the disposition Palladio identified as appropriate, but is still less than the 3 column diameters Vitruvius recommended as a maximum.
Fig. 2.16 Partial plan of Palazzo Chiericati showing alignment of disposition of columns with rooms. From *C.I.S.A.*
2.4 Villa Cornaro

The book *Andrea Palladio: Villa Cornaro in Piombino Dese*, records the author’s accurate survey, and a design analysis based upon the collected data. The villa designed in 1551-1552, came shortly after Palazzo Chiericati and displays the application of similar design principles seen in Palazzo Chiericati.

Fig. 2.17 Plan and elevation of Villa Cornaro (circa 1551) From *I quattro libri dell’ architettura*
The outer columns of the entrance portico align with the interior walls of the sala, and the second most outer columns align with the four columns of the sala. Palladio has spaced the portico Ionic columns at the 2.25 diameter intercolumniation, which corresponds to what he identified as being the order associated with the Vitruvian, eustylon spacing.

Off either side of the main entry, are large rooms (9455 x 5560 mm) with the length-to-width ratio of 3:1 (a ratio not listed in I quattro libri). The ceiling height, 7170 mm, has been generated by finding the geometric mean length and width. Immediately adjacent is a square room, 1:1, which has a ceiling height of a similar dimension, 7238 mm. The ceiling height has been generated by applying the rule that the height-to-width ratio should be 4:3. (Fig. 2.19).

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The four internal columns within the sala, if measured from the central axis to the top of column, delineate a space that has a ratio of 7308:5220 $\sqrt{2}$ mm). The dimension 5220 mm is similar to the width, 5560 mm, of the neighbouring rooms. The height of the columns, 6383 mm, is close to the figure derived from the arithmetic mean of the length-to-width, 6301 mm. (Fig. 2.20).

Fig. 2.19 Room ratios $3\sqrt{2}$ and 1:1 with similar ceiling heights. Sizes from Andrea Palladio: Villa Cornaro in Piombino Dese.

Fig. 2.20 Room ratios $3\sqrt{2}$ and $\sqrt{2}$: with similar widths. Sizes from Andrea Palladio: Villa Cornaro in Piombino Dese.
The walls enclosing the sala provide the dimensions 11135 x 9055 mm, ratio 1.23:1. The width dimension, 9055 mm, corresponds closely with the measurement given by the face diagonal of the square room width-to-height ratio (Fig. 2.15). The length dimension, 11135 mm, corresponds with the space diagonal found in the volume delineated by the internal sala columns (Fig. 2.21). The length-to-width ratio, 1:1.23, matches that of the width-to-height, 9055:7440 mm.

Fig. 2.21. Face and space diagonals from room ratio 1:1, and internal sala columns. Sizes from Andrea Palladio: Villa Cornaro in Piombino Dese.

The width-internal (W-internal), derived from the face diagonal of room ratio 1:1, has a proportional relationship to the length-internal (L-internal), ratio 1.23:1 (3√2/1), and the height-internal (H-internal) ratio 1.22:1. The length-internal, derived from the space diagonal of the volume of the internal sala columns, has a proportional relationship to the order type, Ionic, and its prescribed intercolumniation, 2.25D. The spacing of columns, when measured as length-3 bays (L-3 bays), corresponds to the width of the internal sala column spacing. The Length-internal at the same time relates to the Height-o/all (H-o/all), the height of the internal space ceiling (less the thickness of the upper storey floor), and of the height of the external order elements, which in turn defines the column diameter and therefore the column spacing.
Fig. 2.22. Dimensional relationships of external columns, room width-to-height ratios, and internal sala columns. Sizes from Andrea Palladio: Villa Cornaro in Piombino Dese.

Fig. 2.23. Section view showing external and internal room heights. Sizes from Andrea Palladio: Villa Cornaro in Piombino Dese.
3.0 Methodology

3.1 Methodological Approach of the Project

The development of a design approach based on the principles of Palladio’s parametric design system will require the understanding and application of the system. This will be carried out in the design of a civic building of a suitable programme, within an appropriate context.

3.2 Content

An analysis of Palladio’s buildings, the Palazzo Chiericati and Villa Cornaro, has enabled the design methodology employed to be quantified, through definition of the compositional and dimensional rules displayed, and applied as a tool-set in the designing of an architectural form.

3.3 Context

Suitable constraints will be found through analysis of the site conditions, and of the several previous analysis reports that exist of the site.

The proposed building will be located within Aotea Square, Auckland. The site provides a central position within the Central Business District, within close proximity to commercial, retail and cultural activities. Aotea Square lies within the Auckland City Council designated ‘Aotea Quarter’ a zone that includes Auckland Art Gallery, Auckland Central City Library, Aotea Square, Auckland Town Hall, Aotea Centre and Civic Theatre. A number of architectural programmatic options may be suited to this site. For example, a new or additional library or art gallery, museum or science exposition centre, or a governmental building.

For the purpose of this thesis, the site has a requirement to include a number of immutable parameters, that can provide generators to the external form of the building.

These may include:

• Key Landmarks.
• Activity Layers.
• Pedestrian Thoroughfares.

Suitable constraints will be found through both analysis of the site conditions, and the study of several previous analysis reports that exist of the site.
3.4 Exploration

To develop a systematic approach that provides a design tool based on Palladio’s principles will require the exploration of techniques of form generation. Techniques will be combinations of manual and computer software aided processes, based on the parameter lists ascribed to Palladio’s architectural design theories, and analysis of his drawings and buildings.

A building programme, combined with the physical constraints identified within the site, will be associated to the variables within the rule sets described by Palladio’s design methodology. The form of the building will be derived through the exploration of numerous combinations of linked variables, while at the same time seeking to achieve a building design that exhibits a co-ordination of groups of elements in three dimensions.21 Once the central logic and design relationships have been defined, and the parametric equation formulated, numerous formal variations can be quickly generated and analysed with the use of CAD software and hand drawing, enabling the formulation of a design approach and tool-sets.

21 Ackerman, Palladio, 167.
4.0 Project Development

4.1 Typology and Programme Selection

The function and programme of the proposed building needs to work within the context of the buildings in and around the Aotea Square.

Fig. 4.1. Aotea Quarter

1. The Civic Theatre - Cultural / Entertainment.
2. Aotea Square - Public space.
3. Aotea Centre - Conference / Entertainment.
4. Civic car park.
5. Auckland Town Hall - Cultural / Entertainment / Civic administration.
7. Lorne Street Upgrade - Public space
9. Auckland Central Library - Cultural/ Education.
Possible typologies explored as being suitable for the site context, and for the purpose of this thesis, included; an art gallery, conference centre, library and a council chambers building.

The library was discounted after researching into the programming requirements, which had numerous technical requirements surrounding the relationship of spaces and size of spaces based on the population base served. The need for numerous spaces within the building would have required the design of multiple interlinked variables (rooms) and was anticipated to have generated a building of unwieldy complexity, if Palladio’s design principles were to be applied. If the size of spaces within the library were based on the population of citizens served, the overall size of the building would have been unsuitable for the size of the site.

A conference centre could have combined with the existing facilities of the Aotea Centre, but again the minimum size requirements would have generated a building unsuitable for the site.

An art gallery, although providing the opportunity to devise a suitably simple programme, would have been located in too closer proximity to the existing Auckland City Gallery, and a relational physical connection with the existing buildings did not seem obvious.

The arrival at the selection of a Council Chambers building was achieved after considering several factors. Firstly the proximity of the Town Hall. Until recently the existing council chambers, located within the Town Hall, served as the venue for Governing Body meetings. The building still houses the mayoral office and provides a venue for public debates. As Auckland City has expanded, and therefore the number of Council representatives, so has the requirement for a larger meeting space. A proposed building could provide the larger space required, and function in tandem with the existing Great Hall and Concert Chamber spaces within the Town Hall. Therefore a relational link between the two buildings, visual or physical, would provide a parameter or constraint essential to this project. The classical grammar of the Town Hall can similarly be used as a guiding concern in the design process. The programmatic requirements of a Council of Chambers building can be achieved with a suitably small number of large spaces, enabling the plan composition and exploration of Palladio’s design methodology, without encountering undue complexity. The size requirements of spaces will allow for placement within the available site dimensions.

The relationship of the proposed building to the existing built environment contains some of the possible constraints explored in this project. An obvious and important relation is the connection to the heritage building, Auckland Town Hall and its surrounding context.

The Town Hall, built in the style of Imperial Baroque, has served as the home for civic government since its completion in 1911. Until recently the council Governing Body monthly meetings were held in the chambers. The majority of council offices are no longer housed within the building, but the Mayor’s office and support staff still reside on the second floor. The possible need for a physical connection, providing access for the Mayor to the new chambers, will be an avenue of design exploration. There will also be a need to position any new entrance openings in relation to the existing Town Hall access points, to enhance a combined functionality.

Sensitivity to the form and massing of the Town Hall will impact on the location and overall size of the proposed building to ensure neither one dominates the public square.

Important existing building entrances and landmarks formed by the geometry of the existing built environment are show in Fig. 4.2.

- **A** Main pedestrian access from Queen Street into the existing plaza. The space is bound on two sides, north and west, and partially by the Town Hall clock tower in the south-eastern corner.

- **B** Ground level access into the Town Hall building, with same level access to the Great Hall. Adjacent to the entry is pedestrian access up from the underground car-parking.

- **C** The main entry to the Civic Building, which houses Auckland City Council councillors and administration staff offices.

- **D** A secondary entry into the Aotea Centre lobby.

- **E** The main stairway and entry into the Aotea Centre theatre complex.

- **F** Pedestrian access from a covered walkway that connects to Wellesley Street, West, from Myers Street car-park, and Mayoral Drive.
Fig. 4.2 Aotea Square and surrounding buildings (scale 1:1500)
The facades on the Aotea Centre and the Skycity Metro building partially form a plaza. The axes from the entry points define the centre of the open public space.

The Town Hall clock tower has an elevation which generates an axis through the centre of the existing open space.

There is a pedestrian corridor parallel to the Town Hall, and provides also provides a visual link between Greys Avenue, and Queen Street.

The high-rise Civic Building, generates a corridor between its facade and the southern elevation of the Aotea Building.

Pedestrian access from the Greys Avenue car-park forms an axis with the entrance (D) to the Aotea Centre.

The covered walkway parallel to the Bledisloe building provides a visual sight-line axis for pedestrians entering the public square.

5.2 Spatial Analysis of Site

Exploration of the site and surrounding buildings through a series of figure and ground diagrams helped to gain an understanding of both the possible building location, and the size of building footprint in relation to the available area (Fig. 4.3). When combined with analysis of the spatial relationships of spaces formed by building entrance ways, the geometries of existing buildings forms, and relationships to neighbouring buildings (Fig. 4.4 and 4.5). The information can be further refined to produce a possible building location, indicated by the area labeled A in Fig. 4.6, and show possible axial locations.

Consideration of sun and wind studies22 provided further indications of the best building location and possible locations for public spaces formed by relationships between new and existing buildings.

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Fig. 4.3 Figure and ground diagrams (not to scale).
Fig. 4.4 Spatial relationships (not to scale).

Fig. 4.5 Spatial relationships (not to scale).
4.3 Programme Development

Analysis of the existing Council Chambers within the Town Hall, a survey of plans of other town hall/council chamber buildings, and reference to the Architects Data\textsuperscript{23} and Metric Handbook\textsuperscript{24} has helped in the programme development. The spatial requirements for a council of chamber can be broadly classified in three main volumes;

- Entrance Hall
- Assembly Hall
- Council Chamber

The Council Chamber has a requirement to provide a meeting space for at least 21 council representatives and public gallery seating for at least seating for 200-300 people. Allowance for public viewing and seating may be spread over two floors. An approximate size of 350-450 square metres has been estimated as appropriate.

and dances. The space requirement for a seated function with approximately 300-350 people is 180-210 metres squared.\textsuperscript{25}

The Entrance Hall, which will serve as the main public access space, has a size that is no bigger than the Assembly Hall, and is dependent on the size and location of any adjoining secondary spaces.

There are a number of secondary and service spaces contained within the programme of the building. These include;

- Committee meeting rooms
- Administration offices
- Banqueting reception
- Cafe/catering facilities
- Mayoral suite
- Public reception/information.

For the purpose of this project, the importance will be placed on the three spaces first listed. The design and composition of these spaces will determine Palladio’s parametric design methodology.

4.4 Room Size Ratio Exploration

Room ratio’s can be grouped together so that the ceiling heights, generated by the principle means, are of an identical dimension. Figure 4.7 shows the number of possible combinations with ceiling heights that correspond exactly. Figure 4.8 shows combinations that have heights that are very similar.

Fig. 4.7 Room length-to-width ratios combinations with identical ceiling heights.

\textsuperscript{25} Ibid, chp. 2, 13.
Fig. 4.8 Room length-to-width ratios combinations with similar ceiling heights.

A parametric equation can be formed by relating the rules that determine the preferred room length-to-width ratios to each of the variables, principle means, that generate the ceiling heights. Appropriate combinations of rooms, those that have identical or similar heights can then be grouped as a parametric object.

**List of Palladio’s Preferred Room Length/Width Ratios and Corresponding Ceiling Heights**

<table>
<thead>
<tr>
<th>Room Shape</th>
<th>Length/Width Ratio</th>
<th>Length (l)</th>
<th>Width (w)</th>
<th>Height (h)</th>
<th>Principle means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>1/1</td>
<td>10000</td>
<td>6000</td>
<td>13333.33</td>
<td>(4/3)w</td>
</tr>
<tr>
<td>Square</td>
<td>1/1</td>
<td>6000</td>
<td>6000</td>
<td>8000.00</td>
<td>Harmonic</td>
</tr>
<tr>
<td>Rectangular</td>
<td>√2/1</td>
<td>8485.281</td>
<td>6000</td>
<td>7242.64</td>
<td>Geometric</td>
</tr>
<tr>
<td></td>
<td>3/2</td>
<td>9000</td>
<td>6000</td>
<td>7500.00</td>
<td>Harmonic</td>
</tr>
<tr>
<td></td>
<td>5/3</td>
<td>10000.00</td>
<td>6000</td>
<td>8000.00</td>
<td>Harmonic</td>
</tr>
<tr>
<td></td>
<td>2/1</td>
<td>12000</td>
<td>6000</td>
<td>9000.00</td>
<td>Harmonic</td>
</tr>
<tr>
<td></td>
<td>√3/1</td>
<td>10392.305</td>
<td>6000</td>
<td>8196.15</td>
<td>Harmonic</td>
</tr>
</tbody>
</table>

Fig. 4.9 Ceiling heights generated by principle mean.

Fig. 4.10 Ceiling heights and floor areas.

Once grouped, the length-to-width dimensions of each room change as the width variable is altered. The floor area is calculated and variables modified to achieve floors suitable for the needs of the building programme.
4.5 Part I - Plan Composition Exploration

An attempt was made to locate a loosely organised composition of spaces within the site responding to axes related to the geometry of the existing buildings, and at the same time attempting to create spaces between them.

1. The axis relating to the Town Hall clock tower has informed the angle of the elevation that relates to the public space immediately adjacent to Queen Street.

2. The central axis of the northern half of the building is generated by the elevation axis, it also intersects with the axis generated by the central entry points of buildings A & B.

3. The elevation of the Town Hall has provided an axis that the southern half of the building relates to, and at the same time address the Grey Street access.

4. A public space is created between the proposed building and Aotea Centre, building, A.
A large public plaza is created by the containment of the space by buildings A and B, and the placement of the proposed building.

An external space connects the large public plaza with the pedestrian corridor formed between the proposed building and Town Hall, and the existing building access, D.

The spaces within the proposed building are sized approximately according to the list of preferred ratios, and have floor areas derived from the initial programme design. This initial scheme has incorporated an internal court yard and two large exhibition spaces. The court yard in conjunction with the entrance provide a threshold between the open public plaza and the enclosed semi-public space of the assembly hall, and council chamber. Exhibition spaces are intended to help activate the edges of the public plaza.

At this stage of the design, the composition of spaces is centered around forming spaces with length-to-width ratios from the list of preferred sizes, and can be combined so that ceiling heights are in concordance (Figures 4.9 and 4.10). As the estimated floor areas are manipulated to suit the site, the linked combination of spaces change accordingly. The parameters determined by the site have been explored, but the location of a large public plaza, and access way to the Town Hall remain.
A variation on the first scheme has produced a plan of a similar form, the main elevation, on an angle related to the clock tower, is still helping to define a large public plaza. Exterior spaces of a broadly similar shape are still formed in the same locations. The axes of the two halves of the building are of the same angle, but the axial shift occurs within the internal court yard. This had the effect of altering the shape of the western public space, to produce a more enclosed shape.

Planning composition has been altered to provide for staircase to a second floor level, but the general arrangement has not changed. The overall size of the building appears to be too large proportionally for the site.

1. The axial shift occurs within the internal court yard.

2. A pedestrian connection is identified across the southern elevation.

3. The shape of the smaller public plaza has a more enclosing shape.

A third iteration of the initial scheme (Fig. 4.13) contains a much smaller internal court yard, and a much smaller form overall. The dual axes of the building remain, and the axial shift now occurs within a circular room.

Fig. 4.13 Third version of initial scheme (not to scale).
A circular geometry is chosen to help facilitate the transition between axes. The overall form is considerably smaller, with the effect the public plaza to the west of the proposed building is disproportionately too large in relation to the main public plaza.

Fig. 4.14 Fourth version of initial scheme - Ground Floor Plan (not to scale).

Fig. 4.15 Fourth version of initial scheme - First Floor Plan (not to scale).
The fourth version of the initial scheme again has a dual axis arrangement, but this time the intersection has moved to the southern end and defines the centre of a circular chamber room. The elevation facing Greys Avenue is perpendicular to the street axis, the circular geometry allowing the mass of the southern block to rotate externally. The western plaza has better proportional relationship to the major public space. The overall size of the floor plan, slightly larger than the previous version, seems to be close to an appropriate scale, but appears awkward in its location and proximity to existing buildings.

The dimensions of the vertical heights have been explored in a series of section elevations and elevations. This showed the relationship of spaces relative to each other, and the suitability of size in relation to surrounding buildings.

It is apparent the height and overall size of the Assembly Hall, show in Fig. 4.17, is too large. The expected number of occupants is considerably less than the neighbouring Grand Hall caters for, and the overall height is similar for both.
Fig. 4.18 Northern elevation (not to scale).
Feed back from the first formal critique informed a more resolved plan solution.

1. The central axis is no longer parallel to the elevation of the clock tower, and is now perpendicular to the building opposite, B. This creates a large public plaza with a more regular shape.

2. The western elevation is now parallel to the existing building, A, which creates a more regularly shaped plaza that appears to be a better sized proportionally to the large square.
An entry, in the proposed building, faces towards the entry of the existing building, D.

The relationship with the existing entrance way located in the Town Hall, C, has been maintained.

An additional plaza has been formed between the proposed building and the Town Hall, providing an area that can be served with a cafe and outdoor seating. It serves as a transitional space from the large plaza to the pedestrian corridor, 6.

Minor modifications were then made to the plan, and a series of elevations produced.

Fig. 4.20 Plan variation (not to scale).
Fig. 4.21 Northern elevation (not to scale).

Fig. 4.22 Eastern elevation (not to scale).

Fig. 4.23 Southern elevation (not to scale).
The process of designing the elevations within the context of the surrounding buildings allowed for the analysis of the height of the proposed building. The ceiling height of the rooms, all with an identical height dimension, and grouped together as a parametric object is currently 16 metres. This height determines the overall roof height, and appears to relate well to the neighbouring buildings. Not seeming to be too visually dominant, and at the same time preventing the proposed building from appearing over overshadowed.

A summery of the design process has produced a preliminary list of site constraints:

• The connection to the existing Town Hall entrance.
• An axis parallel to the Town Hall, creating a pedestrian corridor.
• An axis parallel to the Aotea Centre, used to generate two public plazas. One large, formed by the northern elevation, and a smaller by the western elevation.
• An overall facade height between 10 to 16 metres.
4.7 Part III - Formulation of the Parametric Equation

After achieving a composition of the main spaces, which appear to suit the site context, both in plan area and volume height, the next was to link further variables together and begin forming an equation.

Beginning with the largest space, the Assembly Hall, which has the following dimensional parameters (Fig. 4.24), it was necessary to associate this object with another, the order type.

<table>
<thead>
<tr>
<th>Principle means</th>
<th>Room Size 1</th>
<th>metres</th>
<th>arithmetic</th>
<th>geometric</th>
<th>harmonic</th>
<th>( \frac{4}{3}w \times \frac{4l}{3} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle</td>
<td></td>
<td>( l )</td>
<td>( \frac{w+l}{2} )</td>
<td>( \sqrt{wl} )</td>
<td>( 2wl / (w+l) )</td>
<td></td>
</tr>
<tr>
<td>Width (w)</td>
<td>12</td>
<td></td>
<td></td>
<td>18</td>
<td>16.971</td>
<td>16.000</td>
</tr>
</tbody>
</table>

Fig. 4.24 Room height calculated as per principle means.

This is done by exploring the dimensional parameters, for example a length or width dimension, and linking it to the rule set of the order to generate the column object. The rule set for each order has proportionally linked variables which determine the dimensions and size of the associated elements. In the example below, Figure 4.25, three different formulas, using the rules generate three different options for column height and spacing.

<table>
<thead>
<tr>
<th>Corinthian Order (intercolumniation 2D)</th>
<th>Input Width (W)</th>
<th>Input Height (HO)</th>
<th>Input Distance (DX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Elevation (W)</td>
<td>12000 mm</td>
<td>12000 mm</td>
<td>12000 mm</td>
</tr>
<tr>
<td>Number of Bays (E)</td>
<td>3</td>
<td>5</td>
<td>5.00</td>
</tr>
<tr>
<td>Distance between columns (C)</td>
<td>2066.67 mm</td>
<td>1754.30 mm</td>
<td>1600.00 mm</td>
</tr>
<tr>
<td>Distance between axis (DX)</td>
<td>4000.00 mm</td>
<td>2631.56 mm</td>
<td>2400.00 mm</td>
</tr>
<tr>
<td>D (H / 10.4) [DX / 3]</td>
<td>1333.33 mm</td>
<td>877.19 mm</td>
<td>800.00 mm</td>
</tr>
<tr>
<td>Total Height (HO) [D x 11.4]</td>
<td>15200.00 mm</td>
<td>1000.00 mm</td>
<td>9120.00 mm</td>
</tr>
<tr>
<td>Entablature (1/5 column height)</td>
<td>2533.33 mm</td>
<td>1666.67 mm</td>
<td>1520.00 mm</td>
</tr>
<tr>
<td>Column height (9.5D)</td>
<td>12666.67 mm</td>
<td>8333.33 mm</td>
<td>7600.00 mm</td>
</tr>
</tbody>
</table>

Fig. 4.25 Corinthian Order type calculation

The first formula generates an overall height and ideal spacing of the column, based on the width (W) of the room, in this case 12,000 mm and the number of columns, or bays between columns (B). It defines a height, 15,200 mm (HO), to the top of the entablature, which is clearly to large for a room with a ceiling height of 16,000 mm.

The second formula generates an ideal column size and spacing, by in-putting the height (HO), 10,000 mm. The width dimension does not correspond with the one determined by the room, but does provide an indication of what spacing may work. It may provide a solution that could be suitable with double or engaged column configurations.

The third formula defines an ideal column height and diameter, (D), after inputting an intercolumniation dimension (shown in figures 4.26 and 4.27). In this example the dimension divides exactly into the width 5 times, but a slightly larger or smaller number could be used to find a configuration that works generally.
Fig. 4.26 Corinthian Order type calculation described in plan.

Fig. 4.27 Corinthian Order type calculation described in axonometric projection.
A visual assessment of the column configuration concludes that a change can be made to locate the columns on the perimeter of the room, so that the outer dimension of the column delineates the internal space. This in turn raises the overall height height of the entablature to 9,690 mm (figure 4.28). A total ceiling height close to the desired dimension of 16,000 mm can be achieved with a 6,000 mm radius barrel vault over the centre of the space (figure 4.29).

<table>
<thead>
<tr>
<th>Corinthian Order (intercolumniation 2D)</th>
<th>(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Elevation (W)</td>
<td>12750.00</td>
</tr>
<tr>
<td>Number of Bays (B)</td>
<td>5.00</td>
</tr>
<tr>
<td>Distance between columns (IC)</td>
<td>1700.00</td>
</tr>
<tr>
<td>Distance between axis (DX)</td>
<td>2950.00</td>
</tr>
<tr>
<td>D (H / 10.4) [DX / 3]</td>
<td>850.00</td>
</tr>
<tr>
<td>Total Height (HO) [D x 11.4]</td>
<td>9690.00</td>
</tr>
<tr>
<td>Entablature (1.5 column height)</td>
<td>1615.00</td>
</tr>
<tr>
<td>Column height (9.5D)</td>
<td>8075.00</td>
</tr>
</tbody>
</table>

Fig. 4.28 Corinthian Order type calculation with a wider DX.

Fig. 4.29 Corinthian Order type calculation with a wider DX described in axonometric projection.
Aligning the internal columns with external columns of the colonnade (Figure 4.30) is achieved by entering the intercolumniation variable of the Corinthian order, 2550 mm, into the formula (Figure 4.31) associated to the Ionic rule set. A column and entablature height (HO) of 8473.85 mm is generated. If the columns are placed upon pedestals a total height of 10,266 mm is obtained. This corresponds closely to the HO generated by the Corinthian order object (Figures 4.32 and 4.33).

**Fig. 4.30** Corinthian Order and Ionic colonnade calculation described in plan.

<table>
<thead>
<tr>
<th><strong>Ionic Order (intercolumniation 2.25D)</strong></th>
<th><strong>Input Distance (DX) (mm)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Elevation (w)</td>
<td>25500.00</td>
</tr>
<tr>
<td>Number of Bays (B)</td>
<td>10.00</td>
</tr>
<tr>
<td>Distance between columns (IC) (2.25)</td>
<td>1765.38</td>
</tr>
<tr>
<td>Distance between axis (DX)</td>
<td>2550.00</td>
</tr>
<tr>
<td>$D \ (H / 10.4) \ [DX / 3.25]$</td>
<td>784.62</td>
</tr>
<tr>
<td>$D \ (H / 10.8) \ [D x 10.8]$</td>
<td>8473.85</td>
</tr>
<tr>
<td>Entablature (1/5 column height)</td>
<td>1412.31</td>
</tr>
<tr>
<td>Column height (8D)</td>
<td>7061.54</td>
</tr>
</tbody>
</table>

**Fig. 4.31** Corinthian Order and Ionic colonnade calculation.
Fig. 4.32 Corinthian Order and Ionic colonnade section view.

Fig. 4.33 Corinthian Order and Ionic colonnade calculation described in axonometric projection.
Fig. 4.34 Floor plan with new column configuration (not to scale).
In the above elevation (Figure 4.35) if the colonnade is extended along the elevation, the spacing can determine the placement of internal spaces, or elements. For example the placement of the entry adjacent to the Civic Building, (A), is between two columns, and is centred in the room. The central axis of the dome is aligned above.

Fig. 4.35 Western elevation, Ionic columns on pedestals. variation I (not to scale).

Fig. 4.36 Western elevation, Ionic columns on pedestals, variation II (not to scale).
A second elevation composition exploration (figure 4.36) used the same intercolumniation spacing to generate a facade rhythm. The placement of spaces is again determined by the disposition dimension, (DX), but sections of the facade have columns removed.

In both elevations the section of wall raised above the Ionic entablature, done so to accommodate the sixteen metre high ceiling, appears top heavy, and proportionally wrong.

The two following elevations (Figures 37 and 38) explored the same entablature height, but a lowered overall roof height.

Fig. 4.37 Western elevation, Ionic columns on pedestals, and lowered roof height (not to scale).

Fig. 4.38 Northern elevation, Ionic columns on pedestals, and lowered roof height (not to scale).
The Northern elevation (figure 4.38) shows the first experimentation with an appropriate dome form and size. The third dome, seen in the western elevation (figure 5.36), a flattened circular dome, has been replaced with a slightly raised circular dome, which appears more proportionally correct. The exposed rib structure does not seem to fit with the language of the rest of the building.

4.8 Part IV - Further Exploration of the building form

The previous iteration of the scheme, with a lowered roof height, appeared to be a better solution. For this to be achieved the ceiling height need to be lowered. A possible resolution is to retain the existing rooms area sizes, and place additional columns within the space. this has the effect of creating slightly smaller spaces, diluted by the columns, maintaining the existing length-to-width ratios, and generating a lower ceiling height.

The plan now displays a number of dimensional relationships between the internal sizing and external elements (Figure 4.39). These are repeated in the second floor plan (appendix C).

1 The Assembly Hall has retained the same column spacing dimension, but additional columns have been added in each of the corners to define a smaller space, and support the segmental ceiling vault.

2 The exterior column spacing of the Ionic columns have been retained. The overall dimension, and spacings, of the columns along the western elevation has determined the placement of internal spaces and openings.

3 The Exhibition Rooms (B) have a relationship to the columniation of the external Ionic columns.

4 The columns of the Entrance Hall (C) are of the Doric order type, and the intercolumniation (3D) and element height can be adjusted to achieve an alignment.
Fig. 4.39 Ground floor plan (not to scale).

(Refer to appendix 9.3, figure 9.3, page 80, for Upper Floor plan variation.)
Fig. 4.40 Western elevation (not to scale).
Fig. 4.41 Northern elevation (not to scale).
A full length colonnade on the western facade has been retained, but an immediate and obvious observation is the sheer number of columns (fig. 5.40). The proportional relationship between the height of the colonade entablature and the overall height of the roof appears to be correct, and the height relates well to the existing buildings, although possibly slightly too low in comparison to the Aotea building, visible in figure 5.41. The entry portico has Corinthian columns of the same height and overall width as used in the Assembly Hall. The spacing of these columns matches the engaged Ionic columns of the Exhibition Hall facade, producing an even rhythm across the entire elevation. The entry portico appears too narrow across the width, and an adjustment will be required.

The southern elevation (fig. 4.42) highlights the formal condition of the proposed dome. It does not suit and seems to be disconnected from the building whole.

The section through the Assembly Hall (fig. 4.43) illustrates how the smaller space is defined and a lower ceiling height is generated.

The sectional axonometric drawing (fig. 4.44) clearly demonstrates how the design has become unduly complex. The addition of extra columns, combined with the close spacing of the Corinthian order, has resulted in too many columns. The next stage of the process was to clearly define what form the parametric equation takes, and undertake to integrate the internal space of the Chamber room into the overall design.

Fig. 4.42 Southern elevation (not to scale).
Fig. 4.43 Section through Assembly Hall (not to scale).

Fig. 4.44 Sectional axonometric (not to scale).
4.9 Part V - Formulation of the Parametric Equation

The three main spaces are grouped together, and the length-to-width ratio variable is linked to the principle means variable. The now reduced width of 10 metres generates a ceiling height of 13.333 metres (Fig. 4.45).

<table>
<thead>
<tr>
<th>Assembly Hall</th>
<th>Room 1</th>
<th>metres</th>
<th>arithmetic</th>
<th>geometric</th>
<th>harmonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle / (Ratio 2:1)</td>
<td></td>
<td></td>
<td>((l+1)/2)</td>
<td>(\sqrt{wl})</td>
<td>(2l/(w+1))</td>
</tr>
<tr>
<td>Length (l)</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width (w)</td>
<td>10</td>
<td>Height (h)</td>
<td>15</td>
<td>14.142</td>
<td>13.333</td>
</tr>
<tr>
<td>Entrance Hall</td>
<td>Room 2</td>
<td>metres</td>
<td>arithmetic</td>
<td>geometric</td>
<td>harmonic</td>
</tr>
<tr>
<td>Rectangle / (Ratio 5:3)</td>
<td></td>
<td></td>
<td>((l+1)/2)</td>
<td>(\sqrt{wl})</td>
<td>(2l/(w+1))</td>
</tr>
<tr>
<td>Length (l)</td>
<td>16.667</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width (w)</td>
<td>10</td>
<td>Height (h)</td>
<td>13.333</td>
<td>12.910</td>
<td>12.500</td>
</tr>
<tr>
<td>Exhibition Room</td>
<td>Room 3</td>
<td></td>
<td>((l+1)/2)</td>
<td>(\sqrt{wl})</td>
<td>(2l/(w+1))</td>
</tr>
<tr>
<td>Length (l)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width (w)</td>
<td>10</td>
<td>Height (h)</td>
<td>10</td>
<td>10.000</td>
<td>10.000</td>
</tr>
</tbody>
</table>

Fig. 4.45 Room length-to-width ratios linked to the principle means.

Fig. 4.46 Room length-to-width ratios linked to the principle means.
The Chamber Room, which has a floor area requirement of 200-250m² and is circular in shape, to both accommodate the general meeting function requirement and suit the axial shift created by the building placement within the site.

Integrating the size of the Chamber Room with a proportional relationship to the dimensions of the Assembly Hall can be achieved by using the length dimension of the Entry Hall, 16.66 metres to provide the diameter dimension of the circular space delineated by the axis of the columns.

Fig. 4.47 Linking the Chamber diameter dimension.

The dimension 16.666 metres can also be found as a diagonal face dimension in all of the rooms, if the height (h) coupled with the width (w) was to form a rectangle.
For a room with a 1:1 ratio, square or circle, the ceiling height is determined by the ratio 4:3. 16.666 metres generates a height of 22.222 metres. In this case the ratio is repeated to generate the circumference of the external walls. A dimension of 16.666 metres may be suitable for the height of the external walls, and help to generate a well proportioned dome.
To reduce the number of columns, an order type with a wider spacing requirement, Ionic 2.25 intercolumniation-to-diameter ratio, was the variable linked to the room ratio rule set (figure 5.49).

<table>
<thead>
<tr>
<th>Ionic Order (Intercolumniation 2.25D)</th>
<th>Input Distance (DX)(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Elevation (w)</td>
<td>33333.00</td>
</tr>
<tr>
<td>Number of Bays (B)</td>
<td>10.00</td>
</tr>
<tr>
<td>Distance between columns (IC) (2.25)</td>
<td>2307.67</td>
</tr>
<tr>
<td>Distance between axis (DX)</td>
<td>3333.30</td>
</tr>
<tr>
<td>D (H / 10.4) [DX / 3.25]</td>
<td>1025.63</td>
</tr>
<tr>
<td>Total Height (HO) [D x 10.8]</td>
<td>11076.81</td>
</tr>
<tr>
<td>Entablature (1/5 column height)</td>
<td>1846.14</td>
</tr>
<tr>
<td>Column height (9D)</td>
<td>9230.68</td>
</tr>
</tbody>
</table>

Fig. 4.49 Ionic order type calculation.

Fig. 4.50 Ionic order type calculation described in plan and section.

The height of the top of the entablature (HO) is placed well in relation to the desired ceiling height, and the second floor level appears to be placed well in relation to the ground floor level and entablature (figure 4.50).
Fig. 4.51 Parametric Equation described in plan.
The plan now demonstrates a greater level of dimensional integration and alignment throughout.

A. The internal columns align with the external columns.

The dimension 3 (DX) occurs throughout the plan of the building. The Exhibition Rooms, 3 (DX) by 3 (DX) are separated from the Assembly Hall by the dimension 3 (DX), and the proposed space to the right of the Chamber Room has the same

B. The centre of the dome, and the central entranceway and column bay of the proposed space, are alligned with the axis defined by the existing buildings and entrance point of the Civic Building.

C. The geometry of the Aotea Building has generated an axis that the column bay of the colonnade has aligned with.

The walkway entering in to the Aotea Square has provided a axis that is aligned with the centre of one of the Exhibition Room elevations. A pedestrian will view the room as a single complete element, as they approach closer the element will be reveal itself yto part of a larger whole.

D. The corinthian column object, with its corresponding intecolumniation, is used in the entry portico and in the Chamber Room.
5.0 Part VI - Final Design

The plan now demonstrates a greater level of dimensional integration and alignment throughout.

Fig. 5.52 Final ground floor plan composition (not to scale).
Fig. 5.53 Final northern elevation composition (not to scale).
Fig. 5.54 Final western elevation composition (not to scale).
Fig. 5.55 Final eastern elevation composition (not to scale).
Fig. 5.56 Final southern elevation composition (not to scale).
Fig. 5.57 Section A (not to scale).
Fig. 5.58 Section B (not to scale).
Fig. 5.59 Perspective view from Queen Street (not to scale).
5.0 Critical Appraisal of the Final Design

The purpose of this project was to investigate a design methodology that enabled the design of a building which integrated the internal spaces and external elements. This would be achieved through architectural strategies using research by design.

5.1 Site Analysis and Form Integration

An analysis of the site and immediate surrounding buildings defined a number of constraints. A list of the geometrical constraints was compiled, which were then considered when formulating the form generating parametric equation. This was done so that the proposed building might attain an integration within the existing built environment. The list included, a physical connection with the Town Hall, an axial relationship with the Civic Building, a line-of-sight relationship with the pedestrian walkway parallel to the Bledisloe Building, and an axis defined by the geometry of the Aotea Centre building.

The connection with the Town Hall is both physical and programmatic in nature. The position of the relation is determined by the existing entrance way location. A link between the two buildings operates on two levels, at ground level the covered walkway connects the existing and proposed public entrance ways and enhances the programme operability of each building. For example the Assembly Hall of the Council Chambers building can act as a function area for activities utilising the Grand Hall of the Town Hall. The second level link, provides private access for the mayor and mayoral staff.

The remaining constraints have provided broad parameters with which to place the internal spaces within the composition of the plan. The council administration entrance to the Chamber Room aligns with the axis of the existing Civic Building office tower entrance. The geometrical alignments determined by the walkway and building have been centred between columns or column bays.

5.2 Massing and Floor Plan Composition

The massing of the building was generated by associating room length-to-width ratio sizes from the list of preferred room shapes with the areas required to fulfill the programme requirements. The room ratio sizes were chosen so that the ceiling heights corresponded, and as the floor area requirements were altered so did the overall height. Only the main spaces have linked proportional rule sets. This was done to prevent undue complexity, considering the number of secondary and service areas required.

The overall massing of the building, both in floor area size and elevation height was generated by the equations associated to each of the rule sets. Alteration of the dimension variables produced volumes of varied sizes which could then be considered for their suitability within the context of the site and existing building heights. The inclusion of physical and
5.1 Parametric Equation and Integration of Interior Spaces and Exterior Elements

The methodology used to coordinate the design of the interior forms with the external elements was based on quantification of the compositional and dimensional rules associated with each parametric object. The objects consist of spaces which are linked to external elements (columns) of a certain rule-set (order type), and each order type has a rule set which will determine spacing (intercolumniation), which in turn determines the composition of the elements. The resulting generated form had to adhere to the broader parameters defined by the site conditions.

Through a process of trial and error, a number of objects and rule-set combinations were explored for the generation of the external elements. The internal objects were first established, through the combining of room length-to-width ratios with similar ceiling heights. Then floor areas as per the building programme requirements are established within the parameters of the ratio rule-set. The width dimension of the main room provided the variable which is then linked to an order type and its associated rule-set. Explorations within the order type produced an element with a suitable height and spacing disposition. The intercolumniation dimension was then used throughout the composition of the building, enabling the alignment of interior columns with those of the exterior.
6.0 Summary

This thesis investigated the challenge of producing an architectural form that seeks to integrate the internal spatial composition with that of the external elements. This problem was approached by identifying the design guidelines Palladio had established around his design methodology using proportional relationships, and applying them to a design methodology that can be described as a parametric system. Research by design, in the form of exploration and design process, has been used to achieve this goal.

A conclusion can be made that a parametric design methodology can successfully produce an architectural form which to a large degree displays a visual coordination of the internal composition and external visual elements. The creation of the methodology required establishing the rule-sets for each object and then intricately linking them to create a parametric formula. Adjusting the variables for each object provided the exploration of the building design. Although the mathematical approach to generating the proportional geometries has the advantage of providing accurate information rapidly, it was important to remember Palladio’s created his design methodology to provide forms that result in beauty to the eye. This provided a framework in which to design, but Palladio also stated the architect could rely on his judgement to produce forms which do not come under any rule as long as they provide an equally beautiful outcome. A parametric approach provides a useful tool-set with which to design, or begin to design, an architectural form, yet departures from the systematic application can be made, and applied, and suitable results achieved.

If a less complex programme had been selected, or a more symmetrical building form, it may have been possible to achieve a more completely integrated form. An avenue of further investigation may lay in the designing of stand-alone residential dwellings.

The purpose of the research by design was to establish a parametric equation that generated a suitable form, one that worked within the constraints of the site, appeared visually pleasing, and displayed a "relationship of the whole to the parts, and of the parts among themselves and to the whole". This was achieved with the systematic exploration of the parts, or objects, of the equation. Each object was manipulated until it appeared to be a suitable solution, the objects were then combined and an overall building form generated. A visual evaluation of the whole form allowed an assessment to be made as to which object or objects required adjustment.

An element or group of elements can be modelled in computer-aided design (CAD) software, for example ArchiCad, and then saved as a parametric object. The object is created using Geometric Description Language (GDL) programming language, and the variables can be manipulated in the GDL script or through the 2D or 3D views and user interface display. The column objects used in this project were modelled in ArchiCad and the proportional rule-set variables could be easily manipulated. For example as the column height is increased so do

27 Andrea Palladio, I Quattro Libri dell’architettura treatise, Book 1, chp. 1, 54.
28 Ibid. Book 1, chp. 1, 54.
the variables associated to it; diameter, entasis, diminution. Other objects, internal spaces, were created by organising the rule-set information in spreadsheet computer applications, adjusting the variables linked to other objects within the object family and drawing or modelling the results. This method automatically updates each linked variable, but did not generate a model of the results. The form was then explored after it was modelled in CAD, or hand drawn. When used in combination with modelled parametric objects, it provided a useful tool-set with which to explore the design of an architectural form that exhibits internal and external coordination.

A further area of exploration would be utilising the ability to model objects, grouping them as object families, and then manipulating them using the Geometric Description Language programming script employed in CAD software. A tentative exploration was undertaken during the process of this project, and the potential for greater design control was recognised. To learn the scripting language to a suitable level, so that the refined manipulation of complex objects can be made, would have required an inordinate amount of the time available. It was considered outside the scope of this thesis but is considered worthy of further investigation of its potential as a tool to produce internally and externally integrated architectural forms.
7.0 Bibliography


8.0 Appendix

8.1 Site Location

Fig. 8.1 Site location shown shaded (not to scale). Image from Auckland Council Map Viewer, http://maps.aucklandcouncil.govt.nz/AucklandCouncilViewer/ (accessed August 31, 2012).
8.2 Sun and Wind Analysis

"The diagram shows that the southern and western portions of the Square are the sunniest, but are also those areas that are most exposed to the south-westerly winds. Screening is therefore required along the southern edge of the Square in order to provide shelter from the wind in these sunny areas."
Fig. 8.3 Upper Floor plan - Part IV variation (not to scale).
8.4 Underground Carpark Layout

Fig. 8.3 Underground Carpark layout (not to scale). From Architectus Building Consent Documentation, accessed 14 May 2012, Auckland City Council.